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MODERN THERMODYNAMICS.

An Outline of the Theory of Thermodynamics. By Edgar Buckingham, Ph.D. (Leipzig). Pp. xi + 205. (New York: The Macmillan Company. London: Macmillan and Co., Ltd., 1900.)

THE study of thermodynamics is customarily approached, in treatises and text-books, from a point of view to a great extent the reverse of that which is adopted in opening up the subject of dynamics. In dynamics, the usual treatment is essentially theoretical, as opposed to experimental. Newton's laws of motion are regarded as axiomatical; the second and third laws are employed to afford quantitative definitions of force and mass respectively, the parallelogram of forces is practically assumed, and all which follows is mere mathematics. It is only quite recently that the possibility of teaching dynamics from a more experimental standpoint has been seriously considered.

In thermodynamics it is usual to go to the other extreme. Temperature is defined in the first place by a common thermometer, calorimetry is treated largely in its experimental aspect, and the first law of thermodynamics thus becomes more closely associated in the reader's mind with Joule's experiments on the "mechanical equivalent of heat" than with its interpretation as affording a definition of "quantity of heat." The ordinary treatment of the mechanical equivalent of heat would, in fact, have an analogue in dynamics if we were to start with the pound weight as unit of force, and to define the constant *g* as the "kinetical equivalent of force."

Of recent years a great impetus has been given to the study of higher thermodynamics by the development of physical chemistry based on the theories first enunciated by Willard Gibbs. The experimental study of what at first was a purely mathematical investigation plays a part in the history of science closely analogous with the experimental verifications of Maxwell's theory by Hertz's discovery of electromagnetic waves. This new development has, to quote Mr. Buckingham's own words, caused "a considerable gap between the text-books available and the modern memoirs." Mr. Baynes's treatise, so long the favourite English introduction to thermodynamics, does not deal with thermodynamic potentials, yet it is with the study of these functions that modern thermodynamics is primarily occupied. Several subsequent attempts have been made to produce text-books on thermodynamics, but their writers have generally introduced long digressions on extraneous matter while omitting many of the most important features of the theory.

What we have been wanting was, in the first place, an application to thermodynamics of the same deductive methods that have been used in building up other connected theories, such as rational dynamics and hydrodynamics, and, in the second place, an introduction to the study of the thermodynamic potential, the conditions of thermodynamic equilibrium and stability for a generalised system the state of which is defined by any number of variables, and not merely by two of the pressure, volume, temperature triad, and, lastly, an exposition of the phase rule. In compiling this book Mr. Buckingham is practically alone in the field, and the result of his efforts will greatly remove the difficulties which most students experience in acquiring a knowledge of thermodynamics.

In Chapter i. (Thermometry) the author defines equality of temperature, and enunciates the axiom of equal temperatures, according to which bodies which are of equal temperature with a third body are themselves of equal temperature. Absolute temperature cannot, of course, be defined until the second law; but in introducing the so-called "absolute gas scale," the author is careful to guard against misleading assumptions. In Chapter ii. (Calorimetry) the various heat-units are discussed, and the advantage of the dynamical unit explained. The next chapter practically defines thermodynamic systems and thermodynamic equilibrium; while in Chapter iv. we have the first law enunciated in the form of the statement that for a cyclic process the integral of $dW + dQ$ is zero. Chapters v. and vi. deal with the problem of thermochemistry and the thermal properties o fluids, so far as they can be deduced from the first law alone. A recapitulation of the first six chapters makes up the seventh.

Chapter viii. deals with the second law of thermodynamics. The author, having previously defined absolute temperature on the ideal gas scale, here expresses the efficiency of an ideal gas engine in terms of the temperatures, so defined, of the source and refrigerator. In his proof, Boyle's and Joule's laws are assumed. We do not altogether like this order of treatment. We should prefer to see the second law treated somewhat earlier and used to furnish a definition of absolute temperature the properties of gases, as affording a measure of temperature, being subsequently deduced from Boyle's and Joule's law combined with the first and second laws. This method would altogether obviate the necessity of introducing the "gas scale of temperature." Still, the author is so careful in pointing out what is assumed and what is proved in his work that his order of treatment cannot raise any serious objections.

General Equations (Chapter ix.) introduce the thermodynamic potentials. The next chapter deals with the theory of the plug experiment for determination of absolute temperature, Lord Kelvin's equation, application of the laws of thermodynamics to the E.M.F. of a galvanic cell, change of state, and change of osmotic pressure with the temperature.

In the next chapter we have a summary of the hypotheses and conditions involved in the criteria of thermodynamic equilibrium, followed, in Chapter xii., by a concise account of applications of these conditions involving the use of the thermodynamic potentials, in which Duhem's "total thermodynamic potential" and Helmholtz's "free energy" find their explanations. The book concludes with an application of the free energy principle to the galvanic cell, and a discussion on the triple point, which latter leads naturally up to the more general theorem embodied in Gibbs's phase rule. The discussion of this theorem is somewhat condensed, the author referring to the original papers for a more detailed investigation; but for the readers of a book such as the present the brevity of the treatment is probably an advantage. A short bibliography forms a useful appendix.

As implied in the title, the author's object has been to give a general outline of the fundamental theory, and not to enter into detailed discussions of applications. The book thus deals exclusively with the theoretical, as distinct from the experimental, aspect of thermodynamics. It may with advantage be studied in conjunction with any treatise in which the theory of heat is studied from the experimental side, and a clearer understanding of the subject will be obtained than would have been the case had Mr. Buckingham written a larger volume, containing a mixture of theoretical and experimental investigations. In a subject like thermodynamics, the fundamental axioms cannot, as a rule, be verified directly by experiment, and we are compelled to use what Dr. Stoney calls the *a posteriori* method. The evidence in favour of the axioms is mainly derived from comparing the conclusions to which they lead with the results of observation. It is important in the theoretical investigation that no assumption should be made which is not expressly stated, and Mr. Buckingham appears at least to have exercised considerably more vigilance in this respect than any previous writer. We should like to see an outline of the theory of electromagnetism treated on parallel lines. Mr. Buckingham's treatise will be an indispensable addition to the library of every physicist or physical chemist, as well as of every applied mathematician who studies thermodynamics, and the author has done much to place the introductory treatment of the subject on a sound and rational basis.

AN AUTHORITATIVE TEXT-BOOK OF PHYSIOLOGY.

Text-book of Physiology. Edited by E. A. Schäfer. Vol. ii. Pp. xxiv. + 1365. (Edinburgh and London: Young J. Pentland, 1900.)

THIS volume consists of 1258 pages of text, 97 pages of indices (subjects and authors), and is illustrated by 449 woodcuts. There is no preface. The following epitome shows the subjects dealt with, their respective authors, and, in brackets, the length of each article:—"Mechanism of the Circulation of the Blood," by L. Hill (1-168); "Contraction of Cardiac Muscle," by W. H. Gaskell (169-227); "Animal Mechanics" (228-273), "Sense of Taste" (1237-1245), "Smell" (1246-1258), J. B. Haycraft; "Muscular and Nervous Mechanism" of "Respiratory Movements" (274-312), of the "Digestive" (313-337), "Urinary" (338-346) and "Generative Tracts" (347-351), E. H. Starling; "Properties of Striped Muscle" (352-450), J. Burdon Sanderson; "Nerve" (451-560), "Electrical Organs" (561-591), Francis Gotch; "Nerve Cell" (592-615), "Cerebral Cortex" (697-782), E. A. Schäfer; "Sympathetic Nervous System" (616-696), J. N. Langley; "Spinal Cord" (783-883) and "Parts of Brain below Cerebral Cortex" (884-919), "Cutaneous Sensations" (920-1001) and "Muscular Sense" (1002-1025), C. S. Sherrington; "Vision" (1026-1148), W. H. R. Rivers; "Ear" (1149-1205), "Vocal Sounds" (1206-1236), J. G. McKendrick and Albert A. Gray.

Those familiar with the modern development and advances recently made by British physiologists will see at once that the selection of authors is a guarantee of the excellence and accuracy of the subject-matter of the several essays; for they may be regarded as such, each essay containing the results of the observations to which the author has directed his particular attention.

It appears to us that Hill's article on the circulation is an excellent *résumé* of the subject, and the author acknowledges that he is greatly indebted to the perhaps not sufficiently well-known "Lehrbuch der Physiologie des Kreislaufes," by R. Tigerstedt (1893), who has recently become professor of physiology in Helsingfors. There has been incorporated all those recently discovered facts bearing on the action and distribution of vaso-motor nerves, and influence of gravity on the circulations, with which readers of the *Journal of Physiology* are familiar.

Gaskell's paper is a philosophic discussion of the many observations that have been made on the action of cardiac muscle. It is done with a master hand, and by one who has materially advanced our knowledge of the subject. Gaskell explains the beat of the heart, the sequence of its contractions, &c., without bringing in ganglion cells at all; and he sees no more reason to assign special functions to these cells than to any other of the peripheral efferent nerve cells; and we think that he makes good his case.

Starling's articles give a clear and precise account of the subjects with which they deal, but we confess that we think a short chapter on the comparative physiology of some of the subjects would have been most valuable. In discussing the influence of the higher parts of the brain on the respiratory centre, we failed to find noted the researches of Marckwald on the effect of plugging the blood-vessels of certain cerebral areas by injecting coloured fluid paraffin wax. These results point to the importance of the posterior quadrigemina and the nuclei of the sensory part of the fifth cranial nerve as important factors in the discharge of rhythmical respiratory impulses (*Zeit. für Biol.*, vol. xxvi.). The earlier observations of Marckwald are given. We are glad to see a full exposition of the work of Kronecker, Meltzer and others on swallowing of liquids.

