THURSDAY, DECEMBER 31, 1891.

THE PHYSICAL THEORY OF SOLUTION.

Solutions. By W. Ostwald. Translated by M. M. Pattison Muir. Pp. 316. (London: Longmans, Green, and Co., 1891).

WITH certain additions this work is a translation of Book IV. of the second edition of Ostwald's "Lehrbuch der allgemeinen Chemie." At the present time there is no department of physical chemistry which is receiving more attention, and which is the subject of more controversy, than that of solutions. On the Continent, the physical theory of solution, arising out of the ideas of van 't Hoff and Arrhenius, has obtained, for the most part, ready acceptance. Although the earlier of these conceptions is but some six years old, their applications and the facts accumulated around them have already become so numerous that to piece fact and theory together, and keep the main issues of the case to the fore, is a necessity. To carry out these ends no one is better fitted than the Professor of Chemistry in the University of Leipzig. Prof. Ostwald is one of the warmest supporters of the physical theory, and has done more, perhaps, than any other, to make it what it now is.

As contrasted with its reception on the Continent, the new theory has had but little favour shown to it in this country. Men of science on this side of the Channel have, as a rule, been unwilling to grant the more startling consequences which follow in its wake, and have offered more or less decided opposition to its progress. Of late, too, the claims of a special development of the rival hydrate or chemical theory have been brought prominently under their notice. There is therefore a certain fitness in the publication of a "full and authoritative statement" in English of the merits of the physical theory.

The book opens with a definition of solutions. In the light of the physical theory these are "homogeneous mixtures which cannot be separated into their constituent parts by mechanical means." Granting this definition, it forms a basis for classifying the different kinds of solutions, and these, together with the conditions under which they are formed, and under which they exist, are discussed in the first four chapters.

Chapter i., solutions in gases, begins with an account of Dalton's law of partial pressures, and the deviations from the law brought to light by the work of Regnault, Andrews, and others. The somewhat novel result that this gaseous law should be found under the heading solutions, follows, of course, from the fact that a gaseous mixture satisfies the definition quoted. The rest of the chapter is taken up with the evaporation of liquids and solids, as these processes may be regarded as instances of the solution of liquids and of solids in gases.

Solutions in liquids are considered in the next three chapters. Chapter ii. is devoted to solutions of gases in liquids. Henry's law, its verification by Bunsen, the methods of determining absorption coefficients, and the exceptions to Henry's law shown by aqueous solutions of ammonia, hydrogen chloride, &c., are given first. Then follow sections on the theory of gas-absorption, on absorption by saline solutions and by mixed liquids, and on the volume changes of liquids accompanying absorption. Chapter iii. deals with mixed liquids, classified according as they are miscible in all proportions, partially miscible, or practically immiscible. Alexejeff's interesting curves representing the mutual solubility of different pairs of liquids at different temperatures here find a place. The observations of Konowaloff on the vapour pressures of mixed liquids are described at some length, and are worthy of attention, in particular those relating to liquids miscible in all proportions, as they are of especial value in the process of fractional distillation.

Chapter viii. of Book V. of the "Lehrbuch," solutions of solids in liquids, is now introduced. That it is not quite continuous with its predecessors is apparent by the abrupt mention of osmotic pressure, and the use of van 't Hoff's factor *i*, reference being made by the translator to succeeding chapters for explanations. Free application of the gaseous laws to solutions is made in this chapter, which treats of supersaturation, the influence of external pressure and of temperature on solubility, the volume relations of solutions, the influence of melting on solubility, the solubilities of mixtures, the effect of acids on the solubilities of their salts, solutions in mixed liquids, &c. The emphasis laid on the fact that in a saturated solution in contact with undissolved substance, the latter plays an important part in the conditions of equilibrium, is noteworthy.

Under osmose, is next given an account of osmotic pressure, and of the work of Traube, Pfeffer, de Vries, and others, with the theoretical deductions of van 't Hoff which were founded on such researches, and which resulted in quantitative support to the idea of the analogy between solutions and gases. This chapter might with profit have been given at an earlier stage, at least before the previous one, on the solution of solids in liquids.

The chapter following, on the diffusion of dissolved substances, contains a valuable abstract of the main investigations on this subject, from the time of Graham down to the present, when Fick's fundamental law of diffusion follows, as shown by Nernst, from consideration of the effect of osmotic pressure.

Chapters vii. and viii. treat respectively of the vapour pressures and freezing-points of solutions. A full and historical account, with the practical applications to molecular weight estimations, is given in each case. Salt solutions are next discussed, the leading idea of the chapter being to prove that the properties of electrolytes are additive, or can be expressed as the sum of the properties of their constituent ions. Both chemical and physical properties are quoted in support of the existence of free ions in salt solutions. The last chapter is devoted to the simultaneous action of different solvents. The use of some of the results as new methods of determining molecular weights is also indicated.

On the whole, the book is a very suggestive one. The historical method adopted in each chapter adds much to the interest. The arrangement of the facts concerning solutions, and the copious references to original memoirs, are alone sufficient to make the book valuable; and to many, those chapters, such as that on diffusion, which deal mainly with fact, will be the most useful. Even although, in the investigation of solution, the use of the gaseous laws be nothing more than the carrying out of a mere analogy, nevertheless theoretical speculations and practical researches are indicated, which, in the long run, must throw more light on the question.

But, in spite of all this, the book is not satisfying. The main objections which have been urged against the physical theory still exist.

To the fundamental question—"Is solution a physical or a chemical process?"—the answers are various. The opening definition and much that follows seem quite decisive on this point: "Solutions are homogeneous *mixtures*."

Dissolved substances obey gaseous laws because

"the molecules of the solvent in the interior of the solution act equally in all directions on each molecule of the dissolved substance, these molecules are all free to move as if there were, on the whole, no action upon them. Hence it follows that the kinetic energy of the molecules of the dissolved substance is equal to that of the gas at the same temperature."

The deviations of concentrated solutions from the simple gaseous laws are explained by the fact that in such cases the osmotic pressure is high, and that "compound gases of simple composition show marked deviations from the gaseous laws at such pressures."

The inference from such statements obviously is, that solution is purely physical; to the dissolved substance are to be ascribed even the deviations from the gaseous laws; the solvent may be ignored. This is, indeed, the logical outcome of the physical theory.

On the other hand, evidence such as the following has to be considered:—

"Every liquid is capable of taking up every gas, and *combining* therewith to form a homogeneous liquid or solution. . . . Two classes of these gas-solutions are to be distinguished. . . . In cases belonging to the second class, *e.g.* in a *solution* of hydrogen chloride in water, we have sufficient grounds to assert that *chemical change* occurs."

The distinction drawn between crystalloids and colloids is of the same order as the above:—

"Those of the first group (crystalloids) dissolve in water with more or less marked changes of temperature; they raise the boiling-points, lower the freezing-points, and generally exert a marked influence on the properties, of their solutions. The others (colloids) do not exhibit all these properties: their solutions are *mechanical mixtures* rather than *compounds*."

Experiment has shown that the molecular weight of the same dissolved substance, obtained by the Raoult methods, varies in many cases with the solvent. In order to make theory harmonize with practice, this explanation is given:—

"We know that iodine, sulphur, and many other substances exist in different molecular conditions. It is not, then, to be wondered at that a definite substance should exhibit different molecular conditions when dissolved in different solvents. The different solvents act like *different temperatures or pressures*."

The notion of a passive solvent evidently does not here apply. Even on making allowance for a loose use of the terms mixture and compound, it is hard to see how these latter statements accord with the ideas of the functions of the solvent and dissolved substance derived from those quoted previously.

That the book is a portion of a larger treatise is evident, to its detriment, in several ways. One instance, which can hardly escape observation, is the absence of any detailed account of the support to the physical theory which has been drawn from the electrolysis of solutions. At first sight, it is difficult to conceive that, in a work on the physical theory, of which the hypothesis of electrolytic dissociation is an integral part, no mention should be made of the quantitative estimate of the degree of dissociation which has been derived from a study of electric conductivity. The reason is, that electro-chemistry is treated in Vol. II. of the "Lehrbuch," and a second edition of this volume is not yet published. It would have been judicious to have delayed publication of this book till portions of the subject of electro-chemistry could have been included.

It would have been desirable, it seems to us, to have made some adequate reference to other theories which have been put forward in explanation of the phenomena of solution. The only statement which can be construed into an allusion to the hydrate theory occurs when treating of the point as to whether or not a salt in aqueous solution is united with its water of crystallization. And here the question is somewhat contemptuously disposed of:—

"The endeavours of many investigators to find proofs in favour of the existence in solutions of combined water of crystallization have not led to results which can be received without objection; these endeavours may therefore be passed over."

Fault might well be found on the score of incompleteness with much of the evidence put forward in portions of the book. The chapter on salt solutions is one of the most striking; it is, indeed, the only one which has for its theme the dissociation hypothesis; and bearing in mind the contention which this hypothesis has created, here if anywhere the matter put forward should have been beyond criticism. Tables are given of compressibilities, surface-tensions, viscosities, &c.; while, to begin with, these properties are not defined, and several necessary details are omitted. Viscosity may be taken as a special and perhaps the worst example. Two tables are given with numerical values for viscosities. Whether these are absolute coefficients in dynes or relative times of transpiration is not stated. They are in reality relative values, the transpiration time of water under the experimental conditions being taken as unity. The numbers in the first table are said to have been "determined with half normal solutions, and referred to *equivalent* quantities of salt." The meaning of this rather redundant sentence is not quite clear. As a matter of fact, the observations were taken with half normal solutions, and referred to normal solutions by means of Arrhenius's formula connecting viscosity with concentration. Nothing whatever is said about the strength of the solutions used for the observations in the second table. They also relate to normal solutions, and were obtained by a similar but not identical method. The most important omission, however, and one occurring in the case of other properties, is that of the temperature of observation. When it is remembered that at 100° the viscosity coefficient of water is only one-fifth what it is at 0°, the influence of temperature on viscosity is apparent. The difficulty in attempting to compare viscosities has always been the choice of suitable temperatures of comparison—temperatures at which the substances are in comparable conditions. Reference to the original papers shows that the temperature of observation in the examples given was uniformly 25°. Whether under such conditions the viscosities obtained are comparable is open to question, and this point should have been discussed before any stress was put upon the figures. Such details as these ought surely to have been noted as necessary accompaniments of the experimental results.

In other directions the same tendency to omit essential particulars is traceable. In describing the series of operations whereby van 't Hoff was enabled to apply thermodynamics to solutions, it is not shown that the cycle, as conceived by him, is a reversible one. The whole practical utility of the process depends on its reversibility, for then only does the second law of thermodynamics apply. In connection with this point it is not obvious why the translator should prefer the term "reversible cyclical process" to the time-honoured and compact "reversible cycle." The use, too, of the shortened "cyclical process" as the equivalent of "reversible cycle" is inaccurate.

No doubt the incompleteness mentioned is due to the effort made by the author to make the most of his space. In some cases, however, space might be gained. For example, it is surely excessive to give two pages to Voit's method of obtaining diffusion constants, if it led to results which were "quite erroneous"; or to devote three pages to Planck's deduction of the vapour pressure of dilute solutions, if the fundamental thermodynamical equations are assumed.

Several points which require alteration may be summarized here. On p. 7, van der Waals's equation is given wrongly, a bracket being omitted. b in the equation is four times the volume of the molecules, not the volume of the molecules, as stated on pp. 7 and 34. No definite mention is made of what the ordinates and abscissæ are in the diagrams on pp. 66 and 67. On p. 70 "differentiating for T" would usually be "differentiating with respect to T." "Narrower" should be "wider" on p. 97, line 15. The expression "200 grams capacity" is used on p. 118. On p. 136, "square root" should be "square." On pp. 186 and 187, l^b/f' is written for l^f/f'. On p. 237, $1/b$ should be $1/v$. On p. 238, $\frac{b-B}{1-c}$ is given instead of $\frac{b-Bc}{1-c}$.

Mr. Pattison Muir has evidently attempted to give the sense of the original, without confining himself to a literal translation. He has succeeded in making a readable book, although in one or two instances, as in the account of magnetic rotation, the meaning is slightly obscure.

A careful study of this the latest addition to the literature on solution will, we think, confirm what to many has been all along apparent—that solution is in the highest degree a complex process, and that the physical theory errs in treating it as being altogether too simple. Despite the success of this theory, which by establishing a striking analogy has admittedly done much in giving a fresh impetus to investigation, the mechanism of the process is still hidden. The attitude assumed by the upholders of the physical theory, whereby the presence of the solvent is practically ignored, and analogy regarded as identity, must, of necessity, lead to misconception.

Much more work must be done, and, whatever happens, more attention paid to the function of the solvent, before any adequate theory of solution is possible.

J. W. R.

COLOUR BLINDNESS.

Colour Blindness and Colour Perception. By F. W. Edridge Green, M.D., F.G.S. (London: Kegan Paul, Trench, Trübner, and Co., 1891.)

IN a work with this title one naturally expects to find that such recognized authorities on the theory of colour perception as Young and Helmholtz are treated with the respect due to their labours and researches. The writer, however, not only refuses to pay homage at the shrine of such masters of natural philosophy, but deliberately devotes a considerable portion of his work to an exposure of the "fallacy of the Young-Helmholtz theory." The preface informs us that the book has been written for the benefit of those who may have to test for colour blindness. To such it will hardly be a recommendation to learn that the theories of Young and Helmholtz are mere fallacies, and that the tests for colour blindness as instituted by Prof. Holmgren are not worthy of the name. The question, of course, arises, What theory are we to adopt relative to colour perception when we have surrendered our allegiance to the theories which Mr. Green denounces? The author answers this query for us by propounding his own doctrine—"an application of the theory of psycho-physical perception, described in my book on 'Memory,' to the phenomena of colour blindness and colour perception." The arguments in support of this theory are based upon the examination of some 116 colour-blind persons, not an over-large number of cases to generalize from, especially when we learn something of the method pursued in the examination. Information afforded by the colour-blind themselves is one of the chief sources of Mr. Green's knowledge respecting colour blindness. He states that he has derived much valuable information from colour-blind persons relating to facts concerning their colour perception. We question much the trustworthiness of data acquired by interviewing colour-blinds as to the phases of their visual infirmity. Yet Mr. Green characterizes this information as trustworthy, and alludes to it as "definite facts of colour-blindness, to which any future theory must conform." Many writers on colour blindness have stated that naming colours is a useless and misleading method of examination, because the colour-blind must use the conventional colour names and use them at random. But this reasoning, we are told, is a fallacy, because the colour-blind do not name colours at random, but in accordance with their ideas of colour! Such is the language in which the author disposes of the "fallacy" of Holmgren's wool test. Equally illogical is another of his conclusions: "If, as some persons have said, testing by colour names is useless, then the whole series of colour names is useless."

Prof. Holmgren, it is admitted, has done good service in bringing the subject of colour blindness forward; and, in consequence, the writer of "Colour Blindness and Colour Perception" regrets that he has to condemn his test. Probably the test will survive the condemnation. Already, according to the figures of Dr. Joy Jeffries, of Boston, some 180,000 persons have by its means been tested expeditiously and effectively. The mention of the American authority on the subject emphasizes the fact that the name of one whose labours in physiology and optics place him in the front rank of English physicists is omitted from the list of English authorities on the subject. Brewster, Herschel, Tyndall, Maxwell, Pole, Abney, Rayleigh, Galton, Nettleship, Bickerton, Frost, and Hogg are recognized as having added to our "knowledge of colour blindness and the dangers arising from the defect." The name of Dr. Brudenell Carter does not appear in the list! The omission is so glaring when the well-known character of Dr. Carter's contributions to the lore of colour blindness is considered, that there must be some reason for it. Doubtless it is because Dr. Carter has been guilty of the heinous crime of championing the theories of Young and Helmholtz that Mr. Green refuses to recognize him as a contributor to our knowledge of the subject under discussion. Dr. Carter once said, in the course of one of the Cantor Lectures: "I read somewhere, and have vainly endeavoured to find again, a denunciation of the 'fallacies of the Young-Helmholtz theory.'" We recommend "Colour Blindness and Colour Perception" to his attention. The so-called fallacies he will there find completely exposed and shattered in a manner most refreshing, and perfectly satisfactory—at least to Mr. Green.

Careful study of Mr. Green's work forces upon one the conclusion that the theories of Young and Helmholtz are "fallacies" for the simple reason that he has failed to understand them aright. Holmgren's tests are no tests because their principle is opposed to the unscientific elaborations of Mr. Green.

An extension of the field of research, together with an honest attempt to *understand* the "fallacies" of Young and Helmholtz, will, we are certain, induce Mr. Green to remove from his book many of its errors and absurdities.

A METEOROLOGICAL GUIDE-BOOK.

Instructions Météorologiques. Par A. Angot. Troisième Édition. (Paris: Gauthier-Villars et Fils, 1891.)

THE "Instructions Météorologiques," which is the official guide-book for meteorological observers in France, has long been known as a model work of its kind, distinguished by great clearness and sufficiency of detail, while avoiding prolixity. The third edition, lately published, has been revised and extended by M. Angot, whose name is a sufficient guarantee that it maintains the high standard of the original work.

The subject-matter of the present edition has been increased by nearly one-half. One of the chief additions is the description of some of the simpler self-recording instruments, which, it is stated, are coming into general use at the minor French observatories—viz. the sunshine recorder, the recording aneroid, an autographic thermometer on the Bourdon principle constructed by MM. Richard Frères, and an autographic hair-hygrometer. The section on cloud observation has been recast in accordance with the classification proposed by MM. Hildebrandsson and Abercromby, and, under the heading of "Phénomènes Optiques," halos and the aurora borealis are described. The more common appearance of lunar and solar coronas, though mentioned, is not specially noticed in this section. In a book intended for the instruction of beginners, we think it would have been well to point out the distinction of coronas and halos, since, in our experience, the latter are not infrequently recorded by inexperienced observers, when the former have been the phenomena really observed.

Another subject, treated of for the first time in this edition, is the computation of elevations from the barometric readings, and also from those of the hypsometrical thermometer, the use of which is described at length. In the appendix are given tables for facilitating the reduction of the observations of both classes of instruments.

The patterns of the various instruments, thermometer-shelters, &c., approved by the author of the "Instructions," differ in many respects from those generally preferred by English observers, and in such matters there will, of course, be differences of opinion. The French thermometer-screen, represented on pp. 32 and 33, affords, in our opinion, a better exposure than the Stevenson screen adopted by the Meteorological Societies of England and Scotland, but seems hardly to protect the instruments sufficiently in stormy weather; while the simpler form represented on p. 35 seems quite inadequate in the latter respect, and the method of suspending the maximum and minimum thermometers somewhat flimsy and insecure.

In the text of the work we find little or nothing to which we could take exception, but we think one or two of the figures are open to improvement. The close proximity of the wet and dry bulb thermometers represented in Fig. 16 is hardly compatible with accurate registration of the humidity of the air; and surely the wind-vane represented on p. 73, on the slope of a roof at some indefinite distance below the ridge, is scarcely in an ideally good position, and such as should be put before learners as a standard model for imitation. We would also suggest that, in future editions, a simple form of nephescope, such as Marié Davy's, should be described, together with directions for observing the movement of the clouds. It has long been a matter of surprise that a class of observations so important in themselves and so easily made has been so generally ignored by the writers of such manuals as the present.

