THURSDAY, FEBRUARY 3, 1887

A HISTORY OF THE THEORY OF ELASTICITY

A History of the Theory of Elasticity and of the Strength of Materials, from Galilei to the Present Time. By the late Isaac Todhunter, D.Sc., F.R.S. Edited and completed for the Syndics of the University Press by Karl Pearson, M.A., Professor of Applied Mathematics, University College, London. Vol. I. Galilei to Saint-Venant, 1639–1850. (Cambridge: at the University Press, 1886.)

THIS work was projected by the late Dr. Todhunter on the same lines as his well-known Histories of the "Theory of Probabilities," of the "Figure of the Earth," and of the "Calculus of Variations," and will doubtless equal them in usefulness to the mathematical student.

The first object of a writer in the preparation of such a work would be to draw up as complete a bibliography as possible of all books and papers relating to the subject, arranged in chronological order. Afterwards, in reading these memoirs, he would make copious notes, extracts, and criticisms; and then, on reaching the end of this self-imposed task, he would find his materials for a book like the present ready to place in the printer's hands. Incidentally, enough material and ideas would accumulate to form an independent treatise on the subject. Such a task was undertaken by Dr. Todhunter on the "History and Theory of Elasticity," from the standpoint of the mathematician, but he did not live, unfortunately, to complete it.

Prof. Karl Pearson explains in the preface the circumstances in which he undertook to edit and complete the work, and, from his own account, the labour thus devolved on him would have been sufficient to enable him to complete the "History" *ab initio.*

The present volume, like the previous "Histories," carries the subject and commentaries only to the year 1850, although Dr. Todhunter had analysed the chief mathematical memoirs from 1850 to 1870. The preparation of the second volume, to carry the history from 1850 up to date, is a task from which Prof. Pearson appears to recoil, with some justification; but it is to be hoped that he will enlist in his service some of the junior elasticians mentioned in his preface, and, by the application of the modern principle of the subdivision of labour, carry this invaluable work to its proper conclusion.

At the outset Prof. Pearson gives the palm to Galileo Galilei (1638) as the founder of the subject of elasticity and the strength of materials, while Dr. Todhunter asserts in § 18 that "the first work of genuine mathematical value on our subject is due to James Bernoulli . . . 1695." Galileo treated only the question of the breaking moment of a beam, or rather what we should call the *bending* moment, exactly as is done now in calculating the *stresses* in a structure, before proceeding to determine the consequent *strains* and deformations.

At this point the law enunciated by Hooke (1678) must intervene, which goes by his name, "Ut tensio, sic vis," originally published by him, in the fashion of those times, as an anagram, *ceiiinosssttuu.* Stated in the modern form, this law asserts that

$$\frac{\text{tension}}{\text{extension}} = \frac{\text{pressure}}{\text{compression}} = \frac{\text{stress}}{\text{strain}} = \text{modulus of elasticity},$$

and is the law universally employed to connect mathematically the corresponding stresses and strains in an elastic substance, as pointed out by Saint-Venant [8].

When the stresses and strains are large enough for variations on Hooke's law to become observable, a fresh set of phenomena depending on the ductility and viscosity of the substance came into play, and the previous mathematical investigations no longer hold. Much of the confusion pointed out by Dr. Todhunter in the treatment of the subject by experimentalists is due to the fact that in experiments it has been usual to test the strength of structures to the breaking-point, and hence the use of the term *breaking* instead of *bending* moment. The modern experiments of Wöhler show that this point, at which ductility manifests itself, is much sooner reached than was formerly supposed; consequently, modern engineering practice is much less bold than formerly in large iron structures like bridges. For this reason, the diagrams of the frontispiece, though physically extremely interesting, cannot be considered to bear on the mathematical theory.

Returning again to the treatment of the subject by the mathematicians, we find a picturesque diagram given by Galileo (p. 2) of a beam built into an old wall and supporting a weight, the cross-grained character of the wood of the beam being carefully shown; so that it is not surprising that Galileo does not attempt any molecular theory to account for the flexure of the beam. This theory, supplied by Hooke's law, was applied by Mariotte, Leibnitz, De Lahire, and Varignon; but they neglect the compression of the fibres, and so place the neutral plane in the lower face of Galileo's beam. The true position of the neutral plane was assigned by James Bernoulli in 1695, who, in his investigation of the simplest case of the bent beam, was led to the consideration of the curve called the "elastica." This "elastica" curve speedily attracted the attention of the great Euler (1744), and must be considered to have directed his attention to the elliptic integrals. Probably the extraordinary divination which led Euler to the formula connecting the sum of two elliptic integrals, thus giving the fundamental theorem of the addition equation of elliptic functions, was due to mechanical considerations concerning the "elastica" curve; a good illustration of the general principle that the pure mathematician will find the best materials for his work in the problems presented to him by natural and physical questions. The result obtained by Euler for the thrust at which a straight column begins to bend, when the corresponding "elastica" differs from a straight line very slightly in a curve of sines, is of the utmost importance to the architect and engineer; and, as Prof. Kennedy can testify, is employed with the greatest confidence in the design of the highest columns and pillars.

It is interesting to find the complete treatment of the problem of lateral vibrations of elastic bars is also due to Euler, though the analytical difficulties of the *period equations* seem to have puzzled him. If we employ the modern notation of the *hyperbolic* functions, we shall find his period equations all reduced to the form—

$$\cos\omega \cosh\omega = \pm 1,$$

or,

$$\tanh\omega = \pm \sin\omega;$$

and this again is equivalent to

$$\tanh\tfrac{1}{2}\omega = \pm\tan\tfrac{1}{2}\omega, \text{ or } \mp\cot\tfrac{1}{2}\omega,$$

whence a graphical determination of the values of ω is easily inferred (pp. 50, 51, footnote).

Another interesting paper due to Euler is "De altitudine columnarum sub proprio pondere corruentium" (1778), investigating the height at which a mast or tree will begin to bend under its own weight. To this paper he might well have prefixed the old German proverb, quoted by Goethe in "Wahrheit und Dichtung":—"Es ist dafür gesorgt, dass die Baüme nicht in dem Himmel wachsen." We know now that the functions of Bessel are required for the complete analytical solution of this question, though the *Theorema maxime memorabile* enunciated by Euler, "Maxima altitudo, qua columnæ cylindricæ ex eadem materia confectæ, proprium pondus etiamnunc sustinere valent, tenet rationem subtriplicatam amplitudinis," is interesting as one of the first applications of the principle of mechanical similitude, showing why the proportions of the giant of the forest are stunted compared with those of the young tree, and also why it is hopeless to attempt the problem of human flight while *g* is 32.

Lagrange considered the same subject in "Sur la figure des colonnes" (1770), examining and disproving the dictum of Vitruvius that the *renflement* of a column was necessary for strength: the dictum can hardly be called an architectural fallacy, as the *renflement* corrects the tendency, due to *irradiation*, of a perfectly cylindrical column to appear attenuated in the middle; for a similar reason it is necessary to slightly blunt the neighbourhood of the point of a Gothic spire to avoid the appearance of concavity.

Coulomb, a well-known name to electricians, is mentioned by Saint-Venant as giving about this time (1780), in "Remarques sur la rupture des corps," the true position of the neutral line of a beam, although it is asserted by Dr. Todhunter that the ancient erroneous idea prevailed into the present century.

In Chapter II. the work of Young, Gregory, Eytelwein, Plana, Dupin, Belli, Binet, Biot, Rennie, Barlow, Tredgold, Fourier, Nobili, Bordoni, Hodgkinson, and others is analysed. Of these the English writers, who generally were experimentalists as well as theorists, are severely handled by Dr. Todhunter for their heresies on the neutral axis. Considering that the neutral axis is a mathematical fiction, depending on an ignoration of the shearing stress, and the consequent warping of the normal sections of a beam, this treatment of Dr. Todhunter is too severe, compared with the leniency with which he views the metaphysical speculations of the pure theorists. These experimentalists were trusted in their advice on important constructions, and took care their formulæ erred on the right side of strength.

To Navier (1821) we are first indebted for the general mathematical equations of the equilibrium and vibrations of an elastic solid, to be satisfied in the interior and at the surface, and henceforth the researches of mathematicians take a bolder flight from the treatment of the simple beam of former investigators.

Mlle. Sophie Germain's "Recherches sur la théorie des surfaces élastiques" (1821) appears to afford Dr. Todhunter gratification in showing that sex can make itself apparent even in mathematics. However, it is dangerous to argue from this instance, as hardly any mathematician has yet written on elastic surfaces without falling into error in the boundary conditions, and the subject is even now not yet certainly settled.

The vibration of elastic surfaces is important in its bearing on acoustics and music, and received about this time experimental and theoretical treatment from Chladni, Strehlke, Pagani, and Savart.

Chapters IV. and V. give an account of the treatment of the subject by the celebrated mathematicians Poisson and Cauchy, who practically exhausted the soluble problems, if we except the torsion questions considered by Saint-Venant. Poisson's results are generally expressed by means of definite integrals, most of which we see now can be classified as Bessel's functions. Both Poisson and Cauchy appear to have considered the subject of elasticity principally in its bearing on the new theory of physical optics, then receiving such important experimental and theoretical treatment at the hands of Fresnel.

Henceforth the theory receives development at the hands of so many writers that it is possible only to specify the honoured names of Gerstner, Green, McCullagh, Poncelet, and Maxwell as having contributed important advance to the subject.

Lamé's "Theory of Elasticity," carefully analysed in Chapter VII., still remains a standard text-book, in conjunction with the treatises of F. Neumann and Clebsch.

The volume concludes with an account of Saint-Venant's researches before 1850, the subsequent work to be recorded in the second volume. Saint-Venant is the name most honoured by practical elasticians and engineers, inasmuch as he has developed his theories from the definite practical problems presented by the large and daring constructions in iron and steel which mark the middle of this century.

In the appendix Mr. Pearson has carefully analysed the conflicting notations of different writers, and proposed a very convenient terminology and notation, which would save great trouble if universally adopted. He has also given an account of experiments carried out by Prof. Kennedy in his mechanical laboratory, which have an important bearing on the limitations of the truth of Hooke's law, or, in the language of elasticity, the constancy of the ratio of stress to corresponding strain.

The present volume is an indispensable hand-book of reference for the mathematician and the engineer, and in the editing and printing must be considered a very fitting tribute to the wonderful industry and application of its projector, the late Dr. Todhunter.

A. G. GREENHILL

THE ENCYCLOPÆDIA BRITANNICA

The Encyclopædia Britannica. Vol. XX. Pru—Ros. Vol. XXI. Rot—Sia. (Edinburgh: A. and C. Black, 1886.)

THE leading scientific articles in these two volumes are mainly biological. In Vol. XX. Prof. A. Newton contributes the articles on the various important groups of birds; and in those on the Quail, Screamer, Secretary Bird, Seriema or Cariama, it is truly surprising to find so many facts condensed into so small a compass. Mr. C. T. Newton's article on Pterodactyles gives us the newest information on this strange group of fossil reptiles. In the article on Reproduction only the broadest aspects of the phenomena attending it are glanced at, Mr. P. Geddes treating of the Animal, and Mr. S. H.

Vines of the Vegetable, group; though, as was to have been expected, the early phenomena in the two kingdoms are to some extent the same. The facts mentioned are well up to date, and both portions of this article are worthy of their authors. Animal reproduction is illustrated by a few useful woodcuts; but this help to the understanding of the text is wanting in the section on vegetable reproduction. Mr. Vines very correctly criticises Strasburger's idea that the cause of sexuality in cells is purely quantitative. In the article on Reptiles Dr. Günther finds himself on familiar ground, and in the forty pages placed at his disposal he gives a most excellent account of the history and literature of the group, and of the evolution of their classification, from Linnæus to Cope, followed by a brief record of some of the more important systematic works on reptiles, in which the need of a general work on the subject is pointed out. The principal faunistic works are alluded to, and then follow the systematic portions, the anatomy of the chief forms characteristic of the orders, and a paragraph about the distribution of reptiles in time and space. Prof. A. Gamgee, in an article on Respiration, dwells chiefly on the phenomena attending this function in mammals, the phenomena to be observed in all the other groups of the animal kingdom being scarcely even alluded to. The articles on the Rhinoceros and the Seal, by Mr. Flower, are quite models of encyclopædic articles, for in them we have just the information a general reader would require, and this of a thoroughly trustworthy kind. The same may be said of an article on Rhubarb, by Mr. E. W. Holmes.

The article on Rotifera, in Vol. XXI., by Prof. A. G. Bourne, was probably printed ere the finely illustrated monograph of this group by Gosse and Hudson had made its appearance, but the classification given is based on that of Hudson. The account of the general morphology and anatomy is well done, and in a few very pertinent remarks on their affinities the author concludes that, while the high development of the mastax, the specialised character of the lorica in many forms, the movable spines in Polyarthra, the limbs of Pedalion, and the lateral appendages in Asplanchna, the existence of a diminutive male, the formation of two varieties of ova—all point to a specialisation in the direction of the groups of the Mollusca, Arthropoda, and Chætopoda; yet such phenomena would not justify the definite association of the Rotifera in a single phylum with any of them. The phenomena of rotifers being desiccated, and then coming into active existence, are mentioned as if actually proved by exact experiment; but is this so? It certainly does not always succeed, as, no doubt, numerous observers have often noted: too frequently, from inattention, all the water will evaporate from a slide with rotifers; and so far, general experience proves, that if this evaporation be carried to desiccation, not all the drops of water in the world will set up the rotifers that were on such a slide into life again. No doubt it is quite different with their ova.

Mr. J. T. Cunningham contributes an interesting article on Salmonidæ, in which he presents a pretty full synopsis of most of the genera and of all the British species. The life-history of the British forms is given, and some account of the legislation on the subject of our fisheries. The salmon-disease is described. From whence the fresh salmon gets affected would seem to be an, as yet, unsettled problem. Might not one source be frog-spawn? After the tadpoles escape, the gelatinous nidus remaining will sometimes be found permeated with *Saprolegnia ferox*, with ripe oosporangia.

The next biological article of importance in the volume is on the Schizomycetes, by Prof. Marshall Ward, including within this term all those Schizophyta devoid of chlorophyll. The history of these forms, though dating only from 1860, has of late years made rapid progress, and the epitome of this history as here given is full of interest. Most judiciously, while selecting the facts from writings of scientific worth, the author ignores a lot of the rubbish that has appeared in print on the subject. The section on the morphology is very ably written, and the illustrative figures are excellent. Very thoroughly do we agree with the author, that to deny the existence of species in this group is to deny the existence of species altogether. No doubt, before they can be properly defined, the whole life-history of any one of these forms must be known; and equally certain is it that immense advance in a knowledge of the life-history of many of them has been made since the date of Cohn's brilliant researches. As to the important question, Are the Schizomycetes accompaniments only of disease, or have they any causal relation to the diseased condition? no decided answer is given, the discussion as to details being still an active one. The theory that, by the growth and development of certain forms under certain conditions, the medium in which these forms live may be so atomically altered that new and deadly ptomaines may arise, is not alluded to. To the references to authorities given it may be useful to add Just's *Botanischer Jahresbericht*, which year by year laboriously works out the immense literature of this subject.

Dr. Günther's article on Sharks is well illustrated, and well up to date. There is a capital figure of that most interesting and novel form, *Chlamydoselachus anguineus*, S. Garman, from Japan, of which but two specimens are known, one of these being in the British Museum. In reference to the economic use of these fish, allusion is made to the oil abstracted from the larger forms. We may mention that the oil from the basking shark is of considerable commercial value, and that in the case of the immense *Rhinodon typicus*, which abounds during certain seasons in the seas around the Seychelles Islands, the oil is of excellent quality, and there is little doubt would pay well for collecting, although owing to the differences in the respiratory functions, the difficulty in capturing large fishes is vastly greater than in capturing big mammals.

When we turn from the biological to the mathematical and physical sciences, we do not find such a great wealth of articles, but on the other hand some of them are of the highest order, the only fault about them being, perhaps, their shortness. Such are the articles on "Quaternions" and "Radiation," by Prof. Tait. Prof. Dittmar writes on sea-water, and Prof. Ewing on seismometers. Mr. Herbert Rix, the Assistant Secretary of the Royal Society, gives an account of the history and doings of it, which will be read with interest by many. The chemists have their fair share of interest in the volumes; prussic acid, pyrotechny, salts, being among the subjects treated of in all their aspects.

Midway between pure science and its applications, we find an important article on screws by Prof. Roland, while in the various applications of science there is a great wealth of admirable articles: railways, river engineering, roads and streets, shipbuilding, public health, are among the subjects of this nature treated of; and always, so far as we can judge, by the best man.

Of the contributions relating to geography, ethnography, and statistics in these volumes, one of the most important is Prince Krapotkine's part of the article "Russia," in which he presents a very lucid account of the leading facts connected with his subject. Like all other races, the Russians are, of course, to some extent a mixed race. In the course of their history they have taken in and assimilated a variety of Finnish and Turco-Finnish elements. The author, however, points out that, notwithstanding this process, the Slavonian type has maintained itself with remarkable persistency, Slavonian skulls ten and thirteen centuries old exhibiting the same anthropological features as are seen in those of our own day. This he accounts for chiefly by the fact that the Slavonians, down to a very late period, maintained gentile organisation and gentile marriage. Dealing with the circumstances of Russia at the present day, Prince Krapotkine says that much still remains to be done for the diffusion of the first elements of a sound education throughout the Empire, and that the endeavours of private persons in this field, and of the *zemstvos*, are for political reasons discouraged by the Government. The Government also does what it can to check the movement in favour of secondary schools where instruction would be based on the study of the natural sciences. It prefers classical gymnasiums. As every one knows, the natural sciences are much cultivated in Russia; and now the scientific societies of old and recognised standing have to compete with a group of new societies which have sprung up in connection with the Universities.

The geography and statistics of Prussia are dealt with by Mr. J. F. Muirhead. Although somewhat hampered by the fact that the physical features of Prussia had already been fully described under "Germany," Mr. Muirhead has brought together much valuable and interesting information both about the country and about the Prussian people. He has, of course, a good deal to say about the flourishing condition of education in Prussia. Of the recruits levied to serve in the army in 1882–83 the proportion of men unable to read or write was only 2 per cent., the rate varying from 9·75 per cent. in Posen to 0·03 in Schleswig-Holstein, where there was only one illiterate recruit among 3662. Mr. Muirhead contributes several other geographical articles—among them, the one on the Rhine, of which he thinks that probably the Tiber alone is of equal historical interest among European rivers. After a full account of the physical aspects of the river and of its relations to industry and trade, he shows how its whole valley was probably occupied at one time by Celtic tribes, and how they were gradually displaced by the advancing Teutons.

The topography and archæology of Rome have been intrusted to Mr. J. H. Middleton, whose thorough knowledge of his subject has enabled him to make the most of the limited space at his disposal. The article is devoted mainly to those buildings of which some remains still exist. The plan of the Forum and nearly all the cuts were measured and drawn by the author specially to illustrate this article.