The mechanical, thermal and chemical properties of striped muscle are exhaustively treated by Burdon Sanderson, as was to be expected from one who has devoted so much time to the study of the time relations of muscle in action, and who, by the introduction of new methods, has added materially to the apparatus by which time-problems in other tissues may be solved. The same may be said of the admirable article on "Nerve" by Gotch, while his paper on "Electrical Organs" groups up succinctly the chief facts and theories regarding these wonderful organs. As to the nature and activity of these organs, Gotch is led to the view that, as the only excitable structures there present are the nerves and their fine terminations, the organ change is closely related to the production of molecular disturbances in its contained nerves. In any case, he regards the essential primary disturbance constituting the organ shock as nervous.

In the editor's article on the "Nerve Cell" we have, as a basis, a *résumé* of the more recent advances in the minute structure of these organs. The modern "theory of isolated units," often spoken of as the "neurone theory," he regards as by no means conclusively proved. In any case the "neuron" terminology, as introduced by Waldeyer, has taken deep root in neurology.

Langley's article on the sympathetic and allied nervous systems is a masterly summary of a subject which, by his researches, he has made peculiarly his own, and groups up in an easily accessible form the many scattered observations on this subject.

The important topic of the "Cerebral Cortex" is fully dealt with by the editor. In mentioning the old experiment of Kircher, known as the "experimentum mirabile," it is set down to "Kirscher" (p. 712). Several of the illustrations are acknowledged from the well-known work of François-Franck and Pitres. The author deprecates the use of the term "sensori-motor," as applied to denote the so-called "motor" or excitable centres in the Rolandic area, although he does not object to the term "psychomotor" applied to them. A difficult subject is dealt with in a terse but comprehensive manner.

Sherrington's article on the spinal cord displays a mastery of his subject which at once elicits one's admiration. Necessarily, in dealing with the mass of detail many new terms have to be coined for the numerous phenomena which have been discovered in recent years. There is a due admixture of the historical with the results of recent research. What the Germans call Bell's law appears here as "Bell-Magendie law." The word "Bahnung," introduced by Exner into nerve physiology, is, we think, better rendered by "facilitation," adopted by Sherrington, than any of the other proposed equivalents we have seen.

It is evident that a large amount of industrious application has been expended by Sherrington on his articles on "Cutaneous Sensations" and on "Muscular Sense." In the former we find the recent work of Goldscheider, v. Frey and Kiesow treated with ample detail; but perhaps the article on the "muscular sense," grouping up as it does the numerous stray observations, will attract much attention. The value of Sherrington's own work on the "Muscle-spindles," which he showed degenerated after section of the posterior nerve roots outside the spinal ganglion, laid the basis of a more definite physiology regarding the important part played by certain afferent impulses from striped muscle in regulating the activities of the parts from which they proceed. Indeed, the chapter on "the peripheral apparatus of the muscular sense," though short, is an excellent *résumé* of the present knowledge of this important subject, and to which clinicians will find it profitable to devote their attention.

The essay on "Vision" is somewhat unequal, but how can it be otherwise on a subject so vast and which is treated with such wealth of detail in Hermann's "Handbuch der Physiologie."

Although necessarily there is much comparative physiology scattered throughout its pages, we could have wished to see the main facts of the comparative physiology of at least some of the subjects summarised in separate chapters. The work is one which reflects great credit on British physiologists, and we heartily congratulate the editor on its production—a work which must have entailed great labour and careful supervision. Perhaps when the next edition is called for it may be issued in three volumes, as volume ii. has reached rather bulky dimensions.

THE ROYAL OBSERVATORY, GREENWICH.

The Royal Observatory, Greenwich; its History and Work. By E. W. Maunder. Pp. 320. (London: the Religious Tract Society, 1900.)

THE history of the Royal Observatory extends over two centuries and a quarter, and its work is certainly not lacking in general interest; yet Mr. Maunder seems to be the first person to produce a popular account of them, and he has left little room for improvement to any one who comes after him in the near future. The history occupies the first 124 pages of the book in five chapters, and the description of the place as it is to-day, and the work as it is now going on, occupy the other 192 pages in eight chapters. This is probably a fair arrangement. Those who would have liked a little more of the history can find it in such works as Bailey's "Life of Flamsteed," or Rigaud's "Life of Bradley." A "Life of Halley," on a scale worthy of him, has long been wanted, and has several times been nearly undertaken, but the project has, for one reason or another, always fallen through.

The predecessors of the present Astronomer Royal number seven: Flamsteed, Halley, Bradley, Bliss, Maskelyne, Pond, Airy. Of these Bliss only filled the position for two years; but the others lived long and worked hard at their posts, Flamsteed, Maskelyne and Airy for nearly half a century each; Halley, Bradley and Pond for nearly a quarter. And though there is so much straightforward routine work in astronomy, especially at a national observatory (and among national observatories, especially at Greenwich), yet the names of the Astronomers Royal are all associated with one or two notable events, often, though not always, special achievements of their own. The name of Flamsteed calls up at once the foundation of the observatory (which was in great measure due to him), and unfortunately also the quarrel with Newton; that of Halley, the publication of the Principia, and the first prediction of the return of a comet; that of Bradley, the discovery of Aberration and Nutation, as well as his fine catalogue of stars; that of Maskelyne, the invention of lunar distances and the chronometer, and the establishment of the *Nautical Almanac*. Airy deserves to be remembered as the man who first suggested how to compensate the compass in iron ships, though, like Flamsteed, he was unfortunate enough to leave another reputation, from his attitude towards the discovery of Neptune. Pond and Bliss are something of exceptions; but the former has recently been eulogised by Mr. Chandler as a phenomenal observer; and even of Bliss we may say that it was a distinct achievement to leave behind him only one authentic portrait, and that scratched by a boon-companion on a pewter-flagon! The seven Astronomers Royal were not only men of ability, who worked hard, but men of clear-cut individuality; and their average length of life was nearer four score years than three score years and ten. We ought to have all their portraits in our National Portrait Gallery, including an electrotype of that curiosity inscribed "This sure is Bliss, if Bliss on earth there be."

Mr. Maunder has given us the main facts of these interesting lives in a thoroughly readable form. He then passes on to the Observatory as it is now, and we must not forget that its present size and arrangement are due, not only to the seven men mentioned above, but also to nineteen years' work from Mr. Christie, the present Astronomer Royal. In these nineteen years he has contributed to the buildings and equipment about as much as his seven predecessors together. There is a new transit-circle, which can be used on or off the meridian; the 13-inch refractor has been increased and multiplied into a 28-inch visual refractor, a 26-inch photographic refractor, and a 30-inch reflector, besides the 13-inch astrographic equatorial; and a large, commodious building has been erected, which more than doubles the space available for computing, measuring photographs, and all the miscellaneous duties of which the lay-mind has probably never imagined the existence. In this noble extension of our National Observatory, the Astronomer Royal has been generously helped by others, and especially by Sir Henry Thompson, who gave two of the large telescopes, and by Mr. Crisp, the architect of the new buildings, whose name we are sorry not to find in Mr. Maunder's book.

On one day in the year, "Visitation Day," the Observatory is devoted to visitors; and though it is not even then thrown open to the public, those with a definite interest in astronomy can generally obtain a card of admission. They find a great many things to see—those who see them for the first time find the number and variety almost bewildering; there is, in fact, the year's work of fifty busy people to look at, as well as the complicated instruments with which it was done. Things have changed somewhat, in spite of the reluctance of economical Governments, since Flamsteed was installed as Astronomer Royal in 1676 with a salary of 100*l.* a year, a "surly labourer" to help him, and no instruments! To such as are fortunate enough to be admitted on these annual occasions we can recommend the later chapters of the book for perusal both before they go and after they come away; a number of technical matters are described in a thoroughly attractive way.

Sometimes in reading a book a stray sentence or two impress the memory, though they may be only incidental to the main theme. Pond's notion of the kind of man who would make a good assistant in an observatory arrests the attention:—

"I want indefatigable, hard-working, and, above all, obedient drudges (for so I must call them, although they are drudges of a superior order), men who will be contented to pass half their day in using their hands and eyes in the mechanical act of observing, and the remainder of it in the dull process of calculation."

There is undoubtedly a vast amount of drudgery in astronomy, if people choose to so regard it. Other sciences multiply their observations ten or a hundred times; the astronomer deals in thousands and even millions. But men with the spirit of drudges, as Mr. Maunder truly remarks, cannot be trusted to do the work honourably and therefore accurately; and besides this the work is *not* drudgery. Mechanical it may be, but good men and true have found it far from dull. Did Herschel find it dull to pass the whole heavens in review star by star? Does Mr. Denning, of Bristol, find it dull to watch night after night for long hours on the chance of observing a few meteor-tracks, and that after a day's business toil? If it were drudgery they would have stopped, but Herschel went on, and Mr. Denning goes on, and these are only two random instances out of hundreds.

At the same time Pond put his finger on a real difficulty, which is just as pressing to-day, nay, far more pressing since the introduction of photography into astronomy has so enormously increased the work. How are we to get through this work? The army of astronomers is so small; it has not been recruited with sufficient rapidity to keep pace with the extension of our Empire. Pond thought of drudges, as commanders of old employed mercenaries: both found them unsatisfactory. What is the real solution? Conscription will scarcely work here. Will the volunteers solve the difficulty, or may we hope for a big reorganisation scheme? H. H. T.

THE MANAGEMENT OF ROADS.

Road-making and Maintenance: a Practical Treatise for Engineers, Surveyors and Others. By Thomas Aitken, Ass.M.Inst.C.E. Pp. xvi + 440. With numerous plates and illustrations. (London: Charles Griffin and Co., Ltd., 1900.)

SINCE the introduction of bicycles and motor-cars the question of road maintenance has come very much to the front. It formed one of the subjects discussed in Section G at the late meeting of the British Association, and was considered of sufficient importance to warrant the appointment of a committee to inquire generally into the subject, but more especially as to the effect of the condition of the surface of roads on the tractive force required to move vehicles along them.

The author of the book under notice has given an interesting account of the history of road-making from the time of the ancient inhabitants of Peru, and of the Romans, to the days of road revival in this country, when General Wade was employed by the Government in constructing about 250 miles of roads through the Highlands of Scotland as the most effectual means of putting an end to the Rebellion of 1715.