OUR BOOK SHELF.

Chambers's Encyclopædia. New Edition, Vol. VIII. (London and Edinburgh: W. and R. Chambers, 1891.)

WE are glad to welcome a fresh instalment of this admirable edition of Chambers's well-known Encyclopædia. It deals with the subjects indicated by words extending from "Peasant" to "Roumelia." Subjects of scientific interest have, as usual, been intrusted to writers who know how to present concisely and clearly the latest results of research. A clear account of the phonograph is given by Mr. Thomas A. Edison; and

Mr. T. C. Hepworth and Mr. W. T. Bashford trace the history and describe carefully the various processes of photography. Mr. J. S. Keltie has an excellent article on Polar exploration, illustrated with a North Polar and a South Polar chart. A short but very good paper on protoplasm is contributed by Mr. J. A. Thomson; and Prof. Sorley makes the most of the few pages set apart for psychology. Rain is discussed admirably by Dr. Buchan, and the rainbow by Mr. W. T. Omond. Reflection and refraction are dealt with by Dr. Alfred Daniell. The main facts relating to the Red Sea are presented by Dr. John Murray; and Dr. Hugh R. Mill sets down all that is likely to be wanted by students who have occasion to refer to the article "River." Altogether, the various papers we have examined may be commended as in every way worthy of the high reputation secured for the present edition by preceding volumes.

La Place de l'Homme dans la Nature. By T. H. Huxley. (Paris: B. B. Baillière et Fils, 1891.)

MORE than twenty years ago a French translation of Prof. Huxley's well-known work, "Man's Place in Nature," was published. The translator was Dr. E. Dally. In the present volume this rendering is reissued, and along with it are associated translations of three papers in which Prof. Huxley has presented his ideas on various ethnological subjects. These papers have been translated by Dr. Henry de Varigny, to whom Prof. Huxley expresses thanks for the care he has taken to represent clearly and faithfully the meaning of the original. The volume will be very welcome to French students who desire to understand the methods and tendencies of English scientific thought.

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.*]

Smithsonian Standards for Physical Apparatus.

ON the occasion of a scientific expedition of which I had charge many years ago, the need of common standards of size for the parts of different astronomical and physical instruments was brought forcibly to mind; for the instruments used, while of the latest and best construction, were necessarily dismembered, and then transported in fragments to their scarcely accessible destination by numerous independent bearers; and if any accident happened to any fragment of any piece of apparatus, it was found, as a rule, that the whole was rendered useless, since it could not be replaced from the like parts of other pieces which were spared. The weapons of attack of the little scientific force were, then, in one important respect, far inferior to those of modern warfare, in that there had been no attempt to make their parts interchangeable.

My attention having been drawn to the matter, I was led to examine astronomical and physical instruments in all cabinets accessible to me, with a special view to this feature. I found that, as a rule, no draw-tube, screw, or other piece from one instrument would fit the corresponding parts in any other, there being no attempt to make them interchangeable even where they came from the same maker.

This experience must be confirmed by that of most others, who will probably agree that this is a cause of incessant, but quite avoidable, loss and delay, even where apparatus is used under ordinary conditions, and it has led to inquiry for some scheme which would assimilate different parts of the work, not only of the same, but of different makers. Some of the plans suggested are well matured, and in themselves apparently commendable, but all are too complex, the ambition of the authors being, as a rule, to make them so complete as to cover all possible demands of future progress.

What has been wanted by many others doubtless is some simple and practicable plan for *immediate* use, which shall yet be found in accord with the larger scheme which may be under consideration hereafter.

When it fell to me to meet the somewhat varied wants of the Smithsonian Institution by a plan which should at least enable a beginning to be made in the right direction, it seemed that this should be with such simple and general conditions, that common consent to them might almost be counted on, at least on the part of all ready to use the metrical standards.

To provide for the immediate practical wants of this Institution, advice was sought of several of the best instrument makers, and a considerable number of tubes and screws by English, French, and German, as well as American makers were examined to find out the sizes which long-established use in these countries had shown to be practically convenient, and the forms of screws which the best modern practice of scientific instrument makers concurred in; and this having been done, dimensions having a metrical unit, and as near these sizes as practicable, were adopted—not as a finality, but as a beginning.

In the hope that others may consider this very modest attempt to be in the right direction, and that these standards may fall into use for immediate needs, and thus tend to bring about the adoption of that much more complete system of international standards which most will admit to be (at least in the abstract) desirable, I beg leave to inclose a circular which has been sent to all instrument makers employed by this Institution, trusting that you may find it of sufficient interest to bring it to the attention of the readers of NATURE.

S. P. LANGLEY,
Secretary.

Smithsonian Institution, Washington, D.C., December 16.

Circular to Instrument Makers.

In all apparatus used by the Smithsonian Institution a series of standard sizes for metal tubes and for the screws chased on them has been adopted. The metric division is employed, and all tubes ordered are to be finished to some even number of half centimetres in diameter, unless this cannot be done without great difficulty. The series of diameters and corresponding threads to be used is, for a diameter of

10	centimetres,	5	threads to a centimetre.
9	,,	5	,, ,, ,,
7·5	,,	7	,, ,, ,,
6	,,	7	,, ,, ,,
4·5	,,	10	,, ,, ,,
3	,,	15	,, ,, ,,

When any new tube has to be ordered, it should be made one of these diameters and chased with one of these threads, if this can in any way be done.

New eye-pieces are to be as far as possible made to fit the three-centimetre plug gauge supplied by Pratt and Whitney, and in fitting them to old work, this size is still to be adapted wherever possible. The Institution is preparing standard plugs and gauges of the diameters given above, and has on hand chases of 5, 7, 10, and 15 threads to the centimetre. All screws have the 60° thread, with flattened top and bottom. These it will supply at first cost to any instrument maker engaged in its work.

Plug gauges are to be had of great accuracy and at moderate cost from several standard tool makers. Those here referred to have been made for the Smithsonian Institution by the Pratt and Whitney Company of Hartford, Connecticut, and are within a limit of error of two-hundred-thousandths of an inch at 62° Fahrenheit. The hobs are from the same makers.

Pigment in Yellow Butterflies.

Apropos of the interesting discussion on comparative palatability and warning colours (NATURE, November 19, p. 53; November 26, p. 78), it may be of interest to your readers if I restate in your columns some of the properties of the yellow pigment contained in the wings of the common brimstone and many other butterflies; the possible significance of which in conferring protective unpalatability is suggested by Mr. Beddard. My paper on the subject, to which Mr. Beddard refers, was read before the Chemical Society in June 1889; but, being more or less of a preliminary nature, it was published only in the abstracts of that Society's proceedings (Abst. Proc. Chem. Soc., vol. v., 1889, p. 117; *vide* also NATURE, vol. xl. p. 335).

The pigment is freely soluble in hot water, though quite insoluble in cold water, and in most organic solvents. Its aqueous solution is strongly acid to litmus; and, though it appears to be quite innocuous to frogs when injected under the skin, it may well be ungrateful to the ranine palate. At the same time it must be noted in this regard that its solubility in the secretions of the frog's mouth is but very slight.

The substance is, as I have shown, undoubtedly a derivative of uric acid, yielding the latter body as one of its products of hydrolysis. It gives the murexide reaction direct. It forms quite definite salts with metals, its compounds with the alkalies being soluble bodies.

Having regard to the wide-spread presence of the body in the scales of diurnal Lepidoptera, I have ventured to call it *lepidotic acid*. In its physical properties it closely resembles mycomelic acid, a yellow derivative of uric acid; and, in my original paper, I ventured to suggest a formula for the body. I hope shortly to publish a more complete account of the subject, and to assign a formula to lepidotic acid based upon fuller evidence. Meanwhile, in common with many others of your readers, I am looking forward to the appearance of Mr. Beddard's book. The literature of the subject of animal coloration is not easily accessible, and a text-book thereon will be a valuable acquisition. We have, it is true, the interesting work of Mr. Poulton; but the subject is there treated from what is, perhaps, a somewhat limited standpoint.

F. GOWLAND HOPKINS.

Sir Wm. Gull Research Laboratory,
Guy's Hospital, December 16.

The Chromosphere Line λ 6676·9.

IN response to Father Cortie's implied question as to the identification of this line as belonging to the spectrum of iron, I would refer him to Appendix G of Roscoe's lectures on "Spectrum Analysis" (third edition). It is an extract from a joint paper by Ångström and Thalen, giving a list of several hundred (then) new identifications; among them appears K 654·3, ascribed to iron.

The original memoir was presented to the Stockholm Academy of Sciences in February 1865, and an English translation of it appeared the next year. I am unable to assign any reason why many of the identifications given in this memoir fail to appear in the map published three years later; but they do, and K 654·3 is among the missing.

C. A. YOUNG.

Princeton, N.J., U.S., December 15.

Grafts and Heredity.

I HAD not thought of grafts when I wrote my paper, and I have to thank Mr. Beeby for reminding me of an excellent illustration of my views; though I cannot gather from his letter whether he considers the "individuality" for which he contends to be represented by matter or force. Adopting his phrase I would apply it to both. The material form, *e.g.*, of the leaf of the scion, is due to molecular motion, set up by a group of forces acting in a way peculiar to the life of the scion; which *forces*, together with the resulting *form*, constitute its individuality—somewhat as a man is known by his mental and moral characters as well as by his face.

Now, no two individual plants could be fed more alike than a stock and its grafted scion; since they both receive identically the same food through the roots of the former. All I contend for is, therefore, that it would seem to be more probable that the organic molecules constructed out of this food are all alike, only differently arranged in the leaf of the scion and in that of the stock respectively. These arrangements must be due to molecular forces; while it is difficult to conceive in one's mind how any special kinds of matter can be concerned in the construction of the special forms of leaves; to say nothing of the total want of evidence of the existence of germ- or other plasm.

There is, however, a deeper question still which Mr. Croll asked:—"What *determines* molecular motion?"[1] He observed that although physical forces are not only interchangeable but can pass into those which, for want of a better expression, we may call vital energies; yet, as he says, nothing we know of in the properties of physical forces can throw the smallest degree of light upon the above question. There is always, he adds, the "object" which runs through the whole of organized nature; which cannot be accounted for by means of the known properties of physical forces. In concluding his paper he says:—"If one plant or animal differs from another, or the parent from the child [and, we may add, the scion from the stock], it is because in the building up process the determinations of molecular motion were different in the two cases; and the true and fundamental ground of the difference must be sought for in the cause of the determination of molecular motion. Here, in this region, the doctrine of natural selection and the struggle for existence can afford no more light on the matter than the fortuitous concourse of atoms and the atomical philosophy of the ancients." This observation seems to agree with the following remark of Sir J. D. Hooker on the origin of secretory glands of *Nepenthes*:—"The subsequent differentiation of the secretory organs of the pitcher into aqueous, saccharine, and acid would follow *pari passu* with the evolution of the pitcher itself, according to those mysterious laws which result in the correlation of organs and functions throughout the kingdoms of Nature; which, in my apprehension, transcend in wonder and interest those of evolution and the origin of species."[1]

The nearest approach to an answer to Mr. Croll's question is, as it seems to me (though it be but cutting the Gordian knot after all), that there exists *a responsive and adaptive power inherent in living protoplasm* which is called into action by external forces; so that by a change of environment—especially if the old and the new one be strongly contrasted—a plant, as a rule, at once begins to alter its structure so as to re-establish equilibrium with its new surroundings; and further, if these be maintained long enough, the altered structures become fixed and hereditary, while more or less of readaptation can commence again at any time.

We can no more discover the ultimate cause of this power which *determines* or *directs* molecular motion in living beings, than we can that of crystallization or gravity, reflex action or instinct. Innumerable facts, however, justify the full recognition of its existence.

To apply this to grafts. It is obvious that, whatever determines the molecular motion in forming the leaf of the scion, it is different from that which determines the molecular motion in forming the leaf of the stock, since the resulting forms of the leaves are different; and it is just this ultimate *determining power*, which is unknown and apparently unknowable, which characterizes the individuality of the scion on the one hand, and of the stock on the other. Form is but the outward and visible expression of this power. It is this, too, which underlies the responsiveness of protoplasm, and determines a new form in adaptation to, or in equilibrium with, a changed environment.

GEORGE HENSLOW.

[1] "What Determines Molecular Motion?—The Fundamental Problem of Nature" (*Phil. Mag.*, July 1872).

[1] Address to the Department of Zoology and Botany of the British Association, Belfast, 1874.

Mental Arithmetic.

THE very simple method of multiplying large numbers, published in NATURE (p. 78) by Mr. Clive Cuthbertson, is mentioned by Pappus, Book II. (ed. Hultsch), 2–29, as an invention of Apollonius. The same method was known to the Hindoos under the name Vajrâbhyâsa (Algebra with Arithmetic and Mensuration from the Sanskrit Brahmegupta and Bhascara, translated by H. Th. Colebrooke, London, 1817).

The method may be enlarged to multiplying three and even more numbers all at once in the following manner:—

$$\begin{aligned}(100a_1 + 10b_1 + c_1)(100a_2 + 10b_2 + c_2)(100a_3 + 10b_3 + c_3) = \\ c_1c_2c_3 \\ + 10(b_1c_2c_3 + b_2c_3c_1 + b_3c_1c_2) \\ + 10^2(a_1c_2c_3 + a_2c_3c_1 + a_3c_1c_2 \\ + b_1b_2c_3 + b_2b_3c_1 + b_3b_1c_2) \\ + 10^3(a_1[b_2c_3 + b_3c_2] + a_2[b_3c_1 + b_1c_3] \\ + a_3[b_1c_2 + b_2c_1] + b_1b_2b_3) \\ + 10^4(a_1a_2c_3 + a_2a_3c_1 + a_3a_1c_2 \\ + a_1b_2b_3 + a_2b_3b_1 + a_3b_1b_2) \\ + 10^5(a_1a_2b_3 + a_2a_3b_1 + a_3a_1b_2) \\ + 10^6a_1a_2a_3.\end{aligned}$$

Special example :—

$$123 \times 456 \times 789$$

$$\begin{matrix}1\ 2\ 3\\4\ 5\ 6\\7\ 8\ 9\end{matrix}$$

First figure.—3×6×9=162 2

Second figure.—16+2 . 6 . 9+5 . 9 . 3+8 . 3 . 6=403 . . 32

Third figure.—40+1 . 6 . 9+4 . 9 . 3+7 . 3 . 6+2 . 5 . 9 +5 . 8 . 3+8 . 2 . 6=634 432

Fourth figure.—63+1 . (5 . 9+8 . 6)+4 . (2 . 9+8 . 3) +7 . (2 . 6+5 . 3)+2 . 5 . 8=593 3432

Fifth figure.—59+1 . 4 . 9+4 . 7 . 3+7 1 . 6 +1 . 5 . 8+4 . 8 . 2+7 . 2 . 5=395 . . . 53432

Sixth figure.—39+1 . 4 . 8+4 . 7 . 2+7 . 1 . 5=162 . 253432

Seventh and eighth figures.—16+1 . 4 7=44 . . . 44253432

K. HAAS.

Vienna, VI., Matrosengasse 8.

The Migration of the Lemming.

HAVING resided during the summer months for more than twenty years on the plateau from which the migrations of the Norwegian lemming are supposed by many to take their origin, I can speak from personal observation. Some years ago I had the honour to read a rather lengthy paper before the Linnean Society on these animals, and, with one exception, to which reference will be presently made, I am happy in having nothing to alter or recant. The increase of the Lemmings is not cumulative, but rather periodic, as indeed is usual among the voles as well as among many other forms of life. The migrations are not caused by insufficient food *now*, whatever they may formerly have been, and this is evident from the fact that the swarms pass through, but do not exhaust the fertile districts which they encounter on their pilgrimage. Nor are they affected by any personal struggles between these most pugnacious of animals, for the young litters, when reared, go singly on the journey from which none have ever been observed to return. They do not follow the watershed, and they do not always migrate to the west—an error into which I was betrayed by trusting to common report and insufficient personal experience. But they do go straight. It is well known that the eyes of the lemming are so placed on the top of the head as to render it impossible for the animal when swimming, to discern any object not far above the plane of its horizon. On a calm morning last summer, I often placed my boat in the path of the swimmers, and noticed that they crossed my lake in an absolute "bee-line," and that they could not discern my presence until the angle subtended by the boat was infinitely higher than that of the opposite shore. This latter migration was south-east, and in the late autumn the steamer on Lake Mjosen made its way through thousands of these hapless wayfarers; whilst, still later, large numbers were to be seen close to Christiania ; but I venture to prophesy that none will be found in that neighbourhood next year, nor, for the matter of that, in Heimdalen itself, though it is obvious that some must remain. Probably the explanation of these apparently capricious and suicidal migrations may be that they are the result of hereditary instinct, which formerly was of service if not necessary to the species. The straight course which they pursue must be owing to the sense of direction common to migrants, and I would hazard the conjecture that the changes of destination may be due to an instinct which, owing to its present inutility, is gradually diminishing in precision and intensity. W. DUPPA-CROTCH.

Asgard, Richmond, December 24.

The Recent Earthquake in Japan.

DANS la lettre de M. J. Milne, Tokio, 7 novembre, sur le tremblement de terre du Japon du 28 octobre, 1891 (NATURE, xlv. 127), il y a entr'autres un fait intéressant : c'est la mise en oscillation de l'eau d'un bassin de 60 pieds de longueur sur 25 pieds de profondeur. Il est rare que dans un tremblement de terre l'eau des étangs ou des lacs soit mise en mouvement ; le rythme des vibrations du sol ne correspond pas, le plus souvent, au rythme de l'oscillation de l'eau. Dans le cas actuel, les vagues ayant atteint une hauteur de 3 à 4 pieds, il est certain que l'eau a pris un mouvement de balancement.

Le formule d'un tel mouvement d'oscillation pendulaire, si le bassin a un fond horizontal, est :

$$t = \frac{2l}{\sqrt{gh}},$$

$$l = 60 \text{ pieds} = 18{\cdot}29\text{m.},$$

$$h = 25 \text{ pieds} = 7{\cdot}62\text{m.},$$

$$t = 4{\cdot}2 \text{ secondes de temps.'}$$

Il serait intéressant de savoir si le rythme des vibrations du tremblement de terre à Tokio a correspondu à une durée aussi lente ; ou peut-être à la moitié de cette durée, soit 2·1". Ce serait déjà des vibrations extraordinairement lentes pour un tremblement de terre. F.-A. FOREL.

Morges, 12 decembre.

ON THE VIRIAL EQUATION FOR GASES AND VAPOURS.

ALTHOUGH I had, some time ago, written to Lord Rayleigh to the effect that I did not intend to prolong the discussion of this question, it may perhaps be expected that I should say a few words with reference to Prof. Korteweg's paper in the last issue of NATURE.