Mr. George G. Chisholm gives a clear description of the physical features, with an adequate account of the agriculture, mineral wealth, and trade, of Roumania and Servia. He has also a good article on Sardinia. There is an excellent article on the St. Lawrence, by Sir Charles A. Hartley, who points out that the great prosperity and growth of Canada are owing to its unrivalled system of intercommunication, by canal and river, with the vast territories through which the St. Lawrence finds its way from the far-off regions of the Minnesota to the seaboard The statistics of Scotland have been carefully done by. Mr. T. F. Henderson, but the scientific part of the article "Scotland" is remarkable chiefly for Dr. Archibald Geikie's masterly sketch of the physical features of the country and his summary of the facts relating to its geological formations. The article on Siam, by Mr. Coutts Trotter, contains all the information that ordinary readers are likely to want about the physical characteristics and resources of the country, and about Siamese law, education, religion, and art.

It will be evident from what we have said, that although the "Encyclopædia" has already reached its twenty-first volume, there is no falling off either in the care or in the zeal of the editors. If all goes well, it is expected that the whole work will be completed in four more volumes; and we may certainly say that the work has been conducted in such an admirable manner that science will be a great gainer by it, and that it is a production of which everybody concerned may be justly proud.

A TREATISE ON CHEMISTRY

A Treatise on Chemistry. By Sir H. E. Roscoe, F.R.S., and C. Schorlemmer, F.R.S., Professors of Chemistry in the Victoria University, Owens College, Manchester. Vol. III. "The Chemistry of the Hydrocarbons and their Derivatives, or, Organic Chemistry." Part III. (London and New York; Macmillan and Co., 1886.)

IN the present instalment of the organic section of this valuable work the authors begin the consideration of the so-called aromatic compounds—the members of the benzene series.

The attention of chemists had long been directed to a group of organic compounds remarkable for their richness in carbon, and apparently unconnected in any way with the ordinary "fatty compounds"—richer in hydrogen, and correspondingly poorer in carbon—with which organic chemistry chiefly busied itself. Many of the compounds of this anomalous class occurred in Nature as odoriferous principles; this physical property was made the basis of a rough classification, and the name "aromatic compounds," originally employed in its strict sense, was extended so as to embrace the whole class, thus including compounds destitute of aroma. Much was known, in a more or less disjointed fashion, concerning these aromatic compounds; but no attempt had been made to solve the problem of their constitution until Kekulé, in 1865, proposed his well-known benzene formula. This formula has at no time, since it was first introduced, met with universal acceptance; and although, at the present day, most chemists employ it, they generally write it in an elliptical form, shirking or ignoring the difficulties which the fully-expanded formula too obviously suggests. But, in spite of these drawbacks, we may say, without exaggeration, that no formula ever exercised such an influence upon the progress of organic chemistry. Right or wrong, final or only provisional, the benzene formula grouped round it the scattered facts: each member of the mysterious aromatic series found its proper place and appeared in its proper light; cases of isomerism were predicted, even to their exact number; and the synthesis of important natural compounds, so high in the scale of complexity as alizarin and indigo, was rendered possible. The obscure corner is now a vast field, cultivated alike by the scientific and by the practical chemist, and far exceeding in extent the whole of the rest of organic chemistry.

The present work opens with an account of the benzene theory. A very valuable feature in the mode of treatment is the way in which the historical method is employed. The much-enduring student of organic chemistry at the present day is generally loaded with facts; occasionally the teacher condescends to furnish him with reasons; but not one student in fifty has any idea of the historical genesis of the facts and reasons presented to him. The ordinary text-books do little or nothing to supply this want; the exhaustive records of facts, like Beilstein's "Handbuch,"[1] and the short text-books written for the student can neither of them, although for different reasons, spare the necessary space. Here the present work comes to our aid. Nothing could well be more instructive than the historical treatment of this very subject of the benzene theory as here given. The student is enabled to see how the views at present held have been evolved, step by step, from Kekulé's formula. And in this connection the earliest tentatives, however we may despise them now, are in their way as instructive as the latest and most carefully-considered deductions. Witness, for example, the historical tables which the authors give in illustration of "orientation in the aromatic series"—the determination of the position of the substituting atoms or groups in the derivatives of benzene. The reader can follow in detail the process by which errors of method or of experiment were gradually eliminated, until, ultimately, the present satisfactory condition of things was reached, in which the same problem, attacked by half a dozen independent methods, yields in every case the same result. The student who knows these things can give reasons for the faith that is in him, and he knows that, no matter how the theory itself may change, the relations worked out under the theory are permanent, and that when the new theory comes, these relations will find their places in it, differently expressed perhaps, but unchanged in their interdependence.

The descriptive portion of the work deals with benzene and its derivatives, using the latter term in its narrow sense, as excluding all derivatives which are homologous or derived from homologues. There are certain disadvantages in this arrangement: thus, it separates widely compounds which are closely related: toluene is not treated of along with benzene, which it most closely resembles; the toluidines are separated from aniline, and so on. But no system of classification is perfect; and the authors, as practical teachers, have doubtless satisfactory reasons for adopting the foregoing arrangement.

There is little further to be said about the descriptive portion, the nature of which is sufficiently indicated by the above account of its scope. The information is very full. The interesting theoretical and historical discussions are continued throughout the volume, and impart to it a character of "readableness" rather unusual in a work of this nature. Finally, the student of technology will find the various manufacturing processes treated of in some detail.

[1] *Handbuch* in German means, not a *hand-book*, but—*lucus a non lucendo*—an exhaustive treatise which in most cases it would be physically impossible to hold in the hand.

OUR BOOK SHELF

Photography the Servant of Astronomy. By Edward S. Holden. (Reprinted from the *Overland Monthly*, November 1886.)

HALF a century ago the attention of astronomers was almost entirely confined to the study of the movements of the heavenly bodies; indeed, Bessel actually defined astronomy as consisting therein. But since then an entirely new department of astronomy has been developed, to which the name "Astro-physics" has been given, and this new department proceeds along three principal lines—spectroscopy, photometry, and photography. The great Observatory founded by the munificence of the late James Lick is to be chiefly engaged in the development of the third of these methods, though spectroscopy will also receive a large share of attention. Having therefore in view the chief purpose to which the great powers of his Observatory will be devoted, the Director of the Lick Observatory has here given a clear and concise account of the principal services which photography has rendered to astronomy in the past, and an analysis of those which may be expected from it in the future. A description of the facilities for photographic research possessed by the Lick Observatory completes this interesting and instructive paper. Prof. Holden mentions incidentally that Mr. Grubb's ingenious device for placing the observer in position for using the telescope, by raising or lowering the entire floor, will be adopted in the great dome of the Observatory.

Observations nouvelles sur le Tufeau de Ciply et sur le Crétacé supérieur du Hainaut. Par A. Rutot et E. Van den Broeck. (Liége: H. Vaillant-Carmanne, 1886.)

IN view of the stratigraphical gap that exists in this country between the Chalk with *Belemnitella mucronata* and the Thanet Sands, the papers thus re-issued in a collected form have an interest considerably beyond the district with which they immediately deal. The value of passage-beds being that they blur over the hard-and-fast lines laid down by our earlier conceptions, it may seem ungrateful to define the exact upward limit of deposits such as those which close in the Danian series. The observations of the authors, however, go to show that the Tufeau de Ciply of the Mons basin, which has been hitherto referred to the Maestrichtian—a fact incorporated in ordinary text-book information—is in reality intimately connected with the Montian. A close examination of 3000 kilogrammes of the conglomerate that forms its base has yielded rolled *Thecideæ* and Cretaceous Bryozoa; but the principal fauna, as indicated by casts of unrolled shells, is of distinctly Tertiary type, containing such representative forms as *Cerithium montense*, *Voluta elevata*, and *Turritella montensis*. The beds near St. Symphorien, correlated with those of Ciply by MM. Cornet and Briart, are divided by the authors into the true Tufeau de Ciply, with its conglomeratic base, and the "Tufeau de St. Symphorien," with *Belemnitella mucronata*, *Thecidea* (*Thecidium*) *papillata*, &c., which is seen to rest, also with the intervention of a conglomerate, on the Senonian. The lower of these horizons is incontestably Maestrichtian; it remained to show that the Tufeau de Ciply, on the other hand, passes up continuously through the *Cerithium*-limestone of Cuesmes into the Calcaire de Mons. To outsiders, unfortunately, the evidence is not complete. The junctions in the field are still obscure, and even the lack of parallelism between the Tufeaux of Ciply and St. Symphorien is mainly based on palæontological arguments, both beds alike resting in places on the uppermost Senonian. The sharp distinction of the two faunas leaves, however, little room for doubt; and the alliance of the Ciply beds with the Montian is still further emphasised by the occurrence in them of large *Cerithia*, of which the authors record two new species, appropriately named *corneti* and *briarti*. It is probable, then, that when, by fortunate excavations in this phosphatic area, the necessary junctions become exposed, MM. Rutot and Van den Broeck may be congratulated on having added beyond recall some 20 or 30 feet to the Tertiary beds of Europe.

The papers also include a revision of the classification of the Senonian of South-West Belgium. G. C.

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. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

On Two Jade-handled Brushes

SOME years ago, I purchased from Mr. Bryce-Wright, of London, two specimens of jade which I then presumed to be "brushes," the handle and sheath of each being of jade, of that faint greenish-gray so characteristic of the finest specimens of that mineral. I was not led to entertain any further opinion as to their true character until the appearance of a paragraph in NATURE, vol. xxviii. p. 207, being an extract from the *North China Herald*, respecting the foot-measures in China. I was particularly struck by the statement made that "in A.D. 274 a new measure exactly 9 inches in length was made the standard," and further "that the lengths of certain jade tubes used according to old regulations as standards" were employed as terms of comparison. It was further mentioned "that of the jade tubes above mentioned there were twelve, and these formed the basis for the measurement of liquids and solids four thousand years ago. . . . They are mentioned in the oldest Chinese documents, with the astrolabe, the cycle of 60 years, and several of the oldest constellations. It is likely that they will be found to be an importation from Babylon, and in that case the Chinese foot is based on a Babylonian measure of a span, and should be 9 inches in length."

This article led me to measure the lengths of the two jade instruments, which I found to be 9 inches, with some slight difference for one of them. I endeavoured to obtain further information as to the nature of these instruments and whence they came. Mr. Bryce-Wright could only tell me that to the best of his recollection he had procured them from the Chevalier von Siebold, son of Dr. von Siebold, and promised to make further inquiries. As I also learned that no such specimens exist in the British Museum, I was led to attach some importance to them in connection with their lengths. This was strengthened by an article which appeared in NATURE, vol. xxx. p. 565, "On the Connection between Chinese Music, Weights, and Measures," which seemed to confirm the statements made in the *North China Herald*, while adding many others of very great interest for the determination of the real nature of these jade tubes.

The subject was treated by Dr. Wagener in a paper read before the German Asiatic Society of Japan some years ago, in which it was stated that the common origin of the Chinese weights, measures, and musical notes is based on native legends, and is also treated of in the Jesuit "Mémoires concernant les Chinois." Dr. Wagener says that there is not the slightest doubt that the Chinese system of weights and measures is more than four thousand years old, and that it possesses all the advantages for which the French metrical system is so much praised. The paper states that in the reign of the Emperor Hoang-ti, who ruled over China in the twenty-seventh century B.C., the scholar Lyng-Lun was commissioned to complete the musical system, which had been discovered two hundred and fifty years earlier, and particularly to lay down fixed rules for making musical instruments; that he betook himself to the province of Si-yung in North-West China, where, on the northern slope of a range of high mountains, a species of bamboo grew which, on account of its uniformity and its structure, being neither too hard nor too soft, was exceedingly suitable for a wind-instrument. This range appears to contain the head-waters of the Hoang-ho, the rippling of its waters producing a sound similar to the first or fundamental note which he obtained from the bamboo. He determined a scale of twelve notes: these are the notes which are called the six male and six female tones in the scale discovered by Lyng-Lun. Having reproduced the notes by means of bamboo pipes, he proceeded to lay down fixed rules as to the length of the pipes, so that thenceforth they could be easily constructed anywhere. For this he required a unit of length, and sought out an adequately small natural unit for his measurements. He selected for that purpose the seeds of the red millet (*Sorghum rubrum*), which present greater hardness and uniformity than the other kinds of millet. Lyng-Lun fixed the length of the pipe giving the key-note at 81 grains of the seed placed lengthways in a row: placed breadthways, it took 100 grains to give the same length. Thus the double division of 9×9 and 10×10 was naturally arrived at. Lyng-Lun also laid down rules for the breadth as well as the length of the pipe, because, although the note is essentially dependent on the length, it is nevertheless necessary for its purity that the pipe should be neither too broad nor too narrow. He therefore fixed the circumference on the inside at 9 grains laid lengthways. With these dimensions—namely, a length of 81 grains and an internal circumference of 9—the pipe which gave the key-note contains just 1200 grains, and this volume accordingly was made the unit of dry measure, and was called a *Yo*. Thus the units of length and dry measure were connected with the musical key-note. The twelve notes of the scale are all derived from the key-note. "Hence if the 1200 grains contained in the pipe are divided among the twelve notes it gives to each a hundred, and the weight of these hundred grains was made by Lyng-Lun the unit of weight" (as I understand this, it means that the twelve pipes were arranged to represent a series of cubical contents, commencing with 1200 and ending with 100 millet-seed contents). Dr. Wagener concluded by stating that this system of measures dates back 4600 years.

Analysing the statement made by Dr. Wagener, it is evident that the earliest form of pitch-pipe known to the Chinese was a bamboo tube, the sound being produced as in the Pandean pipes. The northern slope of a range of high mountains on the north-west frontier of China, in which lie the head-waters of the Hoang-ho, corresponds fairly well, as locality, with the district whence is supposed to come the jade so prized in China. The twelve bamboo pipes or tubes fixed as standards of musical notes by Lyng-Lun, correspond apparently with the twelve jade tubes mentioned by the *North China Herald* as having formed the basis for the measurement of liquids and solids four thousand years ago. The jade tubes were used as standards of length, and being spoken of as tubes, similarly as the bamboo tubes, it may be inferred that they were also standards of volume-measurement and of musical pitch, therefore that the hollow portion or tube had a depth corresponding to the particular note which it was intended to reproduce. Hence these twelve jade tubes would thus represent a set of Pandean pipes, while the requisite length, so as to allow of their being used each as standards of 9-inch length, could be attained by the addition or insertion of a stick or stop of sufficient length, just as is represented by the two "brushes" in question. The lengths of these were found to be in millimetres, for the longer (which I will call A), 228·4; for the shorter (which I will call G), 227·3; the length of 9 English inches in millimetres being 228·6. The "handle" penetrates into the sheath about 17·7 mm. These handles are tapered to the end penetrating the sheath. The two "sheaths" are not alike in interior form: the sheath A is hollowed out conically to a depth of 46·5 mm., the remainder of its length having a hole drilled through it of about 2·6 mm. diameter; the sheath G is 70 mm. long, is hollowed out to a depth of 50·5 mm., and has no hole through the bottom or end part.

I was led to conjecture that these tubes or "sheaths" might be musical pitch-pipes; and on blowing across their orifices, the shorter produced the sound of high G, the longer or perforated one that of high A. By stopping with the finger the hole which passes through the bottom of the "sheath" A, the sound of high G sharp was produced. These notes I tested with a pitch-pipe.

This led me to further conjecture that they should present an interior diameter in accordance with the condition laid down therefor by Lyng-Lun; that is, such as to give an interior circumference equal to 9 grains of *Sorghum rubrum* laid lengthways. Having carefully calibered the interior diameters, I obtained a series of values, giving for the interior circumference of the G sheath or tube a mean value of 28·32 mm., and for that of the A tube 28·44. Through the kindness of Messrs. J. Carter and Sons, of High Holborn, London, I obtained a sample of *Sorghum rubrum*, and operating on this, as also on a sample obtained in Dublin, I got for the length of nine millet seeds placed end to end the following values in millimetres: 26, 26·50, 27·10, 27·38, and 28. I took as mean the value 27 mm. (the exact mean being 26·995 mm.), so that the difference from that of the interior circumferences found is only 1·44 mm. in the mean. I may add that from a series of ten measurements kindly made micrometrically by Dr. McNab, it appears that the lengths of the grains measured by him vary, and would give for the lengths of nine placed end to end, the limits 28·804 mm. and 24·689 mm.

I consider therefore that, so far, the interior circumferences determined point to the "sheaths" being pitch-pipes having the standard interior dimension laid down by Lyng-Lun.

I thought it worth while furthermore to verify the cubical contents of the tubes in millet seeds. The pipe G gave a contents of 421 red millet seeds, and the pipe A of 375; or a mean capacity in seeds of 398. The white seeds gave me for G 400.

What, however, is interesting, is that the end of the "handle" which penetrates the G sheath is hollowed out cylindrically, and this space holds 39 red seeds, and would seem to represent a standard of one-tenth volume. The corresponding end of the A sheath gives for two measurements 37 seeds, or as near as possible one-tenth the capacity of that sheath measured in seed contained.

With the measures of lengths of millet seed determined, we may attempt to fix the probable or approximate length of the fundamental pitch-pipe; that is, the length of 81 millet seeds placed end to end. Taking 27 mm. as the approximate length of nine grains, this length, or rather depth, would be $9 \times 27 = 243$ mm. Now there is found for the combined lengths of the "sheaths" and "handles" when placed end to end, the values:

$$\text{For the G tube, } 227{\cdot}3\text{ mm.} + 17{\cdot}65\text{ mm.} = 244{\cdot}95\text{ mm.},$$
$$\text{,, A tube, } 228{\cdot}4 + 17{\cdot}7 = 246{\cdot}10;$$

both differing little from the approximate value found above.

Taking, on the other hand, the mean interior circumferences of the two tubes as probably representing the lengths of nine millet seeds, we have from the measurement

$$\text{Of the G pipe, } 28{\cdot}32\text{ mm.} \times 9 = 254{\cdot}88\text{ mm.},$$
$$\text{,, A-pipe, } 28{\cdot}44 \times 9 = 255{\cdot}96.$$

It is worthy of remark that by multiplying the mean, end or bottom, diameters of the two sheaths, $\frac{12{\cdot}96 + 12{\cdot}47}{2} = 12{\cdot}715$, by 20, the product comes out 254·3 mm.

Such coincidences can hardly be fortuitous, and to some extent justify the presumption that the two jade instruments which I originally took to be "brushes," are either original standard measures of very great antiquity, or copies more or less exact therefrom. A further determination of the lengths of the Chinese red millet seed is evidently desirable as a matter of metrical and historical research.

J. P. O'Reilly

The Cambridge Cholera Fungus

In reply to Dr. Klein's letter, I wish to state that although the specimens figured by Prof. Roy in the Royal Society's Proceedings appear to be branched, the one shown to me did not.

