THURSDAY, OCTOBER 26, 1893.

## ANALYTICAL MECHANICS.

*A Treatise on Analytical Statics.* With numerous Examples. Vol. II. By Edward John Routh, Sc.D., LL.D., M.A., F.R.S. (Cambridge: at the University Press, 1892.)

THIS volume finishes Dr. Routh's work on the subject of analytical statics, the first volume of which was reviewed in NATURE, June 16, 1892. It contains, in three long Sections or Books, the subjects of Attraction, Bending of Rods, and Astatics, left over from Vol. I.

In Attraction a start is made with the Newtonian Law, and the Gravitation Constant is introduced.

The experimental redetermination of the numerical value of the Gravitation Constant is engaging the attention of Mr. Poynting (who has just been awarded the Adams Prize for his Essay on this subject) and of Mr. C. V. Boys. But we cannot hope to obtain, with the greatest refinements, an accuracy of determination within limits of error of less than one per cent.; the Astronomical Unit of Mass, defined in § 3, would be subject to the same limits of error, which are far beyond what is permissible in careful measurements with the Balance.

The only reason for the introduction of the Astronomical Unit of Mass is to save the trouble of writing down $k$, the Gravitation Constant, in our equations; but we agree with Prof. Minchin, in his Analytical Statics, in thinking that it tends to clearness if we take the trouble to write $k$ in its proper place, so as always to measure $m$ in such well-determined units as the gramme or kilogramme.

Nowadays the theorems of Attraction receive their most appropriate interpretation, analytical and experimental, from the subject of Electrostatics; the theorems on the Potential of Laplace, Poisson, and Gauss, on Tubes of Force, Green's Theorem, Inversion, Laplace's Functions, and on the Attraction of Ellipsoids of Chasles, all present themselves as fundamental in the Electrostatical chapters of Maxwell's "Electricity and Magnetism;" insomuch that Maxwell ventured to present a demonstration of some of the most abstruse analytical results of Laplace's Functions, founded on physical principles of Electrostatics, and thereby excite the ire of certain mathematicians of the purest proclivities.

For instance, the complicated theorems on Centrobaric Bodies, discussed in §§ 111, 116, become self-evident when interpreted as the analogues of the electricity induced on an uninsulated closed surface by an electrical point in the interior. The external electrical effect being zero, the potential of the induced electricity is equal and opposite to that of the point, and therefore the surface has an electrical coating which is centrobaric, the function which represents the superficial density being *Green's Function* for the surface and the point.

If the dielectric in the interior is stratified, an electrical concentration is distributed throughout the space, and thus the analogue of the centrobaric body is obtained; but incidentally the electric analogy shows that the strata of equal density in the centrobaric body are each separately centrobaric, so that the centrobaric body is built up of centrobaric shells. The sphere is the homogeneous centrobaric body, as Newton showed in the "Principia"; and an application of Sir W. Thomson's powerful geometrical method of electrical inversion deduced the fact that a solid sphere whose density varies inversely as the fifth power of the distance from an external point O′ is centrobaric with respect to the interior inverse point O. So also for a spherical shell, either this or composed of a series of concentric strata; and this by inversion leads to the theorem that a shell bounded by two excentric spheres of which the limiting points are O and O′ is centrobaric if the density at any point P in it is

$$OP^{-5}\phi(OP/O'P/)$$

The discovery of Green's function for a given surface, or rather the discovery of surfaces for which Green's function can be assigned, is one of the most difficult and baffling of modern analysis; and it has so far only been effected for some few simple cases.

The British Association met recently at Nottingham, the birthplace of George Green in 1793. There must be people still living there who remember him, and could supply now, before it is too late, some interesting details of the causes which led to the development of his wonderful mathematical genius, at a time too when little encouragement was vouchsafed to such abnormal proclivities. In France a statue would long ago have arisen in his honour; but at least an interesting paper on the subject of Green's life could be communicated to Section A.

The theorems of Chasles and Maclaurin on the attraction of homœoids and focaloids are fully discussed in §182; the homœoids receive ample illustration in electrical phenomena; but Maclaurin's theorem on the attraction of confocal homogeneous solid ellipsoids is rendered more convincing by supposing the smaller confocal to be scooped out of the larger so as to form a thick focaloid, the matter which is scooped out being condensed homogeneously with the rest of the substance. The effect of this operation is to leave unaltered the external potential, and the original matter may thus ultimately be condensed into a thin focaloid, in which the thickness is inversely proportional to the perpendicular on the tangent plane; and this focaloid will have the same external equipotential surfaces as the solid ellipsoid.

Part ii., on the Bending of Rods, does not assume any new experimental knowledge beyond that of the proportionality of the curvature to the bending moment, an assumption which we know from Prof. Karl Pearson's "History of Elasticity" to be only a first rough approximation to the truth.

The analytical consequences of the hypothesis are, however, very elegant and instructive, and Dr. Routh has brought together an interesting collection of illustrative examples.

He does not, however, develop the elliptic function solution of the plane Elastica or associated Lintearia, curves which can now be drawn with great accuracy and rapidity by Mr. C. V. Boys's scale. He also restricts himself to the uniform helix in the tortuous Elastica; but the student who wishes to pursue this branch of the subject to its fullest development must consult vol. ii. of Mr. Love's "Elasticity," which has recently appeared.

Kirchoff's Kinetic Analogue between this Elastica and the motion of a Top, makes the same analysis serve for both; thus, as pseudo-elliptic solutions, we may mention that tortuous Elasticas are given by:—

$$\text{(i.)}\quad r^2 e^{2i(\psi+ps)} = \sqrt{\{r^2 - \tfrac{1}{4}c(1-4c)a^2\}}\sqrt{\{r^2+\tfrac{1}{4}(1-2c)(1-4c)a^2\}} + \tfrac{1}{2}i(1-4c)a\sqrt{\{\tfrac{1}{2}c(1-2c)a^2 - r^2\}};$$

$$\text{(ii.)}\quad r^3 e^{3i(\psi+ps)} = \{r^2+(1-c)(2-3c)a^2\}\sqrt{\{r^2-(2c-3c^2)a^2\}} + i(2-3c)\sqrt{\{-r^4-(1-c)(1-3c)a^2r^2+(1-c)^2(2c-3c^2)a^4\}};$$

corresponding to parameters $\omega_1 + \frac{1}{2}\omega_3$ and $\omega_1 + \frac{2}{3}\omega_3$ of the related Elliptic Integrals of the third kind.

Here $a$ determines the scale of the figure, and $c$ is an arbitrary parameter, upon which $p$ depends; and it is curious that in case (ii.) the value $c = \frac{1}{3}$ makes $p$ vanish, and then $\omega_3 = \sqrt{(-3)}\omega_1$.

Other interesting applications of the Theory of the Bending of Rods, requiring Bessel Functions, are the investigations of the greatest height consistent with stability to which a vertical wire or mast can be carried, or to which a tree can grow, without drooping over under its own weight; we can thus supply the analysis required in the old German proverb, quoted by Goethe, "Es ist dafür gesorgt, dass die Baüme nicht in den Himmel wachsen."

The third part, on Astatics, is intimately bound up with the distribution in space of Poinsot's central axis for a system of forces; or with Sir Robert Ball's investigation on Screws. A great analogy exists with the analysis required in the distribution of principal axes in space. A problem which might well find a place here is, "The moment of inertia of a body of mass M about any generating line of the hyberloloid of one sheet

$$\frac{x^2}{a^2+\mu} + \frac{y^2}{b^2+\mu} + \frac{z^2}{c^2+\mu} = 1,$$

confocal with the ellipsoid of gyration

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$$

is constant, and equal to

$$M(a^2+b^2+c^2+2\mu)."$$

Dr. Routh has now completed his work on "Analytical Statics," and the two volumes form an indispensable addition to the library of the mathematical student.

A. G. GREENHILL.

## MOLESWORTH'S POCKET-BOOK.

*Pocket-Book of Useful Formulæ and Memoranda for Civil and Mechanical Engineers.* By Sir Guilford L. Molesworth, K.C.I.E., M.inst.C.E., and Robert Bridges Molesworth, M.A., Assoc.M.Inst.C.E. 23rd edition. (London: E and F. N. Spon, 1893.)

OF all the many books published for the assistance of engineers generally there is none so well known to the profession as "Molesworth." This pocket-book is to be found in the possession of every engineer, and rightly so, because it is certainly the most useful and accurate of the many to be obtained.

Any work which has reached the 23rd edition requires no praise to verify its position. This edition is said to contain new and important information on recent engineering and industrial developments, many of them entirely new, and much of the matter in previous editions has been revised. "Molesworth" treats with nearly all the various branches of engineering, and so extensively has this been carried out that it is impossible to notice but slightly its contents; besides the many purely technical formulæ there is to be found a collection of most useful tables applying generally to engineering. There are, however, a few mistakes in the mass of matter brought together in this book, and in some instances statements are made which would have been better omitted.

On page 254 we read that Vickers' straight steel axles should have an ultimate tensile strength of not more than 23 tons per square inch, and that this test can only be made by destroying the tested axle. Crank axles should also have a maximum tensile strength of 23 tons. There is either a typographical error or gross mistake in this statement. Had the maximum limit been given 33 tons it would have been nearer the mark; 23 tons is absurd. Probably the best tensile tests for steel axles would be 30 tons per square inch, 25 per cent. extension measured over a length of three inches, and 40 per cent. contraction of area at point of fracture. The author omits to state that straight axles are tested under the tup, and that it is this test which destroys them. It is usual to take the tensile sample from this axle. Again, in the tests for steel tyres given on page 255, we notice that a tensile strength of 47 tons is required, but no extension or contraction of area is specified. This is all very well, but tyres have been known to stand the tup test and give the proper tonnage in the tensile test, still the extension has only been 5 to 8 per cent. on three inches, when 16 per cent. is the lowest limit safety demands.

On p. 410, under the head of workshop recipes, there are several mixtures given for case-hardening of wrought iron. The first recipe is used by a few people, but the majority use ordinary charcoal mixed with about 2 per cent. of soda ash. This gives a very uniform and close-grained casing. The author gives no time-allowance for the articles to remain in the furnace; this is all-important, because the time governs the depth of the casing. Further on, at p. 418, we find some recipes to prevent the incrustation of boilers. One cannot help being amused to discover in "Molesworth" of 1893 that potatoes, $\frac{1}{50}$th the weight of water in the boiler, when put in prevent adherence of scale. Twelve remedies are given, but the only one a man having any regard for his boiler would use is that of frequent blowing off.

When dealing with the question of the proportions of locomotive boilers on p. 453, the statement is made that—(1) no fixed rule can be established as to the best relative proportions of grate, fire-box, and tube surfaces. (2) Length of tube does not affect economic result. (3) Diameter of tube is a matter of indifference.

These conclusions are, to say the least of it, very dogmatical. Given the class of fuel to be consumed and the work to be done, then the question of the design of boiler is not very difficult, and the general practice in this respect may be said to be uniform. This practice is certainly approaching a fixed rule. Given the conditions, the design, or we should say the proportions, becomes an easy matter to designers worthy of the name.

We leave our readers to form their own opinions upon conclusions Nos. 2 and 3. It is a pity they are to be found in "Molesworth," because they may lead students and others to form the opinion that these most important details are matters of no consequence. The compound locomotive naturally is included in the new matter added to this edition, and being of great interest to all connected with railways, we expected to find the subject thoroughly up to date. In this we are disappointed; two-thirds of a page is considered ample space to discuss this important question, the other third being taken up with a few lines on American locomotive practice! American locomotive engineers do not consider the two-cylinder arrangement for compounding "most suitable," nor does Mr. F. W. Webb, the able locomotive superintendent of the L. and N.W. Railway. Surely these two subjects are worthy of more space and better treatment.

On p. 466 we notice a formula having reference to the blast pipe of locomotive engines, applying in particular to the exhaustive power of the pipe, as the efficiency of a blast pipe seems to depend more on its vertical position in the smoke-box than on anything else. This fact might have been noted with advantage.

The rule given on p. 499 for the safe load on locomotive springs, by Mr. D. K. Clark, is found to be rather excessive; the constant 11·3 can be increased with advantage to 15, the result thus obtained being the actual load to be carried. Notwithstanding these few weaknesses, Molesworth's Pocket-Book is, without doubt, incomparably the best of its kind; and so accustomed have engineers, and particularly draughtsmen, become to the continual use of this valuable book that most of them would be now really lost without it.

This book is clearly and well printed, nicely got up, and is a credit to all concerned in its publication.

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## THE AMERICAN CATALOGUE OF MEDICAL LITERATURE.

*Index Catalogue of the Library of the Surgeon-General's Office U.S. Army.* Vol. xii. (Reger—Shuttleworth), pp. 1004, 1892, and vol. xiii. (Sialogogues—Sutugin), pp. 1005. Imp. 8vo. Washington, (Government Printing Office, 1893.)

IT is a great pleasure to all who are interested in any form of library or literature to observe how punctually, year by year, these magnificent volumes appear, and show in a very practical way how American enterprise can deal with old-world questions of gathering together and keeping up a collection of books that is superior in its own department to any other, and which has been got together in little more than thirty years. What is framed as an Index Catalogue of the Library of the Surgeon-General's Office at Washington constitutes in effect a dictionary of all medical and surgical literature, ancient and modern, with very few *lacunæ;* the entries under authors' headings have now reached 240,007, and under subject-headings 539,927; and the attempt which at first sight may well have seemed too ambitious—viz. to catalogue under subject-headings all the signed articles which touch on medicine which exist in the periodical publications of all languages, as well as to cross-catalogue all medical books and pamphlets of the world under both author and subject-headings—has turned out perfectly successful. In the first eleven volumes there were mentioned 3,929 periodical publications which were thus treated; in the two more volumes which are before us there are 341 additions, and though some of the older ones may have died out, yet the labour remaining is obviously no light one. The thirteenth volume brings us within sight of the end, and it is probable that two years more may finish the first edition of the catalogue; yet it cannot but be that some provision, by supplement or otherwise, must be made for the literature which during fifteen years has been accumulating under the headings of the earlier volumes, and some arrangement must be made for the literature of the future. From the monthly issues of the *Index Medicus*, which is a catalogue issued by Mr. Billings, on similar lines, of purely contemporary medical literature, we may estimate that the sum total of titles of additions to the world's medical literature would amount to about one such volume as the present every three years, which leaves us no doubt that the successors to Mr. Billings, the present librarian, will have occasion for all the indomitable activity and accuracy he has shown. In the twelfth volume, considerable use in various quarters has enabled us to find only one trifling misprint of a well-known physician's initials (xii. 449), but accuracy in such details is indispensable when we have to do with 136 authors of the name of Richter, 227 of the name of Smith, and 240 of the name of Schmidt. The student may be overwhelmed at first by the 39 imperial 8vo. pages that are required for a closely-printed catalogue of the titles of the literature of scarlet fever, but he will find that 46 pages are needed for rheumatism, 63 for small-pox, and 102 for surgery. Under these large headings the sub-indexing is excellent. The great importance of such a classification under subject-headings should never be lost sight of in a catalogue which deals mainly with matters of observation and natural science, for, in a large majority of cases, the importance of the record depends more on the observation than on the observer, and the student for whom all these volumes are such an invaluable help to knowledge is much more likely to be wishing to pursue an inquiry on a particular subject, regardless of those who wrote on it, than to trace out the works of a particular author regardless of what he wrote upon. However, Mr. Billings is extremely liberal to him, and gives him an excellent chance of doing both, of seeing all the vast mass of signed periodical literature as well as the books written on the particular subject, and also of seeing a list of all that each author has written with the exception of the articles in periodical literature that he has not re-published, and he will find that many authors have republished in pamphlet form all that is worth reading.

The task of classification under subject-headings of all literature, both periodical and other, has been felt too enormous for any first-rate general library, and, so far as we know, has only been attempted by the Germans over comparatively small branches of knowledge, *e.g.* Carus and Engelmann's *Verzeichniss der Scriften über Zoologie welche in der periodische Werken enthalten.* The Royal Society's "Catalogue of the Scientific Papers contained in the Scientific Periodicals" (8 vols. 4to) contained only a list under authors' headings of the publications between

1800 and 1873, and did not attempt to deal with any subject-headings, or any of the past history of the subjects as Mr. Billings has done in his rich and varied Index Catalogue of very nearly all the Medical Literature printed between the fifteenth century and the present day. A. T. Myers.

## *OUR BOOK SHELF.*

*Lehrbuch der Botanik nach dem gegenwärtigen Stand der Wissenschaft.* Bearbeitet von Dr. A. B. Frank. Zweiter Band: Allgemeine und Specielle Morphologie. 8vo, 431 pp. with 417 Woodcut Figures in the text, and an Index to Volumes I. and II. (Leipzig: Wilhelm Engelmann, 1893.)

The first volume of this work, dealing with histology, anatomy, and physiology, was noticed in Nature, vol. xlvi. p. 610, where some facts may be found connected with its history, scope, and arrangement. The present volume is concerned with general morphology and special morphology, or classification. It is, on the whole, exceedingly well compiled, and, as was said of the first volume, it is written in the clearest and easiest style, with no superabundance of words, such as often render German text-books unnecessarily difficult to the beginner. The illustrations (upwards of 400) are for the greater part borrowed from the works of Sachs, Gœbel, Schenk, Prantl, Pringsheim, Hanstein, Schimper, Strassburger, Hofmeister, De Bary, Tulasne, Bornet, Brefeld, Woronin, and other specialists, but chiefly from the first. These are all duly acknowledged, and, as the author states in his preface to the first volume, he has made the best selection he could, and he has used these familiar figures because he could not substitute better ones. This is, of course, true; yet we put it on record to inform the student that he will find little that is original in this way. General morphology occupies fifty-four pages, under four heads, namely: discrimination of forms in the vegetable kingdom, directions of growth, general laws of the relative positions of the members of the vegetable body, and origin of the members of the vegetable body. The remainder of the volume is devoted to special morphology, or systematic botany; but the large groups are somewhat unequally treated, 179 pages being devoted to cryptogams, as against 140 to phanerogams. Indeed, too much has been attempted in the space. For instance, the very brief diagonses of the natural orders given at the end of this volume can be of little service to the beginner. Few of them exceed six lines, and many of them are even less, consequently the characters given are often insufficient to include half of the genera. Generally speaking, they are correct as far as they go, but they are often not sufficiently comprehensive. We have said that this is an excellent book, yet here and there one stumbles upon statements that cause no little surprise. Thus the pictures of Nepenthes, Sarracenia, and Cephalotus are described indiscriminately as transformed terminations of tendril-like continuations of the leaves. Then with regard to the bibliography, the selections are by no means critical, and sometimes defective, especially in foreign literature. The indexes, of which there are three, are sufficiently copious. There is an index to the woodcuts, an index to the subjects, and an index to the plant-names. When will authors learn that one general index is preferable to a number of classified references? In this work it would have been much more convenient to have had an index to each volume.

*The Elements of Natural Science.* Part III. Natural Philosophy. By Dr. H. Wettstein. (London: O. Newmann and Co., 1893.)

The German edition of this book is obligatory for all the secondary schools of the canton of Zurich, which partly accounts for the fact that more than seventeen thousand copies have been sold. It is doubtful, however, whether the translation will be so widely appreciated in England. There are already many excellent introductions to science covering practically the same ground as Dr. Wettstein's work. In one feature only is the book superior to the majority of those produced in England; viz. in the abundance of illustrations. As a rule, our text-books of science are very poorly off in this matter, whereas Ganot, and Deschanel, and the book before us, are brightened considerably by the insertion of numerous illustrations.