1. I do not agree with Prof. Korteweg's statement that Van der Waals's method, if it could be worked out with absolute rigour, would give the same result as the direct method. There is but one way of dealing with the virial equation :—if we adopt it at starting we must develop its terms one by one, and independently. In this connection I may refer to Lord Rayleigh's statement (NATURE, 26/11/91) : "It thus appears that, contrary to the assertion of Maxwell, p *is* subject to correction." I cannot admit that p is "corrected" ; it is not even changed either in meaning or in value. It is introduced as, and remains (at the end of any legitimate transformations of the equation) the value of the pressure on the containing vessel. This, of course, depends upon what is going on in the interior. Other terms in the virial equation, which happen to have the same factor, may be associated with p for convenience ; they assist in finding its value, but they do not change its meaning, nor do they "correct" it.

2. I do not think that much aid can be obtained by analogy, at least in the present question, from the case of one-dimensional motion. For the latter may be looked on as virtually the to-and-fro motions between fixed boundaries of a number of particles, each of which keeps its speed for ever unchanged, except at the moments when two *instantaneously* pass through one another. From this point of view the result of Lord Rayleigh and of Prof. Korteweg follows at once. Make the particles mere points, and diminish their free range by the sum of their original lengths, and everything will go on practically as before. Can a corresponding statement be made for three dimensions ? Again, there is in the one-dimensional case a perfectly arbitrary set of speeds, which remains unchanged :—there is nothing analogous to the beautiful statistical distribution of Clerk-Maxwell. And what would be the result if molecular forces were introduced ?

3. Prof. Korteweg seems not to have noticed the following sentence in my second letter to Lord Rayleigh (NATURE, 29/10/91, p. 628) :—"The true mode of getting a cubic here . . . [*i.e.* in Prof. Korteweg's notation,

$$p_1 v = \tfrac{1}{3}\Sigma(mu^2)\left(1 + \frac{\beta}{v}\right)\Big]$$

is to write $\beta/(v - \gamma)$ instead of β/v. This can, to a certain extent at least, be justified ; the other method can not." I had, originally, added a sentence to the effect that, if γ be taken equal to β, Van der Waals's result would at once be obtained. But I struck it out as irrelevant, because the discussion turned mainly upon the question of the value of the free path at a volume nearly equal to the critical volume. Here Van der Waals expressly recognized that his b must be diminished in value. From my point of view, β (having been determined once for all) is unchangeable; while γ is essentially less than β, possibly even negative.

Prof. Korteweg takes a different view, and says that the "true" formula is obtained by the process above hinted at:—*i.e.* by putting (with the preceding notation) $\gamma = \beta$.

4. Prof. Korteweg speaks of the equation written above as "quite worthless." But, in all this discussion, where the rival expressions differ only by the introduction or rejection of terms of the order β^2/v^2; which, according to Prof. Korteweg, make an equation "true" or "quite worthless" as the case may be:—are we not introducing an error, of that order at least, in calmly writing

$$p_1 = p + \frac{a}{v^2},$$

instead of some such expression as

$$p_1 = p + \frac{a}{v(v+a)}?$$

We have, fortunately, one practical test at hand to help in the decision of such questions. The introduction of the form last written, certainly more likely to be approximate than the first, renders the "quite worthless" equation capable of at least fairly representing the results of Andrews. The "true" equation, we know, does not represent them. P. G. Tait.

Edinburgh, 21/12/91.

ON THE RELATION OF NATURAL SCIENCE TO ART.[1]

I.

We are assembled to-day in annual commemoration of a man whose marvellous breadth of view and extraordinary variety of interests are each time a fresh surprise to us. It seems incredible that the same hand could have penned the "Protogea" and the State-paper adjudging the Principality of Neufchâtel to the King of Prussia; or that the same mind could have conceived the infinitesimal calculus and the true measure of forces, as well as the pre-established harmony and the "Theodicea." A closer examination, however, reveals a blank in the universality of his genius. We seek in vain for any connection with art, if we except the Latin poem composed by Leibnitz in praise of Brand's discovery of phosphorus. We need hardly mention that his "Ars Combinatoria" has nothing to do with the fine arts. In his letters and works, observations on the beautiful are few and far between; once he discusses more at length the pleasure excited by music, the cause of which he attributes to an equable, though invisible, order in the chordal vibrations, which "raiseth a sympathetic echo in our minds." However, the world of the senses had little reality for Leibnitz. With his bodily eye he saw the Alps and the treasures of Italian art, but they conveyed nothing to his soul. He was indifferent to beauty; in short, we never surprise this Hercules at Omphale's distaff.

The same neglect, at least of sculpture and painting, strikes us in Voltaire, who as polyhistorian can in some measure compare with Leibnitz. We are obliged to descend as far as the third generation—that is, to Diderot in France, to Winckelmann and Lessing in Germany—before we meet with a decided interest in the fine arts, and an appreciation of the part they play in the progress of civilization.

The period thus defined, though it excels in science, shows with few exceptions a falling-off in the fine arts. On considering the historical development of these two branches of human productiveness, we find no correspondence whatever between their individual progress. When Greek sculpture was in its prime, science scarcely existed. True, Lionardo's gigantic personality, which combines the immortal artist with the physicist of high rank, towers at the beginning of the epoch generally known in the history of art as the Cinquecento. Still, he was too far in advance of his age in the latter capacity to be cited as an example of simultaneous development in art and science; so little that Galilei was born the day of Michael Angelo's death. The mutual development of art and science at the commencement of our century is, I believe, merely a casual coincidence; moreover the fine arts have since been at the best stationary, whereas science strides on victoriously towards a boundless future.

In fact, both branches differ too widely for the services rendered to science by art, and *vice versâ*, to be other than external. "Nature," Goethe very truly observed to Eckermann—little thinking how harshly this remark reflects on part of his own scientific work—"Nature allows no trifling; she is always sincere, always serious, always stern; she is always in the right, and the errors and mistakes are invariably ours." Fully to appreciate the truth of this, one must be in the habit of trying one's own hand at experiments and observations, while gazing in Nature's relentless countenance, and of bearing, as it were, the tremendous responsibility incurred by the statement of the seemingly most insignificant fact. For every correctly interpreted experiment means no less than this: whatever occurs under the present circumstances, would have occurred under the same conditions before an infinite negative period of time, and would still occur after an infinite positive period. Only the mathematician, whose method of research has more in common with that of the experimenter than is generally supposed, experiences the same feeling of responsibility in presence of Nature's eternally inviolable laws. Both are sworn witnesses before the tribunal of reality, striving for knowledge of the universe as it actually is, within those limits to which we are confined by the nature of our intellect.

However, there is a compensation for the philosopher, labouring under this anxious pressure, in the consciousness that the slightest of his achievements will carry him one step beyond the highest reached by his greatest predecessor; that possibly it may contain the germ of vastly important theoretical revelations and practical results, as Wollaston's lines contained the germ of spectral analysis; that, at any rate, such a reward is not only in the reach of a born genius, but of any conscientious worker; and, finally, that science, by subduing Nature to the rule of the human intellect, is the chief instrument of civilization. No real civilization would exist without it, and in its absence nothing could prevent our civilization, including art and its master-works, from crumbling away again hopelessly, as at the decline of the ancient world.

This consciousness will also make up to the philosopher for the thoughtlessness of the multitude, who, while enjoying the benefits thus lavished upon them, hardly know to whom they owe them. The country rings with the name of every fashionable musical *virtuoso*, and cyclopædias insure its immortality. But who repeats the name of him who achieved that supreme triumph of the inventive intellect—to convey through a copper wire across

[1] An Address delivered by E. du Bois-Reymond, M.D., F.R.S., at the annual meeting of the Royal Academy of Sciences of Berlin in commemoration of Leibnitz, on July 3, 1890. Translated by his daughter. This Address was first printed in the weekly reports (*Sitzungsberichte*) of the Berlin Academy, then in Dr. Rodenberg's *Deutsche Rundschau*, and lastly it was published as a separate pamphlet by Veit and Co., at Leipzig, 1891.

far-stretching countries and over hill and dale the sound of the human voice as though it spoke in our ear?

"Life is earnest, art is gay": this saying of Schiller's remains as true if we substitute science for life. Art is the realm of the beautiful; its productions fill us with an enjoyment, half sensuous, half intellectual; it is, therefore, a realm of liberty in the widest sense. No rigid laws are enforced in it; no stern logic binds the events of the present to those of the past and future; no certain signs indicate success; blame and praise are distributed by the varying taste of ages, nations, and individuals, so that the glorious Gothic church architecture came to be derided by the eighteenth century. In art, the definition of genius as a talent for patience does not hold good. Its creations, once brought forth in a happy hour of revelation, stir our souls with elementary force, and scorn all abstruse explanations, subsequently forced upon them by art criticism. Whoever accomplishes such a feat also ministers in a sense to the cares and troubles of humanity. Unfortunately, the nature of things does not allow such fruit to ripen at all seasons; at one time, in one direction, the culminating point will be reached, and then age after age will strive in vain to emulate the past. The finest æsthetic theories can neither carry the individual beyond the limits of his own natural powers, nor retrieve the fortunes of a declining period. Of what use has been the recent strife in the artistic world between naturalists and idealists? Has it protected us from the frequently almost intolerable extravagances of the latter? There is an attraction in every boldly advanced novelty which the common herd is unable to resist, and which will invariably triumph till antiquated ideas are somehow supplanted by fresh ones, or by the lofty rule of some irresistibly superior personality. Nor can science in the stricter sense come to the aid of art; and thus, strangers at heart, without materially influencing each other, each seeks its own way: the former advancing steadily, though irregularly; the latter slowly fluctuating like a majestic tide. Those unfamiliar with science are apt to recognize the supreme development of our mental faculties in art alone. Doubtless this is a mistake; yet human intellect shines brightest where glory in art is coupled with glory in science.

We may notice something here which is similar to what occurs in practical ethics. The more corrupt the morals of an age or nation, the more we find virtue a favourite topic. The flood of æsthetic theories rises highest when original creative power is at its lowest ebb. Lotze, in his "History of Æsthetics in Germany,"[1] gives a wearying and discouraging account of such fruitless efforts. Philosophers of all schools have rivalled in abstract definitions of the essence of beauty. They call it unity in multiplicity, or fitness without a purpose, or unconscious rationality, or the transcendant realized, or the enjoyment of the harmony of the absolute, and so forth. But all these properties, which are supposed to constitute the beautiful, have no more to do with our actual sensation of it than the vibrations of light and sound with the qualities they bring to our perception. Indeed, it would be vain to attempt to find one term equally fitted to describe all the varieties of the beautiful: the beauty of cosmos as contrasted with chaos, of a mountain prospect, a symphony, or a poem, of Ristori in Medea, or a rose; or even, taking the fine arts alone, the beauty of the Cologne Cathedral, the "Hermes" of Praxiteles, the Madonna Sistina, a picture of still-life, a landscape, a genre piece, or a Japanese flower design; not to mention the questionable custom which permits us in German to speak of a beautiful taste or a beautiful smell. Let us rather admit that here, as so often, we meet with something inexplicable in our organization; something inexpressible, though not the less distinctly felt, without which life would offer a dull and cheerless aspect.

[1] Munich, 1868.

In an essay of Schiller's there is a disquisition on physical beauty.[1] He distinguishes between an architectural beauty and a beauty which emanates from grace. I attacked this æsthetic rationalism, to which the last century was strongly addicted, twenty years ago on a similar occasion in a lecture on Leibnitz's ideas in modern science. I ventured to assert that "the attraction which physical beauty exerts on the opposite sexes can as little be explained as the effects of a melody."[2] On reflection, it seems, indeed, incomprehensible why one distinct shape, which, according to Fechner, might be represented by a plain algebraic equation between three variables, should please us beyond a thousand other possibilities. The reason can be traced from no abstract principle, no rules of architecture, not even from Hogarth's line of beauty. A year after this remark was made, Charles Darwin published his "Descent of Man," in which the principle of sexual selection, only cursorily treated in the "Origin of Species," is fully expounded, and pursued in all its bearings. I remember vividly how, in a discussion with Dove as to the necessity of admitting a vital force, he embarrassed me by the objection that in the organic world luxury occurs, for example, in the plumage of a peacock or a bird of Paradise; while in inorganic nature Maupertuis's law of the minimum of action precludes such prodigality. Here was a solution to the problem, allowing that one might attribute to animals a certain sense of beauty. The gorgeous nuptial plumage displayed by male birds may have been acquired through the preference of the female for more highly ornamented suitors, a progeny of constantly increasing brilliancy of colouring being thus obtained. Male birds of Paradise have been observed to vie in showing off their beauty before the females during courtship. The power of song in nightingales might be attributed to the same cause, the female in this case being more susceptible to the charms of melody than to those of brilliant colouring. Darwin goes on to observe that, in the human race likewise, certain sexual characteristics, such as the imposing beard in man and the lovely tresses in woman, might have been acquired through sexual selection.[3] It is a well-known fact that, by the repeated introduction of handsome Circassian slaves into aristocratic Turkish harems, the original Mongol type in many cases has been remarkably ennobled. And carrying the same principle further, we may find therein an explanation for the fascination which female beauty has for man. According to our present views, the first woman was not made of a rib taken out of the first man—a process fraught with morphological difficulties. It was man himself who, in countless generations, through natural selection, fashioned woman to his own liking, and was so fashioned by her. This type we call beautiful, but we need only to cast a glance at a Venus by Titian, or one by Rubens—let alone the different human races—to recognize how little absolute this beauty is.

If one kind of beauty could be said to bear analyzing better than another, it is what might be termed mechanical beauty. It is noticed least, because it escapes all but the practised eye. This kind of beauty may belong to machines or physical apparatus, each part of which is exactly fitted to its purpose in size, shape, and position. It answers more or less to the definition of "unconscious rationality," our satisfaction

[1] "Ueber Anmuth und Würde."
[2] The author's "Collected Addresses, &c.," vol. i., pp. 49, 50, Leipzig, 1886.
[3] The author is not unaware of Mr. Wallace's attack on Darwin's explanation of the brilliant plumage of male birds by the females' preference, and of the discussion arisen between him and Messrs. Poulton, Pocock, and Peckham. This was not the proper place to enter into it, the less so as, whatever may be its outcome, the author's conclusion from the theory of sexual selection would remain unaltered.

evidently proceeding from an unconscious perception of the right means having been employed to combine solidity, lightness, and, if necessary, mobility, with the greatest possible profit in the transmission of force, and the smallest waste of material. A driving-belt is certainly neither attractive nor unattractive; but it pleases the "*visus eruditus*" to see a connecting-rod thicken from the ends towards the middle, where it has to bear the greatest strain. Of course this kind of beauty is of recent origin. I remember Halske telling me that, as regards the construction of physical and astronomical instruments, it was, to his knowledge, first understood and established as a principle in Germany by Georg von Reichenbach in Munich. Berlin and Munich workshops produced instruments of perfect mechanical beauty at a time when those supplied by France and England were still often disfigured by aimlessly ornamented columns and cornices, unpleasantly recalling the impure features of Rococo furniture and architecture.

I forget which French mathematician of the last century, in sight of the cupola of St. Peter's at Rome, tried to account for the sense of perfect satisfaction it gives to the eye. He measured out the curves of the cupola, and found that, according to the rules of higher statics, its shape supplies the exact maximum of stability under the given circumstances. Thus Michael Angelo, guided by an unerring instinct in the construction of his model (the cupola was not erected till after his death), unconsciously solved a problem the true nature of which he could hardly have understood, and which was even beyond the reach of the mathematical knowledge of his age. Apparently, however, there are several roots to this equation of beauty; at least there is one other type, for which I quote the cupola of Val de Grâce in Paris, which, if not as imposing, is quite as gratifying to the eye, as Michael Angelo's.

It will be observed that in this case mechanical beauty becomes part of the art of architecture; and instances of this kind are daily growing more frequent, our modern iron structures being more favourable to its display than stone buildings. In the Eiffel Tower we see mechanical beauty struggling with the absence of plastic beauty. On this occasion it was probably revealed for the first time to many who hitherto had no opportunity of experiencing its effect. It is certainly not wanting in the new Forth Bridge. There is no doubt, however, that in stone structures too, together with much that pleases from habit or tradition, there are certain features which evidently attract through mechanical beauty—such as the outline of the architectural members of a building, or the gentle swelling and tapering of the Doric column towards the top, and its expansion in the echinus and abacus; and there are others which offend a refined taste through the absence of this beneficial element, such as the meaningless ornamentations of the Rococo style.

Even in organic nature mechanical beauty prevails to such an extent that it transforms many objects into a source of delight and admiration to the initiated, which are naturally repulsive to the untrained eye. Anatomists recognize it with pleasure in the structure of the bones, especially of the joints. In their opinion the "Dance of Death" outrages good taste from more reasons than because it differs from the classical conception of death. Mechanical beauty was already perceived by Benvenuto Cellini in the skeleton, much to his credit; and but for our imperfect knowledge, it would invest with its glory every organic form, down to the inhabitants of the aquarium, even under the very microscope. According to Prof. Schwendener, even plants are constructed on the same principle of fitness combined with thrift; and something of this we feel at sight of a spreading oak-tree, proudly distending its vigorous branches towards air and sunlight.

Again, our appreciation of the forms of animals, especially of noble breeds, is greatly influenced by mechanical beauty. The greyhound and the bulldog, the full-bred race-horse and the brewer's dray-horse, the Southdown and the Merino sheep, the Alpine cattle and the Dutch milch-cow, all are beautiful in their kind; even though a bulldog or a Percheron may appear ugly to the uninitiated, because in each the type of the species has been modified to the utmost degree of fitness.

Though science is unable, as we have seen, to check the occasional decline of art and inspire it with fresh vigour, yet it renders invaluable services of a different kind to artists, by increasing their insight, improving their technical means, teaching them useful rules, and preserving them from mistakes. I do not allude to anything so primitive as the manufacture of colours or the technique of casting in bronze; the less so, as, curiously enough, our modern colours are less durable than those of entirely unscientific ages, and the unsurpassed thinness of the casting of Greek bronzes is regarded as a proof of their authenticity. Nor does it seem necessary to recall the notorious advantages of this kind for which art is indebted to science. Linear perspective was invented by Lionardo and Dürer—artists themselves. It was followed by the laws of reflection—unknown to ancient painters, as would appear from the Pompeian frescoes of Narcissus—and by the geometrical construction of shadows. The rainbow, which had better not be attempted at all, has been sinned against cruelly and persistently by artists, in spite of optics. Statics furnished the rules of equilibrium, so essential to sculptors. Aërial perspective, again, owes its development to painters chiefly of northern climates.