Then followed the establishment of turnpike trusts, no less than 1100 Acts of Parliament having been passed for this purpose, and a very large amount of capital was raised for opening out new, or improving old, roads. In this work Telford, the father of modern civil engineering, constructed over 900 miles at a cost of nearly half a million of money. So great was the revolution in the condition of the roads that Macadam, another of the great road-makers, was described as being regarded by the public as a sort of magician, and his invention something preternatural. As the result of their work it became possible to run stage coaches between the principal centres of population at the rate of ten miles an hour. The establishment of railways and the termination of the turnpike trusts under provisions contained in the Acts of Parliament led to the decadence of the main roads of the country, the management of the old turnpikes having reverted to the parochial surveyors. A certain amount of improvement took place when the system of grants out of the county rates towards the maintenance of the main lines of communication was introduced, these grants being subject to the roads being kept in repair to the satisfaction of the county justices. A further improvement took place when these roads were taken over by the County Councils.

The bicycle has, however, been the main agent in recent road improvement. To use these machines with any comfort a road must be in thoroughly good order, level, and free from loose stones and mud. The voice of the bicyclist is heard everywhere calling out when roads are in bad order, and local legislators are driven both by their own experience and that of their constituents to bring about a better condition of the main roads and highways. An institution known as the Roads Improvement Association has been formed, and, besides bringing pressure to bear on the local authorities, has issued a great quantity of literature for the guidance of local surveyors and roadmen as to the management of the roads; upwards of 13,000 pamphlets containing practical information on the management of roads have been distributed by this society.

Fortunately road reformers are able to show, by conclusive evidence, that roads kept in thoroughly good order cost less in annual maintenance than when they are left to get rutty and uneven and covered with mud or loose stones.

Mr. Aitken's book is a good practical treatise on the making and maintenance of roads. It is divided into fifteen chapters, which deal respectively with the history of road-making; traction; the construction of new roads; bridges, culverts and retaining walls; road material; quarrying; stone-breaking and haulage; road-rolling and scarifying; paved roads, including wood, asphalt, brick, and tar macadam; footways, &c.

The book deals principally with main roads and those subject to heavy traffic, which, as a rule, are now under the care of the county surveyors, who are skilled experts, and very little attention has been given to the requirements of the ordinary highways, where improvement is most required. The space devoted to quarrying, which occupies no less than sixty-seven pages, or about one-sixth of the whole book, could well have been spared, as it is rarely in these days that a surveyor has to quarry his own road material, and the space would have been better devoted to showing how ordinary highways may be maintained in good order and kept level and clean, and material placed on them when required without inconvenience to the traffic in situations where steam road-rolling is impracticable.

OUR BOOK SHELF.

Knowledge, Belief and Certitude. By F. Storrs Turner. Pp. viii + 484. (London: Swan Sonnenschein and Co., Ltd., 1900.) Price 7*s.* 6*d.* net.

MR. STORRS TURNER distinguishes knowledge from consciousness as interpretation from datum. He alleges as base of the former three certitudes, as to self, other selves and real things. He finds the sciences to involve the same pre-conditions and to take a permissibly abstract point of view—that of a fictitious independent spectator. But he holds that, therefore, the sciences are not adequate to concrete reality, while the pretension of science in general to present the whole is vain. In psychology the standpoint of the ideal spectator is inadmissible, and philosophy has failed because of the same abstraction. But among concrete ends we find our conviction as to some certain knowledge satisfied. Real knowledge belongs to the teleological sphere.

His conclusion to the failure of the speculative and the success of the purposive reason surprised Mr. Turner with the force of a revelation. The first chapters of his inquiry, which "remain substantially as they were originally written," were committed to paper years ago when "a dense fog" covered his mind. A trace of this is to be found in the attempt to maintain concurrently that the certitude of other selves is an inference of reason (p. 74), that it is plainly one with the certitude of self (p. 89), and that neither is able to come into existence apart from the other (p. 95). Mr. Turner can say within a page that "by real things we mean permanent things" (p. 80), and that "what we have is the certitude that there are a multitude of real things, some of them permanent, most of them changing" (p. 81). It will perhaps be unnecessary to say that his verbal criticism on such writers as Mr. F. H. Bradley depends for its validity on a hit or miss principle. It is a little grotesque to have estimates of Hegelian metaphysics and post-Hegelian logic from the standpoint of "reflective common-sense, aware of its limitations." Mr. Turner thinks that continuity implies indivisibility, and his verdicts on much in philosophy and science rest on similar misunderstandings.

"Knowledge, Belief and Certitude" is, however, by no means a worthless book. There is a certain dialectical ability in much of it, and a tenacity as to main principles which will appeal to the clear-headed reader who can discount the fallacious element. It is, however, as an honest attempt to think the problem of knowledge right through, and to present a record of the process as well as the results of his investigation, that it chiefly commends itself. How and why Mr. Turner came to his estimate of various views and systems, rather than that estimate itself, is the thing worth studying.

H. W. B.

Notions de Minéralogie. Par A. F. Renard et F. Stöber. IIme Fascicule; Classification et Description des Espèces Minérales. Pp. 191 to 374. (Gand: Ad Hoste, 1900.)

THE first fascicule of this text-book, containing the general principles of mineralogy, has already been noticed. The second fascicule (pp. 191–374) is devoted to the detailed description of mineral species. A large number of species are mentioned and, consequently, the majority are only briefly treated; in its main features the book necessarily resembles other mineralogical text-books.

It seems that, by a wise provision, all candidates in natural science at the University of Gand devote one hour weekly to the study of mineralogy, and it is for these students that the book is primarily intended. From this point of view we think that, as in most text-books, more species are mentioned than is necessary; such rare minerals, for example, as chalcomenite and nitrobarite should scarcely come within the range of the elementary student, but the brief descriptions of the commoner minerals leave nothing to be desired.

There are several useful features in the book which deserve special mention. In the case of most of the minerals of commercial importance, such as mica, apatite, cassiterite, galena and sulphur, a statement is given of the annual world's yield and its approximate value.

Another important feature is a summary of the minerals of Belgium with their localities, with which the volume concludes. Such local information is extremely useful, and this is the first authentic list of Belgian minerals and localities which has been given. The list has evidently been compiled with care; special attention is directed to those minerals which are peculiar to Belgium.

Many of the figures will disappoint the modern reader on account of the indifferent printing; but among the illustrations he will find several useful diagrams which are not the familiar figures common to all the text-books, for example, the projection which shows the migration of the indicatrix axes with change of composition in the plagioclase felspars.

The authors have succeeded in producing within a small compass a fairly comprehensive yet lucid treatise on the principles of mineralogy and the chief mineral species, which may safely be recommended to the student in England as well as in Belgium.

The Essentials of Practical Bacteriology: an Elementary Laboratory Book for Students and Practitioners. By H. J. Curtis, B.S. and M.D. Lond., F.R.C.S. (London: Longmans, Green and Co., 1900.)

THIS book consists of a series of lessons upon practical bacteriology, mainly for a course of study required for the Diploma of Public Health. Commencing with the preparation of nutrient media, it passes on to the systematic study of, first, certain typical non-pathogenic bacteria, then to the moulds, including ringworm and allied forms, the account of which is much fuller than usual, and, lastly, to the pathogenic organisms. Fermentation and the beer yeasts are referred to, the malaria parasites, the *Amoeba coli*, and the supposed cancer organisms are described, and the methods employed for the examination of air, water, &c., and for testing disinfectants are given. The practical details described seem to be fairly complete and accurate, and the book is copiously illustrated, many of the illustrations of cultures being extremely good. The *Bacillus enteritidis sporogenes* of Klein is not mentioned, though it is a capital organism for class work. The method of freeing cultures for the "Widal" reaction from clumps by filtration is attributed to Symmers, but is mentioned in Hewlett's "Manual of Bacteriology." The paraffin method of embedding described is needlessly complicated. These and a few other omissions and errors will doubtless be corrected should another edition be called for.

What is Heat? and What is Electricity? By F. Hovenden. Pp. xvi + 329. (London: Chapman and Hall, Ltd., 1900.)

MR. HOVENDEN has set himself the modest task of overthrowing, in the space of about 300 pages, all existing physical tenets, and substituting in their place a remarkable theory of his own. In this effort he has not succeeded, except, apparently, to his own complete satisfaction. In the first part of the book the author quotes freely from Maxwell and others, and endeavours to prove that their reasoning is fallacious. His arguments only show that he does not understand what he quotes, and that he has not appreciated the most elementary principles of the subject, such, for example, as the difference between mass and weight. Having, as he considers, sufficiently disposed of the views held by modern men of science, Mr. Hovenden proceeds to the elucidation of his own theory. It is impossible to regard this part of the book seriously, Mr. Hovenden's deductions from experiments being altogether too extravagantly absurd. It is interesting to note that his treatment of the subject is throughout entirely qualitative; we venture to think that in no single instance would Mr. Hovenden's explanations stand the test of quantitative examination. If modern theory is to be disproved, it will not be by such writings as this. The least one can expect of its opponents is that they should properly understand the fundamental conceptions involved, and this Mr. Hovenden cannot be said to have attempted to do.

LETTERS TO THE EDITOR.

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On a Proof of Traction-Elasticity of Liquids.

I HAVE read with much interest the note of Mr. T. J. Baker, on a surface-tension experiment (NATURE, No. 1600, June 28, 1900). The author describes, with photographic illustrations, a phenomenon at first observed by Savart (1833), and later studied by Hagen, Tyndall, J. Plateau, Boussinesq and myself, but in all these studies, as in Mr. Baker's note, no other force than surface tension is supposed to produce the different phases of the phenomenon. Therefore I resumed the subject two years ago[1] and endeavoured to explain the consecutive phases by proving that in this experiment there arises always some elasticity of traction, not only in both superficial layers, but even in the whole mass of the sheet.