When we say that in the 138 pages of the book the sciences of mechanics, sound, light, heat, electricity, and magnetism are treated, it will be at once understood that the descriptions are of a rather sketchy nature. In spite of this, however, the book will give its readers a good grounding in the principles of physical science. Though most of the text can be easily comprehended by the average pupil, there are portions which should hardly be inserted without explanation. Thus, on p. 44 we read: "The atmospheric pressure carries our legs and arms, for the condyle of the femur fits air-tight into the acetabulum of the pelvis, and likewise the condyle of the humerus into the articular cavity of the shoulder-blade." And it is misleading to say: "The complete spectrum of sunlight consists of three parts—*the heat spectrum, the light spectrum, and the chemical spectrum*" (p. 71). The table of spectra given in the frontispiece is poor, one of its defects being that the solar spectrum only differs from the spectrum of Sirius by the addition of the three lines A, a, and B. With this exception, however, all the illustrations are very clear and accurate.

*A Short Course in the Theory of Determinants.* By L. G. Weld. (London: Macmillan, 1893.)

We have read Prof. Weld's book with much interest, for though there are few, if any, novel results brought forward, he has certainly attained the goal he set before himself, and has developed the theory in a very simple manner. Some of the methods he has employed are new to us. The greater part of the work requires little beyond an intimate acquaintance with the principles of algebra as given in the ordinary school text-books. To confine the treatment within very moderate limits, there is no application of determinants to analytical geometry, but many of the more important algebraical applications find a place. After treating with sufficient detail of the origin and notation of determinants, our author gives a general definition of them, and enumerates and proves the more useful of their properties, and then touches lightly upon their applications to elementary algebra, *i.e.* to matrices and Sylvester's and Euler's methods of elimination. In Chapter vi. he briefly discusses the multiplication of determinants and reciprocal determinants. The last three chapters give a brief account of special forms, and of linear transformation. The text is very clearly printed, and we have detected but few trivial errors. There is a good store of examples, some of which appear to us to be rather "stiff." Due acknowledgment is made in the preface to the sources from which results have been derived.

*A Practical Treatise on Bridge Construction.* By T. Claxton Fidler, M.I.C.E. Second Edition, enlarged and revised. (London: Charles Griffin and Co., 1893.)

The first edition of this book was reviewed at length in Nature, vol. xxxviii. p. 2. Since then the Forth Bridge has been completed, and great advance has been made in the manufacture of steel.

The principal criticism to be added to the former review is that the author should add some remarks on the method of erecting a bridge, large or small. As it is, the structures are described as if they dropped down ready made from the sky into their appropriate place.

Many superior designs could at this rate be made for the Forth Bridge; but then this ignores an important controlling element, that the bridge was to stand, not only when completed, but at every intermediate stage of the erection.

Even the operation of hoisting or rolling into place a forty-foot girder is not a simple matter; during the process the ordinary stresses are mostly reversed, and the structure runs the risk of "cockling."

We find no mention of the Tower Bridge, the most important experiment of a drawbridge *à bascule*. G.

*The Amphioxus and its Development.* By Dr. B. Hatschek. Translated and edited by J. Tuckey. (London: Swan Sonnenschein and Co., 1893.)

THIS is a translation of Dr. Hatschek's well-known paper on the subject published twelve years ago. It will no doubt enable those who cannot read German to follow Dr. Hatschek's statements. But unless the rest of the translation is more accurate than that of the title, readers will be deceived and disappointed. This book is not correctly called "Amphioxus and its Development." That is a salesman's title. There is nothing in it about Amphioxus, except an account of the earlier part of the development. The important facts of the larval development discovered by Willey, as well as the adult structure, are not dealt with. The original plates have not been reproduced in this translation, but very small and often obscure reductions of them are substituted.

E. R. L.

## LETTERS TO THE EDITOR.

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

### The Use of Scientific Terms.

I AM glad that so distinguished a physicist as Dr. Lodge has found certain matters relating to the history of physiology, which I discussed, I fear very imperfectly, in my Nottingham address, to be of sufficient interest to induce him to read and criticise it. Fully appreciating the geniality with which his criticisms are expressed, I will ask your permission to comment on one or two points in his letter, which may not be uninteresting to the readers of NATURE.

One of the principal objects which I had in view in my address was to promote that intercommunication between the physical and physiological sciences which Dr. Lodge thinks so desirable, and I am no less sensible than he is that this solidarity is much impeded by inconsistency in the employment of words. Your correspondent avers that whereas the language of Physics consists in "simple English phrases" and "common words made definite by connotation," our biological words are "polysyllabic," and our modes of expression as unlike those of daily life as can be contrived. We say "devitalising," for instance, when we mean killing, just as the chemist says "desiccating" when he means drying.

It is difficult to express the complicated relations which exist between the phenomena of life without using terms which are themselves complicated. Thus, I venture, notwithstanding Dr. Lodge's good-natured pleasantry, to think that the word "chemiotaxis," bad as it may be, serves better to express the little that we know about the "particular go" of certain processes than any simple English phrase we could substitute for it.

Two words, "life" and "energy," are specially referred to by Dr. Lodge as examples in illustration of the inconveniences which are to apt to arise from their improper use. In Physiology the word "life" is understood to mean the chemical and physical activities of the parts of which the organism consists together with their co-ordination—not the processes only, nor their co-ordination only, but both at the same time. Dr. Lodge uses the word life without making it "definite in connotation," but from what is said about it, it is evident that the life which he has in view is not made up of processes, but merely consists in their co-ordination or adaptation for the purposes of the organism; for it is defined as the "power of *directing* (the italics are mine) energy into otherwise unoccupied channels." This being understood, all that Dr. Lodge says about life, and particularly his statement that it is *not* a form of energy, seems to me to be in accordance with the views that I endeavoured to set forth in my address. The only difference, therefore, that exists between us relates to the sense in which the word life is to be used for scientific purposes. Next follow some trenchant observations as to the misuse of the word "energy." I do not think that I am accused of such misuse. Nevertheless it may be useful to note that in referring to the sense in which J. Müller and his illustrious pupil had used the term "specific energy," it was expressly stated that their use of it was in a sense entirely different from that in which it is employed in physical science; and further, that the words quoted from the "Physiological Optics," viz. "energies of the nerves of special sense," were written in 1886, not "long ago," as Dr. Lodge suggests.

I can assure your readers that to the best of my knowledge the word "energy" is never used in the old sense by physiological writers, excepting, so to speak, between inverted commas; and with reference to the historical importance of Müller's doctrine, and still more of Helmholtz's earlier physiological writings, the words "normal activity," or others of similar import, are substituted for "specific energy," not as necessarily meaning anything quantitative, but simply the mode in which the organ normally reacts.

To the suggestion that "subjective light" should in future be designated by an impressive-looking word beginning with *photo* and ending with *taxis*, I have no objection to make, excepting that it might turn out to be rather sesquipedalian. May I add, that I hope to have the opportunity of recurring to the subject of the vision of the totally colour-blind.

J. BURDON SANDERSON.

### The Thieving of Antiquities.

A RECENT case, which has occupied some space in NATURE, raises much larger issues than the character of individuals, and issues which must be faced sooner or later.

The present conditions of the laws and practice regarding antiquities is most unhappy, both in the interests of science and in the interests of museums. Two matters require much revision: (1) The modes of excavating; (2) the laws regarding excavation and exportation.

As to the mode of excavating it is still generally the custom to leave much in the hands of native overseers, and often the European in charge does not live on the work. Until it is recognised that it is unjustifiable to disturb antiquities without recording everything that can be observed, we shall remain in the state of mere plunderers, without a claim much higher than that of the treasure-hunting natives. In Egypt, hitherto, nearly all official excavations have been made by trusting entirely to uneducated and dishonest native overseers; and while the laws are strict concerning Europeans working, the natives plunder almost at their will under one pretext or another. With suitable regulation it has been proved practicable to entirely excavate a site without any loss or pilfering of the smallest objects by the natives; and such excavation, entirely under trained and educated observers, either native or foreign, should be the aim in all future work.

But in the matter of the legal position it is far more difficult to reach a satisfactory basis. Baldly stated the case stands thus. Every country in which there is anything much worth having, stringently prohibits exportation and excavation; and nearly all the growth of museums of foreign antiquities is in direct defiance of the laws. Most countries are engaged in thieving from others on a grand scale, by various underhand agencies; a form of thieving which is as much tolerated by public opinion as smuggling was in former days According to law, no antiquities of any kind can possibly leave Turkish or Greek territory, and nothing that is of great importance can leave Italian or Egyptian territory. Yet museums grow.

The actual course of affairs is that some private agent, or museum official, hears of something important, and buys it up in order to smuggle it for the museum in which he is interested. Sometimes museum officials go on missions to collect, or to excavate in accordance with the laws, while what they obtain is smuggled out in defiance of law. This is going on yearly, and will go on till some better system is established. Meanwhile all information concerning such discoveries has to be suppressed; and the most important acquisitions of museums are a matter which cannot be published, or even talked about in detail, while official papers have to be treated as secret archives.

In England the Government is a hindrance rather than a help to a better state of things. France and Germany ask other powers in a straightforward way for presents of antiquities by diplomatic channels; and they often get what they want, as we did in the days of Lord Stratford de Redcliffe and Sir Henry Layard. But recently English diplomacy has, on the contrary, repeatedly thrown away what rights Englishmen might claim concerning antiquities, in order to gain petty advantages which diplomatists were capable of understanding.

The work which has been done in Egypt by the Exploration Fund and myself, at least shows that such an unsatisfactory state of things is not unavoidable. The Egyptian laws are administered with more sense than such laws in other lands, and with a little diplomatic protection the position would be all that could be reasonably wished. For many years large excavations have been made openly, and with complete freedom, by Englishmen; nothing has been lost, either of objects or information, owing to surreptitious methods; all that has not been most essential for the country itself has been openly brought to assist study in England, and the fullest statements can be openly and honourably made on the subject. Meanwhile objects smuggled by officials have to be kept quiet, and lose whatever scientific value their record might have possessed.

Until our Government sees its interests in backing up work for its museums by honest methods, and straightforward dealing, we shall continue to lose the greater part of the scientific value of museum acquisitions, and to have a seamy side to our administration which is more discreditable than those personal questions that have lately been raised.

W. M. FLINDERS PETRIE.

University College, London, October 10.

### The Glaciation of Brazil.

DR. WALLACE'S pointed reference to myself in this week's NATURE induces me to send you these few lines.

It has been said by more than one critic of my book on the "Glacial Nightmare" that in some cases I was merely slaying the slain, and notably in regard to Agassiz's views about the glaciation of Brazil. It has been overlooked that Agassiz's experience and authority on glacial matters were unrivalled, and that he had written on this very question: "An old hunter does not take the track of a fox for that of a wolf. I am an old hunter of glacial tracks, and I know the footprint whenever I find it."

Again, Dr. Wallace, whose knowledge of the tropics is so profound, had written: "Professor Agassiz was thought to be glacier-mad, but if we separate his theories from his facts, and if we carefully consider the additional facts and arguments adduced by Prof. Hartt, we shall be bound to conclude that however startling, the theory of the glaciation of Brazil is supported by a mass of evidence which no unprejudiced man of science will ignore merely because it runs counter to all his preconceived opinions." Again he says: "It can hardly be maintained that the discoverer of glacial phenomena in our own country, and who has since lived in such a preeminently glaciated district as the Northern United States, is not a competent observer; and if the whole series of phenomena here alluded to have been produced without the aid of ice we must lose all confidence in the method of reasoning from similar effects to similar causes, which is the very foundation of modern geology."

Lastly, Mr. James Geikie, in his second and revised edition of "The Great Ice Age," quotes Agassiz's conclusions without a word of protest or warning (*op. cit.* 484-5).

With these strongly expressed views before me, it was impossible to ignore the issue, and it can hardly be said I was slaying the slain in criticising those who believed in tropical glaciation.

I did not then know that in his subsequent work on Darwinism Dr. Wallace had, with that candour which makes his works so valuable to some of us, qualified and partially withdrawn his previous conclusions on the subject, a fact which he again emphasises in his letter to you. With this letter *cadet quæstio*, I know no one now who is willing to support Agassiz's theory, and we may take it to be dead. *Requiescat in pace.*

Meanwhile, however, let us do justice to those whose observations and logic have dispelled one phase at least of the glacial nightmare. Dr. Wallace attributes this to his friend and correspondent, but the work had already been done, and amply done, by others, as I tried to show in my recent book. In it I have quoted largely from the admirable remarks of Prof. Orton, Dr. Ricketts, M. Crevaux, and last, but not least, Prof. Hartt himself, who as far back as 1871 had given up Agassiz's views in regard to the Amazonian glacier (see *American Journal of Science*, 3rd ser. vol. i. pp. 294-5).

When we have got rid, however, of Agassiz and his Amazonian glacier, we have not got rid of all our difficulties. While we cannot accept the notion of tropical ice-sheets, we have still to explain the existence of erratic phenomena in the tropics, such as those described by Schomberg in Guiana, by De la Beche in Jamaica, by Blandford in Southern Persia, by Chardin in Media, by Belt in Nicaragua, and by Hartung in the Azores. There seems some difficulty in explaining these phenomena without invoking the former existence of local glaciers in parts of the tropics where they no longer exist, and also the occurrence of large diluvial movements there. I should be greatly indebted to Dr. Wallace, and so would others, for his views on this subject. There remains another and a more critical difficulty which I must reserve for another letter. In conclusion he will permit me to thank him for his very valuable and courteous letter.

HENRY H. HOWORTH.

30 Collingham Place, Cromwell Road, S.W.

### The Glaciation of Brazil.—Scintillation of Stars.

A VERY cursory examination of the gneiss rocks about Rio de Janeiro—particularly the Corcovado—will show how the rock breaks up. In some places it comes off in great flakes like the coats of an onion, and the edges of these flakes are quite friable, and can be reduced to fine grains between the fingers. In many places it is found quite crumbled up by the weather, and down the coast towards Santos fine grains of these rocks can be found in the soundings at some distance from the land.

It is somewhat singular that observation has led me to a contrary opinion to M. Dufour in the scintillations of stars (NATURE, October 19). My attention was first drawn to the phenomenon by an old and experienced sailor, a native of the Western Islands, and a most clever weather prophet. I have constantly observed at sea that steadily-burning stars indicated calm, fair weather, and the more they twinkled the worse the weather was likely to be. The forecast given by this variation in scintillating was almost invariably correct in the high latitudes, though it failed sometimes in the tropics.

DAVID WILSON BARKER.

The *Worcester*, Greenhithe.

### The Summer of 1893.

IN his letter in NATURE of August 31, Mr. W. B. Crump explains how the weather of the year has influenced the times of the flowering of the Halifax flora; and it may be of some interest to offer a note on the blossoming of a few common plants, trees, and bushes around Worcester.

The cardamine blossomed on April 16, herb Robert on the 16th, the oak on May 5, the elderberry on the 10th, the purple orchis on the 13th, and bear's garlic on the 13th also.

In this part of England field blossoms form an important factor in cottage economy. The harvest of this flora begins in spring with the primrose, the violet, and the wild daffodil, the latter here called the Lent lily. This season the Lent lily blossomed in March, as did the primrose and violet. Of late years these flowers have acquired a commercial importance, and engage, especially the former, a multitude of pickers and packers, lending life and colour to lonely railway stations. During the season dealers station in suitable country habitats agents who collect the flowers gathered by the pickers, and in large hampers despatch them to destinations all over the kingdom. This year the daffodil yielded less abundantly than usual.

Next to these blossoms follows the cowslip crop. This, for the sake of the pips, which, at 1*s*. a peck, are in demand at the British wine makers, is collected largely by cotters' children.

Owing to the drought the crop, greatly to the distress of poor folk, proved an utter failure. Happily the wealth of the season's blackberry crop atoned in some measure for the cowslip failure.

The modern taste for cut flowers has given a commercial place also to the blossoms of the wood anemone, the marsh marigold, the ladies' smock, and the yellow iris.

The apple, pear, and plum crops were excellent. In some plantations the gooseberry crop, through the ravages of the scourge known as the red spider, was destroyed, and the bushes killed.

The hop crop was good and great, the bulk being of a quality rarely, if ever, surpassed. As early as July 28 two pockets reached Worcester market; a date, save one, the earliest on record. Some twenty-four years ago—I cannot put my hand on the exact date—a pocket was delivered in this market on July 26.

On August 8 this season picking began to get general. On September 8, some days earlier than picking usually commences, many planters had finished.

On September 19, in ordinary years, hops begin to reach the market. This season much before that date the public warehouses were filled with new hops. The season being in advance of the hop requirements of the brewers, merchants did not attend to buy. For all this, waggons heavily laden with towering loads of hops came pouring in, and not only were the public warehouses filled, but the floor spaces of the Shirehall, the Guildhall, and the Gymnasium were packed.

The most notable feature of the year, doubtless, is the circumstance that during the latter part of July, as well as through the month of August, and down to the present date, there was, and is, a second leafing, blooming and fruiting of fruit and forest trees, and blossoming of the spring and summer flora.

In Paris the horse-chestnut trees blossomed and leafed afresh, as happened with many horse-chestnut trees in Cambridgeshire. In Kent orchards again put forth blossoms, while the ripening fruit of the year loaded the boughs. As far north as Manchester, and likewise near Wigan, the rhododendrons blossomed again. Throughout England many fruit trees are in second bearing. In the avenue of lindens in the New Road, in this city, many of the trees are garnished with new foliage of the exquisite vivid green tincture of spring; the leaves have attained full size. Strawberries ripe and of large size (5 inches in circumference) are common over a wide area of England. At Redruth, Cornwall, primroses, gentians, and golden chain, and most of the early spring flowers are again in splendid blossom; and there also fruit trees, while in full crop, are again in rich bloom.

In the Cottenham district of Cambridgeshire a second crop of various kinds of fruit is being gathered. Green gooseberries have been secured during the last few days from one of the gardens; raspberries have in several places blossomed again, and produced finer fruit than the first crop; while apple-trees also show a rich second bloom. In North Wales dog-roses, honeysuckle, and foxgloves are again in splendid bloom. In Worcestershire the midsummer flora is again in flower. Generally the late potato crop is growing again, and great deterioration of the tubers ensues. In Tenbury, Worcestershire, many of the potato tubers are flabby, as though scalded, and when boiled turn black and become nauseous, and the growers are wondering what is the matter.

At Médoc the vintage began on August 20, a month anterior to the usual date. For generations such an early date has not been known. The Girondins say the crop is splendid; sufficient casks for the crop are not procurable.

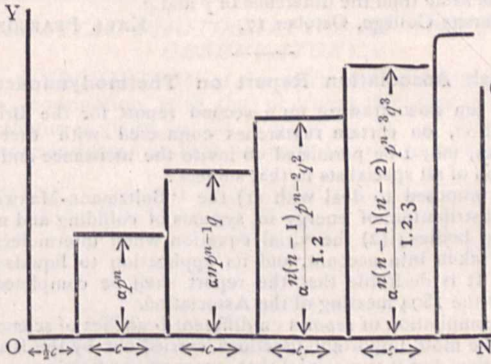
Here, in spite, or perhaps in consequence, of the drought, the familiar wayside wilding, the ladies bed straw, formed (in meadows put up for mowing) a great part of the crop, and, flinging lavish perfume around, lined every wayside hedgerow. The humming-bird moth, of which the bed straw is a food plant, was more common than ever before within my rather long experience. At the end of August, a month before the usual time, the thousand of Irish harvestmen left our shores for home.

The summer of 1818 resembled greatly that of the present remarkable year.

Worcester, September. J. LLOYD BOZWARD.