Dr. Klein is of course perfectly right as to his statements concerning branching Bacteria; and his remarks, if he rigorously distinguishes between real and false branching, are true also of all the Schizomycetes. At the same time, the existence of such a form as *Cladothrix dichotoma* is not without interest, more especially since Cienkowski has described for it an involution form.

Walter Gardiner

Clare College, Cambridge, January 31

As bearing on the subject of the "Cambridge cholera fungus," it may interest some readers to learn that methylene-blue has long been known as a good stain for fungi. My friend Mr. T. Hick, Botanical Lecturer at Owens College, showed me, some years ago, beautiful preparations of moulds stained with this substance, and I have frequently used it for the same purpose, as also chinoline-blue, known as "blue No. 13" of the aniline dyes. It is impossible to keep an aqueous solution of the latter for any length of time free from fungoid growth, the hyphæ of which, at a certain stage of development, exactly resemble the forms described by Messrs. Roy, Brown, and Sherrington, and my specimens, when grown on a slice of potato, developed into *Aspergillus glaucus*. Remembering the very varied appearances assumed by the barren hyphæ of fungi, depending on nature of substratum, relative amount of moisture, &c., I believe that morphological agreement of vegetative parts by no means proves specific identity, even when both can be examined in a fresh state—a great advantage, as the chemical and physical properties of the hyphæ can be compared; but an expression of opinion as to relationship based on the comparison of barren hyphæ with drawings is simply valueless, and only proves a very slender acquaintance with the characters of admitted specific value in the determination of fungi. Members of the Chytridiaceæ are common only in books; during years of practical mycological work I have only once met with a species belonging to this group, and this one I could not succeed in staining with either methylene- or chinoline-blue, but Bismarck-brown gave good results. I was inclined to attach a certain amount of value to this selective power exercised by fungi in connection with dyes, until I discovered that the hyphæ producing the zygospores of *Syzygites megalocarpa* could not be stained with blue, but readily with methyl-green, while the hyphæ of the conidial stage (grown by us from the zygospore) readily absorbed methylene-blue, but had no affinity for green. Interstitial swellings and knob-like outgrowths are not uncommon on mycelium belonging to widely separated groups, especially when the spores are caused to germinate under abnormal conditions, as described in the *Journal of Botany* for October 1882. The protoplasm frequently becomes concentrated in these portions, which are then cut off from the thread by a septum, and serve as centres for a fresh growth, when placed under favourable conditions. The absence, presence, or relative number of septa vary much in the same plant at various ages and under different conditions of growth.

Kew G. Massee

Earthquakes

In Nature of October 14 (p. 570) you published a letter from Prof. O'Reilly regarding the great earthquake of Carolina, and drawing attention to the tendency of earthquake-lines to assume the direction of great circles. So far his observations were identical with a theory I had myself elaborated, and which I embodied in a paper written at the beginning of the year 1884, now in the hands of the Committee of the Geological Society of London, but never presented to the Society. So long ago as that period I had drawn attention to what I pointed out as the two principal earthquake great circles—one, the Japan and Rocky Mountain system, with one of its poles in 170° W. long., 25° S. lat.; the other, the Himalayic, with its north pole approximately in 45° N. lat., 160° W. long. The former has been frequently described, and Scrope ("Volcanoes," p. 303) suggested a theory to explain it occurrence. The latter is little less remarkable, and is at the moment even more interesting, as, with the exception of the Carolina earthquake, all the great earthquakes and volcanic eruptions of the last five years may be referred to it. I may instance the cases of Krakatão, Kashmir, the Caucasus, Spain, Cotopaxi, New Zealand, and the recent Mediterranean disturbance, all of which occurred within a few degrees of the line or actually on it. Now it is remarkable that this line is marked through a considerable portion of its course by the presence of disturbed Miocene rocks, so much so that I have felt justified in calling it the Miocene line.

The paper referred to contained a theory too long to be worked out in the compass of a letter, but founded on the changes in form which must occur when a plastic body falls by the action of gravity towards a primary. A little consideration will show that, as the action of gravity is inversely proportionate to the square of the distance, the forward portion of such a body will be continually pulled away from the posterior, and an original sphere will in its descent become deformed into a prolate spheroid. Now the result is, I believe, calculable for a body like the earth, even under the present conditions of its annual approach to the sun, in other words its *fall* from aphelion to perihelion. During periods of extreme eccentricity of the orbit the fall and consequent deformation were much greater. The main factors in the calculation are of course: (1) the distance from the primary of the commencement of the fall; (2) the diameter of the falling body; (3) the distance fallen; and (4) the comparative masses of the primary and the attracted body. Beyond this, consideration has to be given to what we may term the specific resistance to deformation of the particular body. The latter, indeed, seems to be the principal factor in determining the amplitude and periodicity of earthquakes.

It is difficult for the geologist at this remote spot in the Far East to keep in touch with the daily progress of geology at home, but there is one probably counterbalancing advantage—in the enlarged view he has to take of the mid-Tertiary epoch as a factor in geologic change. THOMAS W. KINGSMILL

Shanghai, November 30, 1886

THE CALENDAR AND GENERAL DIRECTORY OF THE SCIENCE AND ART DEPARTMENT

THERE is a general impression on the Continent, and even in England, that English teachers of science carry on their work with little direct relation to one another. Twenty-five years ago this impression was not incorrect, but any one who will take the trouble to read the "Calendar and General Directory of the Science and Art Department for the year 1887," lately published, will see that it is no longer true, and that very important steps have been taken towards the establishment of an organised and efficient system of scientific instruction. At South Kensington we have now a School of Science, which maintains the most intimate connection with a vast number of science schools and classes in all parts of the United Kingdom. Here we have at least the germs of a proper system, and it depends upon the country itself whether we are to remain content with what has been achieved, or are to continue the work we have begun until it can be pronounced completely adequate to the needs of modern times.

The movement which has led to these results may be said to have begun in 1853, when the Department of Practical Art was expanded into the Department of Science and Art. The immediate object of this change was to secure that the advancement of practical science should be directly encouraged, and it was decided that the end could be most surely attained by "the creation in the metropolis of a school of the highest class, capable of affording the best instruction and the most perfect training," and by help rendered to local institutions for scientific education. For some time it seemed not improbable that the scheme would be, at least in part, a failure. No general system of making grants applicable to the whole country was devised until 1859. Experimental schools were established by special Minutes, the arrangement usually being that the teachers were to receive payments from the Department in the nature of certificate allowances, and that their incomes, from fees, subscriptions, and other sources, were to be guaranteed by the Department for a certain number of years at amounts varying in different places. In this way science schools were opened at Aberdeen, Birmingham, Bristol, Barking, Leeds, Newcastle-on-Tyne, Poplar, Stoke-on-Trent, St. Thomas's Charterhouse, Truro, Wigan, and Wandsworth. It was found, however, that there were but few places where a man could earn his living by teaching science alone; and in 1859 the only science classes in operation under the Department, irrespective of the Navigation Schools, were those at Aberdeen, Birmingham, Bristol, and Wigan, the number of persons in attendance being 395. Then a new plan was tried. In 1859, when the late Lord Salisbury was Lord President, the first General Science Minute was passed, enabling any place to establish science classes, and to obtain State aid according to certain fixed rules. The effect of this measure surpassed the hopes of those by whom it had been suggested. A number of new schools and classes were rapidly formed, so that, in May 1861, at the first general and simultaneous examination of classes, there were 38 classes with 1330 pupils, not including some 800 pupils in classes not under certificated teachers. Since that time there has been constant progress, as the following table will show:—

1862 ...	70 schools	with	2,543 pupils	in	140 classes	
1872 ...	948	,,	36,783	,,	2803	,,
1882 ...	1403	,,	68,581	,,	4881	,,
1885 ...	1542	,,	78,810	,,	5649	,,

In some schools there are classes both for science and for art, and in such cases it is interesting to note the relative proportion of the number of pupils in the two departments. At the School of Science and Art in Reading, for instance, there are 200 art students, and only 90 students of science. At the Central Board School, Rochdale, on the other hand, while there are only 50 students of art, there are 190 science students. In some instances the numbers are evenly, or almost evenly, balanced. At a school in Deptford there are in each department 160 students, and at another, in Bristol, art has 360 students, science 350.

The number of teachers varies, of course, very considerably. The following tables, compiled from the details presented in the "Calendar and General Directory," show the number of schools which have each three or more teachers:—

I.

Schools in which both Science and Art Classes are held

Schools .	110	83	40	32	24	15	14	9	4	1	2	3	2	1
Teachers .	3	4	5	6	7	8	9	10	11	12	13	14	16	18

II.

Schools in which Science Classes only are held

Schools . . .	105	36	24	11	1	2	4	2	1	1	1
Teachers . .	3	4	5	6	7	8	9	10	11	13	14

The progress of the central institution—the "school of the highest class, capable of affording the best instruction"—has been in its own way not less remarkable. The removal of some of the courses of the School of Mines to South Kensington greatly increased the number of students, partly because the instruction was rendered more thorough and efficient by the addition of laboratory and practical instruction in physics, mechanics, biology, and geology, and partly because South Kensington was more convenient for students than Jermyn Street or Oxford Street. The school was also rendered more useful by the fact that, after the transfer, a few teachers, and promising students who undertook to become teachers, were brought up to London to be trained. This system has been developed, and now from fifty to sixty teachers are annually trained in different branches of science. A system of short summer courses for teachers has also been organised, and this opportunity of improving themselves is highly valued by the teachers, about 180 or 200 of whom are selected annually from some 500 or 600 applicants.

The affiliation of the School of Mines to the Normal School of Science in 1881 marked an era in the history of the institution and in the history of scientific work and education in this country. Students of all classes receive in these united schools systematic instruction in the various branches of physical science. The institution is primarily intended for the instruction of teachers and of students of the industrial classes selected by competition in the examinations of the Science and Art Department, but other students are admitted so far as there may be accommodation for them, on the payment of fees fixed at a scale sufficiently high to prevent undue competition with institutions which do not receive State aid.

All this is fully and clearly set forth in the "Calendar and General Directory," where also the reader will find ample details as to the Science Collections, the aid granted to local museums, the Committee on Solar Physics, the relation of the Government to scientific research, the Geological Survey, the Museum of Practical Geology, the Mining Record Office, and the scientific establishments of Edinburgh and Dublin.

In an article on "National Education in Science and Art," the *Times* on Monday last expressed a doubt whether, after all, any country can be much ahead of England in the number and excellence of its scientific institutions. The *Times* takes far too favourable a view of the relative position of the United Kingdom in such matters. Recent Consular reports have shown that our traders are being steadily beaten by German competitors in many great foreign markets; and the explanation is that, notwithstanding the progress we have made, our system of scientific instruction will not compare, in comprehensiveness and thoroughness, with that which has grown up in Germany. The *Times*, although unwilling to admit the superiority of our rivals, readily grants that as a nation we do not yet do enough for the promotion of science. It says:—

"When the general condition of popular artistic and scientific instruction is viewed, there can be no question that it is not in accordance with national responsibilities, whatever the average may be elsewhere. A primary result of the discovery is to abate some of the admiring content which study of the contents of the Science and Art Department's 'Calendar and Directory' is calculated to produce. To the Science and Art Department has been committed the task of imbuing the nation with those two extensive branches of human learning. The depreciatory estimates so freely offered in these days of the industrial attainments of the nation in each of them suggest either that the Department is not altogether equal to the enterprise, or that it has not been provided with the proper instruments."

The *Times* urges, with much force, that wealthy men have a magnificent opportunity of serving their country by following the example of the late Sir Joseph Whitworth in the endowment of scholarships, exhibitions, and prizes for students of science. With its remarks on this point all who are interested in science will agree; but it is necessary to point out that, however generous private persons may be, they cannot possibly meet the wants of England, with regard to science, in our time. This task can be properly undertaken only by the community as a whole, acting through its organ, the State. If it is not undertaken on the scale which circumstances have rendered necessary, we must be prepared to pay the penalty in diminished commerce and industry. On the other hand, the success which has attended our efforts in the right direction in the past ought to encourage us to make further sacrifices. There cannot be the slightest doubt as to the eagerness with which increased opportunities for scientific education of the highest order would be taken advantage of. At South Kensington there is not nearly room enough for the large number of students who annually seek admission, and like pressure will probably soon be experienced at many less important centres of scientific training. Here the *Times* speaks out strongly and well:—

"If the industrial classes in England be more or less deficient in taste and technical intelligence, it is from absence, not of natural aptitude, but of educational opportunities. Keenness of Continental competition may be far from an unmixed evil if it frighten Englishmen who have the ability into using it for the remedy of the shortcoming. Dulness and mental lethargy are in themselves evils, apart from the danger they cause of a loss of trade. A workman without insight into the meaning of the work he is doing, and with no perception of its real capabilities, is a mere bondsman to his occupation, instead of its master. While we suspect, as we have intimated, the existence of an exaggerated tendency to extol foreign technical training, the British mechanic will have no reason to regret the propensity, if it conduce to his equipment with the means of industrial enlightenment needed to convert his vocation from base drudgery into an art."

That the working classes are becoming alive to the necessity of an improved system of scientific and technical instruction may be inferred from the resolution on the subject which Mr. Howell proposes to move in the House of Commons. This resolution we print elsewhere, and our readers will agree with us in wishing Mr. Howell all success in the admirable enterprise he has undertaken.

THE PROGRESS OF ASTRONOMICAL PHOTOGRAPHY

IN the *Annuaire* for the present year, published by the Bureau des Longitudes, is an important article by Admiral Mouchez, the Director of the Paris Observatory. The article is really a history of the various applications of photography used by astronomers up to the present time, and the history is very well done. The article contains many details relative to the work which has recently been going on in the Paris Observatory, which we think will be read with very general interest.

In the new instruments which the Brothers Henry have recently constructed at the Observatory, before a plate is taken the telescope is pointed approximately to a bright star, which is examined with an ordinary eye-piece, armed with a blue glass. In this way a slide can be placed very near the chemical focus, but in order to determine the focus exactly, an image of a star is made to run six or seven times along a very small plate at different marked distances inside and outside the focal point, as previously determined. An inspection by a magnifying glass of the different trails left by the star on the *cliché* shows which was the most exact chemical focus employed to produce them. This when once done really needs no repetition, but as a matter of fact the operation is repeated once a month.

Another point which the Brothers Henry have already settled is, that in the case of very many photographic plates of extreme sensitiveness the plates are practically useless unless they are prepared almost immediately before they are required, so that as a matter of fact very sensitive plates are now avoided.

Another limit to the sensitiveness which can be utilised is the diffused light proceeding from the atmosphere, either from the gas of a large town, as in Paris, or from the presence of the moon. Very sensitive plates are liable to be fogged even by diffused light in the case of very long exposures.

We have before referred to the arrangements employed for enabling the images of stars to be differentiated from any accidental spots or dots on the plate. The plate is practically exposed three times to the region of the heavens, with such a small variation of position, however, that the three images of the star on the plate appear as one to an observer who looks at it casually, and a magnifying glass is really necessary to discover the triple nature of the image. This method of working has been found to have advantages which were not anticipated in the first instance; thus, for the same total time of exposure the images of much more feeble stars are recorded with the three successive exposures than with one alone. This arises from the fact that the stars of the lower magnitudes, only being represented by very small points from 1/30 to 1/40 of a millimetre in diameter, would escape all observation by the naked eye, and would not be visible at all on paper copies; while the three exposures give a larger image visible to the naked eye, and perceptible on a paper positive. Moreover, if a small planet is included in the region being photographed, the deformation of the small triangle would instantly betray its presence, even with an exposure of a quarter of an hour. Admiral Mouchez has calculated that a planet at twice the distance of Neptune would be easily recognised in three successive exposures of an hour each,—the motion of Neptune in half an hour quite destroying the triangle which it, like the stars, would make were it at rest.

The real and serious objection to the triple exposure is the wonderful patience and skill that are required to keep the instrument for three consecutive hours, without a moment's relapse, pointed rigorously towards the same spot in the sky. This is very trying work, and apt to overstrain those who perform it. Admiral Mouchez is alive to the fact that the way to obviate this difficulty is to increase the aperture of the object-glass, and this is what probably will be done before very long.

Some very interesting information is given regarding the microscopical appearances of the images of the stars seen on the negatives:—"The microscopical study of the *clichés* presents, moreover, much interest from many points of view, and the appearances of the images of the stars is so characteristic that it is impossible to confound them with accidental spots, as has been generally supposed; were this point of view alone regarded, it would perhaps be useless to multiply the exposures of the same plate. The stars appear on the plate, in fact, not under the simple form of a round spot of uniform black tint diminishing and becoming clearer as the star gets smaller, but as a mass of small, round, black points, very close together towards the centre for stars of the ten or twelve larger magnitudes, and more and more sprinkled, still retaining their blackness, for the fainter stars; and at the extreme limit beyond those stars which give a definite and certain image, there still appear on the *cliché* some small groups of little points scattered sparsely, but evidently recording still fainter stars, the existence of which can only be suspected without any means of further confirmation.

"Unfortunately, whatever progress we may make in optics or in photography whatever, penetrating and sensitive power we may hope to give to our instruments, it is evident that we shall never succeed in seeing the most distant stars, and that at whatever limit we may arrive, there will always be beyond it an infinity of others lost in the profundity of the heavens which will always escape our knowledge, but it is by photography and the scientific study of negatives that we shall be able to go further than by any other means. From a chemical point of view also the microscopical examination of the stellar images will not be without interest, because it will help us to understand how the light acts upon the molecules of the insoluble salts of silver which are contained in the stratum of organic material which forms the sensitised plate. It is not, as I have already stated, in giving a uniform tint, more or less decided, according to the magnitude of the star, over the whole image, but really in decomposing a greater or less number of particles of salts of silver over this area, that the light works; so that we can define the image of a very feeble star as a resolvable nebula, and the others as insolvable nebulæ surrounded by a resolvable portion. I have never seen around any of these images the rings referred to by several astronomers, which have the appearance of diffraction rings seen in telescopes.

"To establish the relationship between the scales of the optic and photographic magnitude of the stars, Bond has made a series of interesting experiments by varying the time of exposure and the aperture of the object-glass. These experiments have led him to an interesting result on the mode of action of light. He has found that a certain time elapsed before the action manifested itself at all, and then that it did so suddenly, ten or a dozen molecules of salts of silver in each superficial second of arc were attacked by the light; after this the number increased very rapidly according to the time of exposure. This mode of action seemed to him obscure and difficult to explain. But it seems to follow from these facts, and from the examination of our *clichés*, that in the manufacture of the bromide of silver, and the preparation of sensitive plates, it is of the highest importance to obtain the finest possible pulverisation of the salt."

As there is to be a Conference of Astronomers at Paris next Easter to discuss the whole question of astronomical photography, it is well that Admiral Mouchez and his staff are accumulating so many facts to help in the discussion.