For example, if the velocity of the jet is extremely high, the liquid is suddenly compressed by the shock against the disc; but on account of the perfect elasticity of the liquid, there is no sensible loss of *vis viva*, and the little expansion is performed in a very minute fraction of a second, during which the liquid is quickly projected in all directions parallel with the plane of the disc, and forms a sheet; as long as the intermolecular distances do not increase, the only retarding forces are the surface-tensions of both faces of the sheet; therefore the central part of the latter is even and transparent. But soon, by the stretching-out of the sheet, all molecules separate from each other, extremely little indeed, but enough to produce suddenly strong resistances; then each coming layer strikes against a retarded one, and so are formed circular strips from which many drops constantly part. Besides, as the elasticity cannot be the same in all points of a circular strip, some radial strips are also produced in the sheet, from whose broken edge very many little drops are continually thrown.

On diminishing the rate of outflow, the production of interior elasticity of traction becomes also smaller, and therefore the transparent portion of the sheet increases gradually; but the edge sinks slowly, and soon closes inwards and reaches the vertical piece supporting the disc. The surface-tension of both faces of the sheet is not the only force which drags in the water radially; for by the action of gravity the sheet can be compared with a membrane of india-rubber, that is to say, all portions are distended, not only in the superficial layers, but even in the interior mass.

It is easy to show that the distension of falling particles is all the greater as the velocity is smaller. Therefore the elasticity of traction produced by gravity increases in the proportion that the movement slackens.

We can now understand why the motion of the liquid in the vicinity of the summit of the closed figure becomes more and more difficult, until the figure rises above the plane of the disc, afterwards falls again and reforms a closed figure of smaller breadth.

With a still slower stream of water, the figure begins to oscillate vertically, just because the force of gravity draws it down, while the elastic force of traction pulls it up.

Ghent, January 2. G. VAN DER MENSBRUGGHE.

Mathematics and Biology.

IN the interesting address of Prof. Howes published in NATURE of December 10 occur the following words:—

"On this basis there are now being pushed forward attempts to apply statistical, experimental and mathematical tests to the study of vital phenomena. All honour to those who are making them, for it is certain there are phases of life capable of mathematical treatment, but the mystery of life can never be thus solved; and, concerning the objection to the observational method, with confirmation and generalisation, and rejection of the non-confirmable, our non-mathematical procedure is scientific. Huxley has long ago said of mathematics that what you get out of the machine depends entirely upon what you put into it."

[1] "*Sur les nombreux effets de l'élasticité des liquides,*" 3me Communication (*Bull. de l'Acad. Roy. de Belgique*, 3me série, vol. xxxvi., p. 281, 1898.)

Now I think there are several points in the above sentences liable to misconstruction. Mathematics is purely a *form* of reasoning, and, as in the case of all forms of logic, it is merely an instrument, and the product depends upon the material dealt with. This may be the result of observation or of experiment, either of which may or may not be statistical in character. Prof. Howes, in contrasting "statistical, experimental and mathematical tests" with the "observational method," seems to be looking upon mathematical reasoning as something which has more relation to experiment than to observation. I fail to see why as an instrument it is less applicable to the gigantic overthrust of the geologist than to the test-piece in the laboratory, less applicable to an observation on the mottling of birds' eggs than to an experiment on the breeding of mice. It is perfectly true, as Huxley said, that what you get out of the machine depends entirely on what you put into it. Such a platitude in its right context may be a useful reminder. But *without your machine you may be able to get nothing at all out of your material;* and I venture to think that this is the case, not with a few, but with many branches of biological inquiry.

The reason thereof is easy to find. In vital phenomena we are never able to repeatedly observe or to experiment, as we can very closely do in physics, under exactly the same conditions with the same quantities of the same substances. The reader will probably interject, "No, and this is the very reason why mathematics can be applied to the one and not to the other!" On the contrary, because in biological investigation an exact A cannot be associated with an exact B, and an exact C observed (as we can do in physics), biology requires a much more refined logic, much more subtle mathematics than the simplest branches, at any rate, of physical inquiry do. There is nothing more full of pitfalls than "ordinary reasoning" applied to the problems of association. The biologist observes that *some* A is associated with B, and that *some* C is associated with B. But if he wishes to discover whether the relation between A and C is causal, he will need all the refinements of symbolic logic, a mathematical analysis, which is analogous to the geometry of hyperspace, before he can come to a definite logical conclusion on the possible relationship of A and C. He may observe as much as he will, but he will not find out whether the association is confirmable or non-confirmable without this higher logic. It is the all-pervading law of vital phenomena that no two individuals are identical among living forms, that variation exists in every organ and every character, which, so far from disqualifying biological phenomena for mathematical treatment, enforces a need for the most generalised forms of mathematical reasoning. Prof. Howes tells us that the mystery of life can never be solved by mathematical treatment. If he had said that the mystery of life cannot be solved by any treatment whatever, I should have heartily concurred with him. But if he means that observation, rather than observation plus the higher logic, is likely to discover the most comprehensive formula under which the phenomena of life can be described, then I am quite sure he is in error. Observation, for example, has collected a mass of most valuable facts during the past thirty years, but can any one by merely verbal generalising upon these facts venture to assert that evolution by natural selection is more than a probable hypothesis? The very nature of such ideas as variation, whether continuous or discontinuous, as inheritance, whether exclusive or blended, as selection, whether natural or sexual, leads us to the idea of number, of statistics, of frequency, of association, and enforces upon us an appeal to mathematical logic. If we are to feel that evolution by natural selection is as sure a formula as that of gravitation, it will be because mathematics steps in and reasons on the data provided by the Tycho Brahés and Keplers of biological observation.

Prof. Howes must not for a moment suppose I claim biology for the mathematician. I do not even want the mathematician to have a biological training, conscious as I am personally of the disadvantages of its absence. The mathematician who turns physicist is rarely so valuable a discoverer as the born and trained physicist who knows mathematics so far as he needs them. I believe the day must come when the biologist will—without being a mathematician—not hesitate to use mathematical analysis when he requires it. The increasing amount of work being turned out, both in America and Germany, by the younger biologists with a mathematical training, is a sign of the times. In England, I suppose (where, as usual, an Englishman, Mr. Francis Galton, first indicated the great possibilities of a new method), we shall be left behind, and let other nations gather the fruits of our sowing. Prof. Howes, indeed, leaves a field for mathematical investigation; but it was only a few weeks ago, at a discussion at the Royal Society, that another distinguished biologist asserted that in living forms there was no such thing as number!

Et Verbum interrogabat Vitam: Quod tibi nomen est? Et dicit ei: Legio, id est Numeri, mihi nomen est, quia multi sumus. Et deprecabatur eum multum, ne se expelleret extra regionem.

I doubt whether the demon can now be exorcised conjure *Verbum* ever so cunningly. KARL PEARSON.

Education in Science.

SOME discussion has recently arisen as to the methods of teaching mathematics. Euclid has been condemned on the score of its advancement and its antiquity. An infusion of more modern geometry has been recommended, with corresponding arithmetic and algebra. In science, at the same time, there has been a tendency to recognise the historic method. Prof. Perry considers it unnecessary for pupils to traverse the course of their ancestors. But let us ask *why* this course has been recommended. On account of the successive growth of faculties in a historical sequence. Is this a fact or not? It is an undoubtable fact, and it is not sufficiently realised by any teachers. Prof. Perry has two saving principles, first to teach by practice, and second to satisfy the pupils' instincts. These being the same reasons which are used by advocates of historical methods secure a certain amount of agreement. We ought to arrive at the same result whether we study the natural methods of pupils, or the methods of primitive peoples. But Mr. Herbert Spencer has well pointed out somewhere that we ought not to go to the Greeks for examples of primitive peoples. They were highly and very specially developed. Hence arises a very great danger in the historic method.

With regard to practical and rational methods, it must have often been noticed by teachers that a great number of pupils have an inherent objection to carrying out rules without some kind of reason for them. It is also to be observed that a very vague, or even a verbal reason, will be more satisfactory than a real one. This is surely in accord with the studies of the history of science. Although it is somewhat misleading to reason from the experience of men of genius, it may be worth while to call to mind the intense satisfaction of Darwin with Euclid's concatenation, and the disgust of Huxley at the irrational rule and rote method of mathematics under which schoolboys grow up. It is the exceptional boy who delights in carrying out enigmatic rules, although all have a temporary taste for that work as sauce to the rest. It is treacherous to reason from one lesson of this kind to a regular course of it.

It is customary to speak of the activity, observation, ingenuity of children. But it is not found, either in the history of children or of primitive peoples, that they are capable of continued mental application, observation or contrivance. We might just as well speak of the great reasoning powers of children on account of their perpetual "why." It is also improper to underestimate the value of this tendency. By it children acquire and cement their knowledge, although a chain of real reasoning will absolutely exhaust them.

From this kind of reasoning we conclude that the time-taught method now pursued in mathematics is a reasonable one, that Euclid with the algebra and arithmetic corresponding is in the main advantageous. But why? Because it is conformable to the instincts of pupils, and also because it is historic. But is it conformable enough? Is it historic enough? I think not. Euclid was a grown man in a grown community of very special bent of mind. Where he does not agree with the reason for his inclusion in school curricula he should be neglected. But instead of supplementing him from more recent geometry, it should be from more antique writers and from study of pupils' methods.

Now we come to the bearing of this on the teaching of science. We are comparatively new at this game. We are finding that we have started in too high a key, and we are being recommended to go back. I have not yet seen a recommendation to exactly imitate the mathematical teachers, and go back to Pliny, Geber, Gilbert and Pallissy. But several have advised Boyle and Black. Along with this advice is an insistence on quantitative work from the very start. It appears to me this is a very grave mistake. The use of a rough balance and rough methods of measurement is all that should be aimed at in school. For example, one teacher of girls proposes to show by furnace and acid that chalk gives off a definite quantity of gas. This seems to me appropriate for an advanced university student, but is not the thing for schools at all.