But to this fundamental stock of knowledge the progress of science has added various new and important acquisitions, which philosophers, some of first-rate ability, have endeavoured to place within the reach of artists. The great masters of by-gone ages were taught by instinct to combine the right colours, as women of taste, according to John Müller, always know how to blend the right shades in their dress; and Oriental carpet-weavers have not been behindhand with them in that respect. But the reason why they unconsciously succeed was not revealed till the elder Darwins, Goethe, Purkinye, John Müller, and others, called into existence a subjective physiology of the sense of sight. A member of this Academy, Prof. von Brücke, in his "Physiology of Colours"[1] and "Fragments from the Theory of the Fine Arts in relation to Industrial Art,"[2] treats these subjects with such intimate knowledge as could only be obtained by one who enjoyed the rare advantage of combining physiological learning with an artistic education acquired in his father's studio. In France, Chevreul pursued similar aims. Even Prof. von Helmholtz, in his popular lectures, has devoted his profound knowledge of physiological optics, to the service of art, which already owes him important revelations on the nature of musical harmony. Amongst other things, he explained the relation between the different intensities of light in objects of the actual world and those on the painter's palette; and pointed out the means by which the difficulties arising therefrom may be overcome.[3] Thus painters, as von Brücke remarks, have it in their power to reproduce the dazzling effect of the disk of the sun by imitating the irradiation—a defect of our visual perception the true nature of which was recognized by von Helmholtz. An example of this, interesting through its boldness, is the lovely Castell Gandolfo in the Raczynski gallery.

There are so many and striking instances of such imperfections of the human eye that, notwithstanding its marvellous capabilities, von Helmholtz has observed that "he would feel himself justified in censuring most severely

[1] 2nd edition, Leipzig, 1887. [2] Leipzig, 1877.
[3] Prof. von Helmholtz, "Collected Essays and Addresses," vol. ii., Brunswick, 1884.

the careless workmanship of an optician who offered him for sale an instrument with similar defects, and that he would emphatically refuse to take it." The eye being the chief organ of artists, its defects are of great importance in art and its history, and artists would do well to inform themselves, not only on these defects in general, but more particularly on those which they, in their own persons, are subject to; for, as Bessel remarked of astronomical instruments, "an error once well ascertained ceases to be an error."

Our conception of the stars as stars, in the shape adopted symbolically by decorative art, is caused by a defect of the eye closely related to irradiation; stars being luminous spots in the sky without rays, as they actually appear to a privileged few. Prof. Exner, whose line of thought we shall repeatedly cross in the course of these reflections, justly remarks that to this imperfection the stars conferred by Sovereigns as marks of distinction owe their origin, and star-fishes their name, even since Pliny's time. The different varieties of halo, however, are more probably free-born children of our fancy—from the Byzantine massive golden disk, down to the mild phosphorescence proceeding from holy heads and in Correggio's "Night" from the entire child, which illumines the scene with a light of its own. According to Prof. Exner, glories of the latter description are derived from the radiance which surrounds the shadow of one's own head in the sunshine on a dewy meadow, and which in fact has always been compared to halos in religious pictures. This phenomenon even misled Benvenuto Cellini into the pious delusion that it was a gift granted him individually from above, and a reflection of his visions, such as Moses brought down from Mount Sinai.[1]

Certain otherwise quite inexplicable peculiarities which disfigure the later works of the distinguished landscape-painter Turner have also been traced to defects of the eye by Dr. Richard Liebreich.[2] Clouded lenses or a high degree of astigmatism might easily lead a painter to distort or blur objects he was copying from nature. Donders's stenopeic spectacles or cylindrical spectacles, as the case might be, would prove as useful to such an artist as concave glasses to the shortsighted.

The singularities of another English painter, Mulready, are accounted for by Dr. Liebreich through discoloration of the lens from old age. Another defect of the eye—colour-blindness—ought to be mentioned here, which in its milder forms is of frequent occurrence, and even belongs to the normal condition of the eye on the borders of the field of vision. It corresponds in the domain of hearing to the want of musical ear. Colour-blindness was known long ago, but has been inquired into with redoubled zeal latterly, partly with regard to its general connection with chromatics, partly on account of its serious practical consequences in the case of sailors, railway officials, and, as Dr. Liebreich adds, of painters. Both colour-blindness and want of ear are inborn defects, for which there is no remedy. A colour-blind artist is, however, better off than a musician without an ear, if such a one were imaginable, for, even if he neglected the modelling stick and the chisel, he might still seek his fortune in the designing of cartoons.

It is difficult to determine the particular point where optical knowledge ceases to be of use to artists. None will repent having studied the laws of the movement of the eyes, the difference between near and distant vision, and the observations on the expression of the human eye contained in John Müller's early work on "Comparative Physiology of Sight." Yet it must be admitted that a painter may paint an eye exceedingly well without ever having heard of Sanson's images, which cause the soft lustre of a gentle eye as well as the fierce flash of an angry one; as little as the blue sky of a landscape painter will gain by his knowledge of the yellow brushes in every great circle of the heavenly vault which passes through the sun—a phenomenon which has remained unnoticed for countless ages, but has grown familiar to physiologists since Haidinger's discovery.

One point, however, where physicists seem to me not to have been sufficiently consulted, is the much-debated question of polychrome in ancient statues and architecture, and whether it should be adopted by modern art or not. Physical experiments teach that very intense illumination causes all colours to appear whitish; in the spectrum of the sun, seen immediately through the telescope, the colours vanish almost entirely, nothing remaining except a light yellow hue in the red end. As the colours grow whitish the glaring contrasts are softened, they blend more harmoniously. In the open air, therefore, our eye is not shocked by the scarlet skirt of the *contadina*, which recurs almost as invariably in Oswald Achenbach's Campagna landscapes, as the white horse in Wouvermanns's war scenes. The Greek statues and buildings may have looked well enough with their glaring decorations under the bright southern sky on the Acropolis or in the Poikile; in the dull light of our northern home, above all in closed rooms, they are somewhat out of place.

In another direction Wheatstone has added valuable information to the knowledge of painters and designers with his stereoscope. It demonstrates the fundamental difference which distinguishes binocular vision of near objects from monocular vision, as well as from binocular vision of objects so far removed that the distance between the eyes vanishes as compared with their distance. An impression of solidity can only be obtained by each eye getting a different view of an object, the two images being fused into one, so as to appear solid. A painter can therefore only express depth by shading and aërial perspective; he will never be able to produce the impression of actual solidity on his canvas. While Wheatstone's pseudoscope exhibits the unheard-of spectacle of a concave human face, Helmholtz's telestereoscope magnifies, as it were, the space between the eyes, and resolves a far-off range of woods or hills without aërial perspective into its different distances. Finally, Halske's stereoscope with movable pictures confirms old Dr. Robert Smith's explanation of the much-debated circumstance that the sun and moon on the horizon appear larger by almost a fifth of their diameter than when seen in the zenith, and reduces the problem to the other question: why the vault of the sky appears to us flattened instead of hemispherical.

However, the almost contemporary invention of photography was destined to be of vastly greater importance to the fine arts. It had always been the dream of artists as well as physicists to fix della Porta's charming pictures—a dream the realization of which did not seem quite impossible since the discovery of chloride of silver. One must have witnessed Daguerre's invention, and Arago's report of it in the Chamber of Deputies, to conceive the universal enthusiasm with which it was welcomed. Daguerre's method, being complicated and of restricted application, was soon cast into the shade by the one still essentially practised at the present day. However, it is worth recording that, when the first specimens, imperfect as they were, reached us from England, no one foresaw the immense success in store for Talbotypes; on the contrary, the change from silver-coated plates to paper impregnated with the silver salt was received with doubt, and considered a retrogression.

Thus photography entered on its marvellously victorious career. With respect to art it promptly fulfilled what Arago had promised in its name. It not only facilitated the designing of architecture, interiors, and landscapes, and rendered the *camera clara* unnecessary

[1] "Vita di Benvenuto Cellini, scritta da lui medesimo," libro primo, cxxvii.
[2] "Turner and Mulready: the Effect of certain Faults of Vision on Painting, &c.," London, 1888.

even for panoramas, but also furnished many valuable hints with regard to light and shade, reflection and *chiaroscuro*, and the general means of reproducing as closely as possible on a level surface the raised appearance of solid forms. A competent judge of both arts might find it an interesting task to ascertain what share photography has had in the origin of the modern schools of painting, and in the manner of impressionists and pleinairists. It further taught landscape-painters to depict rocks and vegetation with geological and botanical accuracy, and to represent glaciers, which hitherto had been but rarely and never successfully attempted. It caught and fixed the changing aspect of the clouds, though only yielding a somewhat restricted survey of the heavens. It aided portrait-painters without exciting their jealousy; for, unable to rival them in representing the average aspect of persons, it only seized single, often strained and weary expressions, rendering almost proverbial the comparison between a bad portrait and a photographed face; nevertheless it supplied them on many occasions with an invaluable groundwork, lacking nothing but the animating touch of an artist's hand.

However, the recent progress of photographic portraiture claims the attention of artists in more than one respect. Duchenne and Darwin called into existence a new doctrine of the expression of the emotions; the former by galvanizing the muscles of the face, in order to imitate different expressions, the latter by inquiring into their phylogenetic development in the animal series. Both presented artists with photographs which quickly consigned to oblivion the copies hitherto employed for purposes of study in schools of art, dating chiefly from Lebrun; even the sketches in Signor Mantegazza's new work on "Physiognomy and Mimics" will scarcely enter into competition. On Mr. Herbert Spencer's suggestion, Mr. Francis Galton subsequently solved by the aid of photography a problem, which was previously quite as inaccessible to painters as the representation of an average expression to photographers. He combined the average features of the face and skull of a sufficient number of persons of the same age, sex, profession, culture, or disposition to disease or vice, in one typical portrait, which exhibits only those characteristic forms common to their various dispositions. This was effected by blending on one negative the faint images of a series of persons belonging to the same description. In the same manner, Prof. Bowditch, of Harvard Medical School, Boston, obtained the representative face or type of American students of both sexes, and of tramway conductors and drivers. In the latter instance, the intellectual superiority of the conductors over the drivers is plainly visible. How Lavater and Gall would have relished this!

Of course the average expression of a single person might be procured by similar means, if it were worth while summing up on the same plate repeated photographs of different expressions. Instantaneous photography, however, furnishes a welcome substitute for the average expression, by seizing with lightning swiftness the changing phases of the human countenance in their full vivacity. Here, again, pathology places itself at the disposal of art. M. Charcot has found that photographs of the convulsions and facial distortions of hysterical patients resemble our classical representations of the possessed. Raphael's realism in this respect is perhaps the most curious of all, being so much at variance with his idealistic nature. In the possessed boy of the "Transfiguration," a cerebral disease can be almost safely inferred from the Magendie position of the eyes; and the circumstance, recently observed in New York, that the left hand is depicted in a spasm of athetosis, would accord well with this diagnosis.[1]

(*To be continued.*)

[1] Sachs and Petersen, "A Study of Cerebral Palsies," &c., *Journal of Nervous and Mental Diseases*, New York, May 1890.

TELESCOPIC OBJECTIVES.[1]

IT is a frequent source of disappointment to observers, especially beginners, to find that their instruments fail to answer to the tests which are so commonly found in astronomical text-books. It may be that the instrument in question is really an imperfect one; but if it be the work of a maker of repute, it is more probable the fault lies in the absence of proper adjustment, more especially if, for some reason or other, no responsible person is able to superintend the final fixing in position. The information hitherto published on the subject of adjustment, and the phenomena which accompany the various defects of an objective, is very scanty; and observers of all classes will therefore welcome the appearance of the little book recently issued by Messrs. T. Cooke and Sons, the well-known firm of telescope makers The book is the best testimony that one could wish for as to their thorough knowledge of their business, and it abundantly demonstrates that they are worthy of the confidence which astronomers have long placed in them. The benefit of their wide experience is now available to all, and observers need no longer remain in doubt as to the quality of their objectives, or of the course to be pursued in tracing the defects to their proper sources.

For full particulars of the methods to be adopted we must refer our readers to the book itself, but many of the points touched upon are of great interest, considered simply as optical phenomena, and a brief reference to some of them may not be out of place.

It is a matter of common knowledge that, owing to the undulatory nature of rays of light, the image of a luminous point, such as a star, must always be a small disk, the diameter of which varies in inverse proportion to the aperture of the objective. This "spurious disk" is surrounded by a series of diffraction rings, which gradually diminish in intensity away from the centre.

The calculations of Sir George Airy[2] show that the angular radii of the rings, in circular measure, are given by the formula $\frac{\lambda n}{2\pi e}$, where λ is the wave-length of the light-rays in question, e the radius of the objective, and n a constant which depends on the distance from the centre. The first dark ring occurs when $n = 3{\cdot}83$, the second when $n = 7{\cdot}14$, and the third when $n = 10{\cdot}17$. Hence, the angular radius of the first dark ring, which is really the boundary of the spurious disk, may be easily derived from the formula $\frac{3{\cdot}83 \times \lambda}{2\pi e}$, or $\frac{1{\cdot}22\lambda}{2e}$.

The rings are brightest when $n = 5{\cdot}12$, $8{\cdot}43$, and $11{\cdot}63$, with intensities respectively about 1/57, 1/240, and 1/620 of that at the centre.

If s be the angular radius in seconds of arc, as viewed from the centre of the objective, the formula becomes

$$n = \frac{2\pi e s}{\lambda} \cdot \sin 1'';$$

and if λ for mean rays be taken as ·000022 inch,

$$n = 1{\cdot}3846 \times e s.$$

For the first dark ring, therefore,

$$s = \frac{3{\cdot}83}{1{\cdot}3846 e} = \frac{2{\cdot}76}{e}.$$

Messrs. Cooke put these expressions in the form—

$$\text{Angular diameter of first dark ring in circular measure} = \frac{2 \times 1{\cdot}22\lambda}{A},$$

$$\text{Linear diameter of first dark ring} = \frac{2F \times 1{\cdot}22\lambda}{A};$$

where A = aperture, and F = focal length.

For a square aperture the conditions are different, and

[1] "On the Adjustment and Testing of Telescopic Objectives." (T. Cooke and Sons, Buckingham Works, York.)

[2] "Undulatory Theory of Optics," 1877 edition, p. 80.

the size of the first dark *square* is given by the formula $\frac{2\lambda F}{A}$.

Some interesting facts given by Messrs. Cooke show the remarkable agreement between the theoretical and observed values of these diameters. "A 6-inch objective, of 91 inches focal length, was directed to a bright star, and the objective cut down, in the first place, to a *square* aperture, 1·5 inches diameter. The mean of four measurements gave the diameter of the first dark ring (in this case square in shape) as ·0027 inch, while the formula $\frac{2F\lambda}{A}$ (where $\lambda = 1/45600$ inch) gives ·00266 as the theoretical value. A circular aperture, diameter 1·22 inches, was then placed in front of the objective, when the mean of four measurements gave a diameter of ·0039 for the first dark ring, while the formula $\frac{2F \times 1{\cdot}22\lambda}{A}$ gives a value of ·0040" (p. 31). "The diameter of the first dark ring, as depicted with the whole aperture of 6 inches in use, was also measured as nearly as its minute size would allow, the measurement obtained ranging about ·0008 (subject to an error of perhaps 10 per cent.), while the value given by the formula $\frac{2F \times 1{\cdot}22\lambda}{A}$ is ·00081" (p. 32).

As the spurious disk fades away into the first dark ring, its apparent diameter will depend on the intrinsic brightness of the star observed, and also to some extent on irradiation. Hence the necessity for measuring the rings, and not the "disks" themselves.

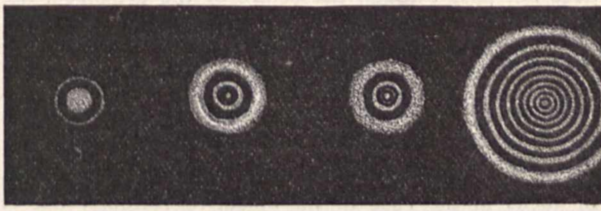
An important fact follows from the application of these considerations, for on the apparent diameter of the spurious disk depends the dividing power of the objective. If the diameter of the star disk—which may, on the average, be taken as half that of the first dark ring—be greater than the distance between the components of a double star, the telescope must obviously fail to divide it, no matter what may be the power of the eye-piece employed. "In all objectives having their focal lengths equal to fifteen times the aperture, the linear diameter of the spurious disk may be said to average ·0004 inch, or about 1/2500 inch. With 6 inches aperture this corresponds to an angular diameter of 0·9 second, and in a 12-inch aperture to 0·45 second. So these respectively represent the dividing powers of such apertures upon double stars of average brightness" (p. 31). For similar apertures, the values given by Dawes for stars in which both components are of the sixth magnitude are 0″·76 and 0″·38 respectively. To reduce the star disks to the extent necessary for the separation of the components of the spectroscopic binary β Aurigæ (the angular distance being about 0″·005), an object-glass no less than 80 feet in diameter would be required.

The images of a star with the diffraction rings as yielded by a sensibly perfect objective are shown in Fig. 1.[1] Fig. 1, *a*, represents the focused disk and ring system seen under a high magnifying power; 1, *b*, and 1, *c*, are sections of the cone of rays taken very near to and on opposite sides of the focus, also seen with a high power; and 1, *d*, is a section taken about ¼ of an inch on either side of the focus, and viewed with a moderate power.

Before this perfection of image can be realized, we gather that the objective must satisfy the following conditions:—(1) The optic axes of the flint and crown glass lenses should be coincident. (2) This common axis should pass through the centre of the eye-piece. (3) The dispersions of the flint and crown should neutralize each other for the most visible rays of the spectrum. (4) There should be no spherical or zonal aberration. (5) The lenses should be free from astigmatism.

[1] The diagrams are reproduced with the permission of Messrs. Cooke.

The second of these adjustments is practically the only one over which the observer himself has any control, and he must remain contented with the means of ascertaining



a *b* *c* *a*

FIG. 1.—Diagrams showing spurious disk and diffraction rings seen with a perfect objective.

how far his objective satisfies the remaining conditions enumerated.

The process of testing an objective is considerably complicated by the imperfections of the eye as an optical instrument. Its want of achromatism when the full aperture of the pupil is used may frequently lead the observer astray in making observations in which colour effects are to be noticed. This defect is demonstrated, as pointed out on p. 14, by the fact that coloured fringes are observed to surround the image of a star seen in the open field of a reflector, of the perfect achromatism of which there can be no question. A sound practical hint accompanies this statement. The use of a power from 50 to 70 times the aperture in inches is recommended for purposes of testing, in order that the pencil of rays entering the pupil may be reduced; for if the power be equal to or less than the quotient of the diameter of the objective and the diameter of the pupil, the full aperture of the pupil is utilized, and the defect is consequently at its maximum.

Colour-blindness, of which no mention is made by Messrs. Cooke, is also common, and it is obvious that no colour-blind eye is competent to make tests depending on colour phenomena.

Astigmatism, too, is not an uncommon defect, the rays falling along one diameter of the lenses of the eye being refracted in a greater or less degree than those falling along the direction at right angles. Oculists combat this by supplying compensating astigmatic lenses as spectacles; and unless such compensation be perfect, an astigmatic eye must clearly be disqualified from making some of the test observations.

Another complication arises on account of atmospheric dispersion (p. 18). This, of course, is at its maximum for stars on the horizon, and the image of such a star would appear to have a red fringe on the upper and a green or blue fringe on the lower side, even in the most perfect telescope, unless a compensating eye-piece be used. Hence the importance of selecting stars of considerable altitude for purposes of adjustment and testing.