METEOROLOGICAL CONDITIONS AT THE TIME OF THE ERUPTION OF MOUNT TARAWERA, NEW ZEALAND

IN the Government Sanatorium at Rotorua there is a self-registering barometer kept by Dr. Ginders. This shows that at 9 a.m. on June 9, the atmospheric pressure was 29·30 (at about 1000 feet above the sea). It decreased and reached its lowest point of 29·00 at 4 p.m. on the 9th. It then began to rise. At midnight it was 29·08, and at 1 a.m. on the 10th—just before the eruption—it was 29·10. This pressure was maintained all through the principal part of the eruption, after which the glass began to rise again, reaching 29·25 at noon on the 10th. The curve, elsewhere smooth and even, shows from 3.30 a.m. to 6 a.m. a number of small oscillations which treble its thickness. None of these oscillations are recorded before and none after 6 a.m. on the 9th, except a single one at 5 p.m. on Friday, the 11th. These oscillations are attributed to earthquakes, but, whatever may have been their cause, they certainly mark the outburst of Rotomahana and the crisis of the eruption.

Another barometer at Ohinemutu, belonging to Mr. Edwards, of the Native Lands Court, read as follows:—

June 9,	10 a.m.	29·30 inches
,,	4.30 p.m.	29·00 ,,
,, 10,	1.55 a.m.	29·20 ,,

The following is the rainfall at Rotorua:—

June 4	1·26 inches
,, 5	0·58 ,,

There was no rain at Rotorua between the 5th and the eruption, but it rained on the 9th at Wairoa and at Ateamuri, on the Waikato.

At Rotorua the slight mud-shower fell in directions from south-east to south-west, but most from the south-east, as ascertained by an examination of the telegraph poles. At Taheke, on Lake Rotoiti, the mud must have fallen with a south-south-east wind. At Galatea, eighteen miles east-south-east from Rotomahana, no mud fell; but the scoria was thicker on the north-west than on the south-east side of the houses: evidently no strong wind was blowing.

The night of the 9th was calm and fine. During the earlier portion of the eruption there was a slight south-westerly wind at Wairoa, which increased to a strong gale at 3 a.m. At Rotorua there was a slight south-easterly wind up to 4 a.m., when the south-westerly gale reached there from Wairoa. At Taheke, on Lake Rotoiti, the wind changed to south-west at 9 a.m., but there was no gale. At Napier a southerly gale commenced at 4 a.m.; at Gisborne, in Poverty Bay, a south-westerly gale was blowing; at Waiapu a strong north-westerly wind was blowing from 3.15 a.m. to 4.30 a.m., when it changed to the south-west. At the East Cape there was a strong southerly gale. It appears therefore that the south-westerly gale at Wairoa had no direct connection with the eruption, for it commenced about the same time all over the east coast from Napier to the East Cape.

I was surprised to find that the eruption had caused no great atmospheric disturbance, except in its immediate neighbourhood, and that there was no evidence at all of any indrawing currents. The reason for this, no doubt, is that the area over the openings which was violently disturbed is small, so that equilibrium was restored at very short distances around. For this reason a volcanic eruption has none of the effects of a cyclone. The eruption was, as usual, the cause of much electrical disturbance, but this did not affect the weather. F. W. HUTTON

A FEW OF OUR WEATHER TERMS

A RECENT skirmish in the *Times*, on certain words in common use among English meteorologists, and prevalent in our weather reports, suggests that a little overhauling of these and similar terms may be from time to time desirable. In a branch of knowledge which, simultaneously with its growth, becomes more and more popular, new terms expressive of new ideas should not only be accurately descriptive of facts, but should be adapted to popular imagination.

If we cannot have such terms as "helix" and "anthelix," the Meteorological Department cannot be on safer ground than in their adoption of the terms "cyclone" and "cyclonic," "anticyclone" and "anticyclonic"; these words being precisely antithetical, and expressive of phenomena which are the opposites of each other in almost all their characteristics. To both of these words, however, objections have been raised, and these objections have been somewhat inconsistently based on different reasons. The word cyclone has been objected to because it terrifies our women; but its equivalent, "revolver," would produce at least as alarming an effect. They would soon, however, get accustomed to the use of either. The most unscientific people will quickly understand that when the laws which govern a particular kind of atmospheric circulation have once been proved to be identical, whether that circulation be violent, moderate, or feeble, it becomes desirable to have a single term descriptive of such a circulation. Such nouns as "hurricane," "storm," &c., can be employed, if we please, to denote that the disturbance is of a violent or severe character; while we have plenty of adjectives, strong or mild, to be employed at discretion. Perhaps this will be still more fully realised when the public understands that, in any particular instance, the circulating winds may vary between the most violent and the lightest during the progress of the disturbance. As Mr. Abercromby clearly states it: "The same cyclone may develop the energy of a hurricane soon after its birth in the West Indies, and, after a long and stormy life in its passage across the Atlantic, die surrounded by gentle summer winds on the rocky coasts of Norway." The original use of the term "cyclone" was almost limited to the phenomenon in its acutest stage; and, owing partly to this fact, meteorologists have been disposed to apply the expressions "cyclonic system" and "cyclonic disturbance," &c., to the gentler instances or stages of this kind of circulation, rather than the word "cyclone" itself; but the latter word might now be used without hesitation, for it is most true that "a progressive science uses words provisionally to express provisional ideas, and as the ideas increase in clearness and precision" (and, we may add, in extension) "the word has to take on new meanings."

The term "anticyclone" has been recently objected to as possessing absolutely no significance, an objection which is not in itself worthy of discussion in these pages. This objection is, however, probably founded on one of a more serious nature, viz. that anticyclones are merely interspaces between cyclones. Such interspaces do, of course, exist, and they occasionally travel on without undergoing any very rapid change of form in company with the cyclones. But the interspaces between circles or ovals are not circular or oval; and further (as is more important to observe, and as has long ago been shown to be true) the anticyclone proper has characteristics of its own which distinguish it from these interspaces: its movements are often slow, or it is stationary for a considerable period, while in both hemispheres it has the power of deflecting the course of the cyclones moving in its vicinity more or less towards the right, except in particular positions.

Now let us look at the word "depression" and the ideas associated with it. It would probably be an impossible as well as an undesirable task to get rid of this term altogether, but for this reason it becomes all the more necessary clearly to define its meaning. Originally it signifies a lowering of the surface of the barometric column due to a diminution of pressure on the surface of the mercury in the cistern. It is equally well employed to designate a "taking off" or diminution of atmospheric pressure. In any case, it might be employed to designate such a diminution of pressure as takes place during the lessening or the passing off of an anticyclone. But by common usage it has come to be practically equivalent to cyclone, the only difference being (1) that it naturally refers to the diminution of pressure within the cyclone, and not the circulating winds, and (2) that it can be usefully applied to areas diverging considerably from the circular form. The ease with which the idea of a saucer-shaped hollow in the ocean of atmosphere is entertained, and the associations of the word "gradient" (a word valuable, suggestive, but figurative—a word for which I can find no substitute, unless it be a coined one), have certainly led to some misconceptions. Over the front or ascensional part of a cyclone, atmospheric pressure is greater at the level of four, five, or six miles above the earth's surface than over surrounding regions at the same level. It would be well for our storm-warnings if more people were careful to observe the violent north-westerly upper-current prevailing immediately in front of, and over, the southerly winds which we feel when a cyclonic disturbance is coming upon us from west-south-west. The few who have noticed this cannot fail to be struck by the fact that at the level of the cirrus the pressure must increase with extreme rapidity at the same time that pressure is decreasing at the earth's surface. It is true that in the rear of the disturbance an extension of the great polar area of depression in the higher regions of the atmosphere is shown by the movements of the higher clouds. Any one who will be at the trouble to chart out these phenomena will feel that the neat little orographical maps of the atmosphere with which some of our popular writers on weather would present us are exceedingly different from the realities.

The terms "col," ridge," "trough," &c., for a similar reason, while assisting the popular imagination, perhaps assist it in the wrong direction, and I would, though with much deference to better authorities, suggest that such terms as "arm," "band," "belt," "extension," &c., might be employed with a little more safety. To the terms "deep," "depth," "high," "height," might not my own respectable old words, "intense," "intensity," even now be found preferable? and for the word "shallow" the word "slight" in many cases be advantageously substituted? I am aware that in a magazine article or in a weather report some variation of terms and expressions is frequently desirable, but the cover has not yet been fairly drawn; and an abundance of useful words is still available, without recourse being had to terms either borrowed from foreign languages or expressive of incorrect ideas. W. CLEMENT LEY

NOTE ON INSTANTANEOUS SHUTTERS

THE introduction of rapid dry plates having made a general demand for mechanical shutters, a large variety are now offered for sale by the various makers. Many of these shutters are neat and ingenious, but nearly all have a tendency to shake the camera during exposure, and in the only one which I have seen for sale in which this mistake has been avoided the photographic efficiency of the arrangement has been impaired by the opening being made to assume the form of a gradually expanding and contracting hole; the idea being, I am told, that while the opening is small it will act as a stop and secure definition. This, of course, is true to a certain extent—how far, I will inquire presently.

I do not know whether the general theory of mechanical shutters has been discussed, but if it has it is certainly not well known, and perhaps the following remarks, which point out what the photographic efficiency of the various classes of shutters is and their effect on the steadiness of the camera, may be of some use.

Shutters may be divided into two chief classes, viz. those in which the principal moving part consists of a single piece, and those where the moving parts are multiple; the great difference between them being that, while the first class must exert either a force or a couple on the camera during exposure, the second class may be so designed as to exert neither. The first class consists of drop-shutters and revolving disks with an aperture which passes across the lens, and of those shutters where a sliding piece rises and falls or a hinged piece opens and shuts. Of the second class I only know of one as being in the market, though probably many amateurs may, like myself, have made them for their own use. In this shutter two plates, occupying the position of the ordinary stop in the lens, separate and come together again. Each plate has a deep V-shaped notch in it; the apex of each V when the shutter is closed being in the axis of the lens. The opening is therefore a quadrilateral figure which gradually expands and contracts.

The mechanical arrangements of nearly all the shutters, except those belonging to the revolving disk and drop-shutter class, are such as to make the motion of the shutter a simple harmonic function, or nearly so, of the time from the commencement of exposure, while in the drop-shutters and disks the aperture may be taken as moving across the lens with a nearly uniform velocity. This, of course, would not be true if the motion of the parts was quite free under the action of the driving force, but friction enters largely into the account; and even if it did not, no large error will be introduced in calculating the photographic effect of shutters of this class by assuming that velocity of the moving part is uniform during exposure and equal to its mean velocity.

The photographic effect of a shutter is measured by the sum of the products of each element of aperture brought into action by the shutter and the time for which that element acts. This measures the total amount of light which passes through the lens during exposure, but it does not necessarily follow that the light should be uniformly distributed on the sensitive plate. This, indeed, only happens when the shutter is at the optic centre of the combination.

In mathematical notation, if the path of a point in the shutter be along a line x, and if U be the area of the lens expressed in terms of x, and T_x the time for which dU, the element of area exposed in passing from x to $x + dx$, acts, then the photographic effect of the shutter is $\int T_x dU$, taken between the proper limits of x.

The photographic efficiency of a shutter may be taken as the ratio of this quantity to the whole area of the lens, multiplied by the whole time of exposure, or $T'U'$.

The result of integrating the above expression may always be put in the form

$$aT'U',$$

where a is a numerical constant, which therefore expresses the efficiency of the particular shutter considered.

I subjoin a few results showing the efficiency of several different types of shutter:—

	Efficiency
(1) Drop-shutter with circular aperture (uniform velocity)	$a = {\cdot}43$
(2) Harmonic opening from one side (x proportional to $\cos pt$)	$a = {\cdot}5$
(3) Harmonic opening from centre, the opening being a circular hole of radius ρ (proportional to $\sin pt$)	$a = {\cdot}5$
(4)[1] Harmonic opening from centre, the aperture being formed by the edges of two plates which recede from a diameter of the lens and the boundary of the lens (x proportional to $\sin pt$)	$a = {\cdot}764$

It will be seen that as far as efficiency goes the drop-shutter is lowest on the list.

The next two have the same efficiency, but while the second has a tendency to shake the camera the third has not. If, instead of assuming that the aperture in this case was circular, we had made it square, as in the shutter before referred to, the efficiency would not have been quite as great as ·5.

No. 4 has the highest efficiency of any, viz. ·764, and differs from the last merely in having no V-shaped notches in the plates which close the aperture, so that the opening begins as a slit instead of a point. Thus by the adoption of the square expanding aperture nearly 40 per cent. of possible efficiency is lost.

The gain in definition caused by the aperture acting as a stop may be estimated by comparing the amount of light (L_1) admitted while the opening is small enough to make the definition good, with the total amount of light admitted (L) minus (L_1), remembering that the greater the aperture up to which the shutter may open without sensibly impairing the definition the less is the possible gain in definition from the use of a stop. Thus, suppose the greatest aperture consistent with good definition to be $\rho^2 \times$ full aperture (R^2). Then the use of a stop of radius ρ can only reduce the radius of the circle of confusion about the image of a point by $\frac{R-\rho}{R}$ times what it would have

[1] This is the form which I use, but I am not aware of any shutter of the kind being in the market.

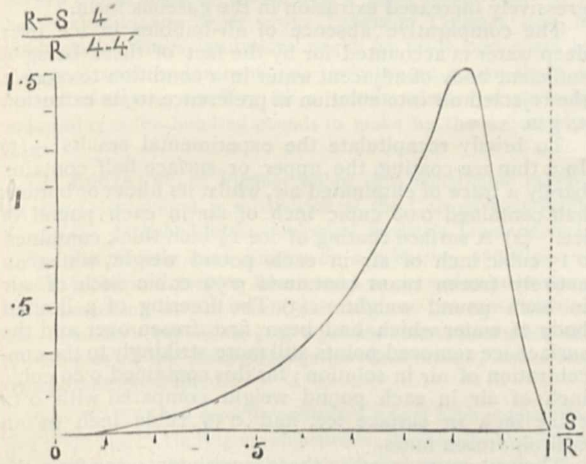
been had the whole aperture been employed. The improvement in definition, then, due to the expanding shutter acting as a stop is given by the expression—

$$\frac{R-\rho}{R} \cdot \frac{L_1}{L-L_1}.$$

The curve below shows the improvement in definition calculated from this expression, the abscissæ being proportional to $\frac{\rho}{R}$. It has a maximum value of 1·5 nearly when $\frac{\rho}{R}$ is about ·8, but falls away rapidly on either side of this value.

Thus when a stop of ·8 times the full aperture is sufficient to secure definition, the square expanding aperture may be said to answer the purpose. But a better result with less exposure could be obtained by the use of shutters of type (4) with a separate stop of the right size; for it may be shown that with the square expanding aperture the amount of light admitted while more than eight-tenths open is not more than 8 per cent. of the whole, and not more than 8 per cent. of the light would be lost if a ·8 stop were used. But a shutter of type (4) admits nearly 40 per cent. more light than the expanding square, so that there would be a gain of something more than 30 per cent. in light by using it.

This is rather understating the case, for the efficiency of a shutter as defined above is increased by the use of a stop,



the whole aperture of the stop being uncovered for a finite time while the whole aperture of the lens is only uncovered for an instant.

To see what effect an unbalanced shutter has on the steadiness of the camera and definition of the image, the mass of the unbalanced moving part of the shutter, the mass of the camera, its period of vibration on its support, and its radius of gyration must be taken into account, as well as the time of exposure. The exact investigation of the motion is very much like that given by Helmholtz of the motion of a pianoforte-wire when struck by a hammer. But without entering into mathematical details it is easy to approximate to the required result in a large group of cases, viz. where the time of exposure is short compared with the natural period of the camera on its supports. This will apply to cameras held in the hand for all exposures which could be effectively used with such a support, and in most other cases when the exposure is less than a fiftieth of a second.

The camera and shutter may now be compared to a fly-wheel free to turn with a small load on its rim, which, by some mechanism on the wheel, can be made to vary its position. If the fly-wheel is at rest to begin with, the motion of the system when the load is caused to move is given by the condition that the moment of momentum of the fly-wheel and load together is nothing, which implies that

$$\frac{\text{velocity of rim of wheel}}{\text{velocity of load}} = \frac{\text{mass of load}}{\text{mass of rim}}.$$

Suppose that the camera is replaced by a fly-wheel which has the same moment of inertia and a radius equal to the distance of the centre of oscillation of the camera on its support from the shutter, the mass of the equivalent fly-wheel will be less than that of the camera on account of its distribution, so that the angular motion of the camera about the centre of oscillation will be somewhat greater than

$$\frac{\text{mass of shutter} \times \text{travel of shutter}}{\text{mass of camera} \times \text{radius of oscillation}}.$$

As an example, suppose the ratio of the masses to be 1/100 and the travel of the shutter one inch, if the radius of oscillation lies between one foot and six inches, the augular movement of the camera will be between three and six minutes of arc, or from one-tenth to one-fifth of the apparent diameter of the sun or moon.

In the case of drop-shutters acting by gravity, the camera begins to move upwards at the moment the shutter is released, and will go on moving upwards until it is as much above the new position of equilibrim which it would assume on the removal of the weight of the shutter as it was below it when the latter was attached. So that if the time of exposure be half as long as the natural period of the camera, the whole extent of the angular motion will show on the sensitive plate.

I have recently made some experiments to see how, when the camera was held in the hand, the accidental motions of the support compared with those due to the action of the shutter. It would, I think, at first sight be supposed that the former were the more important of the two. The experiments were made by weighting a piece of looking-glass to represent the camera, and then, holding it as the camera would be held, reflecting the sun on a distant screen and noting the displacement of the patch of light. I found it in my own case to be continual, vibrating at a rate of something like four per second, through an angle of about one in six hundred to one in eight hundred, implying, of course, half this motion in the camera; that is, from three to two minutes of arc. The time of the whole vibration being about one-fourth of a second, if the time of exposure was as much as one-eighth of a second the whole of this would show on the plate, but for exposures of one-twentieth of a second the loss of definition from this source would hardly be appreciable. The weight of the camera in this case was small—little more than a pound—and so unfavourable for steadiness.

The general conclusions to be gathered from the foregoing remarks are: (1) That there is room for great improvement in the photographic efficiency of shutters; (2) that all the ordinary kinds shake the camera when the exposure is rapid; but that (3) for comparatively long exposures, say more than one-tenth of a second, almost any kind of shutter will do when the camera is mounted on a stand; and (4) that for cameras which are to be held in the hand, in order to secure fine definition the shutters must be dynamically balanced or exceedingly light.

A. MALLOCK

ON SOME PHENOMENA CONNECTED WITH THE FREEZING OF AËRATED WATER

THE elimination in the gaseous form, on the freezing of liquids, of the air and gases held in solution presents some features in its process which may be worth recording.

Bubbles in ice are familiar; but their arrangement and progressive development in the process of freezing-over present some points which I do not think have been generally observed.

Aquatic plants at the bottoms of ponds give off oxygen gas, and marsh gas is emitted from decaying vegetable matter. These two sources of supply will, to some extent, account for the entanglement of bubbles in ice on a pond surface, but only to a very small extent, and may be left out of consideration in dealing with the development of air-bubbles in ice. This takes place independently of any extraneous source of supply other than atmospheric air, and may be as well seen in a glass or earthenware vessel as over a weedy pond surface.