Experiments to show the indestructibility of matter have this advantage, that you must begin with some matter, and that you must have some appliances on both of which the inquiring mind may feed. But as to where the matter goes to is another matter, and as to what the measurements are all for, you might as well be noting them during the progress of a pantomime.

The same criticisms apply to physiology and botany. It is said we cannot properly study the stomach without a preliminary of histology. If so, they cannot be approached in schools, for histology is a late science and is vain and empty to pupils. The microbes of false ideas are thick in it. But Harvey knew no microscopical histology, and yet he was not altogether a fool. I find boys and girls of fifteen and sixteen studying the alternation of generations in a phanerogam, and not only the nutrition but the respiration of plants. Surely this is pushing on to modern methods with a vengeance. But is there anything gained in development of faculty? Can they *observe* these things, or do they trace a dim something which they are told are there, and recognise them with the wild delight of an irresponsible original researcher? It is the delight of a child who has jumped six feet high with just a little assistance. An independent mind rejects all this and begs for a little exercise in kinds of knowledge which you will find well represented in Pliny.

When we turn back to the books of study which we read as boys of fifteen and sixteen in the times when the ambition to kick a goal or vault ten feet was so strong and so easily ousted other ideas, how many very important laws we find which we then read and now for the first time *know*. I can remember the time when I tried to wake a class to the importance of Boyle and Charles's laws, and I can also remember the time when I remembered that my own old master vainly tried to wake us to it. The result in neither case was thanks, and it was the teachers who were wrong, not the pupils. We do our best, but we are vastly wrong, and we inflict many injustices by force of punishment just as in the old *régime* they broke the rulers over our fathers' shoulders in teaching them practical prosody. A little study of history will lessen this injustice.

At the same time we must distinguish essential historic progress from mere accidents of time. I should be sorry to exclude hydrogen explosions absolutely. JAMES SUTHERLAND.

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Abbe's Optical Theorems.

IN the article, "Optical Science" (NATURE, p. 203), as well as in the preface to Prof. S. P. Thompson's translation of Lummer there mentioned, regret is expressed at the neglect in English text-books of Abbe's contributions to optical theory.

Will you allow me to remark that statements and proofs of Abbe's theorems will be found in §§ 205*b*–205*f* of the 1899 edition of my "Deschanel, Part iv." They occur in the chapter on "Systems of Lenses," and are based on careful study of the writings of Abbe and Czapski.

Ealing, January 9. J. D. EVERETT.

Fireball in Sunshine.

ON Sunday, January 6 last, at 0h. 52m. p.m., a brilliant fireball was seen by many observers in Scotland. The sky was clear and the sun shone brightly at the time. The meteor was observed from Whiteinch Park and Great Western Road, Glasgow, flashing across the north-western sky, and resembling a rocket with a long streaming tail. One correspondent at Glasgow says it travelled from the north-east to west, and that in colour it was like reflected sunlight. Another writer describes it as being of considerable size, "the fiery mass being as large as a bowling ball with a glowing red tail attached." At Killearn, N.B., the object passed from N.W. to W.N.W., and was about 12 degrees above the horizon at the time of its disappearance. It traversed a path of about 20 or 25 degrees, during which it fell about 5 degrees. The radiant of the meteor was probably in Auriga, Perseus, or Aries, so that it belonged to a different system from that which furnished the brilliant daylight fireball of January 9, 1900 (NATURE, January 25, 1900). W. F. DENNING.

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Air and Disease.

IN these days of fresh-air treatment, some of your readers may be interested in a quotation from Palladius "On Husbondrie," an early fifteenth century MS. originally in Colchester Castle.

"The longe-woo," says that writer, "cometh ofte of yvel eire," *i.e.* lung-woe or consumption comes often of bad air. The whole verse describes the effects by which you may know bad air or water, and is, perhaps, worth quoting in its entirety.

> "The longe-woo cometh ofte of yvel eire,
> The stomake eke of eire is overtake,
> Take heede eke yf the dwellers in that leire
> Her wombes, sydes, reynes swell or ake,
> If langoure in thaire bledders ough' awake.
> And if thoue see the people sounde and faire,
> No doubt is in thy water nor thin aire."

Thus we are told that both lungs and stomach are affected by bad air and that, to detect bad air or water we are to see whether the inhabitants have aches in stomachs, &c.

The importance attached so early to air and water may, I think, prove worth mentioning, as it is not what most of us would expect. I came across the passage in turning over the leaves of Lodge's edition of Palladius, published by the Early English Text Society. HAROLD PICTON.

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RECENT ADVANCES IN THE GEOLOGY OF IGNEOUS ROCKS.

THE closing years of the nineteenth century witnessed a revival of interest in the petrology of igneous rocks, which must be regarded as marking an important stage in the development of that subject. Much detailed work, especially in the laboratories of German universities, during the three or four decades preceding had already accumulated a large body of information; but that work had been confined in great measure to the strictly descriptive side of the science—in short, to what is properly described as petrography—and some of it fell rather into the domain of mineralogy and physical optics than of geology. The value of such a store of material cannot be overestimated; but any tendency which promises to shape it into a connected system must be welcomed by geologists as the breath of life animating the valley of dry bones. Such a movement is undoubtedly felt at the present time, and may perhaps be held to mark the transition in petrology from the stage of observation to that of generalisation. An igneous rock has come to be regarded, more constantly than before, not merely as a mineral-aggregate, but as the product of consolidation of a molten rock-magma; and consideration has been directed to the constitution of such magmas and the conditions governing their consolidation. Recognition of the importance of studying the mode of occurrence of igneous rocks and their relations to one another has led to a closer union of observation in the field with research in the laboratory. Much is being learnt concerning the geographical distribution of the rocks, their connection with crust-movements, and the sequence of eruption of different types at a given centre. The facts thus acquired, and especially the fertile conception of "petrographical provinces," each with its suite of igneous rocks having a community of characters which bespeaks a common origin, have confirmed the conviction that widely diverse rock-types may be evolved from a common parent-magma. Hence arises the problem, to which Brögger and others have boldly addressed themselves, of the processes by which such "differentiation" is effected and the conditions which control them. Hence, too, another problem, a corollary to the former, to frame a natural classification of igneous rocks, based on genetic principles, to supersede the provisional classifications on various artificial or Linnæan schemes which are at present current. The questions involved obviously present great difficulties, and petrologists would be the first to admit that some of their speculations are of a crude and tentative nature. It is greatly to be desired that students of physical chemistry should turn their attention to petrology; the more so since some subjects, such as the nature of solutions and the constitution of alloys, which have recently been advanced in their hands, may be found to have important applications to the crystallisation of igneous rock-magmas.

Petrological research during the last few years serves especially to emphasise the value of comparative studies of different areas. There are large regions throughout which the igneous rocks show but relatively slight departures from one common type, while elsewhere comparatively small districts exhibit a surprising range of variation. Peculiar rock-types, supposed to be unique and to have the most narrowly restricted occurrence, have in some instances been found to recur at widely separated centres with the same associates and with like geological relations. More generally there are differences as well as resemblances, the rocks of two districts constituting two parallel suites, such that each type in the one suite has its representative in the other. Such a parallelism is that drawn by Brögger between the Monzoni and the Christiania rocks. It points clearly to two somewhat similar, but not identical, parent-magmas having undergone differentiation on similar lines. The investigations of the United States Geological Survey, and of other American geologists, afford numerous illustrations of these and other points. The intrusive masses in the High Plateaux region along the west side of the Rocky Mountains, furnishing, as Gilbert first showed, such beautiful examples of the laccolitic form, are, according to Cross, almost wholly of diorite, diorite-porphyrite, &c. The region lying along, and to the east of, the Rocky Mountains, from Montana to Texas, differing widely from the former belt in geological structure, is equally in contrast with it petrographically. The rocks here are generally richer in alkalies, and they embrace a remarkable profusion of types and varieties. Especially is this seen in the accounts given by Weed and Pirsson of the several mountain-groups of Montana. Some of the rock-types described are new and unique, such as missourite, a leucite-gabbro without felspar; but most of them compare with rocks already known from other areas, though usually presenting points of difference which may be significant. The memoir by Cross and Penrose on the Cripple Creek district, Colorado, may also be cited in the same connection. This district and some of the others alluded to are important mining centres, and it is very interesting to notice how economic geology and what may be termed pure petrology assist one another. Some of the economic questions raised, such as the source and origin of the Montana sapphires (Pirsson, *Amer. Journ. Sci.* 1897, vol. iv. p. 421), may be found to have no unimportant application to the chemistry of igneous rock-magmas.