Further, the Huyghenian and Ramsden eye-pieces, which are almost universally used, are not achromatic in the strict sense of the term, and the eye-piece used for testing should therefore not be selected at random (p. 13).

Bearing these facts in mind, one may proceed to test the adjustments referred to.

(1) Any difference in the position of the axes of the component parts of the objective will cause the combination to act somewhat in the manner of an object-glass prism, such as is used in photographing stellar spectra, and the image of a star seen under such maladjustment will appear as a spectrum. The red end of the spectrum will obviously lie on the side towards which the flint is displaced with regard to the crown lens, an effect which is most noticeable when the eye-piece is racked within the focus (p. 17).

(2) This adjustment is technically called "squaring on," and is usually provided for in telescopes over 3 inches in aperture. If the optic axis of the objective does not pass through the centre of the eye-piece, the diffraction rings which are seen when the star is out of focus, will appear oval, and the focused image will be fan-shaped (p. 8). This follows from the fact that we are dealing with an oblique section of the cones of rays from the object-glass, and the rings will be most expanded and dimmest on the side which is furthest from the object-glass.

Fig. 2, *a*, represents the rings seen when the star is out of focus in the case of an objective seriously out of square, and Fig. 2, *b*, the corresponding focused image.

(3) Ordinary objectives should be so corrected that all the rays between C and F of the spectrum are brought to a common focus, these being the rays to which the

a *b*

FIG. 2.—Appearances observed when the objective is out of square.

retina is most sensitive. When this is done the objective is "over-corrected," and the rays less refrangible than C are brought to a shorter focus, while those more refrangible than F are focused at a greater distance outside. Hence, supposing a white star like Vega is observed, the focused image should be surrounded by an almost imperceptible blue fringe. A little way within the focus the image should show a reddish nucleus, and outside the focus a bluish centre should be observed. The effect of the colour of the star observed must be carefully guarded against (p. 16), and an eye-piece of sufficient power should be employed, for the reason already stated.

A good method of testing for achromatism is to focus the image of a star on the slit of a spectroscope. If the image be perfectly achromatic, as in the case of a reflector, the spectrum seen will be a line of uniform thickness. Any departure from this will be indicated by local

a *b*

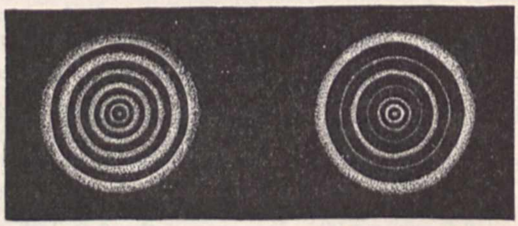
FIG. 3.—Appearances due to spherical aberration.

widenings of the spectrum. With an ordinary objective, the spectrum should be a narrow line from C to F, widening out at each end.

(4) The absence of proper correction for spherical aberration produces very interesting features in the diffraction rings, some of which are admirably shown by the diagrams which are reproduced in Figs. 3, *a*, and 3, *b*. These represent sections of the cone of rays within and outside the focus respectively in the case of a lens in which there is *positive* aberration—that is, in which the rays from the outer parts of the object-glass come to a shorter focus than the central rays. In the first figure the concentration of light in the outer ring is the chief characteristic, while in the second the central ring is relatively brighter.

Zonal aberration, in which different parts of the objective have slightly different foci, modify the ring systems in a very remarkable fashion. In this case, the rings will not gradually diminish in intensity, but will vary according to the degree of imperfection. Figs. 4, *a*, and 4, *b*, show a good example of this, being sections taken within and outside the focus respectively.

(5) The effect of astigmatism in the objective will be



a *b*

FIG. 4.—Effects of zonal aberration.

to produce ellipticity in the rings, a very decided example of which is shown in Fig. 5.

Fig. 5, *a*, is a section taken within the focus, and Fig. 5, *b*, a section taken at the same distance outside. The combined effects of an astigmatic objective and an astigmatic eye may obviously be very variable.

Other causes may also operate in the modification of

a *b*

FIG. 5.—Elliptic rings produced by astigmatism.

the diffraction rings, and some good examples are given The effects of the flexure of a lens supported on three points, for instance, are admirably shown in Fig. 6, *a*. Those who have seen photographs in which bright stars appear with their conventional rays will now have no difficulty in understanding their origin. They depend simply upon the distortion of the lens or mirror with which

a *b* *c* *d*

FIG. 6.—Diagrams showing effects due to (*a*) flexure; (*b* and *c*) strain in cell; (*d*) veins in objective.

the photograph was taken, and the number of rays will correspond to the number of points of support.

An objective which is strained in its cell, but properly squared on, may produce a distortion of the rings similar to that shown in Fig. 6, *b*. A more violent case of mechanical strain is shown in Fig. 6, *c*, and the presence of veins of unequal refractive power may affect the rings somewhat in the manner shown in Fig. 6, *d*.

A. FOWLER.

NOTES.

A NUMBER of very remarkable letters and hitherto unedited memoirs of the great Swedish chemist Carl Wilhelm Scheele, who died in 1786, are to be published under the direction of Baron Nordenskiöld. The work will fill about 500 pages octavo, of the same size and print as Wilson's "Life of Henry Cavendish" (London, 1851). The Baron is considering the question of bringing out an Anglo-American edition of the work. As editor he may not be quite impartial, but he is persuaded that in importance and interest the book will be unsurpassed in historico-chemical literature. He hopes also to obtain permission to consult some of the papers on chemistry left behind by Cavendish. For instance, he would like to know if the date assigned by the Rev. Vernon Harcourt to Cavendish's researches on arsenic (Report of the Ninth Meeting of the British Association, held at Birmingham, 1839, p. 50) is exact, or if any error affects the determination of the date. Where are these papers at present deposited? Are they accessible to a foreign student?

WE understand that the Professorship of Descriptive Geometry, Mechanical Drawing, Machinery, and Surveying, in the Royal College of Science, Dublin, will almost immediately become vacant by the retirement of Prof. Pigott, we regret to say on the ground of ill-health. The salary of the chair is £400, rising to £500 a year with a share of fees. The appointment rests with the Lord President of the Council, and applications, with testimonials, should be addressed to the Secretary, Science and Art Department, London.

THE death of C. X. Vaussenat, the Director of the Observatory on the Pic du Midi, is announced. Quite recently he received from the Société Nationale d'Agriculture de France its large gold medal for the eminent services rendered by his observatory to agriculture. The idea of building an observatory on the Pic du Midi was due to General de Nansouty, but in working out the plan the General owed much to the enthusiastic co-operation of M. Vaussenat. When the institution was made over to the State, General de Nansouty became honorary director, M. Vaussenat effective director. M. Vaussenat was an engineer, and had devoted much time to the study of geology.

PAUL HUNFALVY, whose death is recorded by Austrian journals, was recognized as the most eminent Hungarian ethnographer and philologist. He was the author of many papers on the relation of the Magyar language to the Finnish, but especially to the Ugrian languages, and on the original seats of the Finnish-Ugrian peoples. In a book describing his travels in the Baltic Provinces he had much that was interesting to say about the Esthonians; and to a series of works on the races of the Austro-Hungarian Monarchy he contributed a volume on "The Hungarians or Magyars."

AN Ethnographical Exhibition is to be held at Prague in 1893. The objects exhibited will relate to the life of the Slavonic population of Bohemia, Moravia, and Silesia.

THE U.S. Patent Office proposes to exhibit at the Chicago Exposition a comprehensive array of models to illustrate the progress of mechanical civilization. One group of models will show the progress of the printers' art from Gutenberg's invention to the latest rotary perfecting and folding printing press, capable of turning out newspapers at the rate of many thousands per hour. Other groups will show the development of the steam-engine, sewing-machine, agricultural machinery, applications of electricity, &c.

ACCORDING to *Electricity*, a Chicago journal, Messrs. Siemens and Halske, the well-known German firm of electrical engineers and manufacturers, propose to outdo all their competitors in the extent of their exhibit at the World's Fair. Herr Carl Vogel, the managing director of the firm, recently went to Chicago to make the necessary arrangements. He asked for a special building, but the Committee on Electricity decided that space could not be granted outside the regular buildings. The Department of Electricity has, however, offered to Messrs. Siemens and Halske 20,000 square feet in the electricity building, and 10,000 square feet in the power house, and it is thought that this offer will be accepted.

A POST-GRADUATE course of study in electrical engineering, lasting two years, has for some time been in successful operation at the School of Mines, Columbia College, New York. An undergraduate course of four years in the subject has just been established at the same institution. Admission will be given only to those who pass the entrance examinations which are necessary for the courses in mining, engineering, civil engineering, chemistry, architecture, &c. The first two years of the new course will cover the preparatory work in mathematics, physics, chemistry, mechanics, and other subjects required for admission to the post-graduate course. During the last two years students will receive a thorough training in electrical engineering proper. The course will begin in October 1892. Those who satisfactorily pass the examinations at the end of the course will receive a degree of electrical engineer.

THE Journal of the Society of Arts is printing a very interesting series of Cantor Lectures, by Mr. A. P. Laurie, on pigments and vehicles of the old masters. Mr. Laurie has for some years been studying the literature of this subject; and, having tested the statements contained therein, as far as he could, by experiments in the laboratory, he thinks he has succeeded in clearing up a few points and answering a few questions. He deals with the subject under three heads: (1) the preparation of the painting surface; (2) the pigments, their preparation and properties; (3) the mediums.

THE Adelsberg Cave, with all its recently-discovered side-caverns, has lately been carefully surveyed, in accordance with the instructions of the Austrian Minister of Agriculture, Count Falkenhayn. In the course of the operations some very beautiful parts of the cave, which could formerly be reached only with the greatest difficulty, were made easily accessible. An elaborate plan has been deposited in the office of the Minister of Agriculture, and it is hoped that copies of it, on a reduced scale, may be issued to the public.

MR. W. BRANDFORD GRIFFITH, writing from Iver, St. Elizabeth, Jamaica, says that a very perceptible, not to say alarming, shock of earthquake was felt throughout Jamaica early on the morning of October 27. At Kingston the shock was felt at 1.35 a.m., and the disturbance then seemed to be travelling in a direction north-east by north.

MR. G. JERVIS gives in the December number of the *Mediterranean Naturalist* an interesting sketch of the geology of Pantelleria, to which attention has recently been called by the submarine eruptions off its coast. Mr. Jervis refers to the fact that, like Ischia, Pantelleria possesses thermo-mineral springs, highly mineralized, which might become of much therapeutic and economic importance. The Romans and Arabs, if not earlier peoples, seem to have thoroughly appreciated the value of these springs; but in modern times they have been neglected. Mr. Jervis suggests that the Governor of Malta should despatch one or two medical men to Pantelleria at the public expense at the proper season to study the curative effects of the thermo-mineral waters, and to plan the most practical and efficient method of sending patients there during the summer. It is thought that many military men, suffering from a variety of chronic complaints incident to their rough mode of life and rapid transfer from one climate to another, would be glad to visit the island, especially if they could combine to obtain steam communication occasionally with Malta.

The Meteorological Office of Paris has recently published its Annals for the year 1889, in three volumes, as in previous years. Volume i., under the title of Memoirs, contains a treatise by M. Fron on the course of the thunderstorms during the year, accompanied by daily charts. M. Moureaux has published the details of the magnetic observations made at Saint Maur, with a summary of the disturbances; eight plates reproduce exactly the photographic curves of the most remarkable disturbances. M. Angot gives the results of the first simultaneous observations made at the Central Meteorological Office and on the Eiffel Tower. The diurnal variation of pressure at the summit of the tower shows that the first minimum (4h.–5h. a.m.) is much more pronounced in all months at the summit than at the base, and appears to occur rather later. The first maximum (9h.–10h. a.m.) is much less important at the summit, especially during the summer months, and also appears to occur later. The second minimum (2h.–3h. p.m.) is much less important at the summit, and the second maximum (about 10h. p.m.) is rather more pronounced at the summit than at the base. The temperature of the air at the summit of the tower during the night differs constantly from that of St. Maur by less than the normal value; during the day, on the contrary, the difference of temperature is much greater between the two stations than the normal value. The wind, during all months, has a diurnal variation quite different from that at the Central Office; the maximum occurs at the middle of the night, while the minimum occurs at about 10h. a.m., and rather later in winter. Vols. ii. and iii. contain respectively the general observations and the rainfall values at the various stations.

The idea of a "weather lexicon" has been recently developed by Herr Seemann (*Met. Zeit.*), using the records of the Hamburg Naval Observatory. The design is to find in a collection of daily weather charts a condition of the air over Europe resembling that of the day for which a prognosis is to be formed, and note the former sequence of weather, as throwing light on what the coming weather is likely to be. Herr Seemann uses in his lexicon all the Hamburg weather charts of the ten years 1876 to 1885. Each chart is briefly characterized; the pressure differences in three directions (north-west, south-west, and north-east from Hamburg) being indicated for each day; also wind observations in the Alps and in Norway. The days are arranged according to the amounts of difference in pressure between Hamburg and Stornoway; this gives nine groups. Under these are formed sub-groups according to the differences between Hamburg and Biarritz; and under these, others based on the differences between Hamburg and Helsingfors. The classification is further extended to wind direction. The idea seems a useful one, and experience will doubtless show in what directions the proposed method may be most advantageously modified and developed.

The New York *Nation* of December 17, mentions a rather striking example of the injustice which is sometimes done to American men of science by the McKinley Tariff. A professor in one of the academies near Boston, returning from Europe, brought with him a microscope for his own use in the biological department. Under section 686 of the tariff law, which includes in the free list "professional books, implements, instruments, and tools of trade, occupation, or employment, in the actual possession at the time of persons arriving in the United States," he might very reasonably have expected to import this without duty, but at the steamship dock in Boston a heavy duty was demanded. He appealed to the collector, but was permitted to carry the instrument away without payment of the tax only upon his making a gift of it to the institution with which he was connected. Even then the trouble was not quite at an end. The Principal of the Academy had to take an oath that he accepted the instrument as a free gift to the school, for its sole use, and not to be sold or given away.

In a paper contributed to the current number of the Journal of the Franklin Institute, Mr. John Birkinbine, President of the American Institute of Mining Engineers shows that during the last thirty years the United States has increased its relative production of one ton of pig-iron for every thirty-two inhabitants to one ton of pig-iron for every seven and one-half inhabitants. The Middle States have advanced from one ton for every eleven inhabitants to one ton for every two and one-quarter inhabitants. With regard to Pennsylvania, he notes that while its population of less than 3,000,000 inhabitants in 1860 had increased to 5,250,000 in 1890, its pig-iron product of but little over 500,000 in 1860 was augmented to nearly 4,250,000 in 1890. In 1860, Pennsylvania produced one ton of pig-iron for every five inhabitants; in 1870, it made one ton of pig-iron for every three and three-quarters inhabitants; in 1880, one ton was made for every two and one-half inhabitants; and in 1890 one ton for every one and one-quarter inhabitants. Until 1692, no iron was made in Pennsylvania, and even then so little was produced that the exact locality where it was prepared is not known. As a practical producer of iron, the State's history does not begin until 1716, sixty-one years after the establishment of the industry in Massachusetts. Pig-iron was not made in Pittsburg before 1859, but in thirty-one years the magnificent industry in Allegheny County advanced so steadily that in 1890 a total of 1,337,309 gross tons was produced.

Mr. Charles R. Keyes contributes to the new instalment of the Proceedings of the Academy of Natural Sciences, Philadelphia, a valuable paper on fossil faunas in Central Iowa. In a paper on the lower coal measures of Central Iowa, in 1888, 35 genera and nearly 60 species were mentioned. The figures are now increased to 51 and 84 respectively, and many forms have not yet been thoroughly investigated. The interest, however, lies not so much in the numerical increase of the species as in the information imparted in regard to both the geological and geographical range of the various types within and beyond the limits of the State; and in the exhibition, in many forms, of structural features which have hitherto been more or less obscure. A recent geological study of the locality has disclosed a large number of stations where animal life was at one time very prolific. Several new horizons have been definitely made out, on account of which the distribution in time of the various forms is capable of being traced with greater accuracy than has hitherto been possible.

A third edition of Mr. Charles A. Cutter's "Rules for a Dictionary Catalogue," has been issued by the U.S. Bureau of Education. Mr. Cutter is librarian of the Boston Athenæum, and his experience has, of course, been of the greatest service to him in the working out of his system, which is well worthy of the attention of librarians. The objects of a "Dictionary Catalogue," as he defines them, are (1) to enable a person to find a book of which either (*a*) the author, (*b*) the title, (*c*) the subject, is known; (2) to show what the library has (*d*) by a given author, (*e*) on a given subject, (*f*) in a given kind of literature; (3) to assist in the choice of a book (*g*) as to its edition (bibliographically), (*h*) as to its character (literary or topical).

Prof. E. D. Cope announces in the *American Naturalist* the discovery of a new species of frog in New Jersey. It is a most distinct species, and about the size of the wood frog (*Rana silvatica*). It is not nearly related to any species of the genus

Prof. Cope obtained five adult and two half-grown individuals, and had two other adults almost within his grasp, but they escaped him. The specimens agree nearly in size, the chief differences being observed in the amount of dark blotching of the belly and the regularity of the markings on the inferior side of the femur. The specimens were found in a "cut-off" of a tributary of the Great Egg Harbour River, in Atlantic county, New Jersey. The water is stagnant, and is well grown with Nymphæas, Utricularia, and Sphagnum. The frogs did not display any considerable powers of leaping or swimming, but concealed themselves with much ease within the aquatic vegetation. Prof. Cope did not observe any voice. In the same locality he observed the *Ranæ virescens* and *clamata*. The "cut-off" is in the woods, and he found no individuals in similar situations in the open country, nor any along running water in the woods. The oversight of this conspicuous species, as Prof. Cope says, is a curious circumstance.

ACCORDING to a statement in the Toronto *Monetary Times*, grape-culture is becoming an important industry in Ontario. The centre of the vine cultivation is between Grimsby and St. Catharines. In Essex, especially on Pelee Island, experience has shown that grapes can be profitably grown. Some local experiments show a probability that in the near future the county of Norfolk will be added to the vine land of the province. The quality of the grapes grown has of late been greatly improved, and so prolific are the vines that growers have this season in many instances had to be content to take one and a half cents a pound for good samples. Grape culture is rapidly extending, especially in the county of Welland. This year's price for grapes is perhaps about as low as they can be grown at a profit, but it looks as if the supply might in future outstrip the demand.

IN the report on his work during 1890, lately issued, Mr. R. L. Jack, the Government Geologist of Queensland, refers to a collection of geological specimens forwarded by the Administrator of the Government of British New Guinea. The collection demonstrated (1) the presence of gold, topaz, and beryl in the bed of the Fly River; (2) the presence, within the drainage area of the river, of (*a*) stratified rocks in an unaltered condition, including sandstones, clays, limestones, and lignites; (*b*) metamorphosed stratified rocks, including slates and greywackes; and plutonic and igneous rocks. A number of concretionary ironstone nodules probably indicated the presence of metalliferous lodes. Some fossil corals, in limestone pebbles probably of Mesozoic age, from the first and second rapids of the Fly River, have been sent for identification to Mr. Robert Etheridge, Palæontologist to the Geological Survey of New South Wales and the Australian Museum. A second collection of rocks from Toulon Isle, Port Hennessy, Red Point, Teste Isle, Rossel Isle, &c., was examined by Mr. Maitland. Among these were grits, sandstones, shales, limestones, basalts, granites, and quartz containing a minute quantity of gold.