The following facts must be noticed:—

(1) Ice over deep water invariably contains fewer bubbles of included air and gas than ice formed over shallow water, and probably from this cause ice obtained from over deep water is more durable for storage than ice obtained from shallow pools.

(2) The upper or surface portion of a coating of ice invariably contains less included air than its under or lower portion, and this is more obvious in ice formed over shallow than in that over deep water. In each case there is a fairly regular gradation in the quantity of entangled air, increasing from the surface downwards. I ascertained that the included air from the upper surface (*a*, Fig. 1) of

Fig. 1.

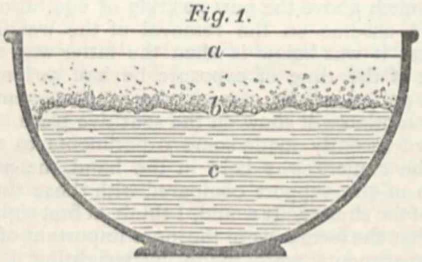
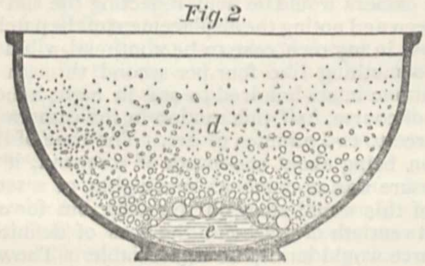


Fig. 2.



a thin coat of ice was scarcely appreciable in quantity, and one pound weight from its lower surface (*b*, Fig. 1) contained 0·08 of a cubic inch of entangled air.

(3) There is more included air in ice formed over water in a small vessel (Fig. 1) than in ice formed over a large body of water.

(4) There is more included air (weight for weight of ice) in an entirely frozen mass of ice (Fig. 2, *d*) than in surface ice from a partly frozen vessel of water. In an entirely frozen mass (Fig. 2, *d*) 1 pound of ice contained 0·59 cubic inch of included air; and surface-ice (*a*, *b*, Fig. 1), over unfrozen water, one pound weight contained 0·15 cubic inch.

(5) In freezing separately the water from which the first frozen coat of ice had been removed (Fig. 1, *c*), the ice contained a much larger proportion of included air (0·89 cubic inch) than either the surface ice (Fig. 1, *a*, *b*) or the ice obtained from entirely freezing a body of water (Fig. 2, *d*).

(6) On re-freezing water which had been frozen and thawed, there was but a very slight further release of air, which had been almost entirely released in the first freezing: one pound of the second ice contained but 0·005 cubic inch of air.

(7) In completely freezing a vessel of water (Fig. 2), not only does the entangled air increase in quantity downwards, but at the base of the frozen mass occurs a large air-cavity (*e*, Fig. 2).

All these facts, and the results of the experiments, seem to point to the fact that, in the process of freezing, the elimination of the air and gases in solution is taking place in two directions: (1) a part of the air is taken into solution by the *un*frozen water as it is progressively rejected by the thickening coat of ice; and (2), a part of it is extruded as bubbles of air, which become entangled in the ice.

If each stratum of ice eliminated the whole of its own proportion of air in solution in the gaseous form, the bubbles would be distributed with fair regularity throughout the collective mass, but their progressive increase in a descending direction exactly agrees with the continuous surcharging of the underlying unfrozen water with the air in solution rejected by the ice above, till, at the end of the freezing process of the mass, the remnant is extruded as one large bubble (Fig. 2, *e*) at its base.

The rejection of the air into continued solution would seem to take precedence of its extrusion in the gaseous form, and would go on as long as there was a sufficient body of adjacent water in a condition to receive it; but the gradual surcharging of a limited body of water with the rejected air is necessarily accompanied by its progressively increased extrusion in the gaseous form.

The comparative absence of air-bubbles in ice over deep water is accounted for by the fact of there being a sufficient body of adjacent water in a condition to receive the rejected air into solution in preference to its extrusion as gas.

To briefly recapitulate the experimental results:—(1) In a thin ice-coating, the upper or surface half contains barely a trace of eliminated air, whilst its under or bottom half contained 0·08 cubic inch of air in each pound of ice. (2) A surface coating of ice $1\frac{1}{2}$ inch thick contained 0·15 cubic inch of air in each pound weight, whilst an entirely frozen mass contained 0·59 cubic inch of air in each pound weight. (3) The freezing of a limited body of water which had been first frozen over and the surface ice removed points still more strikingly to the concentration of air in solution; for this contained 0·89 cubic inch of air in each pound weight, compared with 0·15 cubic inch in surface ice, and 0·59 cubic inch in an entirely frozen mass.

The water employed in these experiments was from the East Surrey Waterworks. GEORGE MAW

NOTES

THE following notice of motion has been given by Mr. Howell, M.P.:—"To call the attention of the House to the subject of technical education, and to move the following resolution:—'That, in the opinion of this House, it is essential to the maintenance and development of our manufacturing and agricultural industries, in view of the rapidly increasing competition of other nations, both in home markets and abroad; and in consequence of the almost universal abandonment of the system of apprenticeship; that our national scheme of education should be so widened as to bring technical instruction, the teaching of the natural sciences, and manual training, within the reach of the working classes throughout the country.'"

IT is stated that in consequence of the financial difficulties of the Bristol College, and lack of endowments, the salaries of all the Professors will be reduced by the Council, and some Chairs are to be abolished. The course pursued by the Council has given rise to much correspondence in the local papers during the past month. It is earnestly to be hoped that circumstances may yet be found to cause the Council to reconsider their position, and that a course so diastrous to the College—an institution which, in spite of its insecure position, has done excellent educational work—and to the town itself, may yet be averted. Is Bristol so flourishing that the citizens can afford to neglect the only true foundation for prosperous trade and commerce at the present time, when we are trying to compete in the markets of the world with men more highly trained than ourselves?

THE Guthrie Memorial Fund, which will shortly be closed, has now nearly reached the sum of 1400*l*. As we explained some time ago, Prof. Guthrie was too exclusively devoted to teaching and scientific research to be able to make adequate provision for his family. The object of the fund is to place his children as nearly as possible in the position they would have occupied but for his untimely death; and subscribers have been glad to have this opportunity of expressing their appreciation of his personal character and scientific labours.

WE are glad to learn that the University Extension Scheme, which has led to such excellent results in England, is likely to be tried in Scotland. The question has been for some time under the consideration of the University Court of Glasgow, and now the matter has been taken in hand by some energetic University men in Edinburgh. The proposal is that the available lecturing power of the Scottish Universities shall be united, so that while any town would naturally in the first place be supplied as far as possible from the nearest University, any desired course might be drawn from a more distant one. It is hoped that in the larger towns Extension Colleges may be established. These institutions might be made permanent by means of small endowments, or towns might secure them as centres of regular teaching for a certain number of years by subscribing a few hundred pounds to make up the deficit from fees.

DR. LEUTHNER, of Vienna, author of a remarkable memoir on the Odontolabini, a subdivision of the Coleopterous family Lucanidæ, published in the Zoological Society's Transactions in 1885, will shortly leave Europe on a collecting expedition to South Arabia and Socotra, where much work remains to be done, notwithstanding several recent excursions to the same district. Dr. Leuthner's expedition is of a private nature, but he has the full support of the Austro-Hungarian Government, and a free passage in their ships.

PROF. G. SÉE has recently published a new book, concerning diet in disease ("Du Régime alimentaire: Traitement hygiénique des Malades"). M. Sée, although he has never studied physiological questions in a special manner, always writes useful books, being familiar with English and German, and very well posted in all foreign experiments and work. The most interesting part of his book, from a physiological point of view, is that in which he discusses the question of foods and their constituents. Criticising the food-ration of the French army, he says that too much bread is allowed, and too little meat.

THE volume of the *Indian Antiquary* for the past year contains a most interesting series of papers by Mr. H. G. M. Murray-Aynsley, under the modest title, "Discursive Contributions towards the Comparative Study of Asiatic Symbolism." They commence in the March number, and, with the exception of the issues for June and July, are, continued consecutively down to, and including, the November number, and are not yet completed. One feature of special value to the European student is the method of illustration adopted. The plates are numerous, and beautifully executed, and a large number describe objects collected by the writer himself in Northern India, which have probably never before been seen by the majority of Western scholars. It is to be hoped that Mr. Murray-Aynsley will ultimately collect these papers into a volume; at present we can do no more than barely indicate the outlines of their contents. His chief object is to make a collection of facts bearing upon the subject of customs and symbols, and, after a general introduction, a chapter is devoted to each of the following divisions:—(1) Sun and cup (or moon) symbols; (2) sun-worship; (3) the *Svastika*, or emblem of fire; (4) stones worshipped in India, and their counterparts in Scandinavia and other parts of Europe; (5) the land of departed souls; (6) the trees which have been held sacred in the East and in Europe; (7) snake-worship; (8) amulets and charms; (9) the evil eye; (10) the wild huntsman of Northern Europe and his possible Asiatic origin; (11) Eastern architecture compared with certain old churches and houses in Norway; (12) Asiatic symbolism in Spain. While this may give a notion of the general contents of these papers, it gives none whatever of the mass of facts collected from different sources, principally by the author himself in India and Cashmere. The coloured illustrations of the *Svastika* symbol, showing the wide area over which it is employed, are very interesting. In addition to many others given, the author might well have added that it is almost universal in this country as a bordering to the commoner kinds of linoleum and other floor-cloths, the manufacturers having probably borrowed it from the designs on Central Asian carpets and rugs.

AN important addition has just been made to the Zoological Society's Collection in the Regent's Park, in the shape of three fine specimens of the sea-lion or eared seal of the Auckland Islands (*Otaria hookeri*). These animals, originally four in number, one having been lost during the transit home, were captured in the Auckland Islands, which lie in the Antarctic Ocean, some 900 miles south of Tasmania, by Capt. John Fairchild, master of the New Zealand Government steamer *Hinemoa*, and were sent to London in the steamship *Tongariro* by the Hon. W. J. M. Larnach, C.M.G., Minister of Marine of New Zealand, as a present to the Zoological Society. The Zoological Society's menagerie already contained specimens of the sea-lion of the Falkland Islands (*Otaria jubata*), and of the Cape sea-lion (*Otaria pusilla*), but no example of the present rarer species has been previously brought alive to Europe. There are, however, stuffed specimens of this animal in the Museum of Natural History in the Jardin des Plantes, Paris.

IN the Report of the Fish and Game Commissioners of Massachusetts for 1886, there is an interesting paper by Mr. George Dimmock on certain fish-destroying insects in the United States. The largest of them, and the most dangerous to fishes, are those which belong to the family called Belostomidæ. They are provided with powerful fore-legs, and strong, somewhat oar shaped hind-legs for swimming; and, when full-grown, they have vigorous wings, and are capable of long-sustained flight. In seizing upon fishes or other small animals, they grasp their prey with their fore-feet, holding it firmly in their claws. Then they pierce it with their beak or proboscis, and suck its blood. They are strongly attracted by the electric light, and Mr. Dimmock suggests that it might be used as a means of destroying them, as it would be easy to contrive a trap that would retain them when they fall after striking the glass. An illuminated trap beneath the surface of the water might, he thinks, be more effective than one above the surface, for the Belostomidæ do not often leave the water, apparently, except when they quit it for the purpose of migration.

THE United States Fish Commission print in one of their recent Bulletins an excellent report by Mrs. Emma Metcalf Beckley, Curator of the Hawaiian National Museum, on "Hawaiian Fishing Implements and Methods of Fishing." The writer gives some curious details about octopus-fishing. The smaller kinds of octopus, which live in shallow water, are caught by women, who do their work with remarkable skill. They can tell whether an octopus is in a hole whose entrance is no larger than a silver dollar, and, plunging their spears in, they invariably draw one out. The larger kinds of octopus, which are always found in deep water, are caught by men with cowries, generally of the Mauritiana, but sometimes of the tiger species. An octopus will not rise to a large-spotted or ugly cowry, so the fishermen have to take care that the spots on the back of the shell are very small and red, breaking through a reddish-brown ground. Cowries with suitable spots, but objectionable otherwise, are slightly steamed over a fire of sugar-cane husks, a process which gives them the desired hue. The fisherman, having arrived at his fishing-grounds, first chews and spits on the water a mouthful of candle-nut meat, which renders the water glassy and clear; he then drops the shell with hook and line into the water, and swings it over a place likely to be inhabited by an octopus. The moment an octopus perceives a cowry, it shoots an arm out and clasps the shell. If the shell is of the attractive kind, one arm after the other comes out, and finally the whole body of the octopus is withdrawn from the hole and attaches itself to the cowry, which it closely hugs, curling itself all around it. The creature remains very quiet while being rapidly drawn up through the water. Just as it reaches the surface, the fisherman pulls the string so as to bring its head against the edge of the canoe, and it is killed by a blow from a club which is struck between the eyes. This must be done rapidly, before the animal has time to become alarmed; for if it lets go the cowry, it becomes a dangerous antagonist, and there is risk of the fisherman being squeezed to death. The cutting off of one or more of its eight arms does not affect the rest in the least.

WE have received *Studies in Microscopical Science*, vol. iv. No. 6, Sections 1–4. The text of the first three sections relates to botanical, animal, and pathological histology; that of the fourth to marine Algæ. The plates are very delicately executed.

WE have also received the seventh, eighth, and ninth parts of the Transactions of the Yorkshire Naturalists' Union. Among the contents is an interesting presidential address on "The Fathers of Yorkshire Botany," delivered, in 1884, by Mr. J. G. Baker, F.R.S., President of the Yorkshire Naturalists' Union.

THE Selborne Society intend to issue letters, from time to time, on its objects and work. They will be written by members who have a special knowledge of the subjects discussed. The first of the series, which has just been published, is on the feeding and protection of wild birds in winter. The next will be on the Wild Birds Protection Acts of 1880 and 1881, and their bearing on bird-catching and bird-nesting during the close season. Other letters will follow on birds, trees, and plants, and it may be hoped that the scheme will be of considerable service in disseminating a knowledge of practical natural history.

THE French Government has purchased the hillock of Sansan (Département du Gers), which is famous for its richness in fossil animal remains. M. E. Lartet was the first discoverer of this palæontological treasure. M. Filhol, the naturalist, has recently examined the hillock; he was commissioned by the Professor of Palæontology at the Jardin des Plantes, Paris. This gentleman, supported by M. Cavaré, found fossil remains not only of Mastodons, Macrotheria, Chalicotheria, &c., but also of bears, stags, dogs, and cats. Noteworthy are some stags' horns, with two main branches, or so-called Dicroceri. All these fossils will be deposited in a museum to be built at Sansan, and will be described in a catalogue by M. Filhol.

PROF. W. J. TSINGER, at Moscow, is busily engaged in preparing his bulky work on the flora of Middle Russia, including the floras of the fifteen central provinces.

A LEARNED Society called the Società Italiana Asiatica has been formed in Italy for the investigation of Eastern languages and archæology. Prof. Amari has been elected Honorary President. The Society has obtained the collaboration of the best Italian Orientalists, and has nominated twenty-four foreign honorary members, among whom are Profs. Böhtlingk, Max Müller, Roth, Fleischer, Renan, Weber, Whitney, Rawlinson, Maspero, Legge, Brugsch, and Friedrich Müller.

THE Anthropological Society of Bombay, the establishment of which less than a year ago has been noticed in these columns, has already over 300 members, and has published the first number of its Transactions. Mr. Tyrrell Leith, the founder of the Society, has a paper on divination by Hazirat among the Indian Mussulmans; Dr. Dymock writes on the hairy man of Burmah, and Indian necromancy; Dr. Weir, on sacrifice in India as a means of preventing epidemics; and Dr. Basu, on embalming in Ancient India, and on Nisi, the night demon. There are other papers, but this list is sufficient to show the activity and utility of the new Society.

THE author of the paper on "Mexican Codices and Graven Inscriptions" inadvertently referred to in a Note last week as "Mr. Z. Nuttall," is "Mrs. Zelia Nuttall," one of two American ladies elected to the honorary position of "Special Assistant" of the Peabody Museum of Archæology, Cambridge, Mass. The paper in question was communicated to the American Association for the Advancement of Science in August last, when Mrs. Zelia Nuttall announced her discovery of "determinative signs," forming a key to Aztec phonetic manuscript records and graven inscriptions, and presented, in support of her statements, comparative tables of phonetic signs for inspection to the Section of Anthropology. Mrs. Zelia Nuttall has recently contributed to the *American Journal of Archæology* an account of the terra-cotta heads of Teotihuacan. These little clay heads, of most varied types, are frequently found in the vicinity of the great pyramids at San Juan Teotihuacan, about 30 miles north-east of the city of Mexico. They had been generally considered the work of different races of people, inhabitants of the valley of Mexico at successive periods, and were therefore held to be of considerable antiquity. Mrs. Zelia Nuttall's comparative researches prove them to be of Aztec workmanship, and thus of more modern date. She found that several of the most typical head-dresses modelled in clay were identical with those worn by Aztecs of different social grades, as depicted in Spanish chronicles at the time of the conquest of Mexico. Mrs. Nuttall adduces satisfactory proofs that these little clay heads were the portrait-models of dead persons adorned with the insignia of their rank. Attached to bodies of perishable materials, they served as effigies of the dead, and were placed on the coffers or jars containing the cremated remains, which were kept in the household dwellings of the relatives. Food and wine were offered before them, incense was burnt, and, at certain prescribed recurrent ceremonials, animals were sacrified in their honour.

WE notice, in the last *Bulletin* of the St. Petersburg Academy of Sciences, a valuable preliminary sketch of the avifauna of the western spurs of the Pamir plateau and its northern border-ridge, the Altai Mountains, by V. Bianchi. The birds were collected by M. Grum-Grzimailo, and the collection includes 136 species, which probably represent about one-third of the species inhabiting the region. With the exception of nine species, the same were found by Dr. Severtzoff in Bokhara, and described in the *Journal of Ornithology*, 1875; and only five species are not yet known in Russian Turkestan. It thus appears that the avifauna of the Western Pamir is very similar to that of the region situated on the other slope of the Kashgar-daban Mountains. Nearly a hundred species out of the above-mentioned 136 are also found in the Western Himalayas, but this last region has a number of endemic species which give it its special character. The poverty of the fauna of the Pamir plateau is obviously the consequence of its valleys being at a height of no less than 10,000 feet above the sea-level. The presence of the following species in the region will be interesting to zoo-geographers :—*Saxicola finschi*, *Cyanecula leucocyana*, *Herbivocula neglecta*, *Acanthopneuste nitida*, *Trochalopterum lineatum*, *Microcichla scouleri*, *Cyanistes flavipectus*, *Rhodopechys sanguinea*, and *Nisaëtus fasciatus*.