## Asymmetrical Frequency Curves.

SOME six years ago (September 1, 1887) Dr. Venn wrote to you pointing out the asymmetrical character of certain frequency curves occurring in physical and biological measurements. I have recently obtained a generalised form of the probability curve which fits with a great degree of accuracy such curves, and propose to discuss it at length shortly. Meanwhile I wish to point out that an asymmetrical *point* binomial may be readily fitted to such curves, although not with the completeness of the above referred to continuous curve. Let $n$ be the number of events in a group, $p$ the probability for single event, and $q$ that against it; let $c$ be the horizontal space selected as the basis of each rectangle forming the point binomial, and let $a$ be the total area. Then we have the following diagram given by the point system:




where the successive heights are the terms in

$$a\left(p^n + np^{n-1}q + \frac{n(n-1)}{1.2}p^{n-2}q^2 + \ldots\right).$$

Then I premise that to fit this to any real curve we *cannot* (1) use the length of base $(n+1)c$, for by trial I find this is never sufficiently accurately known; (2) use the magnitude or position of the maximum ordinate of the observation curves, for the first is not accurately known, and the second is dependent on knowing the exact end of the observation curve.

Accordingly I proceed *not* by the method suggested in Prof. Edgeworth's "Law of Error and the Elimination of Chance" (*Phil. Mag.* p. 318, April 1886), but by a method of higher moments.

Reckoned from O, the distance ON to the vertical through the centre of gravity, G, of the system of rectangles is $c(1+nq)$.

I now calculate the moments of the rectangles round the vertical, OY, and find for the $r$th moment

$$M_r = ac^r \frac{d}{dq} q \frac{d}{dq} q \frac{d}{dq} \ldots \text{ to } r \text{ differentiations } \{q(p+q)^n\},$$

where $p+q$ is only to be put unity after differentiation, and $c$ is supposed small. From the first four moments about OY, I find the first four moments about NG [with the following results:—

$$\mu_1 = 0,$$
$$\mu_2 = npqac^2,$$
$$\mu_3 = npq(p-q)ac^3,$$
$$\mu_4 = npq\{1 + 3(n-2)qp\}ac^4.$$

Now the centre of gravity of the observation curve is found at once, also its area and its first four moments by easy calculation. Thus the position of NG, $a$, $\mu_2$, $\mu_3$, and $\mu_4$ are given quantities. Taking the values of $\mu_2$, $\mu_3$, $\mu_4$, given above, and also $p+q=1$, I have four equations to determine $p$, $q$, $n$, and $c$.

Solving them, I have the following results:

$p$ and $q$ are roots of the *quadratic*;

$$p^2 - p + \frac{(3\mu_2^2 - \mu_4)\mu_2 + \mu_3^2}{4(3\mu_2^2 - \mu_4)\mu_2 + 6\mu_3^2} = 0;$$

$$n = \frac{2\mu_2^3}{(3\mu_2^2 - \mu_4)\mu_2 + \mu_3^2};$$

$$c = \frac{\sqrt{2(3\mu_2^2 - \mu_4)\mu_2 + 3\mu_3^2}}{\mu_2^2}.$$

As verification note that for the normal probability curve $3\mu_2^2 = \mu_4$ and $\mu_3 = 0$.

Thus we have

$$p^2 - p + \tfrac{1}{4} = 0, \text{ i.e. } p = \tfrac{1}{2}, \text{ and } q = \tfrac{1}{2},$$
$$n = \infty, \text{ and } c = 0,$$

as it should be.

The method enables us to fit a binomial to any asymmetrical curve, the results being based on no single ordinates, but on the moments of the whole system throughout.

The importance of this solution is that it enables us to determine $p$ and $q$ very approximately for any system of physical, biological, or sociological measurements; *i.e.* it tells us how much greater is the tendency for a deviation to occur on one side of the mean rather than on the other. A scientific measure of this is clearly given by

$$\frac{\mu_3}{\mu_2} = (p - q)c,$$

which measures the asymmetry of the frequency curve, and tells us at the same time the difference of $p$ and $q$.

University College, October 17. KARL PEARSON.

### British Association Report on Thermodynamics.

As I am now drawing up a second report for the British Association, on certain researches connected with thermodynamics, may I be permitted to invite the assistance and co-operation of all specialists in that subject?

It is proposed to deal with (1) the "Boltzmann-Maxwell" law of distribution of energy in systems of colliding and non-colliding bodies; (2) the virial equation when intermolecular force is taken into account, and its application to liquids and gases. It is desirable that the report shall be completed in time for the 1894 meeting of the Association.

The compilation of reports on different branches of science is one of the most important functions carried out by the British Association, but it is essential that every paper bearing on the subject of a report should be consulted in its preparation. The labour involved in wading through the enormous mass of existing literature on any physical subject can only be appreciated by those who have undertaken such work, and there is a constant risk of overlooking important papers, which are often buried in the Transactions of some obscure foreign society. It sometimes happens, too, that such papers cannot be procured, and hence cannot be consulted, to the great detriment of the report. May I therefore hope that the authors of any investigations bearing on the subjects of my report will kindly send me reprints? Lists of papers or suggestions will also be most acceptable.

G. H. BRYAN.

Thornlea, Trumpington Road, Cambridge, October 18.

### Curious Phenomenon.

I WAS on the top of a small mountain in the Dövrefjeld, near Hjerkin, in the late afternoon of August 26, the sun being 10–15° above the horizon, when I saw a remarkable phenomenon. On the opposite side to the sun was a bright disc, perhaps 5° in diameter, shown on some drifting clouds. The shadow of my head appeared in the centre of the disc, that of my body below, while outside the disc the shadow of my legs was faintly visible. The phenomenon continued on and off—that is to say, when the clouds were favourable—for nearly a quarter of an hour. The landlord of the hotel said he had never seen anything of the sort.

WILLIAM CHURCHILL.

New University Club, St. James' Street, S.W., October 17.

## *HUMAN AND COMPARATIVE ANATOMY AT OXFORD.*

ON October 14, a distinguished company, including the Professors of Human Anatomy in Edinburgh and Cambridge, the President of the College of Surgeons of England, and many well-known medical men and teachers, attended the opening of a new institute of Human Anatomy by the Vice-Chancellor of the University of Oxford.

The occasion is one in connection with which a few words are appropriate concerning the history of anatomical studies in Oxford and the relation between the special technical study of the anatomy of man required by medical students, and the more general study of the comparative anatomy of man and animals, or animal morphology. Historically the study of natural science has had the closest connection with the profession of medicine. In the last century, zoology and botany were not pursued in the universities of Europe as branches of science to be studied for their own intrinsic value as departments of knowledge, but primarily as giving the student acquaintance with "drugs" or "materia medica." Linnæus was the first university professor who lectured on animals from the strictly zoological point of view; until his time, animals had been studied, even in the universities, chiefly in relation to their supposed medicinal virtues. Concurrently the anatomists, who had mainly confined themselves to exploring the structure of the human body and of the animals nearest to man, extended their area of study. Through John Hunter and Georges Cuvier an immense body of knowledge as to the anatomy of all kinds of animals was accumulated and systematised, to which the name Comparative Anatomy was applied—more especially by Cuvier and his followers.

In this country, and very generally elsewhere, the study of "comparative anatomy" was carried on by men like Hunter, members of the medical profession, even practitioners. In the earlier half of the present century it was usual to find in the universities of Germany, as well as of Britain, that anatomy, including the wider comparative anatomy, as well as the topography of man required for medical purposes, together with physiology and even pathological anatomy, were all taught by one professor. Thus the great Johannes Müller discharged this multiple function until his death in Berlin in 1858.

It is not therefore surprising that when the Oxford University Commissioners of 1856 revived the ancient foundation of Linacre, they charged the new professor with the teaching of both anatomy and physiology. To this large task Rolleston, the first Linacre professor, devoted himself with characteristic energy and with a breadth of view which few nowadays could command. Rolleston taught physiology, comparative anatomy, as well as that topographical anatomy of the human body which medical training demands—a pursuit which he loved to call "anthropotomy." Anthropotomy was not neglected in Rolleston's time; those students of the University who wished to pursue human dissections in Oxford found the necessary material and assistance in his department.

The more recent Commissioners (of 1880) came to the conclusion that it was desirable that a separate chair of Physiology should be founded in the University of Oxford, and accordingly instituted such a professorship from the funds of Magdalen College, whilst they altered the title and scope of the Linacre chair to "Human and Comparative Anatomy." It was to the Linacre chair thus modified that Moseley was appointed on the death of Rolleston in 1881, whilst subsequently Burdon Sanderson was appointed to the newly-created Waynflete (Magdalen) chair of Physiology.

A further division of labour now became desirable. The teaching of anthropotomy—the medical student's necessary groundwork—could not be carried on personally by the same professor who was charged with the subject-matter of Cuvier's life-work. It was a question between either assigning to the Linacre Professor a specially qualified assistant to superintend the dissecting-room of Human Anatomy, or appointing an independent lecturer in that subject. The latter course seemed to be the better, and Mr. Arthur Thomson, the senior demonstrator in the Medical School of Edinburgh University, was appointed as Lecturer in Human Anatomy in Oxford. The expressed purpose of this appointment was to relieve the Linacre professor of that part of his duties which consisted in teaching human anatomy for the specific purposes of medical education, and it was in no way proposed to remove from the professor his functions as a teacher of the anatomy of man in its morphological aspects and his duties as guardian of the anatomical and ethnological collections of the University.

On the death of Prof. Moseley, in 1891, I was appointed his successor in the Linacre chair of Human and Comparative Anatomy. The University voted funds for the building and fitting of additional laboratories for the Linacre professor (which were completed and opened without ceremony last year) at the same time that we approved the expenditure necessary for a new laboratory for Human Anatomy. At my suggestion a statute was prepared, and has received the assent of her Majesty in Council, removing the words "human and" from the title of the Linacre professor; so that the professorship in question is now the "Linacre professorship of Comparative Anatomy," whilst the duty of teaching anthropotomy or that special study of the topography of the human body which medical training requires, is definitely assigned to the "lecturer in Human Anatomy."

The consideration of human structure in relation to that of vertebrate animals—the morphology of man as of other animals—the "comparative" anatomy of man and animals—remain as heretofore the charge of the Linacre professorship. In short, the treatment of man's structure as part of the general science of morphology remains necessarily the business of the professor of Comparative Anatomy. The exposition of the geography of the human body, in which the surgeon, and to some extent the physician, must be as expert and familiar as a townsman in the pathways of the city in which he resides and does his business—is the distinctive function of the teacher of "human anatomy" in a medical school. It is for this special purpose that we have just added to the excellent laboratories and museum already arranged and used for the study of anatomy in its widest sense, a new dissecting room and adjuncts adapted to the reception and proper treatment of human bodies.

It is to be hoped that the effort now made by the University to establish technical training in anthropotomy as an independent ffshoot of the Linacre professorship may be successful. The older laboratories and museum-collections of Comparative Anatomy and Craniology, which are attached to the Linacre professorship, do not need advertisement; they have been rendered famous by the scientific discoveries and researches of those who in the past have held that office. Of the new rooms for the study of anthropotomy, we have the expectation that they will in the future, under the care of successive lecturers in Human Anatomy, add to the attractions of the University as a centre of professional training, and justify the policy which has led us to the expenditure necessary for their erection. E. RAY LANKESTER.

## *CELESTIAL PHOTOGRAPHY AT THE PARIS OBSERVATORY.*

A DESCRIPTION of the work that is being done in connection with the photographic star chart and catalogue is given in *La Nature* by M. A. Fraissinet. We are indebted to that journal for the accompanying illustrations and the following information referring to them.

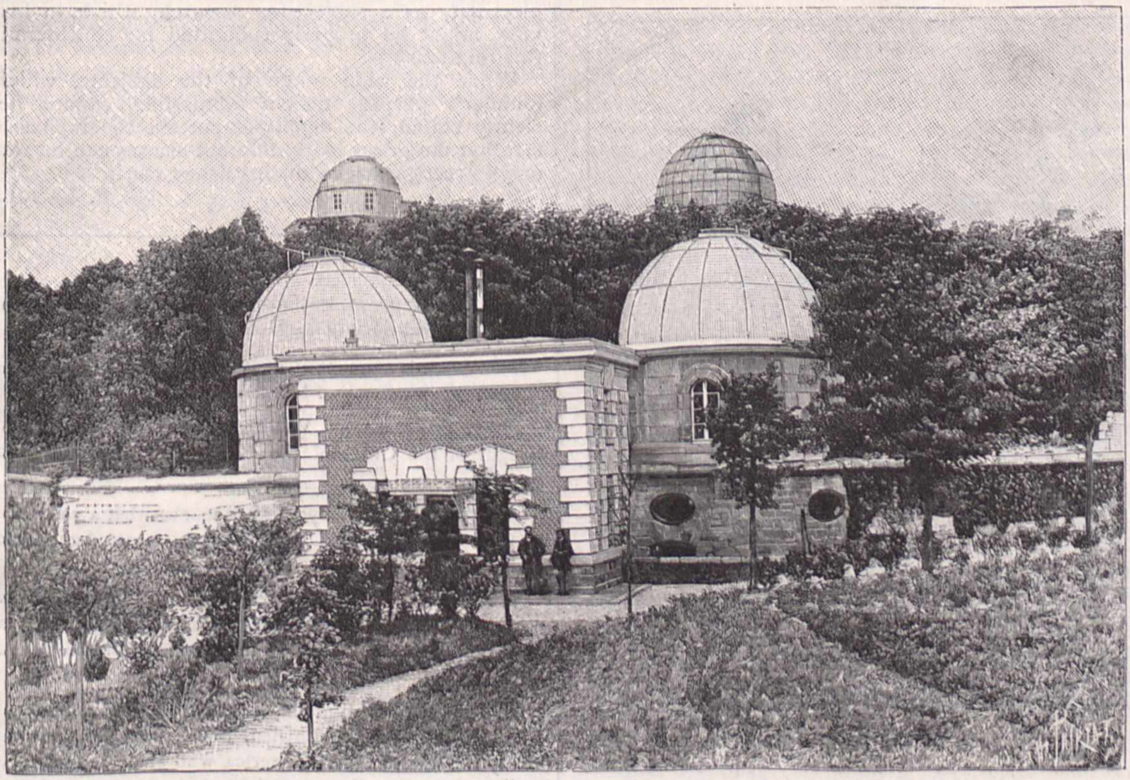


FIG. 1.—The part of the Paris Observatory devoted to the Photographic Star Chart.

A special bureau for the measurement of the stellar photographs designed for the catalogue was organised at the Paris observatory in 1892.

To accommodate the new service the building shown in Fig. 1 was erected. On the first floor of the new building a photographic laboratory has been established. The ground floor has been set apart for the service of the measurement of clichés organised by MM. Henry. This service is under the direction of Mdlle. Klumpke, who is assisted by four other ladies.

Two measuring machines were provided last year of the new kind devised by Gautier, and supplied to the French and some foreign co-operating observatories.

The instrument is illustrated by Fig. 2. It consists at the lower part of a fixed horizontal piece having two rails on which a carriage may be caused to slide by means of a screw. Under the face of the carriage inclined to the horizontal at an angle of 45° is another screw geared to a frame on which moves a circle carrying the fixed holder which receives the plate to be measured.

Each plate after it has been put in the holder can be subjected to three movements: a movement of rotation, which serves the purposes of orientation, and two rectilinear movements, one of which takes place on the horizontal and the other on the inclined plane. Each of the rectilinear movements can be roughly read off by means of the millimetre scales attached to the planes. Fractions of a scale division are determined by means of the micrometer screws. The head of each screw is divided into one hundred parts, and this is further divided into ten by estimation. Since, then, one turn of the screw corresponds to one minute of arc, it is possible to read to 0·6″ by means of the micrometer divisions.

It is hoped that in five or six years all the plates required from each observatory will have been obtained,

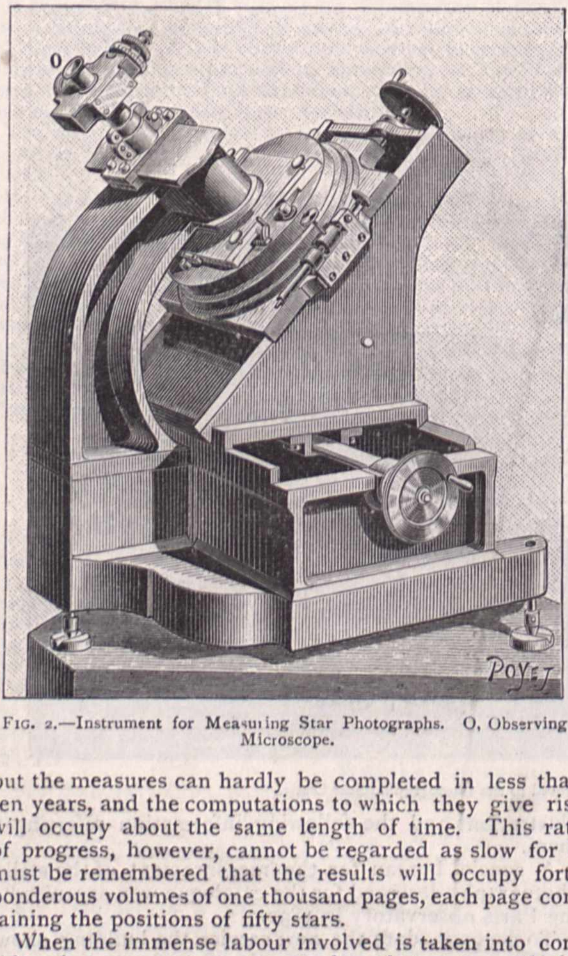



FIG. 2.—Instrument for Measuring Star Photographs. O, Observing Microscope.

but the measures can hardly be completed in less than ten years, and the computations to which they give rise will occupy about the same length of time. This rate of progress, however, cannot be regarded as slow for it must be remembered that the results will occupy forty ponderous volumes of one thousand pages, each page containing the positions of fifty stars.

When the immense labour involved is taken into consideration, one ceases to wonder that some of the co-operating observatories are unable to keep up with the measurements. It is to be hoped that lack of funds may not be allowed to prevent the obtaining of proper assistance in such cases, or to retard the publication of the results as soon as they are ready.

## *SMITHSONIAN INSTITUTION: HODGKINS FUND PRIZES.*

IN answer to inquiries, and in further explanation of statements made in the Hodgkins circular (NATURE, vol. xlvii. p. 611), it may be added that *any* branch of natural science may offer a subject of discussion for the Hodgkins prizes where this subject is related to the study of the atmosphere in connection with the welfare of man.

Thus, the anthropologist may consider the history of man as affected by climate through the atmosphere; the geologist may study in this special connection the crust of the earth, whose constituents and whose form are largely modified by atmospheric influences; the botanist, the atmospheric relations of the life of the plant; the electrician, atmospheric electricity; the mathematician and physicist, problems of ærodynamics in their utilitarian application; and so on through the circle of the natural sciences, both biological and physical, of which there is perhaps not one which is necessarily excluded.

In illustration of the donor's wishes, which the Institution desires scrupulously to observe, it may be added that Mr. Hodgkins illustrated the catholicity of his plan by citing the work of the late Paul Bert in atmospheric electricity as a subject for research, which, in his own view, might be properly submitted for consideration in this relationship.

While the wide range of the subjects, which the founder's purpose makes admissible, cannot be too clearly stated, it is equally important to emphasise the fact that the prizes in the different classes can be awarded only in recognition of distinguished merit.

S. P. LANGLEY.

## *NOTES.*

PROF. VIRCHOW was elected honorary president of the Berlin Medical Society on Monday.

THE death is announced of Prof. Léon Lefort, vice-president of the Paris Academy of Medicine.

PROF. SCHAUTA, of Vienna, has received the Cross of a Knight of the Order of the North Star from the King of Sweden.