Since it is not possible in a short article to give even a summary of the actual results of petrological work during late years, we confine ourselves to a few examples. In Britain one result of recent researches, by the Geological Survey and other workers, has been to reveal the occurrence of a number of rock-types hitherto but little known, or wholly unrecorded, in this country. Among them are rocks of the syenite and nepheline-syenite families and the related families of dyke-rocks, some closely comparable, and probably contemporaneous, with the remarkable suite of Devonian intrusions of the Christiania basin. Especially interesting is Teall's brief account of the intrusive masses of Cnoc na Sròine and its vicinity, in the western part of Sutherland. The main mass is found to consist of a quartz-syenite of the nordmarkite type, which graduates on the one hand into a granite, on the other into quartzless syenite, nepheline-syenite, and the rock formerly described under the name borolanite. The last-named rock is composed essentially of orthoclase and melanite garnet with some ægirine-augite and alteration-products of nepheline. A peculiar feature is the occurrence in it of polygonal pseudomorphs doubtless representing leucite, and the rock is practically identical with the so-called leucite-syenite of Magnet Cove in Arkansas. The associated minor intrusions—sills and dykes—are partly of dark hornblendic rocks approaching camptonite, partly of light felspathic rocks containing ægirine, and comparable in different varieties with the grorudite, lindöite, &c., of the Christiania district. The distribution and petrography of the Scottish lamprophyres and the peculiar felspathic rocks which seem to be their natural complements are as yet imperfectly known; but Flett, *Trans. Roy. Soc. Edin.* (1900) vol. xxxix., p. 865, has described from the Orkneys dykes of bostonite, camptonite, monchiquite and alnöite, and some of these types are known to be represented in various parts of the Highlands. Camptonites and augite-camptonites are described by Hill and Kynaston in Argyllshire, where they are genetically related to another remarkable rock-type, kentallenite, which in its association of alkali-felspar with olivine and augite resembles the olivine-monzonite of Predazzo. The kentallenite itself is related to, and occurs in part as a marginal facies of, the large granite and tonalite masses of the district. This is only one example of the very heterogeneous nature of the intrusions marked on the geological maps of Scotland as granite. The same variability characterises them from the Galloway "granites," recently described by Teall in a Survey Memoir, to the large intrusion of Aberdeen, where the extreme basic modifications are represented by troctolite and peridotite (bastite-serpentine). An interesting group of minor intrusions, as yet only partially described, includes the orthophyres, lamprophyres, and quartz-basalts of South Devon. Finally we may mention a unique rock described by Judd (*Trans. Roy. Irish Acad.* (1897) vol. xxxi. p. 48), and named rockallite after the the remote islet where it occurs. It is a peculiar granite-porphyry consisting of ægirine, quartz and albite; differing from Brögger's grorudite, and from other acid rocks, in its remarkable richness in iron and poverty in alumina and in the absence of potash.

One point worthy of remark is the way in which various crystalline rocks, to which more or less of obscurity has attached, are being reclaimed from the limbo of "gneisses," "granulites," &c., and recognised, some as true products from igneous fusion, others as metamorphosed sediments. A recently published memoir by Holland (*Mem. Geol. Surv. India* (1900), vol. xxviii.) establishes the igneous origin, and describes the petrographical characters, of an important group of Archæan rocks in southern India. We may note incidentally, as illustrating the increasing hold which the idea of genetic grouping is obtaining among petrologists, that the author boldly uses the name "charnockite series" for an assemblage of types ranging in composition from acid to ultrabasic. Their community of origin is attested not only by their intimate association but by remarkable points of resemblance which run through the whole series. The constant presence of hypersthene in the rocks is one characteristic, and the common acid type, to which the name charnockite is given, is in fact a hypersthene-granite. The component minerals exhibit an astonishing freshness of preservation. Since rocks generally similar have been described, under such names as pyroxene-gneiss, pyroxene-granulite, &c., as occupying very extensive areas in Peninsular India, Ceylon, and Burma, a proper appreciation of their nature and origin is a matter of considerable importance.

Microscopical research and chemical analysis, as representing, on the side of the laboratory, the groundwork of all our knowledge of rocks, must necessarily retain the important position which they occupy; and in both fields improved methods are coming into general use, which impart increased precision to the results. Michel-Lévy's elaborate discussion of the optical properties of the felspars has greatly facilitated the discrimination of the several varieties; while among special instruments we may recall Fedorow's "universal theodolite," enabling accurate optical measurements to be made on crystals in random sections. The application of dense liquids to determine the specific gravity of minute fragments of minerals, and to obtain pure material for analysis, has been perfected, and, especially in the form of Sollas's "diffusion column," has been made both simple and convenient for use. The importance of accuracy and completeness in the chemical analysis of rocks has become more generally recognised. Many of the most valuable rock-analyses published in late years are due to the United States Geological Survey, who have realised the importance of maintaining an adequate staff of skilled chemists. One point brought out is the wide distribution in igneous rocks of small amounts of the heavy metals, and of some other elements, such as barium and strontium. Apart from its obvious application to questions concerning the origin of metalliferous deposits, information of this kind will probably be found to throw some light upon matters of more strictly petrological interest.

THE DISAPPEARANCE OF IMAGES ON PHOTOGRAPHIC PLATES.

IT is the aim of the modern astronomer to employ photography, whenever possible, in the many branches of his work, as by this means the peculiarities of the observer are eliminated and a permanent record is obtained that can be examined at leisure at any later date. In some kinds of work photography helps us in obtaining a great number of facts in a very short space of time, facts which would have taken weeks to accumulate by the old method of eye observation. Not only is the science more rapidly advanced by the greater abundance of material at hand, and therefore available for discussion, but the application of photography to astronomy has opened up so many new fields of work that the whole subject has now a far wider horizon than before.

To be able to photograph in a few hours objects which for ever will be outside the reach of the human eye, however aided, is one of the many marvels of this invaluable method.

The fine photographs obtained to-day, and so well illustrated in our books by the aid of the modern processes of reproduction, suggest the importance of recording the appearances of these celestial objects after some years have elapsed, in order to be able to note whether any changes in brightness or form are occurring. The magnificent work of the "Carte du Ciel," started by the far-seeing mind of Admiral Mouchez, is one of those schemes on a large scale for obtaining a survey of the universe at the close of the nineteenth century. The many thousands and thousands of photographic plates that will have been exposed to the sky when this plan will have been accomplished point out to us the immense importance that must be attached, not only to the "*keeping*" qualities of the film on the glass plates, but also to the retention of the *images* on these films.

Since one of the chief objects of Admiral Mouchez's plan was to hand down to posterity a chart of the celestial vault as recorded in our time, to enable those that follow us to compare with it that recorded in their time, the importance of the preservation of the photographic films, and the images impressed on them, cannot be overrated.

Most of the readers of NATURE are familiar with those beautiful photographs of long exposure of nebulæ and star clusters which we owe to the skill and patience of Dr. Isaac Roberts, and which he has given to the world in two magnificent volumes of plates. In the second of these volumes Dr. Roberts makes some very interesting and valuable remarks regarding the "fading" of some of the images on the photographic plates, and his experience shows that such disappearances of images after long intervals of time may assume very considerable proportions.

Although the period over which his experience extended only covered about ten years, this interval of time was sufficiently long to enable him to obtain some very striking facts.

The following brief summary of the two instances which he recorded in his second volume will give the reader a general quantitative idea of the disappearances of images during a short period.

A photograph of a region of the sky was taken on February 15 in 1886, and 403 star-images were counted on the negative. A re-count on May 29, 1895, found only 272 images, a loss of 131 images in about nine and three-quarter years.

Again, another photograph of identically the same region, taken on March 22, 1886, recorded 364 stars; the same plate, examined in May 1895, showed only 234.

These facts, then, indicate that, even after so short a period as ten years or so, the photographic film cannot be depended on, and that for lasting purposes recourse must be made to some means of reproducing the photographs soon after they have been obtained, the reproductions being as faithful to the originals as possible. It is generally known that, in nearly every method of reproduction, very faint details are lost in the process, but this loss could be easily recorded by noting the slight differences at the time; printed on good paper and with permanent ink, such reproductions should be lasting.

The fact that the great photographic chart of the sky is approaching completion causes one to think of the great expense that will be involved in reproducing the large number of individual plates. That many of the observatories which have taken part in this undertaking will find some difficulty in at once getting together the necessary funds is quite possible, so that a delay of a few years may be detrimental to the accuracy of the chart.

It is therefore very important that some means should be at hand to prevent the images of the fainter objects from fading quite away, or, if already disappeared, to bring them back to view.

Fortunately, the latter alternative can be accomplished by a process of manipulation which we owe to Sir William Crookes.

The completeness and success of this method will be gathered from the fact that when Sir William Crookes had "revived" one of Dr. Roberts' negatives that had entirely lost many images, the latter, on re-counting, "found that every one of the missing images had been restored to view, as distinctly, I think, as they were after the negatives were first developed."

The process by which Sir William Crookes accomplished this has been published in detail by Dr. Roberts in the *Monthly Notices* of the Royal Astronomical Society (vol. lxi., No. 1) for last November. As the description should prove of interest and service to many of our readers, the following account is appended, as described by Sir William Crookes himself in a letter to Dr. Roberts.

"(1) Soak the plate for three hours in distilled water.

(2) Prepare, in advance, two solutions A and B.

Solution A.		Solution B.	
Pyrogallic acid	1 oz.	Sodium carbonate (crystals)	12 oz.
Sodium metabisulphite	1 oz.	Sodium sulphite	4 oz.
Water	80 oz.	Water	80 oz.

"Mix equal parts of A and B, and allow the plate to soak in the mixture for ten minutes or a quarter of an hour, in the dark. Wash well.

"(3) Transfer the washed plate to a solution of three oz. of sodium hyposulphite in 20 oz. of water. Allow it to remain for half an hour, and then wash the plate in running water for three hours.

"(4) Prepare a 'clearing' solution according to the following formula :—

Alum	1 ounce
Citric acid	1 ounce
Ferrous sulphate	3 ounces
Water	20 ounces

"Allow the plate to soak in this for ten minutes, and then remove and wash in running water for six hours.

"(5) Prepare in advance two solutions, C and D.

Solution C.		Solution D.	
Ammonium sulphocyanide	100 gr.	Gold chloride	15 gr.
Water	100 oz.	Water	15 oz.

"For use take 1 ounce of each, and add 8 ounces of water. Soak the plate in this mixture for ten minutes, and at the end of the time remove and wash it in running water for half an hour. Transfer to a dish of distilled water, where it may remain for an hour. Finally, drain on blotting-paper, and allow to dry.

"The separate solutions, A, B, C and D, will keep for an indefinite time, and the same may be said of the clearing solution, if kept tightly corked. But when mixed together they will not keep, so fresh mixtures should be made each time.

"I have given you the full process adopted on the plates you sent me, but I think some of them may be omitted with no disadvantage. For example, I should like to try if the soaking in hyposulphite may be dispensed with. I think it can, but I only tried leaving it out on the plates you sent that had not faded.

"I always found the great secret of preventing images from fading out was to wash them very well in running water. The clearing solution allows the time of washing to be a little shortened, but not much.