M. CARTAILHAC contributes to the current number of *L'Anthropologie* an excellent abstract of an elaborate paper by A. J. Evans on a late Celtic urn-field at Aylesford, Kent. Other contributions are a fresh instalment of T. Volkov's interesting account of marriage rites and usages in Ukraine; a paper by E. T. Hamy on the country of the troglodytes; and an essay, also by E. T. Hamy, on the ethnographical work of Nicolas-Martin Petit.

FOR experimental proof of the principle of Archimedes, M. Paquet (*Journ. de Phys.*) recommends the following general method: Into any vessel, V, is brought the body A (which is the object of experiment), with attached wire by which it can be conveniently hung. The vessel is then filled up with water; then A is lifted out, leaving a vacancy equal to its volume. The vessel V is now put into one scale of a hydrostatic balance, and the body A hung under it; then weights are put into the other scale till equilibrium occurs. If now the balance is lowered till A dips wholly in the water of a lower vessel V′, the disturbed equilibrium can be restored by simply filling up the vessel V with water.

IT has been long known that glass is attacked and dissolved in small quantities by ordinary water. This dissolving process Herr Pfeiffer has recently sought to prove and measure by change in the electric conductivity of the water (*Ann. der Physik*). He measured the increase of conductivity undergone by 1 cubic centimetre of pure water when it has been in contact for one hour with one square centimetre of glass surface, and concluded that the amount of glass dissolved at 20° C. was 1 to 2 millionths of a milligram. He found, too, that with temperature rising arithmetically, the growth of solubility is considerably more rapid than that of a geometrical series; that the increase of conductivity of the water for a given kind of glass under like conditions is a characteristic constant; and that later, when a certain quantity of alkali is dissolved, further action involves a dissolving also of silicic acid, and the salts then formed may cause a decrease of conducting power.

BARON NORDENSKIÖLD communicated to the December meeting of the Royal Swedish Academy of Science the fact that he has discovered notable quantities of uranium in the asphaltic or rather anthracitic minerals, accompanying the magnetic and hæmatite iron ores in Sweden. A large block of so-called "anthracite" from Norberg, for instance, leaves, when burned, ashes (13 per cent.) which contain about 6 per cent. of uranium; a similar mineral from Dannemora left, when burned, ashes containing 4 per cent. of uranium. The Norberg mineral also contains cerite and gadolinite oxides, although in small quantities, and it is remarkable that the mixture of gadolinite oxide (yttria, ytterbia, &c.) from this new *provenance* has the normal atomic weight of 255·6 (for R_2O_3).

TETRA-IODIDE of carbon, CI_4, has been obtained in large ruby-red crystals by M. Moissan by the action of his recently-prepared boron iodide, BI_3, upon carbon tetrachloride. Boron iodide is a substance crystallizing from solution in carbon bisulphide in colourless tabular crystals which melt at 43° to a liquid boiling at 210°. It is a substance of great chemical activity, reacting with considerable energy with a large number of substances, as described in NATURE, vol. xliii. p. 568. When it is brought in contact with carbon tetrachloride, double decomposition occurs in the cold, with a large evolution of heat boron chloride and carbon tetra-iodide being formed.

$$4BI_3 + 3CCl_4 = 4BCl_3 + 3CI_4.$$

The best mode of operating is to heat the two substances, the crystals of boron iodide and excess of dry redistilled carbon tetrachloride, in a sealed tube for one hour at a temperature of 80°–90°. Next morning the tube is found to contain large crystals of carbon tetra-iodide, which appears to be produced in theoretical quantity. After opening the tube, the crystals are drained, washed with a solution of bisulphite of soda in order to remove the last traces of iodine, and finally dried *in vacuo*. When the red crystals thus obtained are heated to 100° in an exhausted sealed tube, they slowly sublime into the colder portion of the tube in magnificent brilliant red crystals very much resembling the artificial rubies prepared by MM. Fremy and Verneuil. The reactions of carbon tetra-iodide are somewhat interesting. When heated in a current of hydrogen at a temperature about 140°, it is reduced to iodoform, CHI_3.

$$CI_4 + H_2 = CHI_3 + HI.$$

When the crystals are placed in an atmosphere of chlorine they at once liquefy, and the liquid becomes hot. The products are carbon tetrachloride and liquid chloride of iodine, ICl, which latter gradually volatilizes away in the form of the chloride, ICl_3.

$$CI_4 + 4Cl_2 = CCl_4 + 4ICl.$$

When heated gently in dry oxygen, it becomes decomposed into iodine and carbon, which latter burns away to carbon dioxide upon slightly raising the temperature. Melted sulphur reacts with carbon tetra-iodide with considerable violence; vapour of iodine is evolved, carbon deposited, and iodide of sulphur formed. If, however, powdered sulphur is warmed with carbon tetra-iodide to 50°, iodide of sulphur and carbon bisulphide are produced. Phosphorus acts with great energy upon it, forming compounds which are still undergoing investigation. Sodium and potassium react with incandescence, an alkaline iodide and free carbon being produced. Mercury and silver likewise attack it at the ordinary temperature, and very rapidly upon warming. Warm hydrochloric and hydriodic acids attack the crystals rapidly, with formation of iodoform and liberation of vapour of iodine. A particularly interesting reaction is that with fluoride of silver. When a quantity of this salt is placed in a solution of carbon tetra-iodide in carbon tetrachloride warmed to 50°, a regular evolution of gaseous carbon tetrafluoride occurs.

$$CI_4 + 4AgF = CF_4 + 4AgI.$$

This reaction affords the readiest means yet discovered of preparing carbon tetrafluoride.

The additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii* ♀) from South Africa, presented by Mr. J. Parr; a Bonnet Monkey (*Macacus sinicus* ♂) from India, presented by the Rev. W. P. Beckett; a Black-faced Kangaroo (*Macropus melanops* ♀) from Australia, presented by Mr. P. Clark; two Red-crested Finches (*Coryphospingus cristatus*) from South America, presented by Commander W. M. Latham, R.N., F.Z.S.

OUR ASTRONOMICAL COLUMN.

The Secular Variation of Latitudes.—The *American Journal of Science* for December contains a paper on secular variations of latitudes, read by Prof. George C. Comstock at the Washington meeting of the American Association for the Advancement of Science. The determinations of the latitude of Greenwich made from the time of Flamsteed (1693) to now—that is, over a period of very nearly two centuries—indicate a very appreciable progressive diminution. But as the observations were made with five different instruments, and are affected, to an uncertain extent, by various sources of error, no definite conclusion can be drawn from them. In the cases of the latitudes of Pulkowa, Königsberg, Washington, and Madison, however, Prof. Comstock thinks there is definite evidence of a change of latitude, and from an examination of numerous absolute observations, and a reduction of recorded star-places, he arrives at the data contained in the following table:—

Station.	Longitude (from Greenwich).	Annual Variation of Latitude.	Computed Annual Variation.
	°	″	″
Pulkowa ...	30·3 E. ...	− 0·006 ...	− 0·007
Königsberg ...	20·5 E. ...	− 0·003 ...	− 0·000
Washington	77·0 W. ...	+ 0·042 ...	+ 0·044
Madison ...	89·4 W. ...	+ 0·043 ...	+ 0·041

A least square solution of the observed data was made to determine the most probable direction and amount of motion of the Pole. The result was 0″·044 along the meridian 69° W. of Greenwich. The values contained in the last column of the above table were computed from these elements. For the systematic investigation of the motion of the Pole it is suggested that two stations in about the same latitude, but having longitudes about 70° W. and 110° E. respectively, should have their latitudes simultaneously determined by zenith telescope observations of the same pairs of stars. "An annual motion of the Pole of 0″·045 will alter the difference of latitude of these stations by twice this amount per year, giving a change in the difference of latitude amounting to 1″ in eleven years—a quantity which cannot possibly escape careful observation with the zenith telescope or prime vertical transit. If similar observations be made 20° east of Greenwich, they will furnish the best obtainable data for determining the direction of motion of the Pole." All sources of systematic error can be eliminated by the adoption of such a method, and our knowledge of secular variations of latitude, as important to the geologist as to the astronomer, will be of a more definite character than at present.

The Rotation of Venus.—Herr Löschardt sends us a paper on Schiaparelli's hypothesis as to the period of rotation of Venus, presented by him to the Vienna Academy of Sciences on March 12, 1891. He criticizes the conclusions drawn by Schiaparelli from observations made by others and himself, and points out that the observations made by Denning in 1881 favour the old rotation period of 23d. 21m. rather than one of 224 days. Herr Löschardt has made a number of drawings of the markings on the planet shown by his 3-inch refractor at Nákófalva, and the discussion of them gives support, on the whole, to Cassini's value of the rotation period. The chief reasons which led to this conclusion are the differences between Perrotin's observations and those made at Nákófalva at different hours in the same day, the circular form of polar patches, and the ellipsoidal distribution of the atmosphere, which is said to be the result of swift rotation.

Stars having Peculiar Spectra.—In a communication to *Astronomische Nachrichten*, No. 3070, Prof. Pickering records that the three stars tabulated below show bright lines in their photographic spectra, and belong to the same class as the stars discovered by Wolf and Rayet:—

Designation.	R.A. 1900.	Decl.	Galactic latitude.	Galactic longitude.
°	h. m.	° ′	° ′	° ′
D.M. + 55·2721 ...	22 15·0 ...	55 37 ...	− 0 50 ..	70 29
— ...	22 23·7 ...	55 46 ...	− 1 20 ...	71 38
D.M. + 56·2818 ...	22 32·9 ...	56 23 ...	− 1 25 ...	73 3

It will be seen that these stars, like the 35 others of the same class, fall near the central line of the Milky Way.

THE TOWER OF BABEL AND THE CONFUSION OF TONGUES.[1]

Who among the readers of ancient history has not pictured to himself great Babylon, with its long straight streets at right angles, its quays along the banks of the Euphrates, its royal palaces, its double walls, and last, not least, its towers in stages, dedicated to the various gods? The picture of grandeur is one of which we can form an estimate only, but it must have been magnificent beyond what was customary in those days, for had not the great Nebuchadnezzar built it? He describes at great length what he had done for the city, for its walls, for its streets, its temples, its towers, and its palaces.

But there was a time when Babylon was not the great city. At first a village settlement, it gradually arose to be the capital of a powerful State, a progress that probably occupied 4000 years, not including the pre-historical period. The story of the beginnings of this great city, which are lost in antiquity, is told in Genesis, and forms one of the most charming of the legends of the Bible. The Biblical account is given in the genealogical table just before "the generations of Shem," and seems to be an interpolation to explain the numerous languages of the world. What the source of the legend may be is uncertain, but as a whole it is unique, for though its source is possibly Babylonian, nothing like it has yet come from that country or from Assyria. The so-called Babylonian legend of the Tower of Babel seems to have nothing to do with the Biblical one—indeed, the evidence all points to its referring to something entirely different.

"As they journeyed (so the Bible narrative says) in the East, they found a plain in the land of Shinar." This land of Shinar is generally regarded as the Sumer of the Babylonian and Assyrian inscriptions. The Sumerians and Akkadians were of a different stock from the Semitic inhabitants of the country, and

[1] Abstract of a Lecture by Theo. G. Pinches, before the London Institution, December 3, 1891.

spoke two entirely different dialects, making, with the Kassite, the Semitic Babylonian, the Aramaic, and the Chaldee, no less than six dialects and languages; and, as if this Babel were not enough, the tones of Elamites and other foreigners might also be heard. It will probably be admitted that the confusion of tongues which this gathering of nations made at Babylon was striking enough to the visitor in whose native land one language only prevailed.

The indications point to the fact that the Akkadians were the invaders in Babylonia, and they gave a great many kings to the land. It was a state of things not unlike the heptarchy in Old England—a number of small States fighting amongst themselves, the most powerful gradually absorbing the weaker, until, about the time of the great Hammu-rabi, about 2220 B.C., the whole became united; after which date probably only the wild Chaldæan tribes remained practically independent, under their native chiefs, and afterwards gave kings to Babylonia itself.

The Semitic Babylonians of Mesopotamia were probably rather short and thick-set, though there must have been a great many people of normal height and even tall stature among them. They were dark and heavily bearded, but during the time of the Akkadian supremacy they seem to have shaved, like their rulers. The Akkadians seem to have had noble and dignified features, and their figures, as shown on the engraved and sculptured stones, were far from inelegant. There was also, apparently, a type of Akkadian with a curved prominent nose and a retreating forehead, something like the Elamites shown on the Assyrian bas-reliefs. [Several examples of the various types were shown.]

These people, journeying "in the East," resolved to build a city "and a tower"; and this tower, which the inhabitants of Shinar decided to build, was quite a special thing of their own. Every city in ancient Babylonia had a tower, some more than one, and they were of varying forms. The Semitic Babylonians seem to have called their memorial towers *zikkurāti*, a name which was even applied (as in the Babylonian account of the Flood) to natural eminences of a similar form. The Akkadians appear to have called them "watch-towers." They were intended (according to Perrot and Chipiez) to give that picturesque element to the land which accidents of Nature usually give to other countries more favoured, and also to astonish the contemporary traveller, as well as that posterity for whom no more than a heap of shapeless ruins would remain. However that may be, they certainly served in their time a practical purpose—namely, for religious ceremonies, and for astrological and astronomical observations. There were twenty-two principal erections of this kind in the earliest period in Babylonia, according to one of the lists.

Descriptions and illustrations were now given of the different forms of towers in Babylonia, and it was pointed out that Nebuchadnezzar mentioned a "Tower of Babel" (*zikurat Babilam*) which he "made anew," and "raised its head with burnt brick and bright lapis"; but he did not devote many words to it—why, is not known, unless it be that some ill omen was attached to it. This "Tower of Babel" of Nebuchadnezzar is not the Birs-Nimroud, and for that reason, as well as because the latter did not lie within Babylon, we may doubt whether it be the Biblical "Tower of Babel," as has been, and still is, supposed.

It is difficult now to imagine the place where the great confusion of tongues existed as the site of a great city, with its teeming life. The place where Babylon stood is now a series of mounds more or less shapeless, and masses of brickwork, but otherwise a marsh. The "great city," "the beauty of the Chaldees' excellency," has "become heaps." The ruins of the palace of Nebuchadnezzar, and of the temple-tower of Babil, are among the more prominent remains.

After a sketch of the life of the city of Babylon in ancient times and the religious festivals and ceremonies, and how the temple-towers and the services remained after the cities had decayed and practically vanished, the lecturer recited a translation of the hymn to the setting sun sung by the priests of È-zida, the supposed Tower of Babel—

Hymn to the Setting Sun, chanted by the Priests of Ê-zida.

"Sun-god, in the midst of heaven,
At thy setting,
May the latch of the glorious heavens
Speak thee peace;
May heaven's door to thee be gracious;
May the Director, thy beloved messenger, direct thee.
At È-bara, the seat of thy lordship,
Show forth thy supremacy.
May Aa, thy beloved wife,
Gladly go to meet thee.
May thy heart take rest,
May the property of thy godhood
Be confirmed to thee.
Warrior, hero, Sun-god, may they glorify thee!

Lord of È-bara, may the road of thy path be prosperous—
Sun-god, cause thy highway to prosper,
Going the everlasting road to thy rest.
Sun-god, thou art he who is the judge of the land,
Causing her decisions to be prosperous."

The priests' morning hymn began:—

"Sun-god, in the glorious heavens rising,"

and the lecturer pictured the day when the priests who chanted these hymns were there no more, and the faith which had raised Babylon's splendid temples and noble towers was, at last, as dead as her departed glories, to become the heritage of the student and of those who love to hear the ever-charming story of the romanceful East.

A YEAR'S SCIENTIFIC WORK IN NEW GUINEA.

A RECENT administration report from New Guinea, issued by the Colonial Office, contains an appendix on the scientific work of the year in the island. The first paper in this is a report by Baron von Mueller on the botanical specimens collected He says that the increase in our knowledge of the Papuan flora, derived from Sir William MacGregor's collection in 1890, has been again important. Foremost as a result we learn from these contributions that a considerable number of Australian species of plants, which, as such, were hitherto regarded as quite endemic, are likewise indigenous to the vicinity of the Mai-Kussa and Wasi-Kussa in New Guinea. Thus they occur precisely opposite to Cape York, from whence the seeds may have been carried across by migratory birds or perhaps by some other agencies. These, otherwise only Australian, plants may therefore not really belong to the primitive vegetation of New Guinea, though they are now established in such a way as not to admit of distinguishing them in regard to their origin from the great bulk of the lowland species, whether truly Papuan or simultaneously also Malayan. The occurrence has already been demonstrated of a number of lowland plants of specific Australian type in various parts of New Guinea. To these can now be added a number of others which are specified by Baron von Mueller. It can now be shown also that the cedar (or rather cedrel), of which many shipments have been made to Australian ports, is identical with the Singapore cedar (*Cedrela Toona*). The magnificent and renowned aquatic plant, *Nelumbo nucifera*, has now been located on the upper Fly River. Some other plants, unknown from New Guinea before, such as *Polygala chinensis*, *Salomonia oblongifolia*, *Sesuvium Portulacastrum*, *Leptospermum Javanicum*, and *Limnophila gratioloides*, are recorded in the Administrator's last collection, while some more are awaiting careful comparative elucidation before the fixing of their systematic position. Count Solms-Laubach, the monographer of Pandaneæ, has acknowledged the screw pine from Ferguson Island, in the Louisiades, as a new species under the name *P. Macgregorii*. An essay of Baron von Mueller on the highland plants collected during the year by Sir William MacGregor has appeared in the publications of the Royal Society of Victoria. But he was able to examine only a few of the ferns brought from the upper region of the Owen Stanley Range; among them, however, is the new *Cyathea Macgregorii*, which reaches a higher elevation than any other of the many kinds of fern-trees now known. To expedite the determination of their specific position, Mr. Baker, of Kew, has undertaken to define systematically the seventy species of *Ficilis* and *Lycopodiaceæ*, contained in Sir William MacGregor's collection from the Owen Stanley Ranges. Mr. Baker regards nineteen of these ferns as new, and therefore, so far as our present experience reaches, as exclusively Papuan. These hitherto unknown species are comprised within the genera *Cyathea*, *Hymenophyllum*, *Dicksonia*, *Davallia*, *Lindsaya*, *Aspidium*, and largely *Polypodium*. The Curator of the Queensland Museum reports on the zoological collections. No new animal of the warm-blooded class has been met with during the year;

perhaps those remaining to be found in the coast country are both few and rare. By way of compensation, however, certain Australian birds, the native companion, white ibis, and royal spoonbill, must now be included in the Papuan avifauna as at least temporary sojourners on the banks of the Fly River. It is noteworthy that these birds were found on the Fly River during the continuance in the north of Queensland of a drought which had driven them from their haunts proper and scattered them far and wide in search of water. Of the reptiles, on the other hand, a few new forms are distinguishable. These occur among the lizards. Two handsome snakes, *Chondropython azureus* and *pulcher*, have been added to the State collection of Papuan ophidians. On the whole, the vertebrate collection is subordinate in importance and interest to that of the insect division of the invertebrates. The whole of the insects collected were examined by the Entomological Department, and two reports on the *Lepidoptera* and *Coleoptera* are appended. From these it appears that several species both of butterflies and beetles are new to science. The collection contains in many instances a large series of examples of the same insect, which is all-important in the case of variable forms, whose unknown range of variation is a prolific source of error. Besides *Lepidoptera* and *Coleoptera* it contains many Hemipterous insects which have not yet been determined. The few forms of Mollusca procured on the Fly River have yielded but one new species, a remarkably fine *Nanina*.