A DISPATCH from Valparaiso announces that a volcanic eruption has occurred near Calbuco, causing great damage to that town.

WE are glad to learn that Prof. von Helmholtz is recovering from the injuries he sustained from falling down a companion ladder on board the *Saale,* while returning from his recent visit to America.

THE Franklin Institute has received the sum of one thousand dollars from Mr. A. A. Boyden, to be rewarded as a premium to any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity.

MISS ORMEROD has received a report from her correspondent on crop insect pests in Norway to the effect that the Hessian fly is now for the first time recorded as occurring in Norway and doing damage to barley. Specimens of the infested straw, showing the presence of the flat brown chrysalis of the *Cecidomyia destructor,* were sent with the report.

DR. J. W. GREGORY has returned from East Africa after a very successful investigation of the geology and natural history of Mount Kenia and the neighbouring region. His observations, and the large number of geological, zoological, and botanical specimens collected during the expedition, add considerably to our knowledge of the character and capabilities of British East Africa.

WITH reference to the reported outbreak of cholera at Greenwich, Dr. Thorne Thorne reports that, whilst in certain important respects the materials that have been investigated suggested that cholera was in question, it now transpires that in every case examined one or more of the ordinary proofs as to this have been wanting, and Dr. Klein concludes that the outbreak is not one of true cholera.

AFTER the 1st of November the time of Central Europe, which is employed in Sweden, Germany, Austria, Hungary, Bosnia, and Servia, and is reckoned from the fifteenth degree of longitude, will be adopted upon Italian railway-systems. Railway time in Italy will therefore be exactly one hour in advance of Greenwich time, and 50 min. 39 secs. in advance of Paris mean time, the difference of time between Greenwich and Paris being 9 min. 21 secs.

THE passengers on board the North German Lloyd s.s. *Oldenburg*, which left Genoa for the East on the 23rd inst., include Dr. W. Kükenthal, Ritter Professor in the University of Jena, who proceeds, under the auspices of the Senckenberg Naturalists' Society, on a twelve months' zoological expedition to the Moluccas. After a short sojourn in Java, he will make Ternate his headquarters, exploring the surrounding islands, and especially the island of Halmahera. We are informed that Prof. Kükenthal was the elected one of fifty zoologists who sought the leadership of the expedition. The energy and endurance which he displayed in his recent investigations in the Arctic Seas led to the accumulation of rich material, and they justify an anticipation of good results from the present, less tropical, journey.

THE exhibition arranged by the Deutsche Mathematiker-Vereinigung at Munich, of models, drawings, apparatus, and instruments used in pure and applied mathematics, was closed on October 5. From a circular that has been issued by the Association we learn that the exhibition was in every respect successful. Owing to the support given by the Royal Bavarian Government and the Ministry of the Interior, it was possible to considerably extend the plans originally proposed. The success of the undertaking was largely due to the kindness of the many public bodies and private individuals who lent apparatus, &c., and have participated in the work, often at a pecuniary sacrifice. The committee of the Association desire to express their thanks to exhibitors and others who have supported them during the last two years.

THE following gentlemen have been nominated for election on the council of the London Mathematical Society for the session 1893-4 :—Mr. A. B. Kempe, F.R.S. (President); Messrs. A. B. Basset, F.R.S., E. B. Elliott, F.R.S., A. G. Greenhill, F.R.S. (Vice-Presidents); Dr. J. Larmor, F.R.S. (Treasurer); Messrs. M. Jenkins and R. Tucker (Hon. Secs.). Other members—Dr. Forsyth, F.R.S., Dr. Glaisher, F.R.S., Dr. Hill, Dr. Hobson, F.R.S., Mr. Love, Major Macmahon, F.R.S., Mr. J. J. Walker, F.R.S. The new nominees are Lt.-Col. J. R. Campbell and Lt.-Col. A. J. C. Cunningham, R.E., in the place of Messrs. H. F. Baker and J. Hammond, who retire. The annual general meeting (November 9) will be made special for the consideration of the following resolution, which will be moved by the council : "That the London Mathematical Society be incorporated as a Limited Liability Company under Section 23 of the Companies Act, 1867; and that the Council be empowered to take the necessary steps to carry this resolution into effect." The presentation of the De Morgan medal, awarded by the council in June last, will be made at the same meeting, to Prof. Felix Klein, the medallist, who expects to be present to receive it in person.

WE have received the first part of the second half of vol. iii. of Cohn's *Kryptogamen-Flora von Schlesien*, devoted to the fungi, under the editorship of Dr. J. Schrœter. The present part commences the description of the Ascomycetes, and is occupied by a portion only of the first sub-order, the Discomycetes.

THE second part of vol. vi. of the *Journal* of the College of Science of the Imperial University of Japan is entirely occupied by an elaborate paper, by Prof. Sadahisa Matsuda, on the anatomy of the Magnoliaceæ. It is illustrated by four plates exhibiting the excellence of work to which we are now accustomed in the products of the Japanese press.

DR. R. A. PHILIPPI contributes to the *Verhandlungen* of the German Scientific Society of Santiago in Chile two interesting papers on the "Fauna and Flora of Chile and Argentinia." With regard to the flora he points out that, notwithstanding the wide difference between those of Chile and of Europe, the number of identical species is greater than Europe has in common with South Africa or Australia; while both the flora and fauna of Chile differ in a very remarkable way from those of Argentinia. Dr. Philippi argues from these facts that the mountain range of the Cordilleras must have been formed before the development of the fauna and flora of these countries.

AMONG other excerpts from the Transactions of the Academy of Science of St. Louis, vol. vi., that have recently been received, the following are of interest:—"The Opening of the Buds of Some Woody Plants," by Mr. A. S. Hitchcock. This paper records observations made during the spring of 1892. In "Flowers and Insects—Labiatæ" Mr. Charles Robertson gives an account of the pollinators of various Labiates. Of the twenty-three species described, nine have long-tongued bees as their principal visitors, and eight show special adaptation to bees in general. No species was found to be adapted to the lower hymenoptera, though ten species were visited by them. Diptera occurred as visitors of nineteen species, and butterflies on all but five species. The ruby-throated humming-bird only visited *Monarda, Bradburniana*, and *M. fistulosa*, and beetles were found only on the six least specialised flowers investigated. Mr. J. Christian Bay has prepared the materials for a monograph on Inuline, in the form of a list of papers on the subject, published up to the end of 1890.

DR. EDMUND NAUMANN, the well-known writer on Japan Geology, has just published an interesting paper in *Petermanns Mettheilungen* (Ergänzungsheft, No. 108), under the title of "Neue Beiträge zur Geologie und Geographie Japans." Three coloured plates are given—plate i. the crater of Shiranesan and views of Bandai, two volcanoes active within recent years; plate ii. a stereographic representation of the geology of Japan (scale (1 : 5,000,000); plate iii. the general contours of the country (scale 1 : 2,600,000).

JAPAN is possibly one of the best illustrations of the value of geological knowledge in throwing light and colour on the geographical features of a country. Dr. Naumann, in his account of the geological structure of the great mountain chain, emphasises the presence of a crystalline core throughout the whole length of the islands, and against it the sedimentary deposits may be said to have a zonal distribution. He proves that while there was prepalæozoic folding in these crystalline schists and gneisses, the main period of mountain-movement and the upheaval of the greater portion of Japan took place in early Mesozoic times. The intrusions of the enormous granitic masses are probably of late Mesozoic age, and since that time there have been several periods of volcanic activity, constant recurrences taking place along ancient lines of weakness. The result of the particular processes of mountain-making in Japan on the present configuration of its surface, and the correlation of the rocks with the various types of landscape, are then briefly described.

THE "Fossa magna" is an apt name given some years ago by Dr. Naumann to that curious well-marked depression between the north and south wings of the main island—a de pression bordered by the highest summits in Japan, and occupied by a girdle of volcanoes. Ed. Suess ("Antlitz d. Erde," bd. ii. p. 225) and the Japanese geologist, Harada, are of opinion that the mountains in the north and south wings belong to two independent chains which during the period of upheaval had been pushed against one another at this "fossa magna," and they compare the case of Hindu Kush and the Himalayas. Dr. Naumann still adheres to the view he had previously advanced, namely, that the mountains of the north and south wings form one chain, which after its upheaval was broken by a transverse fault along the "fossa magna," the transverse fault being of later date than the main longitudinal fault on the west or inner side of the islands and cutting through it. The eruptive activity and frequent subsidences within the "fossa" have merely taken advantage of this important tektonic break.

THE Report on the Botanic Gardens at Georgetown, British Guiana, for the year 1891–92, contains some interesting information on the meteorology of that colony for the year 1891. The rainfall was much above the average, though not so much so as in the two previous years. For the nine years ending 1888 the average fall was 80·5 inches, but for the three years ending 1891 the average fall has been 119·6 inches; the returns from various stations show that there is a gradual increase in the rainfall from the south to the north of the colony. The number of days on which the sun shone was 351, leaving only 14 days of unbroken cloudiness; the mean daily sunshine for the year was 7h. 13m. The maximum day temperature in the shade ranged from 84° in February to 90° in September and October. The minimum night temperature ranged from 71° to 74°, and the solar radiation from 148° to 157°.

A CAREFUL study of the vapour pressures of aqueous solutions has been carried out by C. Dieterici, of Breslau, who has communicated his results to *Wiedemann's Annalen*. The determinations were made for 0° C. by means of an apparatus designed for the appreciation of very feeble pressures. The gauge used was an aneroid box with a German silver disc, which has the advantage of yielding to a great extent without elastic fatigue. The motions of the centre of the disc were transferred to a mirror suspended in jewelled bearings by means of a light watchmaker's arbor, the connection being made by a cocoon thread, and the mirror being gently held in position by a small spiral spring. Deflections were measured by reflected scale and telescope. The gauge was fitted to a tube which could be filled with the vapour of the solution surrounded by melting ice, or could be exhausted at pleasure. The gauge and tube were enclosed in another air-tight space which could be filled with pure water vapour at 0° C. or exhausted. The pressure of the water vapour produced a deflection of 170 scale divisions, equivalent to 2·31 mm. of mercury. The author discusses at length the bearing of his results upon Van't Hoff's dissociation theory, and upon the kinetic theory of gases. The curves exhibiting the relation between degree of concentration and the corresponding vapour pressure have the common characteristic that with the concentration increasing from an infinitely dilute solution to about 26 in multiples of the normal solution, they commence at approximately the same angle, then fall with a steep incline, and finally tend to become parallel to the axis of abscissæ. At about 26 the curve of sulphuric acid cuts this axis, showing that the action between the acid and the water counterbalances the osmotic pressure necessary for evaporation. The other bodies investigated were glycerine, phosphoric acid, and the hydrates of potassium and sodium, enumerated in the order of decreasing vapour pressures.

THE current number of the *Philosophical Magazine* contains an account of the most recent determinations of the refractive indices of liquid nitrogen and air, carried out by Profs. Liveing and Dewar. Owing to the bubbles constantly rising from liquid nitrogen, the prism method could not be made to give accurate results. The refractive index was therefore determined by finding the angle of total reflection. The liquid nitrogen, or air, was enclosed in a cylindrical vessel containing two vertical plane-parallel plates of glass with a film of air between them. The light from an electric discharge or a monochromatic flame was sent through a slit into the vessel, a suitable portion being cut off by black paper screens, and an image of the slit was thrown upon the slit of a spectroscope by the glass vessel itself. The vertical plates were turned round a vertical axis till the extinction of the image indicated that the angle of total reflection had been reached. The refractive index thus obtained for sodium light was 1·226 in the case of liquid oxygen (the prism method gave 1·2236), 1·2062 for liquid air, and 1·2053 for liquid nitrogen at −190°, and of density 0·89. The nitrogen probably contained 5 per cent. of oxygen. The refraction constant of nitrogen is therefore 0·225 as determined from the liquefied substance. Mascart gives 0·237 for the constant as determined from gaseous nitrogen. The two results are in as fair an agreement as could be expected, considering the difficulties surrounding the measurements.

WIEDEMANN'S *Annalen de Physique et de Chemie* for October contains a paper, by R. J. Holland, on electrical conductivity of copper chloride solution. The solution, whose resistance was to be measured, was enclosed in a dumb-bell shaped glass vessel about 10 c.m. long, the electrodes, which had a surface of 2¼ sq. c.m., being fixed at the ends. In order to determine the mean section of the tube between the electrodes, it was filled with a solution of sodium chloride and the resistance measured, then using Kohlrausch's results for the resistance of the salt solution the mean section was calculated. The resistance was measured by means of a Wheatstone's bridge, with an alternating current and telephone. All the strengths of copper chloride solution examined show a regular, though slight, increase of conductivity at high temperature, this increase being different for solutions of different degrees of concentration. The maximum conductivity was obtained with a solution containing about 18 per cent. of the dried salt. The temperature coefficient varies with the degree of concentration, and attains a maximum value for a temperature of about 40° C. When the difference in concentration is taken into account, the results obtained agree very well with those obtained by Trötsch and Wiedemann, though they do not show so satisfactory an agreement with those obtained by Isaachsen.

*L'Elettricista* for October contains a paper by Dr. Monti, in which he gives the results of the experiments he has undertaken in order, if possible, to account for the fact that the values obtained by Macfarlane in 1877 for the difference of potential required to pierce a plate of paraffin were very much smaller than those obtained by Steinmetz and himself. Macfarlane found that the difference of potential required to pierce a plate of paraffin 3 mm. thick was 39,000 volts, while Dr. Monti finds that to cause a discharge to pass between two knobs 5 mm. in diameter through a layer of paraffin 1 mm. thick it requires a difference of potential of 155,000 volts. The author employed paraffin which melted at 54·76° C. The terminals were brass balls which were fixed within a glass tube about 10 c.m. long. Their distance apart having been measured by means of a microscope, the paraffin was melted and allowed to cool in a partial vacuum. It was then again melted and allowed to solidify under the ordinary pressure. By this means the formation of air bubbles within the paraffin was avoided, and it is to the presence of such air bubbles in the slab of paraffin employed by Macfarlane that Dr. Monti attributes the difference in the values obtained.

AN electrical method of fog-signalling, which has great possibilities before it, has been invented by an electrician in the employ of the Great Northern Railway Company. A wire is laid by means of a pipe from the signal-box to the various signals, at which points brushes composed of copper wire project some four or five inches above the side of the rail nearest the signal. To the foot-plate of the engine a similar brush is fixed, connecting with an indicator and bell on the engine. If the signal be at danger the two brushes coming in contact has the effect of ringing the bell, and indicating to the driver by means of a miniature signal fixed on his engine that the line is not clear. The arrangement can be switched off in fine weather. The process, which is in working order at Wood Green, has proved so satisfactory that the company have decided to fit up the suburban lines, and eventually the whole of their system.

THE report of the meeting of the *Société Helvétique des Sciences Naturelles*, held at Basle in September 1892, has just been published.

*Natur und Haus*, edited by Dr. L. Staby and Herr Hesdörffer, begins its second year with a number full of articles on a variety of scientific topics. The journal must help to popularise science in the Fatherland, for its contents—both text and illustration—are excellent.

THE second year's meetings of the University Extension Philosophical Society will commence on Friday, October 27, at 8 p.m., when Mr. Bernard Bosanquet will give an address on "Atomism in Psychology," at Whitelands College, Chelsea. Among other gentlemen who will read papers during the present year are Prof. Sully, Mr. G. F. Stont, Mr. C. S. Loch, and Mr. P. H. Wicksteed.

THE trustees of the Australian Museum have issued their thirty-ninth annual report. We are sorry to notice that there has been a slight falling off in the attendance of visitors during the year 1892. The number of visitors was 130,701, being fewer by 2144 than in the previous year. The average week-day attendance was 265, and that for Sundays 712.

THE following lectures will be delivered at the Royal Victoria Hall during November:—November 7, Mr. Francis Bond, on "Norway and the Norwegians"; November 14, Prof. H. G. Seeley, F.R.S., on "Skulls"; November 21, Mr. James Swinburne, on "The Mechanics of Street Toys"; November 28, Mr. Douglas Carnegie, on "The Philosopher's Stone, or the Royal Road to Health and Wealth."

A NEW and revised edition of "Our Reptiles and Batrachians," by Dr. M. C. Cooke, has been published by Messrs. W. H. Allen and Co. As the author remarked in the preface of the original edition, he aimed at producing "a popular volume on a rather unpopular subject," and not a work for the man of science. The fact that a new edition has been called for shows that the general public appreciate tales of snake-stones and the incarceration of frogs in blocks of granite; of the "toad's envenomed juice," and incombustible salamanders. However, in the reading of these accounts something is learned concerning the habits and characters of the lizards, snakes, newts, toads, frogs, and tortoises indigenous to Great Britain; so instruction is happily combined with amusement.

THE "Zoological Record for 1892," edited by Mr. David Sharp, F.R.S., and being the twenty-ninth volume of zoological literature, has just been published. The scope of the Record has been greatly enlarged, and an index of special subjects has been included in each department, in addition to the list of titles and the taxonomical arrangement according to genera. It has not been possible, however, to make a complete epitome of palæontological literature; indeed, Mr. Sharp thinks that palæontologists should undertake the compilation of a separate record. We are inclined to agree with this. Everyone knows that an incomplete record is of very little use; for valuable time may be wasted in searching through it for references which it does not contain. But if every branch of science had a publication which did for it what the "Zoological Record" does for zoology, scientific papers would be in a fair way of organisation.

SOME years ago Prof. Frank Clowes communicated to the Royal Society and to the Aberdeen meeting of the British Association the fact that there occurred in the neighbourhood of Nottingham a large area of sandstone, in which the cementing material was wholly crystalline barium sulphate. The subject was mentioned again in the Geological Section at the recent Nottingham meeting of the British Association, and several geologists gave instances of similar sandstone occurring in other parts of England. Prof. Clowes writes that he would be glad to learn of the occurrence of such sandstone in any locality, and to receive specimens for examination and chemical analysis.

WE have received part 4, vol. v. of the Transactions of the Norfolk and Norwich Naturalists' Society, and are glad to find that both financially and numerically the society is in a satisfactory condition. Of the 250 members many are non-resident in the county, and it is probably owing to their help that for a small subscription the society is able to issue a goodly publication consisting of more than 190 pages. The address of the president, Mr. H. B. Woodward, of the Geological Survey, deals mainly with the geology of the county, which presents many very interesting features, and he also contributes a memoir (with portrait) of the late Caleb B. Rose, one of the fathers of Norfolk geology. These memoirs of local naturalists of note form a marked feature in the society's publication, as also do the lists of the fauna and flora of the county, the twelfth of which, namely the Coleoptera, by Mr. Jas. Edwards, in which 1728 species are enumerated, is included in the present number. Amongst the other contributions are a very interesting paper on tortoises in domestication, by Sir Peter Eade, containing measurements and weights of two tortoises, taken annually since the year 1886; notes on the occurrence of the Siberian pectoral sandpiper and Sowerby's whale in Norfolk, on the Lapland bunting, the Holkham shooting parties at the commencement of the present century, on Norfolk slugs, and other matters of local and general interest.

IN these Notes on August 24, reference was made to some recent modifications in the method for staining the cilia of micro-organisms. Strauss mentions in the *Bulletin Médicale*, 1892, No. 51, that he has succeeded in colouring the cilia of the cholera spirillum, the spirillum Metschnikowi, and Finkler Prior's spirillum in a *living* condition. For this purpose broth cultures, from 1–3 days old, are employed, one needle-loop of which is placed on a microscopic slip and carefully mixed with a needle-loop of Ziehl's fuchsin solution diluted with water (1 : 3-4). A cover glass is then superposed, and the preparation examined under the microscope as rapidly as possible. The above-mentioned organisms become intensely red in colour, and many retain their motility for a short time, and at one of the pores may be seen the extremely thin corkscrew-shaped or wavy cilium-tinted pale red containing more highly coloured granules, which are disposed in longitudinal series in its interior. When the organism is no longer in a living condition, the cilia may still be seen although less distinctly, whilst numerous isolated and detached cilia may be seen moving with great activity in the fluid. Strauss has not so far been successful in exhibiting by this method the cilia of other organisms in a living condition.