"The sulphocyanide and gold solution has the property of precipitating gold on the image, and rendering it of a blacker colour and diminishing the chance of fading. I should think you will find it useful always to use the clearing solution and the sulphocyanide and gold solution in your usual process." WILLIAM J. S. LOCKYER.

VIBRATION OF GUN-BARRELS.[1]

THIS research on the vibration of gun-barrels is a continuation of former investigations on the nature of vibrations set up in a gun-barrel when fixed, with a view to discover how the *error of departure* is affected by rapid oscillations of the barrels when firmly clamped.

The authors' experiments were made on three small-bore rifles, placed at their disposal by the firm of Mauser—viz., one 8 mm. experimental rifle furnished with a wood stock, one 7 mm. Spanish model, and one trial gun 6 mm.—in all cases smokeless powder was used. In their early experiments the rifles were clamped firmly when fired, but in their recent work this method of support was abandoned, as they found that the clamping imposed restraints which altered the character of the shooting of the rifles and also their mode of vibration. This is by no means a new discovery. The late W. E. Metford, of well-known rifle repute, showed long ago (1870) that the shooting of a rifle was greatly changed when the barrel was securely clamped to a heavy mass of iron. In order to avoid this source of trouble the experimental guns were sometimes embedded in cork and sometimes suspended pendulum fashion by ropes, so that they were practically unrestrained and the condition of support approximated to the normal one, namely, the rather free support of the hands and shoulder of the marksman. The movements of the barrels were recorded by means of photography on a moving sensitive plate. Two methods were employed for firing the guns, viz., an electro-magnetic trigger-puller, and a pneumatic method in which a small piston, moving in a cylinder attached to

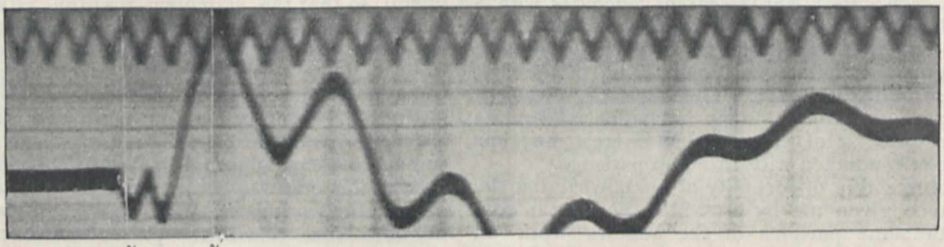


FIG. 1.—8 mm. Cal. gun clamped in cork support. Vibration curve of a point at the muzzle. γ Disengaged spark at the instant at which the shot leaves the muzzle; γ' Disengaged spark at 4·5 m. distance from the muzzle. In the unconstrained method of holding the weapon, the amplitude of the vibration is not so strongly marked as when it is clamped. (See Fig. 2.)

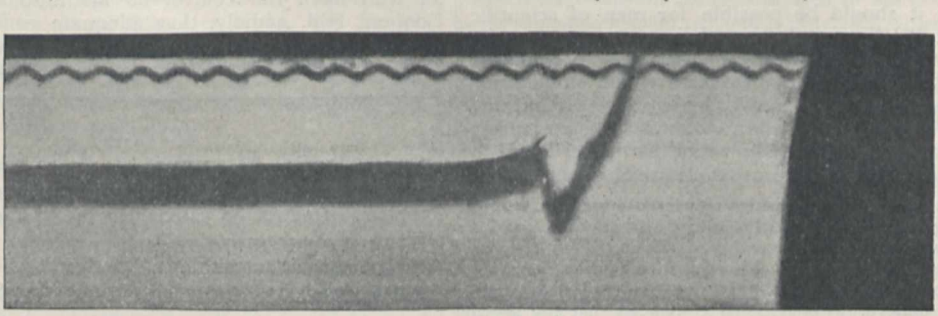


FIG. 2.—Gun 7 mm. Cal. Held by means of artificial marksman, and fired by pneumatic method.

[1] "Untersuchung über die Vibration des Gewehrlaufes." Von C. Cranz und K. R. Koch. Pp. 23; 4 plates. (München, 1900.)

the trigger-guard, moved the trigger. This pneumatic method was employed by the authors of the paper because it introduced no vibration when acting, and the method is strongly emphasised by the writers, who apparently have overlooked the fact that an exactly similar method has been in use in England for the last seven years in connection with the Tram chronograph used in ballistic work. Since the pneumatic method of firing introduces no vibration, it could be used in connection with a gun slung by ropes.

An attempt is made to show nodal points of vibration by means of sand figures, after the manner of Chladni, and sand curves were produced on a surface attached by cement to the guns when clamped and also when supported loosely, and also in the case of a barrel used without a stock. The vibrations appeared to be approximately the same in each case. The research concludes with a list of results, and it is stated that in the case of the 6 mm. gun the exit of the shot takes place just before the completion of the first quarter vibration of the first appearing second over tone. The research, although presented in a form almost too much condensed in parts to be quite clear, is of considerable interest, and has evidently been conducted with care and patience.

I wish to take this opportunity of acknowledging the kind assistance given me by Mrs. Max Schiller in connection with some portions of the authors' work on ballistics. F. J.-S.

THE ROYAL INDIAN ENGINEERING COLLEGE.

IT is evident from the letters and comments which have appeared in the *Times* and other papers, that the summary notice of dismissal of a large part of the scientific staff of the Royal Indian Engineering College, Coopers Hill, is regarded as an act of injustice which, if permitted to take effect, would be distinctly detrimental to the interests of science. The facts of the case were stated in these columns last week, and an examination of them is sufficient to convince any one that the seven gentlemen who have received notice that their services will not be required after the end of the Easter term have been treated with little courtesy and no consideration. That it should be possible for men of scientific eminence to be dismissed from their posts more easily than if they were civil service messengers or clerks, is one of the many indications we have of the small value attached by the official mind to scientific work and distinction. Perhaps Lord Kelvin's letter, which we reprint below from the *Times*, will show that the matter is not to be permitted to rest in its present unsatisfactory position.

SIR,—The correspondence which appeared in the *Times* of January 3 regarding Coopers Hill College has caused a painful shock to all who know of the good work which the college has done in giving to India the benefits of well-trained engineers in the service of its Government. No one can read that correspondence, I believe, without being convinced that the seven professors and teachers whose position is threatened are justified in asking for an inquiry.

The proposed action—a sudden and arbitrary dismissal of able and distinguished scientific teachers who have been doing duty for periods of nine to thirty years in a satisfactory manner—is certainly not to be expected in institutions under the control of the British Government; and I sincerely hope that the Secretary of State for India in Council will see his way to granting the request for an inquiry.

I am your obedient servant,
KELVIN.

Netherhall, Largs, Ayrshire, January 11.

The principle of the action is as bad as the private injury, for it suggests that gentlemen of education and distinction, who have held Government posts for long periods, may have their services dispensed with at the will of a military officer having no special qualifications to enable him to know the value of their work. If there is no more security of tenure for scientific men than is implied in the act of the president of the College at Coopers Hill, it is because they have not asserted their rights with sufficient insistence, and the sooner they do so the better it will be for their positions. Opportunity for showing that the gentlemen who have been instructed to give up their appointments at Coopers Hill have the world of science behind them will be afforded by a memorial in their favour which we hear is being prepared, to be submitted to the Secretary of State for India.

No excuse worthy of consideration has been offered for the dismissal of half the educational staff of the College. The salaries of the gentlemen who have received notice —for that is what it amounts to—are by no means too liberal, so that the statement that the action has been taken with a view of reducing expenses seems altogether insufficient. As "M. A." shows in the *Times*, money is available for the needs of the College, and "it is the worst form of economy to starve the staff of a teaching institution." Another writer goes even further, for he asks, "Is it not the case that the college has been for some years self-supported by fees from students?" But, putting this question aside, we have no hesitation in saying that the work done by the gentlemen dismissed could not be carried on with the present efficiency at less cost. In any case, the method adopted is not the one best calculated to improve the efficiency of any institution.

There is one other point, and it is not the least important. Assuming that the president of the College is able to dismiss arbitrarily as many members of the staff as he cares to dispense with, then some substantial compensation should be given to those thus compulsorily retired. Dr. Johnstone Stoney mentions in the *Times* that "when, twenty-one years ago, the Government through Parliament gave Ireland an Examining Board in place of a University, it allotted when doing so the full amounts of their salaries or emoluments as compensation for loss of office to the outgoing members of the staff of the late Queen's University and to those professors of the University who were required by their statutes to discharge University as well as college duties." This principle should be brought to the front and urged upon all who have the control of institutions like that at Coopers Hill, namely, that adequate compensation for loss of office must be awarded to the members of the staff who have to retire after years of good service.

NOTES.

SIR ARCHIBALD GEIKIE will shortly retire from his post of Director-General of the Geological Survey of the United Kingdom. He will be entertained by his friends at a complimentary dinner early in March. All who wish to attend should communicate with Mr. F. W. Rudler, Museum of Practical Geology, 28, Jermyn Street, London, S.W.

THE death is announced, at seventy-eight years of age, of Prof. Hermite, the eminent French mathematician. He was a member of the Academy of Sciences and a Foreign Member of the Royal Society. Announcement is also made of the death of M. Chatin, the botanist, and a member of the Paris Academy of Sciences.

THE Geological Society will this year award its medals and funds as follows:—The Wollaston medal to Mr. Charles Barrois, of Lille; the Murchison medal to Mr. A. J. Jukes-Browne, of Torquay; the Lyell medal to Dr. R. H. Traquair, of Edinburgh; and the Bigsby medal to Mr. G. W. Lamplugh, of the Geological Survey. The Wollaston fund goes to Dr. A. W. Rowe, the Murchison fund to Mr. T. S. Hall (Melbourne), and the Lyell fund to Dr. J. W. Evans and Mr. A. McHenry.