IN the *Zeitschrift für Instrumentenkunde* for September 1886 there is a paper entitled "Ueber eine Methode zur Messung kleiner Winkeldifferenzen," by Herr Hugo Langner, of Breslau. It describes a method of measuring the angle between two plane reflecting surfaces when it is nearly an aliquot part of two right angles, by measuring the difference between the required angle and the nearest aliquot part. It is known that in looking into the angle formed by two such surfaces the image of any small object lying between them will be seen repeated. If the angle be nearly $\frac{\pi}{n}$ $\left(\text{say } \frac{\pi}{n} - \delta\right)$, then when δ is positive, there will be a certain portion of the space between the two reflecting planes where both *n*th images can be seen, but if δ be negative, there will be a space where neither can be seen. If, again, for a small object a scale be substituted, then when δ is + two images will be seen, and a certain portion of the scale will be seen in both images; while if δ be − there will be a portion which is in neither image, and this superfluous or defective portion will be a measure of δ. Herr Langner proposes to place in front of the angle, and at a considerable distance from it, a scale bent to a cylinder whose axis is the intersection of the reflecting planes. Observing with a telescope looking into the angle, the position where a division of one image of the scale falls on the other image can be read, and, if the radius of the scale be known, the angle subtended by the relative displacement of the images, and thence the difference between the approximate and real values of the angle between the reflecting surfaces found. Herr Langner gives as an example the determination of the angle of a right angled prism of glass, of which a single determination would seem not to be liable to a greater error than 4″ or 5″. And he suggests that the method might be applied advantageously to determine the movements of a magnet by determining from time to time the changes of the angle between a mirror fixed to the needle, and one which is absolutely fixed, and to measure small variations of an angle in other cases.

THE little marine laboratory connected with the Johns Hopkins University is almost as old as the great laboratory at Naples. A sketch of its history is presented in a recent report by Dr. W. K. Brooks, Director of the Marine Laboratory, to the President of the Johns Hopkins University. In 1878 a small appropriation was made by the Trustees of the University to enable a party of biologists to spend a few weeks at the seashore in the study of marine zoology ; and the scientific results of the season's work were printed in an illustrated volume, the cost of publishing which was borne by some citizens of Baltimore. The next year the appropriation was renewed, and in 1880 the Trustees voted that the laboratory should be continued for three years more, providing 4500 dollars for outfit and an annual sum of 1000 dollars for current expenses. The scheme worked so well that at the end of three years the institution was maintained. After an examination of all the available localities, the town of Beaufort, N.C., about 400 miles south of Baltimore, was selected as the site for the laboratory ; and a vacant house, suitable for the accommodation of a small party, was found, and rented as a laboratory and lodgings. This house has been occupied during five seasons, and much good work has been done in it. During the season of 1886 a party of seven students went, under the direction of Dr. Brooks, to carry on zoological investigation in the Bahama Islands.

THE additions to the Zoological Society's Gardens during the past week include three Hooker's Sea Lions (*Otaria hookeri* ♂ ♂ ♀) from New Zealand, presented by the Government of New Zealand ; a Blue Penguin (*Eudyptula minor*) from New Zealand, presented by Dr. Bernard Lawson ; a Domestic Sheep (*Ovis aries* ♂, four-horned var.) from Cashmere, presented by Major Roland Poole ; two Wood Hares (*Lepus sylvaticus*) from North America, presented by Mr. Walter Ingram, F.Z.S. ; a Blotched Genet (*Genetta tigrina*) from South Africa, presented by Capt. J. Robinson ; a Grey Ichneumon (*Herpestes griseus*) from India, presented by Mr. Stanlake Batson ; a Spotted-billed Duck (*Anas pœcilorhyncha*) from India, received in exchange ; three Lions (*Felis leo*), an Axis Deer (*Cervus axis* ♂) born in the Gardens.

OUR ASTRONOMICAL COLUMN

THE NEW ALGOL-TYPE VARIABLE.—Mr. Chandler has been able (Gould's *Astronomical Journal*, No. 150) to secure some further observations of this star, which, so far as they go, tend to confirm the hypothesis of a period of about three days. Minima were observed on January 2 and 11, but these were inconclusive as to the period. The star was, however, observed on January 12, between 17h. 15h. and 18h. 5m., to be apparently of its normal maximum brilliancy, whereas the first rough elements formed would have given a minimum at 17h. 50m., had the period been 1·4992d. or 0·7496d. Further observations are much desired. It unfortunately happens, from the star's period being very closely commensurable with the mean solar day, that further observations of minima will be scarcely possible in Northern Europe or Eastern North America for many months.

GORE'S VARIABLE NEAR χ^1 ORIONIS.—Dr. G. Müller, from a series of observations extending from 1886 November 9 to 1887 January 8, finds that the star attained its maximum on 1886 December 12. Assuming the light-curve the same at the preceding maximum, it will have been at its brightest on 1885 December 13, so that the period will be about 364 days.

THE SOUTHERN COMET.—The following telegram has been received from Cape Town, from which it appears that the new southern comet resembles that of 1880 I. in its orbit as well as in its physical appearance :—"Cape Town, January 26.—No condensation observable ; riband of light 35° long, narrowing towards sun, position narrowest part near as can observe, January 22·317 G.M.T., R.A. = 322° 31′, N.P.D. = 135° 48′. The orbit presents a close resemblance to Comet 1880 I. Perihelion, January 11, noon." The comet is rapidly diminishing in brightness, and it is already invisible to the naked eye.

A SHORT METHOD FOR COMPUTING REFRACTIONS.—In the *Astronomische Nachrichten*, No. 2768, Mr. Schaeberle, of the Ann Arbor Observatory, explains a short and convenient method for computing astronomical refractions between 0° and 45° zenith distance. Let k and k_0 be respectively the true and mean refractions when $z = 45°$, then for any other zenith distance less than 45° the approximate true and mean refractions would be given respectively by

$$r = k \tan z, \qquad r_0 = k_0 \tan z,$$

from which is derived

$$r = r_0 - \frac{k_0 - k}{k_0} r_0,$$

an expression which, for the assigned limits of zenith distance, will give the true refraction within 0″·01, provided the true value of r_0 is used in the second member of the equation. The factor $\frac{k_0 - k}{k_0}$ will, however, be constant only so long as the barometer and thermometer readings remain unchanged. To allow for changes in these quantities, let F_1 and F_2 denote respectively the values of these factors at the times T_1 and T_2 ;

the value of the factor at any intermediate time T will be given by

$$F = F_1 + \frac{T - T_1}{T_2 - T_1}(F_2 - F_1),$$

which can be easily taken from a table of double entry with the arguments barometer reading and thermometer reading. Such a table, together with one giving the values of the mean refractions computed to hundredths of a second of arc for every ten minutes of zenith distance, and a convenient multiplication table, are all that is required for the practical application of Mr. Schaeberle's method.

COMET BROOKS (1887 *b*).—A Science Observer Circular (No. 19) gives the following elements and ephemeris for this object:—

T = 1887 March 28·63 G.M.T.

$$\left.\begin{aligned} \pi &= 121^\circ\ 20' \\ \Omega &= 294\ \ 45 \\ i &= 94\ \ 17 \end{aligned}\right\} \text{Mean Eq. 1887·0}$$

$\log q$ = 0·1016

Ephemeris for Greenwich Midnight

1887	R.A.	Decl.	Brightness
	° ′	° ′	
Jan. 31	305 24	+ 79 5	1·41
Feb. 4	337 32	79 59	
8	8 39	77 41	
12	28 4	72 57	1·95

The brightness at discovery is taken as unity.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1887 FEBRUARY 6–12

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

At Greenwich on February 6

Sun rises, 7h. 32m.; souths, 12h. 14m. 18·5s.; sets, 16h. 56m.; decl. on meridian, 15° 37′ S.: Sidereal Time at Sunset, 2h. 2m.

Moon (Full on February 8) rises, 14h. 54m.; souths, 22h. 49m.; sets, 6h. 37m.*; decl. on meridian, 18° 2′ N.

Planet	Rises	Souths	Sets	Decl. on meridian
	h. m.	h. m.	h. m.	° ′
Mercury	7 46	12 16	16 46	17 38 S.
Venus	8 14	13 17	18 20	11 47 S.
Mars	8 14	13 23	18 32	10 39 S.
Jupiter	0 10	5 11	10 12	12 8 S.
Saturn	13 58	22 6	6 14*	22 16 N.

* Indicates that the setting is that of the following morning.

Feb.	h.	
6	6	Saturn in conjunction with and 3° 21′ north of the Moon.
6	18	Mercury in superior conjunction with the Sun.
8	—	A partial eclipse of the Moon occurs in the morning, not visible in Europe.

Saturn, February 6.—Outer major axis of outer ring = 45″·8; outer minor axis of outer ring = 18″·8; southern surface visible.

Variable Stars

Star	R.A.	Decl.			h. m.	
	h. m.	° ′				
S Ceti	0 18·3	9 57 S.	Feb.	11,	0 0	*M*
U Cephei	0 52·3	81 16 N.	,,	10,	21 19	*m*
Algol	3 0·8	40 31 N.	,,	8,	1 12	*m*
			,,	10,	22 1	*m*
V Tauri	4 45·5	17 21 N.	,,	12,		*M*
ζ Geminorum	6 57·4	20 44 N.	,,	8,	4 0	*m*
U Monocerotis	7 25·4	9 33 S.	,,	6,		*M*
S Cancri	8 37·5	19 26 N.	,,	12,	0 11	*m*
δ Libræ	14 54·9	8 4 S.	,,	10,	1 23	*m*
U Coronæ	15 13·6	32 4 N.	,,	7,	3 55	*m*
U Ophiuchi	17 10·8	1 20 N.	,,	9,	5 48	*m*
		and at intervals of			20 8	
β Lyræ	18 45·9	33 14 N.	Feb.	8,	0 0	*M*
			,,	11,	6 0	*m*
S Vulpeculæ	19 43·8	27 0 N.	,,	11,		*m*
χ Cygni	19 46·2	32 38 N.	,,	6,		*M*
V Cygni	20 37·7	47 44 N.	,,	8,		*M*
δ Cephei	22 25·0	57 50 N.	,,	7,	19 0	*m*

M signifies maximum; *m* minimum.

Occultations of Stars by the Moon (visible at Greenwich)

Feb.	Star	Mag.	Disap.	Reap.	Corresponding angles from vertex to right for inverted image
			h. m.	h. m.	° °
6	3 Cancri	6	21 17	22 27	77 239
7	B.A.C. 2731	6½	2 13	2 47	172 239
7	54 Cancri	6½	16 29	17 14	77 195
7	o^1 Cancri	6	19 21	near approach	132 —
11	46 Virginis	6	23 17	0 19†	23 226
12	48 Virginis	6	1 43	2 7	336 299

† Occurs on the following morning.

GEOGRAPHICAL NOTES

VARIOUS rumours have been afloat during the past week as to difficulties having arisen between the Egyptian Government and Mr. Stanley and as to the escape of Emin Pasha. To these rumours Mr. Stanley has telegraphed a positive contradiction, and it should be remembered that there is a small party in Egypt opposed both to the expedition and to Emin Pasha. Mr. Stanley leaves Cairo this week for Zanzibar, and every preparation has been made for his taking the Congo route. Meantime important information has reached Europe from Dr. Junker as to his explorations in what is known as the Wellé-Makua region. Dr. Junker's furthest position on the River Wellé, according to the calculation of Dr. Schweinfurth, was the village of Bassanga, 22° 47′ 40″ E. of Greenwich, and 3° 13′ 10″ N. lat. This position, combined with what we already know of the course of the Wellé, leaves little doubt that it is an affluent of the Congo. But that it reaches the Congo through the recently-discovered Mobangi is by no means so certain. Taking into account the altitudes and the general lie of the country, it seems more probable that it reaches the Congo at some point between the Mobangi and the Aruwimi. However, this is one of the problems which it is hoped Mr. Stanley will be able to solve. And even if Emin Pasha has escaped, it is to be hoped that the expedition will proceed, if not to take possession of the Equatorial Province, at least to carry out the exploring work which Mr. Stanley has planned for himself. The attempt of the Balloon Society to get up a second expedition by the Congo it is impossible to treat seriously.

To the new number of the Proceedings of the Royal Geographical Society Dr. Edmund Naumann, late head of the Geological Survey of Japan, contributes a paper of great scientific value, on the physical geography of Japan, in which he gives the results of his own surveys. Considering the Japanese chain as one continuous mass, the lowest parts of which are submerged, this great wave of the earth's surface bears the same relation to the Pacific Basin, according to Dr. Naumann, as the Himalaya mass does to the Indian peninsula. The dimensions of the two colossal earth-waves are almost equal. The ocean-bed on the Pacific side of Japan really rises very gradually to the coast-line, making an angle of not more than 3°, while on the opposite side the inclination is very slight indeed. The general character of the Japanese earth-wave establishes its close relation to the Asiatic continent. In fact, it is nothing else than the advanced frontier of Asia, and not a chain of volcanic ejections accumulated over a fissure of the ocean-bed, as certain famous geographers of past periods conjectured. One of the most original and interesting parts of Dr. Naumann's paper is that in which he deals with the magnetic map of Japan, a reproduction of which is given in the Proceedings. On this map is perceived a most remarkable correspondence between the lines of equal declination (the trogones) and the leading lines of geological structure described by Dr. Naumann. In general, the magnetic lines exhibit very striking and quite unexpected irregularities, and these irregularities are found to be in most intimate connection with the abnormal curvature of the folds. No less than two hundred complete observations for magnetism, at a like number of stations, were made. The results seem extremely satisfactory. Across the centre of the main island is a great depression which Dr. Naumann calls the Fossa Magna, and the map shows that the magnetic lines are influenced in their course by this cleft, in the same manner as by the folds. He is even inclined to say that the deviations of the lines of equal declination and the fold lines coincide to a certain extent. Where one of the great lines of horizontal dislocation, separating two unequally advanced sections of the Japanese Archipelago, crosses the chain, the trogones describe bends and sinuosities of a most peculiar character. As Dr. Naumann states, these results seem to open up a new field of research quite worth investigating.

A PAPER of unusual scientific interest was read at Monday's meeting of the Royal Geographical Society by Mr. H. J. Mackinder, B.A. (Oxford), on the field and methods of geography. Mr. Mackinder aimed at showing how geography could be made more than a mere cultivation of dry facts, and become indeed a department of scientific inquiry. He takes man as the centre of the field and defines geography as the study of man in relation to so much of his environment as varies locally; Mr. Mackinder thus takes geography to be the physical basis of history. He insists on a clear separation being made between physical geography and both geology and physiography. The physical geographer has to deal with only so much of the past as will enable him to interpret the present, whereas the geologist deals with the present, only that he may be able to interpret the past. So with other departments of science, as meteorology; from the new stand-point only so much of them is to be included as is pertinent to the geographical line of investigation. Mr. Mackinder illustrated his position by two sets of three maps—one of South-Eastern England, physical, geological, political; and the other of India, showing physical features in relation to rainfall and population. He attempted to show, on the basis of physical conditions, why, among other things, London should have become the metropolis of the Empire and why the three south-eastern counties should have had their existing boundaries. With reference to India, again, he showed how geographical conditions determined that Delhi and Calcutta should have become the ancient and modern capitals of India. Geography, when studied in this way, Mr. Mackinder thinks, might become a bridge between the physical sciences on the one hand and classical and historical studies on the other. The lecture was illustrated by some very fine and instructive maps and lantern views.

PHYSICAL NOTES

THE inverse electromotive force of the voltaic arc has recently been investigated by Prof. C. R. Cross, of the Massachusetts Institute of Technology, and by Mr. W. E. Shepard. It appears that with currents varying from 3 to 10 amperes the inverse electromotive force is about 39 volts when the arc is silent, and about 15 volts when it is hissing; but both these values show a diminution as the currents employed are increased. The transition from one state to the other is abrupt. Addition of volatile metallic salts to the arc always decreases the inverse electromotive force. In rarefied air the inverse electromotive force is unaltered, but the true re-istance of the arc is diminished.

SENSITIVE hygrometers have lately been constructed upon a principle resembling Bregnet's metallic thermometer. A spiral composed of two substances having different hygrometric coefficients of expansion tends to curl or uncurl according to changes in the hygrometric state of the air. Some of these have been made by Prof. W. Holtz out of thin brass spirals with a thin coating of gelatine on one side. Independently, M. Nodon, of Paris, has constructed some recording hygrometers having spirals made of Bristol board coated on one side with gelatine (with a little salicylic acid), and on the other with bitumen. The principle is not new: in various collections of physical apparatus similar arrangements have existed for at least a dozen years.

LENSES which magnify, and yet are perfectly flat on both sides, have been constructed by Schott and Co., of Jena, the manufacturers of Abbé's optical glass. These lenses are mere curiosities. They consist of single disks of glass, such that the refractive index decreases in a regular manner from the surface inwards. The properties of this arrangement have been investigated by Prof. K. Exner, of Vienna.

QUADRANT electrometers have been lately described by M. Ledeboer, in which the motion of the needle (often of very annoying duration) is damped so as to be aperiodic. This is achieved by making each of the four "quadrants" of steel highly magnetised. The needle is therefore damped by magnetic friction. The suspension is unifilar.

SEVERAL modifications have been lately introduced into the Leclanché battery. Mr. Sydney Walker proposes to substitute sulphur for the manganese: it is cheaper, and less of it is required. Mr. A. Pollak does away with the manganese, but employs a special, porous, coarse, annular block of carbon, which stands half out of the liquid and absorbs oxygen from the air to depolarise. M. Germain introduces a novel material to hold the liquid, an absorbent preparation, chiefly cellulose, made from cocoa-nut fibre, and which has received the curious name of "cofferdam." It has truly remarkable absorbent properties, as it will suck up and hold from twelve to fourteen times its own weight of water. A "cofferdam" cell does not spill the liquid.

DRY portable cells appear to be coming into favour, gelatine being the favourite medium. They are claimed as novelties both in Paris and in Frankfort. Joule's "glue-battery"—a Daniell's cell, having a gelatinous mass impregnated with sulphates of copper and zinc—is the parent of all these later forms.

ELECTRIC welding is the latest of the industrial applications of electricity, and it would seem to have already reached a thoroughly practical stage. Prof. Elihu Thomson, of Lynn, Massachusetts, has shown that bars of iron, steel, copper, and brass can be welded firmly together in a few seconds by passing through their junction a very powerful electric current. He has invented a special kind of transformer or induction coil to enable him to accomplish this operation. It is possible thus to weld iron and brass together in a firm joint. Simultaneously, researches on the same subject have been made by two Russian gentlemen in the laboratory of M. Marcel Deprez in Paris, and they have announced their discovery under the name of "electrohephaest." If we are not mistaken, similar experiments were made before the Académie des Sciences some years ago by the late M. Ruhmkorff. Moreover, in Mr. J. P. Joule's papers he mentions the discovery of the practicability of electric welding by himself and Sir William Thomson.

ACCORDING to Olszewski, the critical temperatures of nitrogen and oxygen are respectively -146°, $-118{\cdot}8^{\circ}$, of the Centigrade scale.