IT is usual in cases of thrush to recommend the use of alkaline substances in order to counteract the acidity of the mouth, which is generally supposed to favour the growth of the thrush fungus. Some recent researches of Marantonio ("Contributo alla biologia del fungo del Mughetto" Istituto d'Igiene di Roma, vol. xii. 1893, p. 199) show, however, that this fungus grows abundantly in strongly alkaline as well as in acid media. Experiments were made to ascertain what substances exerted a bactericidal action on this organism, special attention being given to those usually prescribed in the treatment of thrush. It was found that many of these were quite ineffective, on the other hand salicylic acid, amongst others, was highly efficacious; these laboratory experiments were, moreover, confirmed in actual practice, for extremely encouraging results were obtained when this substance was tried in some cases of thrush in children in one of the hospitals in Rome. In some hospitals it appears that thrush is endemic, and Marantonio was able to isolate out the organism of this disease from the dust in the interstices of the flooring of a children's ward; considering that the fungus can successfully resist the effects of desiccation over four and a half months, this fact is not surprising. The behaviour of this organism when exposed to sunshine was also investigated. Portions of vigorous agar-cultures were spread in thin layers on pieces of white cardboard, which were placed in glass boxes, some being preserved in the dark, whilst others were insolated for various lengths of time. It was found that thirteen hours' exposure to direct sunshine retarded the development of the fungus, whilst when prolonged for seventeen hours it was completely destroyed. The great mortality which prevails amongst children suffering from thrush should render these elaborate and carefully-conducted experiments of especial interest and importance.

CARBIDE of boron has been isolated by Dr. Mühlhäuser, of the University of Chicago, and is described by him in the current publication of the *Zeitschrift für Anorganische Chemie.* It proves to be an extremely stable substance, being capable of successfully resisting the action of almost all the usual solvents and reagents. Its composition has been ascertained by taking advantage of the fact that chromate of lead is capable of oxidising it at the usual temperature of a combustion furnace. The analytical data indicate the simple empirical formula BC, but its constitution is assumed to correspond to double that formula, namely $B_2C_2$ or $\begin{array}{l} C \equiv B \\ | \\ C \equiv B \end{array}$. Boron carbide was prepared by heating boric anhydride with the hard variety of carbon employed for making the terminals of electric arc lamps. The reaction proceeds in accordance with the equation: $B_2O_3 + 5C = B_2C_2 + 3CO$. Five parts of borax were dissolved in twenty parts of water, one part of sulphuric acid was added, and the solution allowed to cool. The crystals of boric acid which were formed during the cooling were separated by filtration, washed with water, dried, fused, and finally heated to low redness, by which they were dehydrated, and boric anhydride produced. The powdered boric anhydride was then mixed with the powdered electrode carbon, in the proportion of five parts of the former to eight parts of the latter, and the mixture disposed upon a suitable carbon support between the terminals of a powerful arc lamp. Upon the generation of the arc by means of a current of 350 ampères action almost immediately commenced, the mixture of boric anhydride and carbon fusing and evolving a considerable amount of gas with effervescence. The operation is concluded when the effervescence ceases, when the current should be switched off and the product allowed to cool. Carbide of boron is thus produced in the form of black graphitoidal spherules, frequently aggregated so as to resemble the shape of a bunch of grapes. The spherules possess a bright metallic lustre. They may be freed from traces of the ingredients of the mixture used in their preparation by heating for a few hours in a platinum crucible, then powdering, and repeatedly treating the powder with hydrochloric acid, water, a mixture of hydrofluoric and sulphuric acids, and finally once more with distilled water. The powder thus prepared yields numbers on combustion with chromate of lead which agree closely with the formula above given. Carbide of boron closely resembles graphite in outward appearance; it blackens the fingers in a similar manner, and the coating thus transferred possesses the same bright metallic lustre and greasy feel. Examined under the microscope it appears bluish black and transparent, and reflects light with chromatic effects. When heated to a high temperature the powder cakes together, forming a soft mass, which is readily malleable and capable of being rolled. At a very high temperature it completely fuses to a liquid much resembling a molten metal. It burns only with great difficulty in oxygen, but is combustible, as above stated, with chromate of lead. It is insoluble in all the ordinary solvents, but fused caustic or carbonated alkalies attack it with formation of borate of the alkali and liberation of carbon.

NOTES from the Marine Biological Station, Plymouth.—Last week's captures include the Mollusca *Lima Loscombii* and *Pholadidea papyracea*, and the Schizopoda *Leptomysis gracilis* and a number of *Erythrops elegans*. The floating fauna is unusually rich in Diatoms and Dinoflagellates, and a few Radiolaria are still to be seen. The larvæ of *Polynoë*, *Chætopterus* and *Terebella* are fairly numerous, and *Cyphonantes* and larval Lamellibranchs are plentiful. On the other hand the larvæ of Decapoda (esp. of Brachyura) are scarce, and a few Ophiuria *Plutei* are the only representatives of the Echinoderma. The more oceanic forms (*Muggiæa*, *Podon* and *Evadne*, &c.) have of late become increasingly scarce. The Hydroid *Aglaophenia tubulifera* is now breeding, and a few *Erythrops elegans* contain late embryoes in their brood-pouches.

THE additions to the Zoological Society's Gardens during the past week include a Wanderoo Monkey (*Macacus silenus*, ♀) from Cochin, presented by Capt. Morgan; two Macaque Monkeys (*Macacus cynomolgus*, ♂ ♀) from India, presented respectively by Mr. John Cook and Mr. Stanley Sinclair; a Chacma Baboon (*Cynocephalus porcarius*, ♀), two Common Quails (*Coturnix communis*) from South Africa, presented by Capt. F. Baker; two Manatees (*Manatus america*, ♀ *et juv.*) from Manatee Bay, Jamaica, presented by Sir Henry A. Blake, K.C.M.G.; a Black-headed Lemur (*Lemur brunneus*, ♀) from Madagascar, presented by Miss Hoare; a Rufous Rat Kangaroo (*Hypsiprymnus rufescens*) from Australia, presented by Kenneth Crawley, Esq., R.N.; a Kite (*Milvus ictinus*) from the Canary Islands, presented by Mr. E. G. Meade-Waldo, F.Z.S.; two Purple Porphyrios (*Porphyrio cæruleus*) South-east European, presented by Mr. Joseph S. Whitaker, F.Z.S.; a Turtle Dove (*Turtur communis*) British, presented by Miss Alice L. West; a Kinkajou (*Cercoleptes caudivolvulus*), a King Vulture (*Gypagus papa juv.*), a Common Boa (*Boa constrictor*) from South America, two Ospreys (*Pandion haliætus*) from Hayti, W.I.; two Rufous-necked Weaver Birds (*Hyphantornis textor*) from South Africa; a Dunlin (*Tringa alpinus*) British, purchased; a Burchell's Zebra (*Equus burchelli*, ♀), a Wapiti Deer (*Cervus canadensis*, ♀) born in the Gardens.

## OUR ASTRONOMICAL COLUMN.

A NEW COMET.—*Edinburgh Circular* (No. 40, dated October 19) informs us of the discovery of a comet by Mr. W. R. Brooks, of Geneva, N.Y., at 15h. 52m. local time, its place then being R.A. 12h. 21m. N. declination 12° 55′. The comet has also been observed at Hamburg, October 17, 17h. 5·8m. Hamburg mean time. R.A. 12h. 22m. 42·9s. Declination + 13° 25′ 24″. It has a tail, and is about as bright as a star of the ninth magnitude.

DETERMINATION OF GEOGRAPHICAL LONGITUDE.—In part 15 (August 1) of the *Zeitschrift für Vermessungswesen*, Herr C. Runge, of the Technical Hochschule, Hannover, gives a very interesting account of his results in determining geographical longitude with an ordinary camera. The negative from which the results were obtained, was taken on June 17, the camera being pointed to the new moon. Eight exposures were made one after the other, with intervals of about two minutes. Without moving the camera, and after an interval of about thirty minutes, another series of pictures was taken (on the same plate), the objects this time being some stars in Leo, which were allowed to record their trails on the plate for the period of about an hour and a quarter with regular intermittent breaks of five seconds. The times of exposure were noted with an ordinary watch, and the measuring of the plates made with an accurate micrometer. Dealing here only with the accuracy of the method, we may say that the declination of the moon can be determined to 20″, and in some cases with greater accuracy; in the example given the differences between the measured and calculated values were + 11″, – 19″, + 15″, – 6′. In the measuring of the moon-distance Herr Runge says that although this was the first trial, and the star-images were not all that could be desired, yet the accuracy was surprising, and can perhaps be still increased, even without the help of any "mechanische Hülpmittel." Since the above example was made he has obtained the geographical latitude and local time by this photographic means, and with excellent results. The instrument employed consisted of a simple camera with a so-called "gruppenantiplanet" objective, by Steinheil in München, with a focal length of 24 cm. The stop used for the above plate had a diameter of 17 mm.

ASTRONOMY AND ASTRO-PHYSICS AT CHICAGO.—A few of the many papers on astronomy which were read at the series of meetings that commenced at Chicago on August 22 appear in this month's *Astronomy and Astro-Physics*, and as they are too long for individual description, we give simply the titles of the papers and their authors: "Great Telescopes of the Future," by Alvan G. Clark. This deals with the subject completely from the object-glass point of view.—"A Field for Woman's Work in Astronomy," by Mrs. M. Fleming; "Engineering Problems in the Construction of Large Refracting Telescopes," by Worcester R. Warner. This is accompanied by a photograph taken by Mr. Burnham of the 40-inch Yerkes instrument, as exhibited at the Columbian Exposition.—"The Two Magnetic Fields surrounding the Sun," by Prof. Frank H. Bigelow; "The Constitution of the Stars," by Prof. Edward C. Pickering. This paper concludes as follows: "With few exceptions all the stars may be arranged in a sequence beginning with the planetary nebulæ, passing through the bright line stars to the Orion stars, thence to the first type stars, and by insensible changes to the second and third type stars"; "Concerning the Nature of Nova Aurigæ's Spectrum," by Prof. W. W. Campbell; "Preliminary Note on the Corona of April 16, 1893," by Prof. J. M. Schæberle, being a discussion of the facts gathered from the numerous photographs taken; "The Wave-lengths of the Two Brightest Lines in the Spectrum of the Nebulæ," by Prof. James E. Keeler; and lastly, "Contributions on the Subject of Solar Physics," by Prof. E. R. von Oppolzer.

A NEW ASTRONOMICAL OBSERVATORY AT MANILA.—Manila already possesses a Government meteorological and seismographic observatory, and an important astronomical observatory will soon be established there. The chief instruments will be a novel photographic meridian instrument and a large Merz refractor (19·2 inches), the latter being provided with a photographic correcting lens. Father Algue seems to be taking the work in hand, and he proposes to institute a series of latitude observations in connection with a similar series to be carried on at the Georgetown Observatory, for the determination of the variation of latitude. The instrument at Manila will consist, according to *Astronomy and Astro-Physics* for October, of two telescopes in the same tube; or at least there will be two object glasses, one at each end of the tube, their foci coinciding. These will be of the same diameter, 6 inches, and focus 3 feet, the tube being equal to the sum of the focal lengths of the object-glasses. The photographic plate is placed in the focus of the two objectives, *i.e.* in the centre of the tube. The method adopted is that of Talcott, and during the observation of both stars the instrument is not moved. The upper objective throws the image of the first star on the upper side of the sensitive film, while by the help of a basin of mercury below, and the lower objective, the trail of the second star is recorded on the under side of the same film. Besides visual work the Merz refractor will be used for photographic observations of double stars, spectrographic work, photographic parallax, &c.

THE VISIBILITY OF VENUS TO THE NAKED EYE.—Principal A. Cameron, at Yarmouth, Nova Scotia, and M. Bruguiere, at Marseilles, have made a series of observations with a view of determining for how long a period the planet Venus can be seen in the day time without optical aid (*Trans. Nova Scotia Institute of Science*, vol. i. part 2. 2nd series). Beginning with the superior conjunction of February 18, 1890, Mr. Cameron saw Venus with his naked eye 26½ days after that date, and M. Bruguiere, in the same latitude, detected the planet 4½ days before the inferior conjunction of December 4, 1890; so that altogether she was visible to the unaided eye during 259 days. The elongation of the planet when first picked up by Mr. Cameron was 6⅓°, and when M. Bruguiere saw her last in November, 1890, the elongation was nearly 9°, but the brilliancy was only 6½ per cent. of the mean greatest brilliancy.

MEYER'S CONVERSATIONAL LEXICON.—The popularity of this series of volumes can only be accounted for by the very judicious way in which the publishers have dealt with every branch of science, treating it fully, accurately, and in such language that it can be understood by the most general reader. Under the heading "Astronomy" is given an excellent and concise account of the early history and development of the science. This lexicon has reached its fifth edition.

## *GEOGRAPHICAL NOTES.*

A CABLE has recently been laid between the seaport of Bundaberg, in Queensland, and New Caledonia. This line of 910 miles, although not very important in itself, is of some interest as possibly the commencement of a great Pacific cable which may ultimately unite Australia and Canada. Should this scheme be carried into effect the probable route of the cable would be from New Caledonia to Fiji, thence to Samoa, and by Honolulu and the Fanning islands to Vancouver.

THE last number of the *Bulletin* of the Paris Geographical Society publishes the list of awards of the society's medals, the bestowal of which was noticed in this column (vol. xlviii. p. 40), together with the reports of the awards, which were too lengthy to be read at the meeting in April. A notable fact connected with these prizes is the custom of recognising the value of original maps and books of geographical research, historical or critical, as well as the work of explorers.

AN amusing instance of the danger of commenting on geographical news without referring to a full report occurs in the last number of the *Revue Française*, a journal which is valued for its full and usually accurate record of recent and projected travels. In mentioning the fact of the discovery of Active Strait, near Erebus and Terror Gulf, by the Dundee sealers this spring, the editor adds parenthetically, "volcanoes of Victoria Land to the south of New Zealand"—a pardonable mistake, as the names of Ross's ships were perhaps too freely scattered over the Antarctic regions. But in this instance it happens, somewhat oddly, Erebus and Terror Gulf is in land named after a French and not a British monarch, being in Terre Louis Phillippe, south of the Falkland Islands.

THE full programme of the Royal Geographical Society's Evening Meetings for the Session 1893–94 has been published. In addition to the subjects intimated in this column last week, we note that papers are expected by Prof. Lapworth, F.R.S., on the ups and downs of the earth's surface; by Dr. J. W. Gregory, on his expedition to Mount Kenia; Mr. R. D. Oldham, of the Indian Geological Survey, on the geographical development of India; Mr. K. Grossmann, on a journey in Iceland; Mr. T. J. Alldridge, on journeys in the interior of Sierra Leone; Dr. H. R. Mill, on the survey of the English lakes; Mr. H. Warington Smyth, on journeys on the Upper

Mekong; Mr. W. H. Cozens-Hardy, on surveys and research in Montenegro; and Mr. E. J. L. Berkeley, on British East Africa. It is also hoped that the Prince of Monaco, Sir Archibald Geikie, and Mr. J. Y. Buchanan may contribute papers. If Mr. and Mrs. Bent return in time from their projected exploring journey in Hadramant, an account of their work will be looked forward to before the close of the session.

A number of the *Journal* of the Manchester Geographical Society just issued (January to June, 1893) contains a paper on the Yoruba country, Abeokuta, and Lagos, by the Rev. J. T. F. Halligey, which gives some vivid descriptions of native life and manners.

Dr. Gerhard Schott's physical observations on a voyage in a sailing ship from Hamburg to the China coast and back are published as an Ergänzungsheft of *Petermanns Mitteilungen*. In the discussion of his work Dr. Schott takes account of previous researches on the parts of the ocean he traversed, and his paper is an interesting addition to our knowledge of oceanography. The memoir is divided into two parts: hydrography, including a discussion of surface temperature as affected by diurnal range, rainfall, and wind, the specific gravity of surface water, surface currents and drifts, and observations on waves; and meteorology, dealing with the instruments employed, the record of air-temperature, humidity, and cloudiness. The memoir is, of course, well illustrated by maps and diagrams.

## *THE THICKNESS AND ELECTRICAL CONDUCTIVITY OF THIN LIQUID FILMS.*

In August, 1883, an article was published in Nature (vol. xxviii. p. 389), signed by Prof. Rücker and myself, giving an account up to date of our researches on liquid films. Since that time our work has from time to time as opportunity offered been ontinued and further results have been obtained, a brief account cummarise the results to which attention was drawn in 1883. of which I now propose to give. It may be useful first to briefly

A cylindrical soap film when allowed to thin under the action of gravity shows in succession the tints of the various orders of Newton's Colours, and finally becomes black. The thickness of any part of the film may be determined (supposing the refractive index to be known) from the colour it exhibits when light is reflected from it at a definite angle. The mean thickness of a horizontal ring of the cylindrical film may also be determined by measuring the electrical resistance of the ring, and by assuming the specific conductivity of the film to be the same as that of the liquid in mass. In the case of a liquid consisting of a mixture of soap solution and glycerine with a little potassium nitrate added to increase the conductivity, we proved by comparing the thickness of a film obtained by the optical method with the thickness deduced from its electrical resistance, that down to a thickness of 374 $\mu\mu$ (micromillimetres)—corresponding to colours of the second order of Newton's scale—the specific conductivity of the liquid remains unaltered. When the film becomes thinner than 374$\mu\mu$, and exhibits the colours of the first order, estimates of its thickness derived from colour observations are less trustworthy, and when these colours are replaced by black, we only know from the colour that the thickness of the film has less than a certain maximum value. Assuming, however, the specific resistance to be unchanged when the film became black we showed that the thickness of such a black film does not differ much from 12$\mu\mu$.

Experiments were then carried out by the electrical method on a solution of oleate of soda (hard soap) containing 3 per cent. of $KNO_3$ but no glycerine. Black films made of this solution were found to have a mean thickness of 11·7$\mu\mu$, showing that the thickness of the black is practically the same whether the solution does or does not contain glycerine. As this result, however, depends upon the validity of the assumption that the specific resistance of a black film is the same as that of a large quantity of the liquid, it was desirable if possible to measure the thickness in question by a method free from the assumption involved in the electrical method. For this purpose an optical method depending upon interference phenomena (Phil. Trans. 1883, p. 652) was employed. Two glass tubes about 16 inches long and ¾ inch in diameter were placed horizontally side by side and were traversed by two interfering beams of light, the interference bands being produced by thick glass plates. The tubes were filled with plane soap films, each tube containing from 40 to 60 films and having its ends closed by pieces of plate-glass. After an hour or more, when the films had thinned sufficiently to appear black, the position of the central interference band in the field was noted, and its displacement when the films were broken, first in one tube and then in the other, carefully measured. From these measurements the average thickness of a black film could be easily deduced, the only assumption made being that the refractive index of the liquid is unaltered by the tenuity of the film. The average thickness of about 900 films was found to be 12·1$\mu\mu$. This result justified the assumption made in the electrical method with regard to the constancy of the specific conductivity of the liquid.