A MEDIUM FOR PRESERVING THE COLOURS OF FISH AND OTHER ANIMALS.

OUR readers may remember that Mr. Haly, Curator of the Colombo Museum, has for some years been making experiments so as to discover a medium which will preserve the colours of fish and other animals. We quote the following from the last Annual Report of the Colombo Museum :—

"In my last year's report I made some remarks on the use of carbolized oil as a mounting fluid for specimens already prepared by other means, the idea that it was a preservative in itself not having occurred to me. Further experiments this year seem to show (I do not like to speak too confidently in a climate like this, even with twelve months' experience) that it is one of the most perfect preservatives known both for form and colour.

"Coco-nut oil and carbolic acid freely mix in all proportions. The mixtures at present under trial are oil raised to the specific gravity of 10° and 20° below proof-spirit by the addition of acid. Whilst the gum and glycerine process is absolutely useless for any animals except certain families of fish, this mixture is good for every kind of vertebrate. The most delicate frogs are quite uninjured by it, and snakes undergo no change. The delicate plum-like bloom on the geckoes, the fugitive reddish tint on such snakes as *Ablabes humberti*, are beautifully preserved by it.

"Another most important use is in the preservation of large fish skins, which can be packed away in it for an indefinite period, and mounted when wanted. These skins do not require varnishing, neither do they turn brown, but although, of course, they do not preserve their sheen like fish in the oil itself, they always maintain a silvery and natural appearance, quite different from that of ordinary museum specimens. If ever we get a new fish gallery, a show of our large species prepared in this way would form a most effective exhibition.

"It appears also to be a most excellent preservative for Crustacea and the higher orders of Arachnids, and also for Centipedes, but it has hitherto proved a failure for marine invertebrates in general. It must be remembered, however, that the perfect miscibility of the two liquids opens up endless possibilities. Its absolutely unevaporable nature makes it invaluable in a tropical climate, quite apart from its other qualities.

"With regard to this last remark I take the opportunity of stating that the acid enables coco-nut oil and turpentine to be mixed together. This forms a splendid microscopic fluid, in which objects may be allowed to soak without any previous preparation, and in which they become very transparent. A minute species of Crustacean, of the order Copepoda, and the leg of a fly, simply laid on a slide in a drop of this fluid and covered with an ordinary covering-glass, without any cell being made or cement employed, have lain on my table unaltered for the last ten months, and I cannot help thinking that such a medium as this cannot fail to prove a great boon to all workers with the microscope."

SCIENTIFIC SERIALS.

American Journal of Science, December.—On Percival's map of the Jura-Trias trap-belts of Central Connecticut, with observations on the up-turning, or mountain-making disturbance, of the formation, by James D. Dana.—The detection and determination of potassium spectroscopically, by F. A. Gooch and T. S. Hart. By dipping platinum coils of different sizes in a solution of the salt to be tested it was found possible to take up known quantities of material for introduction into the volatilizing flame employed. Experimenting in this manner with a single-prism spectroscope, it was found that $\frac{1}{750}$ of a milligram of potassium produced a line distinctly visible with a slit of 0·18 mm., and $\frac{1}{1000}$ mgr. with a slit of 0·23 mm. The test appears to be less delicate with potassium sulphate than when the chloride is used, and rather more delicate in the case of the carbonate. The red line of potassium was unmistakably seen when only $\frac{1}{2000}$ mgr. of potassium was introduced into the flame in the form of the carbonate. For quantitative determinations a standard solution, from which $\frac{1}{500}$ mgr. of potassium was taken by a certain platinum coil, was employed. The *modus operandi* was to dilute the test-solution until the line given by the potassium contained in a coil-full was of the same brightness as that given by the same quantity of the standard solution. Remarkably consistent results were thus obtained. An interesting point brought out by the experiments is that the presence of sodium salts in the flame is of direct influence in strengthening the spectrum of potassium.—The ultra-violet spectrum of the solar prominences, by George E. Hale. This important paper was read at the last meeting of the British Association, and has been previously noted.—Phonics of auditoriums, by Ephraim Cutter. It is generally known that a well-constructed auditorium resonates certain sounds better than others, and that many clergymen accommodate their tone of speaking to the key-note of their church. Dr. Cutter has made observations on this point in four halls, and recommends those who control auditoriums to find the key-note and post up the result. Thus, an auditorinm at Saratoga Springs was tested in 1890, and a notice was put up, "The key-note of this hall is F."—The secular variation of latitude, by George C. Comstock. This is a general account of the observations made at Greenwich, Pulkowa, Madison, and elsewhere, which indicate that the latitude of a single place is subject to a secular variation.—On the capture of comets by planets, especially their capture by Jupiter, by H. A. Newton.—Distribution of titanic oxide upon the surface of the earth, by F. P. Dunnington. An estimation has been made of the titanium in eighty different specimens of soil taken from different parts of the earth's surface. Soils from Virginia gave an average of 1·57 per cent. of titanic oxide, and twenty-two samples from other portions of the United States gave an average of 0·85 per cent. The average proportion in air-dried soils from Oceania and Asia (14 specimens) was 0·90 per cent., and 16 specimens from Europe gave 0·54 per cent. The eight remaining estimations were made on typical rocks of the localities which furnished the samples for analysis.—Notes on a Missouri barite, by C. Luedeking and H. A. Wheeler.—The contraction of molten rock, by C. Barus. A sample of diabase has been fused and allowed to cool slowly. The molten rock contracted regularly until a temperature of 1093° was reached, when the diabase solidified with a sudden contraction of bulk. The density of the original rock was 3·0178, and that of the glass obtained 2·717. The observations indicate that "structural rock texture is due to pressure, *i.e.* pressure induces a redistribution of molecules, such that the smallest specific volume possible under the given conditions may result."—Notes on Michigan minerals, by A. C. Lane, H. F. Keller, and F. F. Sharpless. The minerals considered are chloritoid, grünerite, and riebeckite.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, December 10.—"On a Compensated Air-thermometer." By H. L. Callendar, M.A.

The air-thermometer is the ultimate standard to which all measurements of temperature have to be referred. It therefore becomes a question of considerable importance to determine what form of instrument is capable of giving the most accurate results.

For practical purposes there can be no doubt that electrical resistance thermometers, which are much easier to read and manipulate, and which are, at the same time, exceedingly constant over a very wide range, would be much more convenient as standard instruments. But for theoretical work it is always necessary to reduce their indications to the scale of absolute temperature.

With this object the writer has been for some years engaged in endeavouring to construct an air-thermometer which should be capable of reading to a degree of accuracy comparable with that attained by the use of electrical-resistance thermometers. This he believes that he has at length succeeded in securing by the adoption of the modified and compensated form of differential air-thermometer described in the paper.

The common and familiar form of differential air-thermometer consists essentially of two equal bulbs, communicating with opposite limbs of a U-tube of small bore containing sulphuric acid, which serves to indicate the difference of pressure between them. If the standard bulb be kept in melting ice, so that its temperature is constant, it is possible, by using a kathetometer microscope, to read small changes of temperature in the thermometric bulb with an accuracy of the order of a thousandth of a degree.

In order to make the instrument capable of reading over a wider range, it is only necessary to add an auxiliary bulb, as in the ordinary "constant-pressure" type of air-thermometer, into which the air from the thermometric bulb is allowed to dilate. The auxiliary bulb is provided with taps, through which mercury can be introduced or withdrawn in weighed quantities, to equalize the pressures. The dilatation of the air at constant pressure can be very accurately measured by weighing the mercury displaced. This form of air-thermometer has the advantage of being entirely independent of barometric readings. A great deal of trouble is thus saved; moreover, it is certain that a much greater degree of accuracy can be attained in this way in the measurement of a volume than in the measurement of a pressure by means of a mercury manometer, as in the "constant-volume" type of air-thermometer.

With almost every form of air-thermometer, some part of the air contained in the connecting tubes is necessarily exposed to temperatures different from those of the bulbs. In accurate work a correction must always be applied for this by calibrating the connecting tubes and estimating their mean temperature. This correction, however, is exceedingly troublesome to apply, and becomes a very serious source of uncertainty in attempting to work to a thousandth of a degree.

It is, perhaps, the greatest advantage of this particular form of differential air-thermometer, that this troublesome and uncertain correction can be completely eliminated both from the observations and from the calculations by simply duplicating the connecting tubes—that is, by making the thermometric and standard bulbs communicate with similar sets of connecting tubes fixed side by side in such a way that their mean temperatures are always equal. Provided that the two bulbs contain equal masses of air, and that their pressures are adjusted to equality, any change in the temperature of the connecting tubes will affect both equally, and will not, therefore, alter the reading of the pressure-gauge.[1] In this way not only is the work of taking and reducing the observations immensely simplified, but the results are also rendered much more accurate.

The form of instrument above described is designed for the most accurate work. For rough purposes, and especially for limited ranges of temperature, for which the auxiliary bulb can be dispensed with, much simpler instruments may be constructed and compensated on similar principles.

In ordinary work it would be inconvenient to have to keep the standard bulb always at a constant temperature. The necessity for this may, however, be avoided by adjusting the *quantity* of sulphuric acid in the pressure gauge so that its expansion compensates for the increase of pressure in the standard bulb due to rise of temperature of the surrounding air. When the instrument is thus compensated, one of the tubes of the pressure gauge can be directly graduated in degrees of temperature. The indications are then as easy to read as those of a mercury thermometer. Such thermometers are very convenient for rough work at temperatures beyond the range of mercury thermometers. They can be made with a range from 300°–500° C.[1] (500°–900° F.), and will read to a tenth of a degree at 450° C. They are practically free from change of zero, and if properly compensated their indications are very reliable. Since the connecting tubes are compensated, they can be made of considerable length, and even of flexible material, such as compo-tubing, without much loss of accuracy. This is often a matter of great convenience, especially in high temperature work.

[1] The equations and conditions of compensation are fully given in the paper.

"Repulsion and Rotation produced by Alternating Electric Currents." By G. T. Walker, B.A., B.Sc., Fellow of Trinity College, Cambridge. Communicated by Prof. J. J. Thomson.

The author described the following experiment:—A sheet of copper is placed so as to half cover an alternating magnetic pole. Upon this, near the pole, is laid a hollow sphere of copper. The electro-magnetic action produces a couple so powerful that the friction of rotation is overcome, and the sphere spun round.

In order to throw light on this, after a theorem in § 2 as to the kind of currents set up in a conductor, I have considered a number of cases. A thin circular infinite cylindrical shell lies in an alternating field of currents parallel to its axis, and the couple upon it is found. The result is applied to give the couples on two such shells in the presence of a parallel current and of a pair of currents forming an electro-magnet.

The couple in action upon a thin spherical shell in a general periodic field has next been found, and is applied to give the couples on two thin shells under the influence of—

(i.) An alternating current in a straight infinite wire.
(ii.) A pair of such currents forming an electro-magnet.
(iii.) An alternating magnetic pole.
(iv.) An alternating electro-magnet of very short length.

Chemical Society, November 19.—Sir Henry Roscoe, F.R.S., in the chair.—The following paper was read:—Iron carbonyl, by L. Mond, F.R.S., and Dr. Langer. An account of this paper has already appeared in NATURE of November 26 (p. 89).—A lecture was then delivered on colour photometry, by Captain Abney, C.B., F.R.S. According to the lecturer, the colour of a body, when viewed in a light of standard quality, is known when (*a*) its luminosity, (*b*) its hue, and (*c*) its purity, or the extent to which it is freed from admixture with white light, are known and expressed by numbers. The luminosity of a colour can be given in absolute number by referring it to the standard of white. The standard of white employed is a surface coated with zinc oxide. It is also necessary to employ a standard light in these experiments, and the light recommended is that from the crater of the positive pole of the electric light, or from a petroleum lamp, when the illumination need not be so intense. The luminosity of the pure spectrum colours may be measured by what the author calls the colour patch apparatus, which is described in the Phil. Trans., 1886, and in his book on "Colour Measurement and Mixture." The luminosity of a colour is not the same when viewed from all parts of the eye. The luminosity of any pigment on paper can be found by rotating it with two or three colours, red, emerald-green, and ultramarine. The colour of a pigment can be referred to the spectrum colours by measuring the absorption. The mixture, in varying proportions, of red, green, and violet of the spectrum, makes white. Any other colour can be matched by the mixture of the same three colours. Since three colours will make white, and the same three colours will make a match with an impure colour, every colour in nature can evidently be matched by mixing not more than two of these colours with a certain proportion of white light, and if these colours be red and green, or green and violet, the colour can be matched by one spectrum colour and white light, since there is some intermediate colour which has the same hue as the mixture of these two colours. Hence any colour may be expressed in terms of white light and one spectrum colour, the latter in wave-lengths and the former in percentage of luminosity. The lecturer performed experiments in illustration of all the points brought forward. The importance of using some uniform light was insisted upon throughout. In conclusion the lecturer claims to have demonstrated that the reference of colours to numbers is not only possible but easy.

December 3.—Prof. A. Crum Brown, F.R.S., in the chair.—The following papers were read:—Phosphorous oxide, Part ii.,

[1] An air-pyrometer and also a long-distance thermometer of this pattern are made by Mr. J. J. Hicks, of Hatton Garden, E.C.

by T. E. Thorpe, F.R.S., and A. E. Tutton. In this paper the authors have continued their description of the properties of phosphorous oxide, P_4O_6. In their first paper they state that phosphorous oxide becomes red on exposure to light. They have now obtained the oxide in large crystals, unaffected by light, by exposing the freshly-distilled oxide to sunshine for several months at a time, and decanting the melted oxide from the red phosphorus produced. Large crystals of the oxide are also obtained by sublimation in a vacuum, and these are unaffected by light so long as they retain their crystalline form. The authors also describe the reactions of the oxide with the following substances: bromine, iodine, hydrogen chloride, sulphur, sulphur trioxide, sulphuric acid, sulphur chloride, ammonia gas, nitrogen peroxide, phosphorus pentachloride, and phosphorus trichloride. The following substances are apparently without action on phosphorous oxide: hydrogen, phosphoretted hydrogen, carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen, nitric acid, cyanogen, and ethylene.—Frangulin, Part ii., by T. E. Thorpe, F.R.S., and Dr. A. K. Miller. The authors have prepared frangulin more nearly in a state of purity than was previously possible. They find that crude frangulin contains a substance isomeric with emodin, which ciings to it persistently, and is very difficult to remove. They have succeeded in proving the correctness of Schwabe's formula, $C_{21}H_{20}O_9$, for frangulin. On hydrolysis it yields emodin, $C_{15}H_{10}O_5$, and rhamnose, $C_6H_{12}O_5$, according to the equation $C_{21}H_{20}O_9 + H_2O = C_{15}H_{10}O_5 + C_6H_{12}O_5$.—The structure and chemistry of flames, by A. Smithells and H. Ingle. The authors have been engaged for twelve months in investigating the chemistry of flames produced by burning known hydrocarbons, and are still continuing the experiments. If a long glass tube be fitted over the metal tube of a Bunsen burner so as to form a wider continuation of it, and if the gas be carefully regulated, it is possible to divide the flame into two cones, one of which remains at the top of the tube, and the other oscillates inside the tube. By heating the glass tube at one point so as to increase at that point the rate of inflammation, it is possible to fix the oscillating inner cone—that is, to prevent its re-ascent. The same result is obtained by narrowing the bore of the glass tube at one point, so as to diminish the rate of inflammation, *i.e.* to prevent the descent of the inner cone past that point. In this way the two cones can be kept any distance apart for any length of time. This permits of the aspiration of the gases from the space between the cones without any chance of admixture of outside air or of products of combustion from the upper cone. The apparatus used by the authors is described. The flames of liquid hydrocarbons were examined by charging air with the vapour of the liquid, and afterwards mixing this vapour-charged air with more air in suitable proportions. The hydrocarbons examined were ethylene, methane, pentane, heptane, and benzene. The results obtained show that the products of combustion of the first cone are essentially CO_2 . H_2O . CO and H_2, and that the second cone is due to the combustion of the CO and H_2 with the external air. These results are in harmony with the conclusions of Blochmann, and with the work of Dalton on the explosion of methane and ethylene with oxygen in quantities insufficient for complete combustion. The authors point out: (1) that, even in excess of oxygen, carbon turns preferentially to CO and not to CO_2; (2) that the heat of combustion of gaseous carbon to CO is probably greater than that of hydrogen to H_2O; (3) that, according to Dalton, CH_2, when burnt with its own volume of oxygen, gives products represented in the equation $CH_2 + O_2 = CO + H_2O + H_2$. But as the two substances, CO and H_2O, act upon one another, $CO + H_2O \rightleftarrows CO_2 + H_2$, the case is one of reversible change, and four products will result —viz. CO_2, H_2O, CO, and H_2. They have succeeded in dividing into two cones the flame produced by admixture of air with cyanogen; the products of the inner cone were found to consist of 2 vols. of CO and 1 vol. of CO_2.—Note on the structure of luminous flames, by A. Smithells. A brief summary of the various views that have been held on this subject is given. The author would describe a luminous flame as follows: (1) an outer sheath or mantle, with (2) an inner, bright blue portion, visible at the base of the flame—these two parts correspond respectively to the outer and inner flame cones of a Bunsen flame, and mark the region where the coal gas or candle gas is burning with a large quantity of air; (3) the yellow luminous part, where the heat of the parts (1) and (2) is decomposing hydrocarbons, setting free carbon which rapidly glows and burns; (4) the dark inner region, consisting of unburned gas. —The existence of the mydatic alkaloid hyoscyamine in lettuce, by T. S. Dymond. The alkaloid was obtained from the commercial extract of wild lettuce, of the edible plant known as cos lettuce, and from a specimen of the dried flowering plant of wild lettuce. It was found to have approximately the same melting-point and other properties as hyoscyamine, the poisonous mydatic alkaloid existing in belladonna, henbane, and other plants belonging to the natural order *Solanaceæ*. The aurichloride melted at 159°·75, and on analysis gave results corresponding to the formula $C_{17}H_{23}NO_3 . HAuCl_4$.—Cryptopine, by D. Rainy Brown and Dr. W. H. Perkin, Jun., F.R.S. The authors have commenced an investigation on the rare alkaloid cryptopine, which occurs in small quantity in opium. Analyses of the base and of the oxalate confirm the results of Hesse, and show that cryptopine has the formula $C_{21}H_{23}NO_5$. On oxidation with permanganate it yields, among other products, metahemipinic acid (m.p. 179°–180°). It contains only two methoxy-groups, as shown by its behaviour with hydriodic acid, these two groups being situated in that part of the molecule which is converted to metahemipinic acid on oxidation.—The action of sodium on ethereal salts, Part iii. benzylic orthotoluate, by R. W. Hodgkinson. When benzylic orthotoluate is heated to 200° and sodium dissolved in it, the temperature rises to 250°, when an oil distils over. This oil was separated into toluene, benzoyl alcohol, and a small quantity of the original salt. The sodium salt in the retort gave pure orthotoluic acid, unchanged benzylic orthotoluate, and a substance of the composition $C_{22}H_{20}O_2$. The author is continuing the experiments.—The gas-volumeter and gravivolumeter, by G. Lunge. A reply to Prof. Japp's reply to the author's criticisms (*Ber.* xxiv. 1656).—The action of sulphuric acid on the bromides of hydrogen, potassium, and sodium, by F. T. Addyman. The author has sought to determine the extent to which hydrogen bromide is oxidized by sulphuric acid under varying conditions of mass and dilution.—The iodometric estimation of chlorine, by Dr. G. McGowan. Finkener has stated that Bunsen's method when applied to chlorates gives less than the theoretical amount of chlorine. The author describes experiments which prove the accuracy of Bunsen's method, and suggests that Finkener's error arose from a slight loss of chlorine.