ON THE MORPHOLOGY OF BIRDS[1]

THERE are several things that go to increase the interest in the morphology of these culminating Sauropsida at the present time.

(1) The discovery by Gegenbaur, Huxley, and others, of the close relationship of birds and reptiles, especially of the extraordinary fact that the hind-limb and pelvis of even the most minute bird pass through a stage in which they correspond almost exactly with the hind-limb and pelvis of the most gigantic kinds of extinct reptiles—the Dinosaurs or Ornithoscelida.

(2) The recent discoveries of biologists as to the composition of the cheiropterygium in the various types of air-breathing Vertebrata. It is now well known that the five-fingered hand and the foot with five toes are the specialised modern representatives of hands and feet that had at least seven rays in their composition.

And (3) the study of the development and general morphology of birds is at the present time of great interest, now that we are looking to the study of metamorphosis for some initial elucidation of the mystery as to the origin of the various types of Vertebrata.

The labour of each succeeding day at this culminating class makes it more and more impossible for me to conceive of birds as arising *direct* from the Dinosaurians, or indeed from any other order or group of reptiles.

Long attention to the metamorphosis of the Amphibia has intensified this difficulty to me; for the newly-transformed frog or newt appears to me to be the true counterpart of a newly-hatched reptile—snake, lizard, turtle, or crocodile.

Each of these young creatures, whether it has undergone a true metamorphosis or has been the subject of pre-natal transformation, is evidently an imago, although an imago that continues to grow.

Now each amphibian has its own larva, for the larvæ of the various species have their specific differences.

The thousand known species of existing Amphibia—Anurans, Urodeles, and Cæcilians—and all the fishes that undergo meta-

[1] Paper by Prof. W. K. Parker, F.R.S., read before the Royal Society on January 27, 1887.

morphosis, are as truly, if not as remarkably, distinct from each other in their larval as in their imago form; as much so as is the case in insects, or any other of those invertebrate types that are truly metamorphic.

If *many* of the existing Vertebrata are metamorphic *now*, is it not very probable that they were *all* metamorphic *once?*

The fact that we have even now such forms as the larval lamprey (or Ammocœte), the larvæ of Ganoids and Dipnoi, and the tadpoles of newts and frogs, suggests to me the possibility of the existence of huge swarms of low proto-Vertebrata in the early ages of the inhabited planet.

If such proto-vertebrate forms existed, then it is quite supposable that a metamorphosis may, from time to time, have taken place, of this and that *quasi*-larval form into archaic reptile, ancestral bird, or primitive mammal.

I am not afraid that anyone familiar with the development, structure, and habits of the existing Amphibia will see any difficulty in the passage of a metamorphic into a *so-called* non-metamorphic type, during time, and under the pressure of new outward conditions—when the dilemma offered to the supposed low vertebrate was *Transform or perish*.

To me it seems that the creature's necessity was Nature's opportunity; and that, during long ages, the morphological force had accumulated in those low forms an enormous surplusage of unused energy, which, in the ripeness of time, blossomed out into this and that new and noble type.

Of all the types of Vertebrata, there is none like the bird of high degree for illustrating what Prof. Huxley calls "the three-fold law of evolution,"[1] namely, overgrowth of some parts, starvation and even death of others, and fusion of parts originally distinct.

No kind of vertebrate whatever presents to the osteologist so hopeless an enigma in the adult skeleton, as that of the bird; in the overgrowth of certain parts, the abortion or suppression of others, and the extensive fusion of large tracts of skeletal elements.

Hence this class has largely acted upon the morphological mind; the "comparative anatomist" has, of necessity, undergone evolution into the "morphologist," and the latter has had to be refined and developed into the "embryologist."

In the bird class we meet with this remarkable phenomenon, namely, that the swiftest creatures by far that inhabit the earth have had, for the purposes of their most consummate mechanism, the greatest loss of freedom of the individual parts of the skeletal framework.

Between the pigeon, on one hand, above, and the emu, on the other, below, there are several families of related birds; but there is no direct superposition—they are obliquely above or below each other.

Amongst the Carinatæ, which lie in the intermediate space, there is none better for the purposes of study than the common fowl; to this type I have devoted most attention, and have now worked out the limbs in as many stages as I formerly did the skull.

I can now give an account of the vertebral column with the ribs and sternum, the limb-girdles and limbs, from the end of the seventh day of incubation; by which time the hyaline cartilage is perfect, and certain even of the bony tracts are begun.

The fowl is an intermediate form between the emu and the pigeon, but most akin to the latter. I shall now confine myself to what is seen in the development of the skeleton (excluding the skull) in this medium type.

The vertebral column, at the end of a week's incubation, is formed of hyaline cartilage; up to the end of the true sacrals, the notochord is completely invested with cartilage; but, behind those four segments, only at the sides.

The notochord has its constrictions in the middle of each centrum, and is most dilated at the intercentra.

The neural arches do not nearly meet above; the atlas is in four pieces—a superficial and an inner piece to the centrum, and a pair of arch-rudiments; the inner segment of the centrum becomes the odontoid process of the axis.

Between the axis and the first true sacral, all the vertebræ have separate ribs; in the cervical region, except near the dorsal region, there are small styloid cartilages lying horizontally, which have their head, or thick end, wedged in between the upper and lower transverse processes. Near the dorsals they are transversely placed, and then begin to develop a descending process.

The first vertebra of this stage with complete ribs becomes, by absorption of the lower part of the arch, the last cervical in the adult. Behind the twenty pre-sacrals there are fifteen sacrals, and this series has its subdivisions.

The first develops ribs (it is dorso-sacral), the next three develop minute but distinct ribs, like those near the lower part of the neck; these are lumbo-sacral. Then come the four sacrals with no ribs, and then the seven uro-sacrals, the first two of which have rib-bars that ossify separately, below the upper transverse processes, which latter form a complete series from the third cervical to the last free caudal segment.

Of those there are five; then come five more paired imperfect rudiments, clinging to the terminal part of the notochord.

At the end of the eighth day there are six of these, with the last elongated, and the notochord projecting behind far enough for three or four more rudiments.

At the end of the tenth day the vertebral chain has undergone a great change. The atlas is still composed of four distinct pieces of cartilages, but the ribs have become fused above and below with the transverse processes, and the notochord is now most constricted at the intercentra.

Besides this, in the pre-sacrals, it is constricted in two places within each centrum; so that each centrum in the modern bird corresponds to three subdivisions of this axial chord.

For two or three days there is evidence of an archaic subdivision of the notochord into three times as many vertebral divisions as are made now in the modern bird.

In the sacral the constrictions are fewer; they are only at the intercentra, and in the middle of the centrum.

The only absolutely necessary part of the sternum is that where the sternal ribs are attached; that is a very small part, and the rest is for the attachment of the huge muscles that act upon the wings, and for the obliqui and recti abdominis.

The limb-girdles are each in three pairs of distinct cartilages. In front, the scapula, the minute pre-coracoid, the coracoid; behind, the ilium, pubis, and ischium; the pre-pubis is part of the ilium, and that has two regions, the pre-ilium and the post-ilium.

These parts in the bird are not continuous tracts of cartilages, ossified by several centres, but are distinct, first as cartilages, then as bony tracts; those of the shoulder keep distinct; those of the hip soon coalesce.

The wings at the end of the seventh day are three-toed webbed paws, with all the digits turned inwards. The rods that compose the main part of it are composed of solid cartilage: the humerus, radius, ulna, and first and second metacarpals have a bony sheath round their middle part; the ends of the digits and the carpals are but partly chondrified. Five carpal nuclei, however, can be made out, and the two proximal nuclei are known to be further subdivided, each into two, in other types; hence we can already account for seven carpals in the bird, which has only two in the adult, in a free state.

Moreover, the first digit has two, and the second three phalanges, the normal number, as in lizards; the third, which should have four, but in birds has as a rule only one, has now two, as in the ostrich, and a few other birds; there is no sign at the end of the seventh or even of the eighth day of incubation of any more than three digits, but we have in the wrist an intermedio-radiale, a centralo-ulnare, and three distal carpals, answering to the three developed metacarpals. The digits up to the end of the eighth day are rounded and flattish, and are quite like those of a young newt or frog. But in two days more, at the end of the tenth day, the wing has almost acquired the adult form; and one more bony centre, that of the first metacarpal, has appeared. The overgrowth of the second distal carpal and the second metacarpal, with its large and dilated digit, has arrested the distal carpal of the first or short digit, the "pollex." This is the last nucleus to chondrify. It is still a very small, limpet-like disk of cartilage, and is now only to be seen on the flexor face of the manus, inside the top of the second metacarpal; the distal carpal of the third ray is also small as compared with the large crescentic second distal nucleus. It is thrown on to the ulnar or outer side of the manus by the overgrowth of the middle rod and its carpal. The curve of the digits at their end is now, not inwards, or to the radial side, but outwards; and the two developed distal segments form now the core of two claws, that of the first, or pollex, being of considerable length.

[1] See his paper "On the Application of the Laws of Evolution to the Arrangement of the Vertebrata, and more especially of the Mammalia" (Zool. Soc. Proc., December 14, 1884, pp. 649-662).

Thus, by the end of the tenth day, the reptilian type or fore-foot has been attained, and the amphibian type lost, whilst the limb as a whole is now a fore-leg no longer, but a wing, thoroughly specialised by evolutional transformation.

The fore-limb has not simply become modified into a wing by the shortening of the pollex and third ray, the enlargement of the second, and the abortion of the fourth and fifth of a fore-paw, like that of the lizard; but we have now the historical representatives of three more rays which have cropped up since the end of the eighth day.

I have repeatedly noticed that aborted parts, like over-shadowed plants, are late to appear, and soon wither, or are arrested in their growth. This is the case here, for the new rays are late, small, and scarcely functional in the fullest development. They are not lost, however, but, like certain larval structures to be found in the skulls of the highest types of birds, they are built up into the finished wing, although they form an unimportant part of it as far as function goes.

The first of these additional rays is the "pre-pollex"; this is a lunate tract of fibro-cartilage attached to the inner face of the first metacarpal. The other two are composed of true hyaline cartilage, and appear, one on the ulnar side of the second, and the other on the ulnar side of the third developed metacarpal.

I have described them as intercalary metacarpals, for they seem to be the starved twins of the second and third large rays; each distal carpal, very probably, in the archaic forms carried two rays. Thus there is supposed, for such a fore-limb, a digit inside the pollex of the modern bird, and then two pairs of rays, of which only the inner in each case has been retained.

The paddle of Ichthyosaurus shows this kind of primitive cheiropterygium admirably.

Thus we can account for seven carpals and six digits in the wing of the modern bird; in the legs the specialisation is not so intense, but is very great; the study of the embryonic stages shows in it many parts that the adult bird gives no signs of whatever.

Instead of there being even two tarsals, free and functional, there is only one, and that has merely the function of a "sesamoid," and has been mistaken continually for a bone of that sort, that nucleus answers to our naviculare, morphologically termed the "centrale."

Notwithstanding the extreme diversity in the habits of existing birds, and the great difference seen in their shank bone, this part is always single, although composed of three metatarsals. As in reptiles, the joint at this part is not between the astragalus and tibia, as in mammals, but through the tarsal series; no sign of this structure is seen in the adult bird. That which appears to be the condyloid end of the tibia is a row of tarsal bones, the tibiale, fibulare, and intermedium: these have long been known as separate bones in young birds, but their distinctness in the early embryo as cartilaginous nuclei has only lately been made out.

I have been able, however, to demonstrate this repeatedly in different kinds of birds. The centrale also, although seen in the embryo as one of the tarsal series, was not properly identified; it is a constant element, but becomes degraded.

The distal series of tarsals exists as a single tract of cartilage, and then as a single plate of bone. But it is related to three metatarsals, and the middle or thick part is the first to chondrify in the embryo, and to ossify in the chicken or young bird; there are here three connate nuclei, with very slight signs of distinctness. The whole mass answers to our middle and external "cuneiform bones," and to the inner half of the "os magnum." Thus five tarsals can be always made out clearly, and two more accounted for.

The first metatarsal, which has been known, for some time, through the valuable researches of Morse, to have occasionally a proximal as well as a distal rudiment, has, I find, always a proximal rudiment as well.

Then, as Dr. G. Baur and Miss A. Johnson have shown, there is a fifth metatarsal; it is a small pisiform cartilage, which soon coalesces with the fourth, and with the great distal tarsal. I can only find a "pre-hallux" by turning to teratology, and this is not the lawful method.

There may, however, be some "reversion" or "atavism" in the polydactyle foot of the Dorking fowl, which has a well-developed "pre-hallux" and a double "hallux"; the twin digits of that part have a very ichthyosaurian appearance.

SCIENTIFIC SERIALS

Annalen der Physik und Chemie, xxix., No. 11.—B. Dessau, on metal films arising from the disruption of a kathode. Discusses the production of mirror-like films such as obtained by Plücker, Crookes, and Wright from the disgregation of the metal kathode in Geissler-tubes. With a pointed kathode and a flat glass surface as recipient, the film forms a flat conical deposit, showing interference-rings in reflected light, and proving also the presence of optical dispersive power in the metal. The dispersion in films of platinum, iron, nickel, and silver. It is anomalous in the case of gold and copper. The films are double-refracting, and, in the case of oxidisable metals, disappear on oxidation.—Ed. Hagenbach, propagation of electricity in telegraph-wires. Experiments made with chronographic apparatus on Swiss lines, together with a discussion of the results of Wheatstone, Walker, Guillemin, and others. Arguing from theory, the author compares, not the apparent speed, but the ratio of the time to the square of the length of circuit.—B. von Kolenko, reply concerning the pyro-electricity of quartz. Maintains, against Prof. Hankel, that the poles of a warmed quartz crystal are not altered during cooling by passing through a flame.—E. Edlund, remarks on H. Hoppe's communication on the theory of unipolar induction.—S. von Wroblewski, on the representation of the rotation between the gaseous and liquid states of matter by isopyknal lines. The transition of state is represented by curves drawn on a diagram having, for given definite densities, pressures as ordinates and temperatures as abscissæ; such curves being termed *isopykns* or isopyknal lines. The result of examination of these curves shows that, though there is no such thing as an absolutely definite critical temperature or critical pressure *per se*, there is a critical density for every liquid.—K. Schmidt, on reflection at the surface of crystalline elliptically-polarising media. Experiments made with a crystal of cinnabar, and results compared with the formulæ of Voigt and that of Ketteler. The latter leads to closer correspondence than the former with the facts of observation.—H. Muraoka, on the deformation of metal plates by grinding. The radius of the curvature produced by grinding metal disks set in a bed of fusible alloy is proportional to the cube of their thickness.—K. Exner, validity of lens formulæ for non-homogeneous lenses.—E. Budde, a means of deciding between the electro-dynamic point-laws of Weber, Riemann, and Clausius. This gives the elementary theory of an experiment not yet made.—J. Kollert, on a new galvanometer. This is practically identical with Gray's form.

No. 12, 1886.—C. Fromme, on the galvanic polarisation evoked by small electromotive forces. This gives a first series of results with platinum electrodes in dilute sulphuric acid.—Edm. Hoppe, on the theory of unipolar induction; with a reply to Prof. Edlund.—F. Himstedt, on a determination of the quantity "v." The method was that of comparison of the two capacities of a condenser; the result $v = 3 \cdot 0074 \times 10^{10}$ cm./sec.—R. Lamprecht, on the action of the magnet upon electric discharges in rarefied gases, concludes that the law of Biot and Savart holds good as the calculated trajectories agree with curves observed by Hittorf in 1869.—A. Foeppl, the spread of the electric charge in conductors.—L. Boltzmann, remarks on the opinion of Herr Lorberg on a point in electro-dynamics.—W. Voigt, on the torsion of a rectangular prism of homogeneous crystalline substance; a mathematical investigation.—J. Kiewiet, on the elasticity of bending of pure zinc, copper, tin, and their alloys. The moduli of elasticity of alloys is not constant, but depends on the mode of preparation of the alloy as well as on its composition. Wertheim's rule for calculating the moduli of alloys from those of their components, according simply to the proportion of the constituents, appears to be inexact. The change of moduli of alloys with temperature is a simple linear function.—J. Stefan, on the relation between the theories of capillarity and evaporation.—A. Heritsch, on radiophony. The author combats Graham Bell's view that the condensed gases of a smoke deposit or carbon strip have something to do with its radiophonic properties. He finds that a coke plate heated to redness and then instantly placed in a tube and exposed to intermittent illumination from sunlight or electric light, emits tones. He further constructed a sort of flat glow-lamp, which, even when raised to brilliant incandescence, emitted tones when exposed to intermittent sunlight. No other source than sunlight was sufficient for this experiment.—G. Kobb, on the spectrum of germanium.—Greiner and Friedrichs, on a new mercury airpump; a modification of Geissler's form.—A. Grosse, a wire-tape rheostat. Fine german-silver wires are spiralled around cotton threads, which are then woven into a sort of tape, the warps being thereby insulated from one another. A piece 2 cm. wide and 4 metres long has 1000 ohms resistance.—W. Holtz, a Wheatstone's bridge for air and water flow. An illustrative apparatus of tubes such as has often been used.

IN the *Scottish Geographical Magazine* for January there is an excellent bathy-orographical chart of the Clyde sea-area, constructed for Dr. H. R. Mill by Mr. J. G. Bartholomew. The colouring of the map is designed to show with special effect the area and depths of the Firth of Clyde and its inlets. For this purpose the land and sea have been treated separately, and coloured in strong contrast to each other. The system of colouring is, however, uniform, and in both cases the lowest or deepest areas are distinguished by the darkest tints, and graduated up to the lighter tints of the higher or shallower portions. The same number contains a paper on the configuration of the Clyde sea-area, which was read by Dr. Mill at the last meeting of the British Association.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, December 16 — "Note on Specific Inductive Capacity." By John Hopkinson, M.A., D.Sc., F.R.S.

Consider a condenser formed of two parallel plates at distance x from each other, their area A being so great, or the distance x so small, that the whole of the lines of force may be considered to be uniformly distributed perpendicular to the plates. The space between the plates is occupied by air, or by any insulating fluid. Let e be the charge of the condenser and V the difference of potential between the plates. If the dielectric be air, there is every reason to believe that $V \propto e$, that is, there is for air a constant of specific inductive capacity. My own experiments ([1880] Phil. Trans., vol. clxxii p. 355) show that in the case of flint-glass the ratio of V to e is sensibly constant over a range of values of V from 200 volts per cm. to 50,000 volts per cm. From experiments in which the dielectric is one or other of a number of fluids and values of V upwards of 30,000 volts per cm. are used, Prof. Quincke concludes (Wiedemann, *Annalen*, vol. xxviii., 1886, p. 549) that the value of e/V is somewhat less for great electric forces than for small. From the experiments described in that paper, and from his previous experiments (Wiedemann, *Annalen*, vol. xix., 1883, p. 705, *et seq.*) he also concludes that the specific inductive capacity determined from the mechanical force resisting separation of the plates is 10 per cent. to 50 per cent. greater than that determined by the actual charge of the condenser. The purpose of the present note is to examine the relations of these important conclusions, making as few assumptions as possible.