The results established before the recent work was begun were therefore as follows:—(*a*) The thickness of a black soap film formed of a solution containing one part of oleate of soda dissolved in 40 of water with 3 per cent. of $KNO_3$ added is about twelve micromillimetres. (*b*) It is practically the same when to the soap solution is added two-thirds of its volume of glycerine. (*c*) From this it follows that the specific conductivity of such a solution is the same whether the liquid be considered in large quantity or in the form of a minutely thin film. (*d*) The thickness of the black, though often varying from film to film, is always the same in the same film—*i.e.*, is independent of area and age. With regard to these results it may be said at once that they have all been repeatedly and completely confirmed by subsequent investigation.

We now come to the more recent work. Since in the earlier experiments the solutions were always of the same strength as regards soap, and always contained not less than 3 per cent. of KNO, it was important to determine whether the thickness of a black film is or is not dependent upon the proportion of soap or salt in the solution. The optical method was first employed. The strength of the soap solution being kept constant, viz. 2 grammes of hard soap to 100 cc. of water, the proportion of salt was diminished from 3 per cent. to zero. Under these circumstances, the mean thickness of a black film was found to steadily increase from 12 $\mu\mu$ to about 24 $\mu\mu$. A similar large increase in the thickness was found when the solution contained glycerine, or was made of soft instead of hard soap. When no metallic salt is present, and the strength of the soap solution varies, the thickness of the black increases as the solution becomes more dilute. Thus for a hard soap solution, when the percentage of soap was 3·3, the thickness was found to be 21·6 $\mu\mu$ and rose to 29·3 $\mu\mu$ as the percentage of soap diminished to 1·25. If, on the other hand, the solution contains as much as 3 per cent. of $KNO_3$, variation in the proportion of soap has little or no influence on the thickness of the black. This is shown by the following table:—

Hard Soap Solution, containing 3 per cent. of $KNO_3$.

| | | | | |
|---|---|---|---|---|
| Percentage of soap in the solution | 2·5 | 2·0 | 1·66 | 1.14 |
| Mean thickness of the black in $\mu\mu$ | 13·1 | 12·1 | 11·6 | 12·1 |

The results above given have been deduced from the optical method of measurement, and the question arises whether the large increase in the thickness of black films formed from an unsalted solution is real, or whether it is due to some incorrect assumption. The only point where error is possible is in the hypothesis that the refractive index is the same as that of the liquid in mass. The thickness of a film varies inversely as $\mu - 1$ ($\mu$ being the refractive index), and as the refractive index of the soap solution is 1·34, it would have to be reduced to 1·17 in order that the calculated thickness might be doubled. It appears therefore *à priori* extremely improbable that the mere addition of 3 per cent. of $KNO_3$ should so completely change the optical properties of the liquid that whereas if the salt be added the refractive index is practically the same in the thin films and in the liquid in mass, yet without the salt the refractive index should be as much as 13 per cent. less than that of the liquid in mass. It may further be mentioned that Drude (*Wied. Ann.* xliii. p. 169, 1891), by an optical method quite different from that employed by us, has compared the refractive indices of black and coloured films, of which the latter may unquestionably be taken as nearly if not quite identical with that of the liquid in mass, and has shown that they do not differ by more than 1 part in 140. Such a variation would not affect the apparent thickness of the films as measured by the optical method by more than 3 per cent., whereas, as we have seen, the presence or absence of the salt alters the apparent thickness by 100 per cent. On the whole, then, the evidence is very strong that the differences of thickness indicated by the optical method are not merely apparent but real, and this point may now be treated as established.

We now pass on to consider the thicknesses of black films as deduced by the electrical method. The method adopted was in all essentials identical with that previously employed and described (Phil. Trans. 1883, pt. ii. p. 645, NATURE, 1883, *loc. cit.*).

The apparent thickness of a black soap film as measured by the electrical method increases as the percentage of added salt diminishes, but in a far larger ratio than would be inferred from the optical method. If the proportion of salt be diminished to zero the thicknesses thus calculated are greater than the greatest thickness at which a film can appear black. Thus with a hard soap solution the apparent thickness rose from 10·6 $\mu\mu$ to 26·5 $\mu\mu$, as the percentage of $KNO_3$ added was diminished from 3 to 0·5, and became 148 $\mu\mu$ when the solution contained no salt, this number being the mean value derived from fourteen films, the individual thicknesses of which ranged from 79 to 240 $\mu\mu$. In another set of experiments made with a rather stronger soap solution, the apparent mean thickness of the black was 184 $\mu\mu$, the extreme values for six films being 84 and 250 $\mu\mu$. Similar results were derived from a soft soap solution, the mean apparent thickness obtained from the examination of twenty-three black films being 162 $\mu\mu$, and the extremes about the same as before, viz. 80 and 252.

Now a film 148 $\mu\mu$ thick (to take the smallest of the mean thicknesses given above) could not possibly appear black. According to Newton the beginning of the black occurs when the thickness is 36 $\mu\mu$, which is about one-fourth of the smallest mean value obtained from unsalted solutions. We are therefore driven to the conclusion that the close agreement between the results of the optical and electrical methods, which has again and again been proved when the solution contains 3 per cent. of $KNO_3$ does not hold in the case of unsalted solutions. The measured thicknesses cannot be true thicknesses, and therefore there must be a difference between the specific conductivity of a film, and that of the liquid from which it is formed.

Apart from this, however, is the fact that the apparent thickness varies considerably from film to film, although all the conditions are maintained as far as possible constant. This is certainly due in some cases to a real variation in thickness. We have frequently seen in the same film two different shades of black separated from each other by a definite sharp line, which is generally very irregular in form. The line which separates the black from the coloured part of a cylindrical film thinning in the normal way is always a horizontal circle. This is rarely the case with the boundary between the two black tints. Sometimes a patch of the darker black is completely surrounded by the other, sometimes the line of separation is sinuous, or stands higher at one point than at another. It is thus difficult to obtain comparative measures of the thicknesses of the two tints, as the method of experiment employed assumes the thickness of a cylindrical film to be the same at all points on the same horizontal circle. Such measures, however, as have been made indicate that the thickness of the thicker black is about twice as great as that of the thinner.

The two black tints are not always easy to detect or to distinguish from each other. If only one occurs it is almost impossible to say whether it is the thinner or thicker variety. Frequently the passage of an electrical current through a film, the black portion of which appears to be homogeneous, discloses the existence of the two different tints by producing or intensifying little white flecks which lie along the boundary between the two. On the suppression of the current the flecks become smaller or disappear, but the attention of the observer having been called to the boundary line, there is no difficulty in distinguishing between the regions on the two sides of it, the thinner appearing more intensely black than the other. We have never, when experimenting with solutions containing 3 per cent. of $KNO_3$, seen any indication of the two shades of black. If the added salt is reduced to 0·5 per cent., the phenomenon is seen occasionally; but with unsalted solutions it is of frequent occurrence. The two varieties of black in a soap film were noticed by Sir Isaac Newton, who remarks that sunlight is reflected from even the darker spots.

But to return to the question of the mean apparent thickness of a black film. As has been stated, the optically measured thickness differs little if at all from the true thickness. If the electrical thickness is approximately equal to the optical thickness, we may assume that the specific conductivity of the liquid is unaltered by the tenuity of the film. If they differ considerably the inference is that the specific conductivity has changed. Now in the case of an unsalted solution containing one part of soap dissolved in sixty of water the optical thickness is 27·7 $\mu\mu$, while the mean apparent electrical resistance is 160 $\mu\mu$. The specific conductivity is therefore greater in the film than in the liquid in mass in the ratio of 5·8 to 1.

A number of experiments have been carried out for the purpose of determining whether the change in the specific conductivity is a function of the thickness of the film, or is peculiar to black films. The result is to show that with an unsalted solution of hard soap the change begins when the film is comparatively thick. Thus, the ratio of the electrical to the optical thickness (which measures the proportional increase of conductivity) is 1·66 when the film exhibits the green of the second order (thickness = 641 $\mu\mu$); it is 1·98 at a thickness of 296 $\mu\mu$, 4·47 at 97 $\mu\mu$ (white of first order) and becomes 5·8 when the film is black.

When the solution contains 3 per cent. of $KNO_3$ we know that for the black films the conductivity is the same as for the liquid in bulk. That it remains constant under all circumstances is highly probable, though not absolutely certain.

We have now to inquire into the possible causes of the fact that a black film made of an unsalted soap solution appears to be about six times as great as it really is, or, in other words, that the specific conductivity of the film is six times as great as that of the liquid in mass. This increase might possibly be due to (1) evaporation or absorption of water by the film as it thins, (2) changes of temperature, (3) changes in the chemical constitution of the film by the electrolytic action of the current employed, (4) absorption of carbonic acid or of oxygen from the air. In considering these it must be borne in mind that our observations are based on a comparison between two solutions which differ from each other only by the addition to one of them of 3 per cent. of $KNO_3$. If, therefore, the change in conductivity were ascribed to any one of these causes it would be necessary to assume not only that the cause was competent to produce the change, but that its efficiency was very greatly modified by the addition of the salt. It is extremely improbable that evaporation or absorption of water, changes of temperature, or absorption of carbonic acid (if occurring in the one liquid), would produce the enormous observed change in the conductivity, while they were inoperative in the case of the other. We have not, however, been satisfied with *à priori* considerations, but have experimentally examined each of these possible causes.

With regard to the first, it is sufficient to say that all the precautions which experience has shown to be efficient in securing constancy of composition in the case of *liquide glycérique*—a liquid much more susceptible to changes of composition, due to variations of hygrometric state, than plain soap solutions—have been taken. We may be perfectly sure that the change in conductivity is not due to the loss or gain of water by the film when thinning.

Experiments have been made at various temperatures between 17° and 27° C., but there is nothing in the results obtained to indicate that the apparent thickness of the black either increases or diminishes as the temperature changes. Thus, to take four films out of many that might be selected, we have the following results:—

| | | | | |
|---|---|---|---|---|
| Temperature | 18°·7 | 21° | 21°·1 | 26°·3 |
| Apparent thickness of black film in pipe | 171 | 237 | 201 | 135 |

There is no doubt that the relatively small changes of temperature which occurred in our experiments are not the cause of the large increase in the apparent thickness of a black film.

But the observed result might be due to change in the composition of the liquid caused by the passage of an electric current through the film. The current employed to measure the resistance of the film is always a feeble one; but in order to produce a rapid thinning, we have frequently passed a current from a battery of 28 Leclanché cells down the film from the moment of its formation. Such a current, though probably never exceeding 100 microampères, is passed for a long time, and might conceivably affect the specific conductivity of the liquid. As a specimen of the kind of results obtained, the following, derived from a soft soap solution, may be given. Each of the values of the thickness was obtained from a different film, and the number of cells indicated is that employed to pass a continuous current through the film from its first formation. The measuring current was small and intermittent.

| No. of cells. | | Apparent thickness of black film, measured electrically, in $\mu\mu$. |
|---|---|---|
| 0 | ... | 150 171 148 150 |
| 14 | ... | 155 145 142 |
| 28 | ... | 150 157 179 |

The conclusion to be drawn from this table was confirmed by experiments in which transient currents from a Ruhmkorff induction coil were employed; they leave no doubt that the passage through a film of such electrical currents as we have used has no appreciable influence on the phenomenon under discussion.

To determine the possible influence of carbonic acid, or of oxygen, absorbed from the surrounding space comparative experiments were made. The apparatus not being air-tight, the plan was adopted of allowing a stream of air carefully freed from $CO_2$, or of pure oxygen, as the case might be, to flow through the film-box. The results obtained under these conditions, though in some respects not quite satisfactory, justify the assertion that neither the total (or almost total) absence of $CO_2$ nor a large increase in the quantity of oxygen in the neighbourhood of the film produces any appreciable change in the specific resistance.

It thus appears that a number of possible causes, to which the increase in the conductivity of a thin film might be due, prove on examination to have little or no influence. Although a satisfactory explanation is not at present possible, it will probably be found to depend upon the connection which subsists between the chemical constitution of a film and the surface forces which are brought into play, or are modified by its tenuity. Prof. J. J. Thomson ("Applications of Dynamics to Physics and Chemistry," p. 234) has drawn attention to this connection, and has shown that under certain conditions the chemical action in a thin film throughout which the forces producing capillary phenomena are active, may be totally different from the chemical action in the same substance in bulk. The experiment of Liebreich (*Berlin, Sitzungsberichte*, 1886) is often cited as illustrating this point. When solutions of chloral-hydrate and sodium carbonate are mixed in suitable proportions in a glass tube, chloroform is slowly precipitated as an opaque cloud. Close to the surface, however, and from 1 to 3 mm. below the surface, there is a space perfectly clear and free from chloroform. It is supposed that in this space either the chemical action does not go on, or that if it does chloroform is not deposited. The explanation is not very satisfactory, and in any case the "dead space" is too large to justify us in referring it solely to the action of surface forces. Again, there is no doubt that the surface of a film becomes altered by the action upon it of the surrounding medium, so that the outer layers have different properties from the rest of the liquid. Lord Rayleigh has shown that the surface tension of a soap solution when the surface is new is nearly the same as that of pure water, but diminishes rapidly by exposure to the air. Reinold and Rücker have proved that the surface tension of a cylindrical film is increased by giving the film a new surface (letting fresh liquid flow over it) and that from ten to fifteen minutes elapse before the old value is regained. Other properties of the surface-layer besides its tension may be modified where it is very thin, and the electrical conductivity may be very different from that of the interior liquid. Although the peculiarities of the surface-layer certainly are in some way connected with the main facts here considered, we have shown that they cannot all of them be explained by the simple theory of the formation of a pellicle of different conductivity from the rest of the film.

It is difficult to assign a reason why the addition of salt to the liquid should produce so great a change in the results. In part, the better conducting salt probably masks effects which, when soap alone is used, become predominant; but it is likely that, in part at all events, it actually prevents the changes to which the change in conductivity is due.

The optical method of investigation illustrates the controlling influence of the metallic salt when present in the solution. As we saw above, a small variation in the proportion of dissolved soap has a large effect upon the thickness of the black when no salt is present; but the quantity of soap may be doubled without influencing the thickness, provided the solution contain 3 per cent. of salt.

A. W. REINOLD.

## SPONTANEOUS COMBUSTION.[1]

WHEN an inflammable substance ignites or becomes incandescent without the application of fire or other apparent cause, it has been customary to speak of it as spontaneous combustion, a term which I think I shall be able to show you presently does not correctly express the actions which lead to this apparently mysterious result.

Early in the eighteenth century a woman was found burnt to death under circumstances which gave no clue as to the cause of the accident, and in order to satisfactorily explain her death, the theory of spontaneous combustion was devised by the experts of the day, and was generally accepted at a time when little or nothing was known of what takes place during the process which we know as combustion; but as the years rolled on, men's views upon this important subject became wider and more exact, until, in the latter part of the last century, the great French philosopher Lavoisier, partly by his own experiments, and partly by the teachings of the work done by others, gave us a true knowledge of combustion and the changes which take place when a body is burnt, whilst the commencement of this century marked still further the advance of our knowledge in this direction, and also as to the conditions necessary for continuing the combustion or burning of any inflammable substance.

We now know that from the nature of combustion it is impossible for the human body to undergo spontaneous ignition or combustion in the way in which the novelists and scientific experts of the last century believed possible, but there are few amongst us who have not heard of, and even come across, cases in which large masses of coal, small quantities of oily rags, or waste, and hayricks which have been made from grass stacked before it was thoroughly dried, have ignited without any apparent cause, and have kept alive in our minds and on our tongues the term "spontaneous combustion"; and you must pardon me if I commence my lecture this evening by reviewing the teachings of Lavoisier's classical work, and then apply the conclusions we arrive at to those cases of spontaneous combustion which we meet with in our daily work.

The theory of combustion which was generally accepted during the last century, was that every combustible body contained within itself the products of combustion combined with a "something" called phlogiston, and when the substance was burnt, this phlogiston escaped, giving the flame or incandescence of combustion, whilst the products were set free. This theory could not, however, for long stand the test of exact experiment, and as soon as Black introduced the balance into scientific research, it was found that when any substance underwent combustion, the products weighed more than the body before it had been burnt, the reverse of what one would have expected had the phlogistic theory been correct.

During the last century lived Joseph Priestley, one of the most remarkable men this country has ever claimed as her own—a man so varied in his attainments, and so energetic in his life and labour, that he published over one hundred different works dealing with every conceivable subject, from theology to science; but it was in the latter field that he especially shone, and the greatest achievement of his life was the discovery of the gas which we now call oxygen, a discovery which he communicated to his friend Lavoisier.

Lavoisier at once saw the importance of the discovery which Priestley had made, and then conceived and carried out an experiment which has become historical as proving for the first time beyond doubt the fact that the air was not a simple elementary substance, but contained two perfectly distinct gases—oxygen and nitrogen.

Lavoisier placed in a long-necked retort about four ounces of mercury, and so arranged the apparatus that the air above the mercury in the retort should freely communicate with the air in a measured receiver, all contact with the outer air being prevented by standing the receiver in a vessel of mercury. He now heated the four ounces of mercury in the retort nearly to its boiling-point, and kept it at this temperature for twelve days and twelve nights. At first no change took place, some of the mercury merely distilling into the upper part of the apparatus and falling back again; but presently some little red specks began to appear on the surface of the metal, and increased in amount for several days, but at length ceased to form; and after continuing the heating for a day or two longer,

[1] A lecture to working men, delivered by Prof. Vivian B. Lewes at Nottingham, in connection with the British Association

in order to make sure that the action was completed, he allowed the whole apparatus to gradually cool down again to its original temperature.

Before starting the experiment he had carefully measured the air in the apparatus, which amounted to fifty cubic inches, and the first thing which he now noticed was that of this forty-two cubic inches only remained, and that this residual gas had lost all the most characteristic properties of air; a taper plunged into it was at once extinguished, a mouse placed in it died after a few moments; it would, in fact, neither support life nor combustion, and he recognised it as a gas discovered some three years before by Rutherford, and now called nitrogen.

He then collected the red film formed on the surface of the mercury, which weighed forty-five grains, and heated the powder in a hard glass tube to a higher temperature than that at which it had been formed, when it again broke up, leaving behind metallic mercury, and yielding eight cubic inches of a gas which had to an exaggerated extent all the properties which the air had lost—a gas which he at once recognised as being the oxygen or "vital" air which Priestley had discovered in 1774.

It was in this way that the air was shown to consist of the two gases, oxygen and nitrogen, and we know from experience that air is necessary for carrying on those cases of combustion which we ordinarily meet with, and the quickest way to extinguish a fire is to cut off the supply of air from it.

Having reached this point, the next question which suggests itself is, which of the constituents of the atmosphere is it which supports and carries on combustion, and how does it act in doing so? And the answer to these points can most readily be given in Nature's own words, by carefully translating the result of a few simple experiments.

Here are two gas jars, the one containing oxygen, the other nitrogen, and, taking a small ball of tow soaked with turpentine which is burning vigorously, I plunge it into the atmosphere of nitrogen, when it is at once extinguished, but on now relighting it, and plunging it into the oxygen, it burns far more fiercely than before, and emits a most brilliant light. If we continued experimenting in this way, we should find that everything tends to confirm the impression gained from our first experiment, and we soon learn, as Lavoisier did, that anything which will burn in air will burn with still greater vigour in oxygen, whilst nitrogen alone instantly stops the combustion of those bodies which require air to enable them to burn; indeed, we might go a step beyond Lavoisier's experiments, and find that many bodies not looked upon as combustibles, such as iron and zinc, burn with considerable brilliancy in pure oxygen; and it is from these facts that we came to look upon oxygen as our great supporter of combustion.