Mathematical Society, December 10.—Prof. Greenhill, F.R.S., President, in the chair.—The President announced the recent decease of Prof. Wolstenholme, with whom he had been associated at Cooper's Hill, and paid a feeling tribute to his memory, in the course of which he touched upon Prof. Wolstenholme's mathematical work.—The following communications were made:—The equations of propagation of disturbances in gyrostatically loaded media, by J. Larmor. In the first instance an extended body is imagined, in Sir W. Thomson's manner, as built up of rigid solid elements, each containing a cavity in which is mounted a rapidly rotating fly-wheel; and this structure is then pushed to the limit when it gives a continuous elastic medium. Such a medium possesses at each point two coefficients of inertia —a scalar one which is specified as the density, or mass per unit volume, and a vector one which measures the angular momentum per unit volume. As we can thus imagine a solid with two persistent constants of inertia, and as it is apparently not possible to have more than these two, it seems worth while to formally express the general equations of elasticity that will apply to such a body. It turns out that, for a homogeneous body having (LMN) as its vector constant of inertia, there must be added to the force per unit volume due to the tractions of the surrounding parts a term of which the x component is

$$-\tfrac{1}{2}\left(L\frac{d}{dx} + M\frac{d}{dy} + N\frac{d}{dz}\right)\frac{d}{dt}\left(\frac{dv}{dz} - \frac{dw}{dy}\right),$$

(uvw) being the displacement. The waves of permanent type in such a medium, otherwise isotropic, are all circularly polarized, the coefficient of rotation being simply proportional to the component of the rotary inertia in the direction of propagation. If the rotary apparatus is more complex than a simple fly-wheel, so as to have free periods of its own, these will be indicated by anomalous rotatory dispersion, and the equations will require modification. It is pointed out that of the three terms put forward by Sir G. Airy as competent to explain the magnetic rotation of light, the one verified by Verdet enters simply in the above manner; while the others, which do not by themselves agree with experiment, imply absolute time-constants, such as free periods of molecular vibration, associated with the rotational property.—On the theory of elastic wires, by A. B. Basset, F.R.S. The stresses which act across any section of a thin elastic wire consist of a tension along the tangent, two shearing stresses along the principal normal and binormal respectively, and three couples about these directions. By resolving parallel to these directions, and taking moments about them, six equations can be obtained, which determine the stresses, when the unstrained form of the wire is given. The values of the three couples can be obtained by a method similar to that employed in my papers on thin elastic plates and shells; and when the wire is inextensible, these values lead to four equations connecting the displacements of any point on the axis, together with a quantity β, such that $d\beta/ds$ measures the twist per unit of length. The torsional vibrations of a complete circular wire are afterwards investigated; and it is shown that they consist of a long period and a short period; that the gravest note is due to the torsional vibrations, and its frequency is proportional to the square root of $18nqc^2/\rho a^4(8n + q)$, where a and c are the radii of the axis and cross-section respectively, ρ the density, n the rigidity, and q is Young's modulus.—Researches in the calculus of variations; ii., discrimination of maxima and minima solutions when the variables are connected by algebraical equations, the limits being supposed fixed, by E. P. Culverwell.—Note on the algebraic theory of elliptic transformation, by J. Griffiths.—Messrs. A. B. Kempe and J. Hammond made short impromptu communications, and also took part with Messrs. Larmor, Basset, Forsyth, Love, S. Roberts, and the President, in the discussions on the papers.

Royal Meteorological Society, December 16.—Mr. Baldwin Latham, President, in the chair.—Mr. W. Marriott gave the results of the investigation undertaken by the Society into the thunderstorms of 1888 and 1889, which he illustrated by a number of lantern slides. The investigation was originally confined to the south-east of England, but as this district was found to be too circumscribed, it became necessary to include the whole of England and Wales. After describing the arrangements for collecting the observations, and the methods adopted for their discussion, Mr. Marriott gave statistics showing the number of days on which thunderstorms occurred at each station; the number of days of thunderstorms in each month for the whole country; the number of days on which it was reported that damage or accidents from lightning occurred; and also the number of days on which hail accompanied the thunderstorms. In 1888 there were 113 days, and in 1889 123 days on which thunderstorms occurred in some part of the country. The number of days with damage by lightning was 33 in 1888, and 38 in 1889; and there were 56 days in each year on which hail accompanied the thunderstorms. The tables of hourly frequency show that thunderstorms are most frequent between noon and 4 p.m., and least frequent between 1 a.m. and 7 a.m. Thunderstorms appear to travel at an average rate of about 18 miles per hour in ill-defined low barometric pressure systems, but at a higher rate in squally conditions. The author is of opinion that individual thunderstorms do not travel more than about 20 miles; and that they take the path of least resistance, and are consequently most frequent on flat and low ground. Detailed isobaric charts, with isobars for two-hundredths of an inch, were prepared for 9 a.m. and 9 p.m. each day for the month of June 1888. An examination of these charts showed that, instead of the pressure being so very ill-defined as appeared on the daily weather charts, there are frequently a number of small but distinct areas of low pressure, or cyclones, with regular wind circulation; and that these small cyclones passed over the districts from which thunderstorms were reported. Sometimes it is not possible to make out well-formed areas of low pressure from two-hundredths of an inch isobars, but there is a deflection of the wind which shows that there is some disturbing cause; and thunderstorms have usually occurred in that immediate neighbourhood. The author believes that the thunderstorm formations are small atmospheric whirls—in all respects like ordinary cyclones; and that the whirl may vary from 1 mile to 10 miles or more in diameter. There are frequently several whirls near together, or following one another along the same track. The numerous oscillations in the barometric curve are evidently due to the passage of a succession of atmospheric whirls; and it appears that lightning strokes are most frequent when these oscillations are numerous.—Mr. F. J. Brodie read a paper on the prevalence of fog in London during the twenty years 1871 to 1890. The popular notion that November is *par excellence* a month of fog is not confirmed by the figures given by the author. The number of fogs in that month is, if anything, slightly less than in October or January, and decidedly less than in December, the last-mentioned month being certainly the worst of the whole year. The latter part of the winter is not only less foggy than the earlier part, but is clearer than the autumn months. In February the average number of days with fog is only 6·6, as against 8·9 in January, 10·2 in December, 9·2 in October, and 8·8 in November.

Linnean Society, December 17.—Prof. Stewart, President, in the chair.—Mr. G. C. Druce exhibited specimens of *Sagina maritima*, Don MS., var. *alpina*, Syme, gathered on steep rocky places on the Cairngorms, and of *Illecebrum verticillatum*, Linn., found near Wellington College, Berks.—Dr. R. C. A. Prior exhibited some fruits of the baobab (*Adansonia*), and an undetermined species of palm, which had been sent from Matabele Land as good to eat, under the misleading names of "cream of tartar fruit" and "wild orange." He read an extract from Oates's "Matabele Land," describing the natural growth and appearance of the baobab as observed in that country.—The Hon. W. B. Espeut exhibited some nests of humming-birds from Jamaica, and pointed out the variety of materials used by the same species, though placed in the same tree (a mangrove), the coloration in some cases being protective, in others not.—A paper was then read on the occurrence of two species of Crustacea belonging to the sub-order *Cumacea* in New Zealand, whence none had been previously described. The author gave the result of his dredging in the Bay of Islands in the north, and in the inlets of Stewart Island in the south, and furnished drawings and descriptions of the species referred to.—A paper on the development of the head of the imago of Chironomus, by Prof. L. C. Miall and A. R. Hammond, was read by Mr. Hammond, accompanied by a series of illustrations with the oxyhydrogen lantern. The subject was introduced by a brief sketch of the life-history of the insect in its three stages, followed by detailed descriptions of the head both of the larva and of the imago. The history of the epidermic invaginations, by which the imaginal head is formed within the larval head and prothorax, was then followed out to its consummation in the development of the fly. The lantern arrangements were successfully carried out by Mr. Frederick Enock.

PARIS.

Academy of Sciences, December 21.—M. Duchartre in the chair.—List of prizes awarded to successful competitors in 1891:—*Geometry*.—Prix Francœur, M. Mouchot; Prix Poncelet, M. Humbert. *Mechanics*.—Extraordinary Prize of 6000 francs: this was divided into four, two principal prizes of equal amount to MM. Pollard and Dudebout, one to M. Guyon, and the fourth to M. Chabaud-Arnaud. Prix Montyon, M. Caméré. Prix Plumey, M. de Maupeou. Prix Dalmont, M. Considère; MM. Autonne and Ocagne being given honourable mention. *Astronomy*.—Prix Lalande, M. G. Bigourdan. Prix Damoiseau (not awarded). Prix Valz, Prof. Vogel. Prix Janssen, M. G. Rayet. *Physics*.—Prix La Caze, M. J. Violle. *Statistics*.—Prix Montyon, MM. Cheysson and Toqué. *Chemistry*.—Prix Jecker, MM. Béhal and Meunier. Prix La Caze, M. A. Joly. *Geology*.—Prix Delesse, M. Barrois. *Botany*.—Prix Bordin, M. Léon Guignard. Prix Desmazières, M. Auguste-Napoléon Berlese. Prix Montagne, M. Henri Jumelle. Prix Thore, MM. J. Costantin and L. Dufour. *Anatomy and Zoology*.—Grand Prix des Sciences Physiques, M. Jourdan. Prix Bordin, M. Beauregard. Prix Savigny, Dr. Lionel Faurot. Prix Da Gama Machado (not awarded). *Medicine and Surgery*.—Prix Montyon, divided between MM. Dastre, Duroziez, and Lannelongue; mentions were accorded to MM. Sanchez-Toledo and Veillon, to M. Soulier, and M. Zambaco; and citations to MM. Arthaud and Butte, M. Batemann, MM. Bloch and Londe, M. Catsaras, M. Debierre, M. Garnier, M. Gautrelet, and M. Netter. Prix Barbier, M. Tscherning; mentions were accorded to MM. Delthil and Dupuy. Prix Bréant (not awarded). Prix Godard, M. Porier; honourable mention to Dr. Wallich. Prix Chaussier, Dr. Brouardel; honourable mention to the late M. E. Duponchel. Prix Bellion, divided between MM. Carlier and Mireur. Prix Mège, M. Frédéric Courmont. Prix Lallemand, divided between MM. Gilles de la Tourette, H. Cathelineau, and F. Raymond; honourable mentions were accorded to MM. Legrain, Debierre, and Le Fort, Bruhl, Sollier, and Colin. *Physiology*.—Prix Montyon, MM. Bloch and Carpentier; mentions were accorded to MM. Hédon and Lesage. Prix La Caze,

M. S. Arloing. Prix Pourat, M. Gley. Prix Martin-Damourette, M. Gley. *Physical Geography.*—Prix Gay (not awarded). *General Prizes.* — Prix Montyon (unhealthy industries): the principal portion of this prize was awarded to M. Gréhant, and the remainder was divided equally between MM. Bay and Brousset; honourable mention was made of MM. Bédoin and Lechien. Prix Cuvier, the Geological Survey of the United States. Prix Frémont, M. Émile Rivière. Prix Gegner, M. Paul Serret. Prix Jean Reynaud, the late M. George-Henri Halphen. Prix Petit d'Ormoy (Sciences Mathématiques), M. Edouard Goursat. Prix Petit d'Ormoy (Sciences Naturelles), M. Léon Vaillant. Prix de la Fondation Leconte: a grant was accorded to M. Douliot. Prix Laplace, M. Champy.—The following prizes were proposed for the years 1892–1896:—*Geometry.*—Grand Prize for Mathematical Sciences: determination of the number of prime numbers inferior to a given quantity. Prix Bordin: study of the surfaces of which the linear elements may be reduced to the form

$$ds^2 = [f(u) - \phi(v)](du^2 + dv^2).$$

Prix Bordin: applications of the general theory of Abelian functions to geometry. Prix Francœur. Prix Poncelet. *Mechanics.*—Extraordinary Prize of 6000 francs: any improvements tending to increase the efficiency of the French naval forces. Prix Montyon. Prix Plumey. Prix Dalmont. Prix Fourneyron: historical, theoretical, and practical study of the bursting of fly-wheels. *Astronomy*—Prix Lalande. Prix Damoiseau: improvements of the lunar theory with reference to secular inequalities caused by planets; to see also if any sensible inequalities exist in addition to those already known. Prix Damoiseau: improvements in the methods of calculating perturbations of asteroids which are necessary for the representation of their position within a few minutes of arc, in an interval of fifty years; also to construct numerical tables which will allow the quick determination of the principal parts of the perturbations. Prix Valz. Prix Janssen. *Physics.*—Prix L. La Caze. *Statistics.*—Prix Montyon. *Chemistry.*—Prix Jecker. Prix L. La Caze. *Mineralogy and Geology.* — Grand Prix des Sciences Physiques: an exhaustive study of a question relative to the geology of a part of France. Prix Bordin: the genesis of rocks, exemplified by experimental synthesis. Prix Vaillant: applications of the examination of optical properties to the determination of mineral species and rocks. Prix Delesse. Prix Fontannes. *Botany.*—Prix Barbier, Desmazières, Montagne, de la Fons Melicocq, and Thore. *Agriculture.*—Prix Morogues. *Anatomy and Zoology.*—Prix Thore, Savigny, and Da Gama Machado. *Medicine and Surgery.*—Prix Montyon, Barbier, Bréant, Godard, Serres, Chaussier, Parkin, Bellion, Mège, Dusgate, and Lallemand. *Physiology.*—Prix Montyon. Prix L. La Caze. Prix Pourat: experimental and chemical researches on the inhibition phenomena of the nervous shock. Prix Pourat: researches on the effects of subcutaneous or intra-vascular injections on the normal liquids of the organism or on liquid extracts from different tissues or organs. Prix Martin-Damourette. *Physical Geography.*—Prix Gay: study of terrestrial magnetism, and, in particular, the distribution of the magnetic elements in France. Prix Gay: study of the trajectory of cyclones moving from North America or the West Indies. *General Prizes.*—Prix Montyon (unhealthy industries), Cuvier, Trémont, Gegner, Delalande-Guérineau, Jean Reynaud, Jérome Ponti, Petit D'Ormoy, Leconte, Tchihatchef, and Laplace.

BRUSSELS.

Academy of Sciences, October 10.—M. F. Plateau in the chair.—Note on a number of Hyperoodons stranded in the Thames and on the Normandy coast, by P. J. Van Beneden.—Study of heat and light phenomena accompanying electrolysis, by E. Lagrange et Hoho. In an electrolyte of dilute sulphuric acid, a positive electrode having an area of 180 sq. cm. was immersed, whilst the negative electrode consisted of a wire of copper 0·25 mm. in diameter, submerged to a depth of 0·5 mm. below the level of the liquid. On passing a current from accumulators through the electrolyte, the ordinary phenomena of electrolysis were observed. When the electromotive force was increased, a kind of decrepitation, resembling the fizzing noise which is heard when drops of water fall on a hot metal plate, was produced at the negative electrode. The liquid about this electrode appears to be in a state of ebullition. The phenomena increased in distinctness as the difference of potential between the negative electrode, and a point in the liquid 3 mm. from it, approached 16 volts. At intervals, when the difference of potential had reached 16 volts, a number of luminous points were produced between the electrode and the liquid, and their frequency was found to increase with the difference of potential. The author has studied the phenomena, using electrodes of Pt, Cu, Zn, Sn, Fe, and C of different diameters, and electrolytes of different degrees of dilution and different natures. He finds, among other things, that the phenomena commence when the electromotive force is the same (for a given degree of acidity) whatever the nature of the electrolyte. The intensity of the current increases, *cæteris paribus*, with the sections of the electrodes, and varies with the nature of the electrode. For the same degree of acidity, the same electrode, and the same amount of immersed surface, the intensity of the current tends to remain constant, although the electromotive force varied from 76 to 98 volts.—On the case in which two hemihedric conjugate forms are not superposable; conditions necessary and sufficient for a polyhedron to be superposable on its image seen in a plane mirror; possible existence in crystals of a class of hemihedra giving superposable conjugate forms, although possessing neither centre nor plane of symmetry; direct and inverse symmetry; tetrahedric group of the quadratic system represented by Λ_{-4}, by C. Cesaro.

BOOKS AND PAMPHLETS RECEIVED.

BOOKS.—Die Elementarstructur und das Wachsthum der Lebenden Substanz: Dr. J. Wiesner (Wien, Hölder).—Magnetism and Electricity; 2nd edition, elementary stage: J. Spencer (Percival).—Arithmetic for Schools: C. Smith (Cambridge University Press).—The Story of the Hills: Rev. H. N. Hutchinson (Seeley).—A History of Epidemics in Britain from A.D. 664 to the Extinction of the Plague: C. Creighton (Cambridge University Press).—Indigestion: Dr. T. Dutton (Kimpton).—Studies in Ratcatching: H. C. Barkley (Murray).—The Century Dictionary, 6 vols. (Unwin).—Year-book of Pharmacy, 1891 (Churchill).—Società Reale di Napoli; Atti della Reale Accademia delle Scienze Fisiche e Matematiche, serie seconda, vol. 4 (Napoli).—Theory of Heat: J. Clerk Maxwell, 10th edition (Longmans).—Journeys in Persia and Kurdistan, 2 vols.: Mrs. Bishop (Murray).—The Fauna of British India: Mammalia, part 2: W. T. Blanford (Taylor and Francis).—The Collected Mathematical Papers of Arthur Cayley, vol. 4 (Cambridge University Press).

PAMPHLETS.—Old Glasgow, Greater Glasgow: J. B. Russell.—The Character and Influence of the Indian Trade in Wisconsin: Dr. F. J. Turner (Balt).

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