In words, the specific inductive capacity as determined by charge or discharge of a condenser at any given potential and distance between the plates is the arithmetic mean of the inductive capacities determined by the force resisting separation of the plates and that determined by lateral pressure, the potential and distance being the same. This is true whatever be the relation between charge and potential difference, but it is at variance with the experimental result that K_p and K_s are both greater than K.

The results obtained by Prof. Quincke are not easy to reconcile. For that reason it is the more desirable that their full significance should be ascertained. Full information is given of all the details of his experiments except on one point. It is not stated whether, in the experiments for determining K by direct discharge of the condenser, the capacity of the connection and key was ascertained. It would in most ordinary arrangements of key be very appreciable in comparison with the capacity of the condenser itself. If neglected, the effect would be to a certain extent to give too low a value of K, the effect being most marked when K is large.

The property of double refraction in liquids caused by electrification is sometimes cited as showing that electrification is not proportional to electromotive force. The fact that the double refraction in a liquid under powerful electromotive forces is very small would further show that there is a close approximation to proportionality, and that the deviation from proportionality would be insensible to any electro-static test. Such conclusions, however, cannot be safely drawn in the case of bodies such as castor-oil, in which $K \pm \mu^2$. In such bodies, assuming the electro-magnetic theory of light, the yielding to electromotive force is much greater if the force be applied for such tine as 10^{-4} second than when applied for 10^{-14} second, and it is quite possible that the law of proportionality might be untrue in the former case, but very nearly or quite true in the latter.

"On the Dielectric Constants of Fluids." (Addendum to Dr. Hopkinson's "Note on Specific Inductive Capacity.") By Prof. G. Quincke, For. Mem. R.S.

In investigating the properties of dielectric fluids (*Wiedemann's Annalen*, vol. xix. 1883, p. 707; vol. xxviii., 1886, p. 529), I found the dielectric constants with the electric balance or by the hydrostatically measured pressure of an air-bladder greater than when measured by the capacity of a condenser surrounded by air or the insulating fluid, and discharged by turning a key through a ballistic galvanometer.

The capacity of the key and of the short thin junction-wire connecting the key with the condenser was, however, in that calculation left out of account as being evanescently small.

In consequence of a written communication from Dr. John Hopkinson, I quite recently compared the capacity of the key and the junction-wire with the capacity C of the condenser by observations with the ballistic galvanometer with the same difference of potential between the surfaces, and thereby found the relation—

$$\frac{x}{C} = 0{\cdot}1762\,;$$

greater, therefore, than I had conjectured.

Let there be subtracted from the observed galvanometer readings s_1 and s_{11} for the condenser in air and in the dielectric fluid, the deflection calculated for the electricity on the key and junction-wire, then there will actually be obtained from the ratio of the readings thus corrected (s_1) and (s_{11}) values of the dielectric constants (K) of the fluid almost exactly coinciding with the measurements of the electric balance. The agreement is indeed as perfect as might be expected, considering the difference in the methods of observation employed.

Thus, for example, it was found:

	Dielectric constants with Ballistic galvanometer (K)	Weighing K_p
Ether	4·211	4·394
Carbon disulphide	2·508	2·623
,, ,,	2·640	2·541
Benzole	2·359	2·360
Petroleum	2·025	2·073

[Note added by Dr. Hopkinson.—Prof. Quincke's explanation sets the questions I have raised at rest. There can be little doubt that K, K_s, and K_p are sensibly equal and sensibly constant. The question what will happen to K_p and K_s if K is not constant has for the present a purely hypothetical interest.

Physical Society, January 22.—Prof. McLeod, Vice-President, in the chair.—Dr. F. Wormack was elected a Member of the Society.—The following papers were then read:—The permanent and temporary effects on some of the physical properties of iron produced by raising the temperature to 100° C., by Mr. Herbert Tomlinson, B.A.—On some new measuring-instruments used in testing materials, by Prof. W. C. Unwin, F.R.S. In most measuring-instruments previously used, it has been considered sufficient to make the measurement of elongation from one side of the bar, but this, the Professor showed, was liable to serious errors owing to the fact that test-bars are not always perfectly straight, and to the possibility of originally straight bars being bent by improper fixing in the testing-machine. In such cases the modulus of elasticity calculated from the apparent elongations are subject to considerable error. In endeavouring to overcome these difficulties the author has devised several new forms of measuring-apparatus, which are attached to two sides of the bar by steel points, and the mean elongation of the two sides determined. The first apparatus described consists essentially of sliding calipers read by microscopes to 1/10,000 of an inch. Another form has two clamps provided with sensitive levels. Each is attached to the bar by two steel points, the line joining which is perpendicular to the direction of the stress, and the clamp can rotate in a vertical plane about this line as an axis. The lower clamp is levelled by a screw pressing against the surface of the bar, and the upper one by means of a micrometer-screw parallel to the axis of the bar, the nut of which is secured to the bottom clamp. By this means the elongation can be measured to 1/10,000 of an inch. In a third form two similar clamps without levels are kept apart by a steel rod ending in knife-edges. One of the clamps carries a small roller, which turns about an axis parallel to the line joining the steel points above mentioned, and the axis carries a small plane mirror. The other clamp supports a projecting arm parallel with the axis of the test-piece, and which presses on the surface of the roller. When the bar is elongated the mirror is turned through a small angle and the elongation is determined by a reading-telescope and vertical scale to 1/100,000 of an inch. A similar apparatus is used for testing the compression of stone, but in this the compression is multiplied by a lever and measured by a micrometer microscope to 1/100,000 of an inch.—At the conclusion of the meeting Prof. Unwin invited the members to visit the Engineering Laboratory of the City and Guilds of London Central Institution, where he broke a bar of Staffordshire iron in the 100-ton testing-machine, the force and elongation being automatically recorded.

Royal Meteorological Society, January 19.—Mr. W. Ellis, President, in the chair.—Mr. J. Willis Bund was elected a Fellow of the Society.—The following papers by the Hon. R. Abercromby, F.R.Met.Soc., were read:—(1) On the identity of cloud-forms all over the world, and on the general principles by which their indications must be read; (2) On the cloud to which the name "Roll-Cumulus" has been applied.—After the reading of these papers the annual general meeting was held, when the Report of the Council was read by Dr. Tripe, which showed the Society to be in a satisfactory condition. The number of Fellows is 524.—The President, Mr. W. Ellis, then delivered his address.—The Officers and Council for the ensuing year were elected:—President: William Ellis; Vice-Presidents: George Chatterton, Charles Harding, Cuthbert Edgar Peek, George Mathews Whipple; Treasurer: Henry Perigal; Trustees: Hon. Francis Albert Rollo Russell, Stephen William Silver; Secretaries: George James Symons, F.R.S., John William Tripe, M.D.; Foreign Secretary: Robert Henry Scott, F.R.S.; Council: Hon. Ralph Abercromby, Edmund Douglas Archibald, Francis Campbell Bayard, William Morris Beaufort, Arthur Brewin, Frederic William Cory, Henry Storks Eaton, Richard Inwards, Baldwin Latham, William Marcet, M.D., F.R.S., Edward Mawley, Charles Theodore Williams, M.D.

Entomological Society, January 19.—Mr. R. McLachlan, F.R.S., President, in the chair.—This was the fifty-fourth anniversary meeting.—An abstract of the Treasurer's accounts was read by Mr. Stainton, one of the auditors; and the Secretary read the Report of the Council.—The following gentlemen were elected as Officers and Council for 1887:—President: Dr. David Sharp; Treasurer: Mr. Edward Saunders; Secretaries, Mr. Herbert Goss and the Rev. W. W. Fowler; Librarian: Mr. Ferdinand Grut; and as other Members of the Council: Messrs. Robert McLachlan, Gervase Mathew, R.N., George T. Porritt, Edward B. Poulton, Osbert Salvin, F.R.S., Henry T. Stainton, F.R.S., Samuel Stevens, and J. Jenner Weir.—The retiring President delivered an address, and a vote of thanks to him was moved by Mr. E. B. Poulton, and seconded by Prof. Meldola, F.R.S.—A vote of thanks to the Treasurer, Secretaries, and Librarian was moved by Mr. McLachlan and seconded by Mr. Stainton; and Mr. Goss and Mr. Grut replied.

Middlesex Natural History and Science Society, January 18.—Dr. Archibald Geikie, F.R.S., in the chair.—Mr. Robert B. Hayward, F.R.S., read a paper on the water in the Chalk, beneath the London Clay, of the London Basin. The geology of the area in question was described, and the water in the beds above the Chalk briefly referred to. Mr. Hayward then drew attention to the great extent of the Chalk area, to the rainfall, and other atmospheric conditions affecting the water-supply, and gave detailed chemical analyses of the waters of a large number of wells in and near London, which draw their supplies from the Chalk. Those of Harrow and the north of London, being well known to the lecturer, received special attention. The water-levels were described and elucidated by Joseph Lucas's hydro-geological maps, and the movements of the underground waters fully treated of. A table of the above-mentioned chemical analyses was distributed to the members present. In the discussion which ensued, Dr. Geikie gave some interesting observations upon the probable origin of Harrow Hill, and the other hills of London Clay to the north of London, and was followed by Mr. Clement Reid, Mr. Mattieu Williams, and Mr. Klein.

PARIS

Academy of Sciences, January 24.—M. Gosselin, President, in the chair.—Fresh statistics of persons that have been treated at the Pasteur Institute after having been bitten by animals either mad or suspected of madness, by M. Vulpian. This report covers the whole period from October 1885 to December 31, 1886, the tabulated results showing 2682 subjects treated in the Institute, of whom only 31, or 1·15 per cent., succumbed.—On the direct fixation of the gaseous nitrogen of the atmosphere by vegetable soils, by M. Berthelot. The experiments are here described which the author carried on during the year 1886 at the Meudon establishment for agricultural chemistry. As a general result it appears that vegetable soil is incessantly fixing free atmospheric nitrogen, apart even from any vegetation properly so called. Nor can the phenomena be attributed to the exclusive action of rain-water, for it was shown that in some cases the rain carried off under the form of nitrates alone more nitrogen than it had contributed under the combined forms of ammonia and nitric acid. In a future paper the experiments will be described that have been carried on simultaneously on the same soil with the co-operation of plant life.—The mechanism of the flight of birds studied by chrono-photography, by M. Marey. This is a further application of the author's new chrono-photographic method, already so successfully applied by him to the study of human motion. The paper is provided with four illustrations, one of which shows fifty images per second of a bird on the wing. Measured by the metric scale, the distance traversed during one complete revolution of the wing was 1·37 metre, or 6·85 metres per second, and 24,660 metres per hour.—Solar observations for the second half of the year 1886, by M. P. Tacchini. The results, as here tabulated, show a progressive diminution of spots and faculæ, with a very marked minimum in November. The phenomenon of protuberances also shows a falling off, although not to the same extent as that of the spots. This result appears to be in harmony with the fact that the maximum of protuberances always occurs after the maximum of spots.—On surfaces whose isothermal lines are constituted by a family of circles, by M. Demartres.—On the theory of algebraic forms with p variables, by M. R. Perrin. It is shown that a form of order m with p variables possesses a pure covariant, distinct or reducible, of $2p-3$ degree and order $(2p-3)m-2p$.—On the action of the tetrachloride of carbon on chlorochromic acid and the phosphates of sesquioxide, by M. H. Quantin. To the reactions of the tetrachloride of carbon already described by M. Demarçay, the authors here add two others, dealing fully with that produced by making this substance act on the oxygenated salts. They describe the action that it exercises, without previous decomposition, on the neutral phosphate of the sesquioxide of iron. They hope by the dry method to be able to apply this reaction to the separation of minute quantities of phosphoric acid.—Preparation, properties, and constitution of inosite, by M. Maquenne. This substance, hitherto unavailable in sufficient quantities for the purpose of experiments, the author has succeeded in producing by a process here described, very rapidly and easily. The analysis of anhydrous inosite yields carbon 40·00, and hydrogen 6·66, and its formula, $C_6H_{12}O_6 + 2H_2O$, is shown to be correct.—On the separation of mono- and di-isobutylamine by means of oxalic acid, by M. H. Malbot.—On the preparation of a silicostannate of lime corresponding to sphene, by M. L. Bourgeois. The object of this paper is to show the possibility of preparing a silicostannate of lime, CaO,SiO_2,SnO_2, isomorphous with sphene, CaO,SiO_2,TiO_2. In solving the question, the author has employed the same method by which Hautefeuille obtained some fine specimens of the latter mineral.—Description of a lamellary thomsonite from Bishopton, Renfrewshire, by M. A. Lacroix. This specimen, picked up by the author in 1884, shows the same optical properties as the substance known as Stirlingshire gyrolite, and contains a considerable proportion of aluminium. At 13° C. the density is 2·34.—Note on a white epidote from Beagle Channel, Tierra del Fuego, by M. A. Lacroix. This specimen, brought back by

Prof. Domenico Lovisato, of the Cagliari University, is remarkable for its richness in aluminium, and the highly oxidised state of the iron contained in it. Outwardly it strongly resembles zoïsite, although its crystalline system and optical properties leave no doubt as to its true character.—On some peculiarities in the organisation of the Schizonemertians, by M. Remy Saint-Loup. The exact disposition of the cephalic fossettes is here determined by a comparative study of three types of these organisms.—On the colonial vascular system of the Tunicata, by M. F. Lahille. A careful study of this system leads the author to the conclusion that there is no valid reason for separating the Monascidians and Synacidians into two distinct orders of Tunicata.—On the cranial nerves of a human embryo thirty-two days old, by M. C. Phisalix. Balfour's theory, based on negative grounds, that the cranial nerves are disposed on a type absolutely different from the spinal nerves, seems disproved by the anatomical study of this subject.—Researches on the physiological action of methylal, by MM. A. Mairet and Combemale. These researches show that, in whatever way introduced into the system, methylal always produces the same hypnotic effects, but more rapidly by hypodermic than by pulmonary injection.—On the existence of submerged valleys in the Gulf of Genoa, by M. A. Issel. From the recent hydrographic surveys of Capt. J. B. Magnaghi, it appears that the valleys of the Bisagno, Polcevera, Quiliano, and other Ligurian streams are continued seawards by submarine valleys, which retain the same fluvial direction, and are perfectly distinct to a depth of at least 900 metres.—On the Artesian wells and new oases created in the Wed Rir', South Algeria, by M. G. Rolland. Since 1859, the French have sunk 117 wells in this region, creating five new oases, and increasing fivefold the value of the land. In the same period the population has been doubled, and many thousands of date-palms planted.

Berlin

Physical Society, December 3, 1886.—Prof. von Helmholtz in the chair.—Dr. König exhibited a von Kries colour-mixing apparatus, the third specimen of the kind hitherto turned out in the factory of Schmidt and Hänsch, and discussed in a searching manner the construction of this instrument. The instrument contained essentially two displaceable slits, the light of which was by a prism decomposed into two spectra falling on each other and producing the mixture of the colours. A second double slit, and a simple fifth slit allowed a comparison of the mixed colours and an admixture at pleasure of white light.—Dr. Weinstein reported on his deductions from observations of the earth's current in the telegraph lines of the German Empire. Among the results already elsewhere published of his calculations (*vide* NATURE, vol. xxxiii. p. 624) it may here be brought out that, apart from its disturbances, the earth's current showed a daily period with eight fluctuations, which, however, did not occur throughout the whole year, nor always in a similar direction. These fluctuations were least in the morning between five and seven o'clock. They were the cause that the statements respecting the daily maxima and minima differed so considerably among the different authors. The earth's current showed an intimate relation to the earth's magnetism, and especially to the declination. The speaker failed, however, to discover a relation in the earth's current to the period of the sun's rotation, although such a relation was asserted for the earth's magnetism. The latter, too, was a point which the speaker doubted, and that because he had been unable to confirm the relation, which was likewise affirmed, between the aurora and the sun's rotation. It was true he obtained an average period of about twenty-five days, but the minima amounted to twelve and the maxima to thirty-seven days, and between such extremes a mean was not allowable. For the earth's current likewise he found minima of twelve days and maxima of thirty-seven days, and this result appeared to him to conflict with the assumption of a connection between the earth's current and the sun's rotation. He conjectured that in the case of the earth's magnetism single values deviating too strongly from one another had been united into a mean. Be it further related that the intensity of the earth-current proved itself to be nearly proportional to the length of the lines. In the discussion following this address, Dr. Brix spoke of the earth plates which had been introduced in the lines used for measurements of the earth-currents, and which had hitherto proved so little disturbing that for the present the introduction of unpolarisable plates was desisted from.

Christiania

Society of Science, October 15, 1886.—Herr Schöyen announced that through experiments carried out during the summer he had succeeded in demonstrating that the parasite *Tylenchus hordei*, described by him, which in the district of Lom causes the remarkable disease on rye termed "krok," also attacks *Elymus arenarius*, whereby his opinion that the parasite was transmitted from the latter to the rye-fields has been confirmed. He further stated that he had received samples of rye affected with the same disease from Heligoland; here, too, it extended along the coast in the proximity of *Elymus arenarius*.

BOOKS AND PAMPHLETS RECEIVED

Die Klimate der Erde, 2 vols.: Dr. U. Woeifog (Kostenoble, Jena).—The Factors of Organic Evolution: H. Spencer (Williams and Norgate).—Beiblätter zu den Annalen der Physik und Chemie, 1886, No. 12 (Barth, Leipzig).—The Electrician's Directory (Tucker).—Outlines of Classification and Special Morphology of Plants: Dr. K. Gould (Clarendon Press).—Travels in the Wilds of Ecuador: A. Simson (Low).—Meteorological Observations at Stations of the Second Order, for the Year 1882.—Hourly Readings, 1883, part iv.—Resultate der Polarlicht Beobachtungen augestellt im Winter 1882 und 1883: Dr. K. R. Koch (Asher, Berlin).—Gold Fields of Victoria: Reports of the Mining Registrars for Quarter ended September 30, 1886 (Ferres, Melbourne).—Report on the Administration of the Meteorological Department of the Government of India in 1885-86.—An Explanatory Arithmetic, 3rd edition: G. E. Spickernell (Griffin, Portsmouth).—An Elementary Treatise on the Differential Calculus, 6th edition: B. Williamson (Longmans).—Celestial Motions. 5th edition: W. T. Lynn (Stanford).—Year-Book of Pharmacy (Churchills).—Catalogue of Canadian Plants, part 3, Apetalæ: J. Macoun (Dawson, Montreal).—Archives Italiennes de Biologie, tome viii. fasc. 1 (Loescher).—Aluminium: J. W. Richards (Low).—Examples of Exercises given in the National Philosophy Class of Glasgow University: M. Maclean (MacLehose, Glasgow).—Report on the Medusæ collected by the U.S. Fish Commission in 1883-84: G. W. Fewkes (Washington).—The Blue Hill Meteorological Observatory: A. L. Rotch (Boston).

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