The enunciation of these truths by the great French philosopher was one of the most important steps in the history of science, but with increase of knowledge we find that we must still further widen our views with regard to combustion, and must take care not to fall into the error of looking upon those substances which will burn in air or oxygen as the only combustibles, and oxygen as the only supporter of combustion; we find, indeed, that these terms are purely relative, and a substance which we look upon as a combustible may, under altered conditions, become a supporter of combustion. Indeed, a body like coal gas, which burns in air or oxygen, will support in turn the combustion of air, and we can experimentally show that it is just as easy to have a flame of air burning in coal gas, as under ordinary conditions to have a flame of coal gas burning in air.

Again, we find that many cases of combustion will take place without the presence of oxygen or those substances generally looked upon as combustibles, and we can take a metal like antimony, and cause it to undergo brilliant combustion by throwing it in a powdered condition into an atmosphere of a gas called chlorine, although neither the metal nor the gas answer to our general ideas as to combustible or supporter of combustion.

If we examine carefully all cases of combustion, we find that in them we have a body with certain definite properties of its own, uniting itself with something else to form what we call the products of combustion, which are equal in weight to the sum of the weights of the two bodies uniting, and which have characteristic properties differing from those of the original substances, an action which we term one of chemical combination; and extended experiments show us that in order to obtain a true conception of combustion, we must look upon it as "the evolution of heat during chemical combination."

The rapidity with which chemical combination takes place varies to a very great extent with surrounding circumstances, and inasmuch as heat is very rapidly dissipated it often happens that where a chemical combination is slow, the heat produced by it is given off as rapidly as it is generated, so that the temperature of the mass becomes but little raised, and escapes detection by our senses. For instance, if I take a steel watch-spring, and having ignited a small piece of German tinder attached to the end of it, plunge it into a vessel of oxygen gas, the combustion of the tinder ignites the watch-spring, which burns away in the gas with the greatest brilliancy, and the evolution of heat is sufficient to fuse some of the metal, the result being that the watch-spring is converted into a chemical compound of iron and oxygen. If instead of bringing about the combination of the iron and oxygen as we have done in a few seconds, we allowed it to remain in moist air for two or three months, combination with the oxygen of the air would result, and the metal would rust away, and if the weight of metal had been the same in each case, and the same weight of oxygen had been combined with, exactly the same amount of heat would have been generated in each case; but in the rapid combustion of the metal, this heat, being all generated in a few seconds of time, would have made its presence perfectly manifest; whilst when the same action is spread over a long period, as in the rusting of the metal, the heat being dissipated as it is generated, escapes our notice; and there are many amongst us who would smile at the idea that the rusting of their garden railings was giving rise to any increase of temperature.

In this case the heat generated by the combination of the iron with oxygen was made manifest by raising the burning metal to a high temperature in the presence of oxygen free from the diluting action of the inert nitrogen which is mixed with it in the air; but we can do the same thing by taking the iron in a very finely-powdered condition, so that a very large surface shall be exposed to the action of the oxygen of the air. I have here iron in this condition, sealed up in a glass tube, and on opening and shaking out the finely-divided metal into the air, it at once enters into combination with oxygen, and the heat generated is sufficient to make it red-hot. If, however, the same weight of iron in a compact form, such as wire, be taken, a long period of time, extending perhaps over years, would be required for its conversion into oxide by air and moisture, and the heat generated would be spread over such a duration of time that it would be inappreciable, unless the conditions were such that the heat was unable to escape or the surface of metal exposed very large. A case of this kind occurred during the manufacture of the Mediterranean telegraph cable, which was enclosed in a strong casing of iron wire, and tightly coiled in water tanks, one hundred and sixty-three miles of cable being wound in a coil thirty feet in diameter. Owing to a leak in the tank which contained the cable the water ran off, leaving the wire casing exposed to air, and the moist metal oxidised so rapidly that sufficient heat was generated to form considerable quantities of vapour, and to give rise to serious fears as to the softening of the insulating material of the core.

Many cases of chemical combination with the oxygen of the air take place in nature, which are so slow that the heat evolved during the action escapes our senses, and indeed all cases of decay are processes of this kind, and the action is termed one of "slow combustion."

A tree left to rot upon the ground gradually disappears in the course of years, being mainly oxidised into gaseous products such as carbon dioxide and water vapour, and yet scarcely any evolution of heat is observed, although the same amount of heat is generated as if the tree had been cut into logs and burnt.

In all cases slow combustion is accelerated by increase of temperature, and the higher the temperature the more rapid becomes the chemical action, and all combustible bodies, at a certain temperature, undergo what is termed "ignition," that is to say, a temperature is reached at which slow combustion passes into ordinary combustion with manifestation of flame or incandescence, the chemical combination being then so rapid that the heat evolved is manifest to our eyesight, whilst a still greater increase in the rapidity of combustion will in some cases bring about the most rapid form of combustion, which we term "explosion."

Many substances are capable of undergoing all three rates of combustion. For instance, it can readily be proved that when organic substances containing hydrogen undergo decay, some of the hydrogen present unites with the oxygen of the air to form water, and the heat generated by the combination is spread over so long a period that at no one moment of time is it perceptible to the sense. If, however, hydrogen gas be confined under pressure in a gas-holder, and allowed to escape through a jet into the air, on being ignited it burns with an intensely hot flame, the heat energy of which can be converted, by suitable contrivances, into other forms of energy, such as mechanical force. In this case as much hydrogen is converted into water in the course of a minute as would have been formed in some years by the process of slow combustion, and the increase in calorific intensity obtained is solely due to the increased rate of combustion, the total thermal value of the hydrogen being the same, whether it is burnt by a slow process taking years, or a rapid one in a minute. If now the same volume of hydrogen be mixed with sufficient air to supply it with the oxygen required to convert it into water, and if a light be applied to the mixture, the hydrogen being side by side with the oxygen necessary for its conversion into water, combustion takes place with enormous rapidity, and the intense heat generated expands the vapour formed to such an extent that an explosion results.

We have now seen that during the decay or slow oxidation of combustible bodies, heat is generated, and that it is only necessary for this heat to reach a certain point, *i.e.* the point of ignition, for the little noticeable slow combustion to become ordinary combustion with its manifestation of flame and incandescence, and it is this action to which the term spontaneous combustion has been given.

When the combustible substance has a great affinity for oxygen, and at the same time a low point of ignition, spontaneous combustion will take place with great ease. Indeed, in some cases, such as that of phosphorus, we are obliged to prevent the access of air to the body if we wish to prevent ignition taking place, and we also find that the finer the state of division of the substance, the more readily will its spontaneous ignition take place, not because dividing the body up in any way lowers the point of ignition, but because the increase in the size of the surface exposed to the oxidising action of the air is so much increased, that the heat is generated with greater rapidity than it can be dissipated. If we take a piece of phosphorus, and expose it to the action of the air, it almost directly commences to give off white fumes, and if the weather is warm, it will in the course of a short space of time even ignite; in cold weather, however, it may be left until it has nearly all undergone slow oxidation without ignition. If, however, we dissolve it in the liquid called bisulphide of carbon, and pour some of this solution upon a piece of blotting-paper or linen, the carbon bisulphide, being highly volatile, will all evaporate, and leave the phosphorus in such a fine state of division that it will at once spontaneously ignite.

In practically all of the cases of spontaneous ignition which come under our notice, we have the heat evolved during the slow combustion kept in by the presence of a mass of non-conducting material, and this heat being unable to escape gradually grows higher and higher, the chemical combination becoming more and more rapid as the temperature increases, until we reach the point at which ignition of the mass takes place.

Sometimes, also, the increase in temperature necessary to bring about spontaneous ignition is partly due to physical actions. If a gas be suddenly compressed heat is always evolved, a fact prettily shown by the so-called fire syringe, in which the heat evolved by the compression of air is sufficient to ignite a piece of German tinder.

Certain bodies have the power of absorbing many times their own volume of gases, and in doing this they not only give rise to a certain increase in temperature, due to the compression of the absorbed gas upon their surfaces or in their pores, but they also increase the chemical activity of the gas so compressed.

Carbon is one of those substances which possess to an extraordinary degree the power of attracting and condensing gases upon their surface, this power varying with the state of division of the particular form of carbon used. The charcoal obtained from dense forms of wood, such as box, exhibits this property to a high degree, one cubic inch of such charcoal absorbing—according to Saussure—

| | | |
|---|---|---|
| Ammonia gas ... | 90 | cubic inches |
| Sulphuretted hydrogen | 55 | ,, ,, |
| Carbon monoxide | 35 | ,, ,, |
| Ethylene—olefiant gas | 35 | ,, ,, |
| Oxygen ... ... | 9·25 | ,, ,, |
| Nitrogen ... ... | 6·5 | ,, ,, |

This absorption is very rapid at first, but gradually decreases, and is, moreover, influenced very much by temperature. It is at first purely mechanical, and itself causes a rise of temperature, which in the case of charcoal formed in closed retorts, as in preparing alder, willow, and dogwood charcoal for powder making, would produce spontaneous ignition if it were not placed in sealed cooling vessels for some days before exposure to air. The rate of absorption varies with the amount of surface exposed, and is, therefore, able to take part in this condensing action, so that when charcoal is finely powdered, the exposed surface being much greater, absorption becomes more rapid, and rise of temperature at once takes place. If, after it has been made charcoal, it is kept for a day out of contact with air, and is then ground down into a powder, it will frequently fire after exposure to the air for thirty-six hours, whilst a heap of charcoal powder of one hundred bushels or more will always ignite. It is for this reason that in making the charcoal for powder it is always kept, after burning, for three or four days in air-tight cylinders before picking over, and ten days to a fortnight before it is ground.

There are several very interesting points with regard to the spontaneous combustion of charcoal, which call for more attention than has yet been devoted to it. It is self-evident that the more porous a body is, the greater amount of exposed surface will be available for the condensation of gases, and the great power that charcoal has of absorption is undoubtedly due to its great porosity. Now the temperature at which wood can be carbonised varies very considerably, and wood will begin to char; that is to say, will begin to be converted into charcoal at temperatures very little above that of boiling water, and in the manufacture of some of the newer kinds of gunpowder the charcoal is formed by heating with superheated steam.

Charcoal formed at this low temperature, however, still contains large quantities of hydrogen and hydrocarbons, and is not nearly so porous as charcoal made at a high temperature; and although the diminution in porosity reduces the quantity of oxygen absorbed, yet another cause which tends still more to dangerous rise of temperature comes into play.

When a substance condenses oxygen upon its surface from the atmosphere, the gas is in a very chemically active condition, and will bring about chemical combination with considerable rapidity. For instance, if a piece of platinum foil be heated to redness, so as to drive off all gases from its surface, and be then allowed to cool until it ceases to be visibly red, and is held in a stream of mixed air and coal gas, or air and hydrogen, it again becomes red-hot, owing to the chemical combination of these substances upon its surface; that is to say, it has been able to condense these gases together and set up combustion.

If now charcoal be burnt at a high temperature, the carbon is in a dense condition, and resists to a considerable extent the setting-up of chemical action by the oxygen condensed and absorbed in its pores, but if it has been formed at a low temperature, this condensed oxygen will rapidly act upon the hydrocarbons and hydrogen still remaining in the mass, and will raise in this way the temperature to a dangerous point; and it is more than probable that very many unexplained fires have been brought about by beams and woodwork becoming charred in contact with flues and heating pipes.

It has been experimentally determined that when wood has been charred at 500° it will take fire spontaneously when the temperature is raised in the presence of air to 680°, and that when wood has been carbonised at 260° a temperature of 340° only is required for its spontaneous ignition.

If a beam is in contact during the winter months with a heated flue, or even steam-pipes, it becomes carbonised upon its surface, and during the summer, when the flue or pipe is probably not at work, it absorbs air and moisture, and during the next winter it again becomes heated and further carbonised, whilst the moisture and air are driven out, leaving the pores in a condition eminently adapted for the absorption of more air as soon as the temperature is allowed to fall, and in many cases sufficient heat is generated to cause the charred mass to smoulder and, when air is freely admitted to it, to burst into flame.

In the case of charcoal burnt at a higher temperature, it may be taken that the cause of heating is to a great extent physical, whilst in the low-burnt charcoal it becomes chemical as well as physical, and it is this chemical action which is the most dangerous, and acts in most cases of spontaneous combustion.

The spontaneous ignition of coal has been the cause of an enormous number of serious accidents, and the earliest theory as to its cause was that it was due to the heat given out during the oxidation of the pyrites or "coal brasses," which are compounds of sulphur and iron, and are present in varying quantities in nearly all coal. This idea has held its ground nearly up to the present time, in spite of the researches of Dr. Richters, who twenty years ago showed the explanation was an erroneous one, and even earlier, in 1864, Dr. Percy pointed out that the cause of spontaneous ignition was probably the oxidation of the coal, and that the pyrites had but little to do with it. Pyrites is found in coal in several different forms, sometimes as a dark powder closely resembling coal itself, and in larger quantities in thin golden-looking layers in the cleavage of the coal, whilst sometimes again it is found in masses and veins of considerable size; these masses, however, are very heavy and are carefully picked out from the coal, and utilised in various manufactures. The yellow pyrites, and even the dark varieties, when in the crystalline form, remain practically unaltered, even after long exposure to moist air, but the amorphous and finely divided portions will oxidise and effloresce with great rapidity, and it is during this oxidation that the heat is supposed to be generated.

Some coals that are very liable to spontaneous ignition only contain 0·8 per cent. of pyrites, and if we imagine this to be concentrated in one spot instead of being spread over the whole mass, and to be oxidised in a few hours, the temperature would rise only a few degrees, and under ordinary circumstances this rise in temperature would be practically inappreciable.

The oxidisation of masses of pyrites under certain conditions gives rise to the formation of ferrous sulphate and sulphur dioxide, with liberation of sulphur, and one might easily imagine that this free sulphur, which has an igniting point of 250° C., would play an important part in the action by lowering the point of ignition. This, however, could only happen with large masses of pyrites undergoing oxidation, and with the small amount of pyrites present in coal, supposing air were present in sufficient quantity to oxidise it, the sulphur formed would be converted into sulphur dioxide at temperatures as low as 60° C. This oxidation of sulphur at low temperatures is an action not generally known, but in my experiments I have found it takes place with considerable rapidity. The only way in which pyrites can assist the spontaneous ignition of coal is that when it oxidises, it swells and splits up the coal, thus exposing fresh surfaces to the action of the atmospheric oxygen.

I have carefully determined the igniting points of several kinds of coal, and find that

| | | | |
|---|---|---|---|
| Cannel coal | ignites at | 698° F. | = 370° C. |
| Hartlepool coal | ,, ,, | 766° F. | = 408° C. |
| Lignite coal | ,, ,, | 842° F. | = 450° C. |
| Welsh steam coal | ,, ,, | 870° F. | = 477° C. |

So that it is impossible for the small trace of pyrites scattered through a large mass of coal, and slowly undergoing oxidation, to raise the temperature to the necessary degree.

When coal is heating, a distinctive and penetrating odour is evolved, which is the same as that noticed when wood is scorched, and the gases produced consist of nitrogen, water vapour, carbon dioxide, carbon monoxide, hydrocarbons of the paraffin series, and sulphuretted hydrogen, the presence of the latter gas showing beyond doubt that oxidation of the sulphur has nothing to do with the action.

Ever since coal has been generally adopted as a fuel, it has been recognised that great care was necessary in the storing and shipment of masses exceeding 1000 tons, and if the coal has been stored wet or in a broken state, firing or heating of the mass has frequently taken place. Much inconvenience and loss has been caused by this on shore, but the real danger has occurred during shipment, and owing to this many a vessel has been lost with all hands, without any record of the calamity reaching shore.

Owing to the greater facility for treating the coal when it becomes heated on shore in coal stores and gas works, absolute ignition only rarely takes place, and it is mainly from evidence obtained in the case of coal cargoes that we learn most as to the causes which lead to it.

Coal is a substance of purely vegetable origin, formed out of contact with air, by long exposure to heat and pressure, from the woody fibre and resinous constituents of a monster vegetation which flourished long before the earth was inhabited by man. Coal therefore may be looked upon as a form of charcoal, which having been formed at a temperature lower than that of the charcoal-burner's heap, and under great pressure, is very dense, and still contains a quantity of these constituents which, in the ordinary burning, are driven off as wood naphtha, tar, &c., and these bodies consist of compounds containing essentially carbon and hydrogen, together with a little oxygen and nitrogen, and form the volatile matter and hydrocarbons of the coal. Coal also contains, besides these, certain mineral bodies, which were present in the fibre and sap of the original wood, and these form the ash which is left behind on the coal being burnt. These mineral substances consist almost entirely of gypsum or sulphate of lime, silica, and alumina, together with some oxide of iron, which gives the colour to the reddish-brown ash of many coals, and which has been formed by the decomposition of the pyrites in the original coal.

The mineral constituents of coal are the only ones, with the exception of the pyrites, that play no part in the phenomena attending the heating and spontaneous ignition of coal, and we need therefore only regard the actions which take place when the carbon, hydrocarbons, and pyrites in freshly-won coal come in contact with air and moisture.

Certain kinds of coal exhibit the same power of absorbing gases which charcoal has, although to a less degree. The absorptive power of new coal due to this surface attraction varies, but the least absorbent will take up one and a-quarter times its own volume of oxygen, whilst in some coal more than three times their volume of the gas is absorbed, which gives rise to an increase in temperature, and tends to increase the rate of the action which is going on, but is rarely sufficient to bring about spontaneous ignition, as only about one-third the amount of oxygen being absorbed by coal that is taken up by charcoal, and the action being much slower, tends to prevent the temperature reaching the high ignition point of the coal.

All coal contains a certain proportion of hydrogen, with which some of the carbon is combined, together with the nitrogen and oxygen, forming the volatile matter in the coal. The amount of this volatile matter varies greatly, anthracite containing the smallest quantity, and cannel and shale the largest. When the carbon of the coal absorbs oxygen, the compressed gas becomes chemically very active, and soon commences to combine with the carbon and hydrogen of the bituminous portions, converting them into carbon dioxide and water vapour. As the temperature rises so this chemical activity increases, so that the heat generated by the absorption of the oxygen causes it to rapidly enter into chemical combination. This kind of chemical combination—oxidation—is always accompanied by heat, and this further rise of temperature helps the rapidity of oxidation, so that the temperature rises steadily; and this taking place in a large mass of coal, which from physical causes is an admirable non-conductor, will often cause such heating of the mass that if sufficient air can pass into the heap in order to continue the action the igniting point of the coal will be reached.

It has been suggested that very bituminous coal, such as cannel and shale, are liable to spontaneous ignition from the fact that heavy oils would exude from them on a rise of temperature, and that these, by oxidising, might produce rapid heating. Experiment, however, shows that this is not the case, and that the heavy mineral oils have a decided effect in retarding heating.

We can now trace the actions which culminate in ignition. As soon as the coal is brought to bank, absorption of oxygen commences, but except under rare conditions the coal does not heat to any great extent, as the exposed surface is comparatively small, and the largeness of the masses allows of the air having free access to all parts, so keeping down the temperature. After the coal has been screened and the large pieces of pyrites picked out, it is put in trucks. Here it begins to get broken up, owing to the many joltings and shuntings, and so offers a larger surface to the action of the air. When it has arrived at the ship, it is further broken up by being shot down the tips or shoots, and more harm is done at this than at any other period, for the coal is broken by reason of the distance it has to fall, and it has to bear the impact of every succeeding load falling upon it, and it rapidly becomes slack, so that the under part of the ship-load is a dense mass of small coal, which soon rises in temperature by reason of the large surface exposed to the air and the consequent absorption of oxygen. This sets up chemical combination between the oxygen absorbed by the coal and the hydrocarbons, and in some cases culminates in combustion.

It is found that the mass of coal exercises a most important action in the liability to spontaneous combustion, as although with 500 tons of coal to the cargo the cases of spontaneous combustion amount to only about ¼ per cent. when the bulk is increased to 2000 tons, cases of spontaneous combustion rise to 9 per cent., this being due to the fact that the larger the cargo the more non-conducting material will there be to keep in the heat, and also to the fact that the breaking-up of the coal and the exposing fresh surfaces will of course increase with increase in mass; and it is also found that coal cargoes sent to European ports rarely undergo spontaneous combustion, whilst the number of cases rise to a startling extent in shipments made to Asia, Africa, and America. The result is party due to the length of time the cargo is in the vessel, the absorption and oxidation being a comparatively slow process, but the main cause is the increase of heat in the tropics, which causes the action to become more rapid; and if statistics had been taken, most of the ships would have been found to have developed active combustion somewhere about the neighbourhood of the Cape, the action fostered in the tropics having raised the temperature to the igniting point by that time.

Moisture has a most remarkable effect upon the spontaneous ignition of coal. The absorption of oxygen is at first retarded by external wetting, but after a time the presence of moisture accelerates the action of the absorbed oxygen upon the coal, and so causes a serious increase of heat. The researches of Cowper, Baker, Dixon, and others, have of late years so fully shown the important part which moisture plays in actions of this kind, that it is now recognised as a most important factor. A very marked case of the influence of moisture came under my notice a few months ago. A ship took in a cargo of coal at a South Welsh port, the weather being fine and dry whilst she was loading at the main hatch, but wet whilst she was taking in the coal at the after-hatch, the result being that the temperature in a few days was uniformly about 10° higher in the coal that had been loaded wet, than in the dry portion of the cargo, spontaneous ignition being the final result at the after-hatch.

In order to prevent the spontaneous ignition of large masses of coal, it is manifest that every precaution should be taken during loading or storing to prevent crushing of the coal, and on no account must a large accumulation of small coal be allowed. Where possible the depth of coal in the store should not exceed 6 to 8 feet, and under no conditions must steam-pipes or flues be allowed so near the mass of coal as to give rise to any increase of temperature. These precautions would amply suffice to prevent spontaneous ignition in stored coal on land, whilst special precautions would have to be taken in the case of coal for shipment.

Perhaps the commonest case of spontaneous combustion is the ignition of oily waste or greasy cotton rags. Nearly all vegetable and animal oils have the power of slowly absorbing oxygen, and in some of them this goes on with considerable rapidity, with conversion of the oil into a resin, a property which gives them the power of drying, and causes a considerable rise of temperature. A mass of oil, however, only exposes a very small surface to the oxidising influence of the air, but when such oil comes to be spread upon any non-conducting fabric, the oxidisation is very rapid, and the non-conducting power of the fibre of the fabric prevents the rapid dispersion of the heat, with the result that even a small quantity of such oily substance will readily inflame.

There are plenty of well-authenticated cases in which even a handful of oily cotton waste, which has been used for polishing furniture, has ignited when thrown on one side, and caused most disastrous fires. Just twenty years ago Mr. Galletly read a most valuable paper before the Chemical Section of the British Association, in which he showed that the liability of oils to produce spontaneous combustion was in proportion to their tendency to dry. If a substance like cotton-waste be rendered oily with anything except the mineral oils, it acquires the power of taking up oxygen from the air, and this gives rise to heat. The oxidation is slow at ordinary temperatures, and accordingly it may be some time before the increase of temperature becomes manifest; but when this point is reached, the action proceeds with great rapidity, and the point of ignition is reached in a very short time, and then the mass bursts into flame. If the oily matter be placed in a warm position at first, spontaneous ignition may take place within a few hours, or even minutes. Galletly found that oily cotton at ordinary temperatures took some days to heat and ignite, whilst if placed in a chamber warmed to 130° to 170° F. (54° to 76° C.) the cotton greasy with boiled linseed ignited in 1 hour 15 minutes, and olive oil on cotton in 5 hours; and in a chamber heated to 180° to 200° F. (82° to 93° C.) olive oil on cotton ignited in two hours.

Cases of spontaneous combustion, due to this cause, have been more abundant than from any other, and cases are even on record where serious fires have resulted from sparrows using oily waste in the construction of their nests. In all well-regulated workshops the orders against allowing any accumulation of oily waste are very stringent, and the most reasonable precaution to be taken is that all oily material, when done with, should be thrown into a metal vessel containing water, or which, at any rate, can be either emptied of waste or filled with water at night. If a sheet of cotton be hanging in a warm room and is splashed with oil, a hole will often be found charred in the fabric by the next morning, whilst if a few drops of a drying oil be allowed to fall on powdered charcoal or lamp-black, ignition is almost certain to follow in a few hours.

Another common case of spontaneous ignition is that of haystacks which have been made up before the grass has been thoroughly dried, this being due to the sap left in the vegetable fibre undergoing fermentation, which being a process of oxidation gives rise to heat. This heat is kept in by the surrounding hay, which is an admirable non-conductor of heat, and gradually increases until the ignition point of the mass is reached, when the stack bursts into flame. In some cases the action does not go as far as this, and we often see the inside of a haystack charred to an almost black colour, showing that the action has stopped but little short of the point required to give active combustion, this being probably due to the stack having been very closely built, and the access of air to the centre being small, and in some cases, when such a rick is cut, the air coming in contact with the central portion causes active ignition. If hay has once been properly dried, and then becomes wetted with rain, spontaneous ignition hardly ever takes place, although the hay becomes mouldy, and it is evident that the action which leads to ignition of the hay is fermentation of the sap.

Having now discussed the more common cases of spontaneous ignition, and seen that in every case it is due to rise of temperature, brought about by chemical action until the igniting point of the substance is reached, we are in a position to understand the impossibility of spontaneous combustion taking place in the human body.

The process of respiration by which the tissues of the body used up in every action, voluntary or involuntary, are got rid of by a process of slow combustion, gives a normal temperature to the living body, and it might seem, at first sight, possible by preventing the escape of such temperature, to increase it to a point at which ignition might be possible; but we know by experience that the effect of swathing the body in non-conducting materials, so as to prevent the escape of heat from it, results in profuse perspiration, and before the living flesh could undergo combustion it would be necessary to drive from it the whole of the moisture which it contains.

The human body contains from 75 to 80 per cent. of its weight of water, and in order to evaporate this amount, an enormous amount of heat would be required, and life would have been impossible long before the necessary dryness of the mass had been arrived at. In fact, the moisture present in the body may be looked upon as its great safeguard against the effect of heat, and it is perfectly possible for a living man to remain in an oven which would roast a steak or cook an egg; the evaporation of water from the skin taking up so much heat that the temperature of the living flesh would never rise above a certain point until the moisture was exhausted. It used to be supposed that the cases of spontaneous combustion took place in people whose intemperate habits had caused the body to become saturated with alcohol, and that it was this substance which caused its ready ignition; but as Liebig pointed out, some forty years ago, the presence of the alcohol could have no effect, as if we take a sponge and soak it in spirits of wine and ignite it, the alcohol burns away and leaves the sponge untouched, and the same thing would undoubtedly happen in the case of the living flesh.

In this lecture I have tried to bring before you the important fact that spontaneous combustion merely means that the heat due to chemical actions taking place in any substance, heat which has been unable to escape has raised the temperature to the point of ignition, a point at which slow combustion passes into rapid combustion with manifestation of incandescence ; and in speaking of spontaneous combustion, we must clearly remember that it represents merely the acceleration of an action which has been going on slowly and surely, although our senses may have been too deadened to detect it, and that if we wished to be hyper-critical, "Unaided Ignition," or "Natural Ignition," would be a far more correct term to apply to it than "Spontaneous Combustion."

## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

CAMBRIDGE.—The following appointments in connection with the scientific departments are announced :—Mr. Francis Darwin, Reader in Botany, to be Deputy Professor in the place of Prof. Babington, who is still unable to lecture ; Dr. D. MacAlister to be Assessor to the Regius Professor of Physics ; Dr. Hill, Master of Downing, and Dr. H. D. Rolleston to be Examiners in Anatomy ; Dr. A. S. Lea and Prof. Schäfer to be Examiners in Physiology ; Dr. W. J. Sollas and Mr. P. Lake (St. John's) to be Examiners in Geology ; Mr. Skinner (Christ's) to be an Examiner in Chemistry ; Prof. J. J. Thomson and Prof. G. F. Fitzgerald (of Dublin) to be Examiners in Physics ; Mr. A. Sedgwick (Trinity) and Mr. W. Bateson (St. John's) to be Examiners in Zoology ; Prof. Lewis and Mr. H. A. Miers to be Examiners in Mineralogy ; Mr. Seward (St. John's) and Prof. D. E. Oliver to be Examiners in Botany.

Prof. Sir R. S. Ball has been appointed an Elector to the Isaac Newton Astronomy Studentships.

The Moderators and Examiners for the next Mathematical Tripos (Part I.) are Mr. Walsh (Jesus), Mr. Dawson (Christ's), Mr. Burnside (Pembroke), and Mr. Whitehead (Trinity). For the Second Part, Dr. Forsyth, Sir R. S. Ball, Prof. Lamb, and Mr. H. F. Baker (St. John's) are to examine.

Mrs. E. J. Moore, daughter of the late Colonel Fletcher, has presented to the University her father's valuable collection of Silurian fossils, in supplement of the Fletcher collection purchased many years ago for the Woodwardian Museum.

The Clerk Maxwell Studentship in Experimental Physics, of the value of about £180 a year, tenable for three years, is vacant by the resignation of Mr. W. Cassie, who has been appointed to a professorship at the Royal Holloway College. Candidates must be members of the University who have been a student for one term or more at the Cavendish Laboratory. The names of applicants are to be sent to Prof. J. J. Thomson before November 18.

A grant of £100 from the Worts Travelling Scholars Fund has been made to F. W. Keeble, Frank Smart student of Caius College, to enable him to pursue botanical research in Ceylon.

An examination for scholarships and exhibitions in Natural Science, of the value of £80 a year and under, will be held at Trinity College on Tuesday, October 31.

AT the annual meeting of the New Decimal Association, on October 18, Mr. Samuel Montagu, M.P., remarked that there was a prospect of the United States adopting the metric system as well as a decimal system of coinage. Efforts had been made to induce Mr. Acland to instruct inspectors to examine in the metric system in those schools where it was taught, and, in a letter received from the Education Department on the subject, it was said : "The Code does not prescribe knowledge of the metric system, but of the principles of that system—*i.e.* of the diminution of quantities by tenths, and their increase by tens, with examples sufficient to illustrate the conveniences of the system. Her Majesty's inspectors are required to satisfy themselves that the principles as thus defined are properly taught. It is proposed to issue a memorandum to inspectors on the point at an early date."

## *SCIENTIFIC SERIALS.*

*American Journal of Science*, October.—On endothermic reactions effected by mechanical force, by M. Carey Lea. The object of this investigation was to find whether the blackening effects of pressure upon the silver haloids and other salts could be made immediately visible to the eye, instead of after the application of a reducing agent. For this purpose the pressure was increased to about a million pounds per square inch, or about seventy thousand atmospheres. This pressure was obtained by means of a vice actuated by a screw with six turns to the inch and a lever three feet long. The nuts had to be four inches in length to prevent stripping of the thread. The jaws were specially constructed, and faced with steel welded on. The materials experimented upon were wrapped in platinum or silver foil, which remained unaffected by the pressure. Silver sulphite and carbonate were moderately darkened by two days' pressure, and silver salicylate considerably so. Salts of mercury also showed pronounced effects, which prove that mechanical force can bring about endothermic reactions corresponding to those affected by light, heat, and other forms of energy.—Conditions of Appalachian faulting, by Bailey Willis and C. Willard Hayes. The authors discuss the antecedent conditions for the development, the mechanics of step-folds and thrust-faults as bearing upon actually observed Appalachian structure, and the direction from which the compressing force acted. They come to the conclusion that the latter was equal in opposite directions, and directed north-westward and south-eastward.—On the separation of copper from cadmium by the iodide method, by Philipp E. Browning. The copper was precipitated from a mixed solution by potassium iodide, and filtered through an asbestos felt, washed, dried at 120° C. and weighed. The filtrate and washings containing the cadmium were heated to boiling, and sufficient sodium carbonate was added to complete the precipitation. The precipitate was washed with hot water until free from sulphate or iodide. The crucible containing the cadmium carbonate was heated gently at first, then gradually to a higher degree until the white carbonate had changed to the brown oxide. The method, as tested by means of standard solutions, is fairly accurate, and it is simple in manipulation.—Also papers by Messrs. Foerste, Hidden, Wheeler, Eakins, Williams, Penfield, and Marsh.

THE *American Meteorological Journal* for October contains an account, by A. L. Rotch, of the establishment of a meteorological station at Charchani, near Arequipa, at an altitude of 16,650 feet, which is said to be the highest station in the world. A sum of money was left to Harvard College Observatory by U. A. Boyden, for the purpose of establishing an observatory at a high station, and owing to the remarkable clearness of the air at Arequipa, Peru, this situation was selected for the purpose. The establishment is fully equipped with instruments and is 8,050 feet above the sea ; to the north east and ten miles distant is the quiescent volcano of the Misti, 19,000 feet in altitude, and twelve miles north rises Charchani, 20,000 feet high. The meteorological station now in question has been established just below the permanent snow line, and is supplied with self-recording aneroid and thermometers. The ascent from the permanent observatory, 8,600 feet below, can be made by mule in about eight hours, and an assistant is entrusted with the duty of visiting the station periodically to attend to the records. The results of the observations at both stations will be published in the Annals of the Harvard College Observatory, and will furnish a valuable addition to our knowledge of mountain meteorology.

In the same number, Prof. G. E. Curtis gives an analysis of the causes of rainfall, with especial relations to surface conditions. Among these a principal question is whether forestation increases and deforestation decreases the rainfall. The author considers that the influence of forests has been over-estimated, and that if they affect the rainfall, the amount has, in most cases, not been greater than the amount of probable error in the observations themselves, and therefore that the statistics give no assurance that the effect is not an error of observation. If the rainfall is increased it must be due either to an increase of evaporation, and its subsequent precipitation over the same region, or to the diversion of rain to the forest area, which might have fallen elsewhere.

## *SOCIETIES AND ACADEMIES.*

### PARIS.

Academy of Sciences, October 16.—M. Lœwy in the chair.—On the stability of equilibrium of the axis of the gyroscopic top, by M. H. Resal.—On the partial differential equation presented in the theory of the vibrations of a membrane, by Émile Picard.—On the crystallisation of water by decompression below zero, by M. E. H. Amagat. The experiments were performed with the apparatus provided with glass sights used for studying the solidification of liquids under pressure. But the conical sights mounted in ivory were apt to split into plates, and lose their transparency under high pressures. Cylindrical pieces mounted with marine glue were substituted, some of which resisted pressures up to 1800 atmospheres. The water enclosed in the steel cylinder was first solidified and maintained at a temperature below zero. By gradually raising the pressure, the ice was fused and made to disappear completely. On diminishing the pressure, crystals were deposited on the inner surface of the glass, just as in the case of bodies denser in the solid state when the pressure was raised. The phenomenon is, however, rather more difficult to produce. The solidification was especially retarded when care was taken to fuse all the crystals by pressure, but even when a few fragments were left no such beautiful crystals were obtained as in the case of chloride of carbon. It would be extremely interesting to follow up, for a certain number of liquids, the variation of the point of fusion under very high pressures; as the ratio of the coefficients of compressibility of water and of ice is unknown, it may be asked whether under sufficient pressures the density of ice does not exceed that of water, thus giving rise to a point of inversion which would assimilate the behaviour of water to that of other liquids, or whether other liquids show such a point of inversion in the opposite sense. This would explain certain appearances observed in the case of chloride of carbon.—On an extension of Riemann's method applied to equations of the second order to equations of any order, by M. Delassus.—On the third principle of energetics, by M. H. Le Chatelier. This is a reply to M. Meyerhoffer's criticism, and shows that the term capacity for energy is differently defined by the two authors. Thermodynamic theory is based upon two experimental principles and an hypothesis concerning the nature of heat. The latter may be eliminated by substituting for it the experimental principle which can be expressed as follows: It is impossible to extract energy from a system of bodies without making two at least of its constituents experience changes of opposite sense. From this the proportionality of work performed and heat consumed or generated is easily deduced. It is this proportionality which enables us to reduce the number of algebraic equations to two, sufficient to represent three distinct experimental principles.—On the electric conveyance of heat, by M. L. Houllevigue. The difference of potential between a conductor and iron is different accordingly as the iron is magnetised or not. One joint of a copper-iron couple was brought into a magnetic field, and the other left out. Since this arrangement could not give rise to a steady current without creating energy, an opposing electromotive force was to be expected between the variously magnetised parts of the iron. Such a difference of potential was, in fact, found, the balance being in favour of the less magnetised portions.—On some properties of the oxides of lead, by M. A. Bonnet.—On the interior temperature of bread coming out of the oven, by M. Balland. Experiments performed on various kinds of bread from different ovens show that the temperature of the crumb during baking reaches 100° or 102°, that of the crust being much higher. When beyond 100° the steam imprisoned by the crust is under a certain pressure. If this pressure is relaxed by the bursting of the crust, the temperature of the interior falls to 100°.—Observations of the phenomena of karyokinesis in the blastoderm cellules of the teleostea, by MM. E. Bataillon and R. Kœhler.—On the germination of the Ricinus, by M. Leclerc du Sablon.—A new enemy of the vine, *Blanyulus guttulatus*, Fabr., by M. Fontaine. This is a myriapod which invades the buds in numbers, ranging from five to ten per bud, forming balls of the size of a small pea. Washing with potassium sulphocarbonate and sulphuring the soil are remedies proposed.—On some phenomena relating to the movement of the sea near Bonifacio, by M. Nicol.

## DIARY OF SOCIETIES.

### London.

*THURSDAY*, October 26.

Institution of Mechanical Engineers, at 7.30.—On the Working of Steam Pumps on the Russian South-Western Railways: Alexander Borodin.

*FRIDAY*, October 27.

Physical Society, at 5.—On Air-Core Transformers: E. C. Rimington.—Two Experiments on the Rings and Brushes in Crystals, and Electrical Radiation in Copper Filings: W. B. Croft.

*SUNDAY*, October 29.

Sunday Lecture Society, at 4.—Savages and Barbarians: a Sketch of their Institutions and their Growth from Savagery to Barbarism: Prince Kropotkin.

*THURSDAY*, November 2.

Linnean Society, at 8.—A Contribution to the Phanerogamic Flora of Mato Grosso and the Northern Chaco: Spencer Le Marchant Moore.—On a New Freshwater Schizopod from Tasmania: G. N. Thomson.

*FRIDAY*, November 3.

Geologists' Association, at 8.—*Conversazione*.

## BOOKS RECEIVED.

Books.—Plane Trigonometry: S. L. Loney (Camb. Univ. Press).—The Mummy; Dr. E. A. W. Budge (Camb. Univ. Press).—With the Woodlanders and by the Tide: a Son of the Marshes (Blackwood).—Romance of Low Life amongst Plants: Dr. M. C. Cooke (S.P.C.K.).—Eleventh Annual Report of the U.S. Geological Survey, Part i: Geology.—Eleventh Annual Report of the U.S. Geological Survey, Part ii: Irrigation: J. W. Powell (Washington).—Measurement of Light and Colour-Sensations: J. W. Lovibond (G.ll).—Results of Astronomical Observations made at Sydney Observatory, N.S.W. in the years 1879, 1880, and 1881: H. C. Russell (Sydney, Potter)—Horns and Hoofs, or Chapters on Hoofed Animals: R. Lyddeker (H. Cox).—The Municipal Technical School and School of Art, Manchester, Session 1893-94, Syllabus (Manchester).—Round the Works of our Principal Railways (Arnold).

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