THE Council of the Manchester Literary and Philosophical Society have awarded the Wilde Medal for 1901 to Dr. Elias Metchnikoff, of the Institut Pasteur, Paris, for his researches in comparative embryology, comparative anatomy, and the study of inflammation and phagocytosis; and the Wilde premium to Mr. Thomas Thorp, for his paper on grating films and their application to colour photography, and other communications made to the Society. The Dalton Medal for 1901 has not been awarded. The presentation of the Wilde medal and premium will take place on February 5, when Dr. Metchnikoff will deliver the Wilde Lecture on "La Flore microbienne du Corps humain."

IN connection with the dispute between the Kew Observatory and the London United Tramways Company, it was mentioned in a note in our last issue that the double trolley system was in successful operation in America. The tramways referred to are at Cincinnati, and they were originally compelled to adopt this system by the Telephone Company, which successfully opposed their allowing waste current to leak into the earth. Over two hundred miles of track are thus equipped, and the managers find, after ten years running, that the cost of maintenance is considerably reduced in consequence. This seems in itself a sufficient answer to the London United Tramways Company, who urge that it is impossible to adopt the double trolley system. It is interesting to note that the advocates of earth returns are not in agreement amongst themselves. On the one hand, the London United Tramways Company claims that there is already a potential difference between their rails and earth, greater than the maximum accepted by Kew, due to leakage currents from the Central London Railway. On the other hand, the *Electrician*, in a note in the issue of January 11, maintains that the return current in a deep level railway cannot escape from the tunnel and rise to the surface in sufficient quantity to be observable by any but a mathematician. We are afraid the engineers of the Tramways Company will not regard this as a very welcome contribution to their side of the argument.

THE twenty-eighth annual dinner of old students of the Royal School of Mines will be held at the Hotel Cecil on Wednesday, February 6. The chair will be taken by Sir G. Stokes, senior past professor of the Royal School of Mines, and Sir W. Roberts-Austen will act as vice-chairman. In view of the fact that this year is the jubilee year of the School, it is expected that a large number of old students, as well as past and present professors, will be present at the dinner.

THE president of the Röntgen Society has placed at the disposal of the Council a gold medal to be awarded to the maker of the best practical X-ray tube for both photographic and screen work. The competition is open to makers in any country. Tubes intended for competition must be sent in addressed to the Röntgen Society, 20 Hanover Square, London, W. The package should contain the full name and address of the sender, and must reach the Society not later than May 1.

THE Turin Académie royale des Sciences announces that a Prix Bressa of 9600 francs (384*l.*) is open to competition among investigators and inventors of all nationalities. The prize will be awarded to the person who, in the opinion of the Academy, made the most brilliant or useful discovery in the four years 1897–1900, or who produced the most celebrated work in pure or applied science. Works intended for consideration in connection with the prize must be sent to the President of the Academy before the end of next year. The right is reserved to award the prize to an investigator whose work is considered to be the most distinguished, even though he does not submit an account of it.

THE Rome correspondent of the *Times* states that under the auspices of the Italian Geographical Society, and in the presence of the King and Queen of Italy, the members of the Royal Family, the Diplomatic Corps, the Ministry, and an audience composed of the principal personages of Roman society, his Royal Highness the Duke of the Abruzzi delivered a lecture on Monday upon his Polar expedition, in the great hall of the Collegio Romano. Captain Cagni, who commanded the sledge party, then succeeded the Duke of the Abruzzi at the desk, and related the story of the dangers and difficulties successfully overcome in planting the Italian colours furthest north at 86° 33′ north latitude.

A ROYAL Commission has been appointed to make investigations respecting the beer-poisoning epidemic. The Commissioners are:—Lord Kelvin, Sir W. Hart Dyke, Sir W. S. Church, president of the Royal College of Physicians, Prof. T. E. Thorpe, Mr. H. Cosmo Bonsor, and Dr. B. A. Whitelegge. Dr. G. S. Buchanan, one of the medical inspectors of the Local Government Board, is the secretary to the Commission. The instructions to the Commissioners are:—To ascertain with respect to England and Wales (1) The amount of recent exceptional sickness and death attributable to poisoning by arsenic; (2) Whether such exceptional sickness and death have been due to arsenic in beer or in other articles of food or drink, and, if so, (*a*) To what extent; (*b*) By what ingredients or in what manner the arsenic was conveyed; and (*c*) In what way any such ingredients became arsenicated; and (3) If it is found that exceptional sickness and death have been due to arsenic in beer or in other articles of food or drink, by what safeguards the introduction of arsenic therein can be prevented.

IT is to the credit of the members of the medical profession at Colchester that they have decided to show how they honour the memory of Dr. William Gilbert, the famous physician to Queen Elizabeth, whose work, "De Magnete," published three hundred years ago, constitutes the bed-rock of modern knowledge of magnetism. The intention is to erect a full-length marble statue of Gilbert in a niche in the main façade of the new Town Hall at Colchester, the city in which he was born, and where his remains are buried. Already the sum of 130*l.* has been contributed by the medical men of the borough, and as the minimum amount required is only 150*l.*, it will no doubt soon be subscribed. Gilbert's work is, however, so widely known and appreciated that it is almost a pity to neglect the opportunity to make the memorial a national one. The medical men of Colchester are to be congratulated upon the initiative they have taken, but there are many other men of science who would like to see that the memorial to be erected is a worthy testimony of the regard in which Gilbert's work is held in the whole scientific world. The treasurer of the Colchester committee is Mr. Henry Laver.

A BRITISH Congress on Tuberculosis will be held in London on July 22–26, and will be opened by the Prince of Wales. There will be four sections, with presidents as follows:—I. State and Municipal, Sir Herbert Maxwell, Bart. II. Medical, including Climatology and Sanatoria, Sir R. Douglas Powell, Bart. III. Pathology, including Bacteriology, Prof. Sims Woodhead. IV. Veterinary (Tuberculosis in Animals), Sir George Brown, C.B. Every British Colony and Dependency is invited to participate by sending delegates; while the Governments of countries in Europe, Asia and America are invited to send representative men of science, and others, who will be the distinguished guests of the Congress. The information already gained, both at home and abroad, shows that consumption and other forms of tuberculosis, although preventable and controllable by intelligent precautions, still remains the direct cause of a high rate of death and sickness. In the United Kingdom alone some 60,000 deaths are recorded annually from tuberculosis, and it is stated on good authority that at least thrice this number are constantly suffering from one form or another of the disease. The object of the forthcoming Congress is to exchange the information and experience gained throughout the world as to methods available for stamping out this disease. Papers wlll be read, and clinical and pathological demonstrations will be given; while the museum, which is to be a special feature of the Congress, will contain pathological and bacteriological collections, charts, models, and other exhibits. The address of the General Secretary of the Congress is 20, Hanover Square, London, W.

PROF. P. K. E. POTAIN, whose death we regretfully announced last week, at the age of seventy-five years, delivered his last lecture on clinical medicine at the Charity Hospital about six months ago. His treatises on diseases of the heart and lectures on clinical medicine are renowned both among physiologists and medical men. Referring to his death at the meeting of the Paris Academy of Sciences last week, M. Marey remarked that Prof. Potain developed the means of diagnosis, and showed how various sounds characteristic of diseases of the heart should be interpreted. Not only was he able to determine with precision any injury or morbid change in the exercise of functions of organs; he showed also that the disorders themselves revealed the interrelations between such functions, that, for instance, diseases of the liver and the kidney have echoes in the heart, and that pulmonary tuberculosis prevents the development of certain cardiac lesions. He was a master of clinical medicine, and an excellent physiologist, as well as a renowned physician. He devised an ingenious colorimetric method for testing certain substances, and his sphygmometer for the measurement of arterial pressure is still among the best. Prof. Potain was a member of the Paris Academy of Medicine, a member of the Academy of Sciences, and Commander of the Legion of Honour.

CUPELLATION is one of the most ancient of metallurgical processes, and was well known at least as early as the year 600 B.C. It was used by the Romans to extract silver from its ores in Spain and at Laurion, but it has been hitherto supposed that the hearths of their furnaces were made of comparatively non-absorbent materials, such as clay and marl, the litharge and other oxides being skimmed off or allowed to flow away in side channels. It is now shown, however, by Mr. Gowland, in a paper read before the Society of Antiquaries in May last, that a silver refinery was worked at Silchester in which argentiferous copper was cupelled on hearths made of bone-ash. Bone-ash has the property of absorbing molten litharge and some other oxides as readily as blotting-paper absorbs water, and apparently only its high cost prevented its use by the Romans in all their later cupellation furnaces. Careful examination of the remains found at Silchester convinced Mr. Gowland that the work there resembled some of the operations formerly practised in Japan, and that it is probable that it consisted in the recovery of the silver from Roman copper coins issued in the third century A.D. The metal contained 4 per cent. of silver, and was cupelled in three furnaces in succession with the aid of repeated additions of small quantities of lead.

DR. R. MINERVINI, of the University of Genoa, has published recently, in the *Zeitschrift für Hygiene*, the bacteriological investigations he has made of samples of air and water collected in mid-ocean during a trip from Genoa to New York and back. He finds more bacteria in air at sea than did Fischer in his classical investigations. Out of 42 determinations, however, 6 yielded no bacteria, whilst the highest number found in a volume of 27 litres of air was only 17. As was to be expected, he obtained the best results after heavy rain. No pathogenic bacteria were discovered. It is unfortunate that as regards the author's water examinations his stock of apparatus did not permit of his cultivating the samples at once after collection, but compelled him to keep them from seven to ten days until he landed. This fact deprives his quantitative results of their value. The report of the German deep-sea expedition, carried out during 1898–99, is awaited with great interest. It will be remembered that the German man-of-war *Valdivia* was placed at the disposal of the members by the Government, and it visited the African coasts as well as the Indian and Antarctic Oceans, and bacteriological investigations were included in the work of the expedition.

THE contents of the Cape *Agricultural Journal* (November 22, 1900), which has just reached us, testify to the widespread interest which is being taken in scientific agriculture in Cape Colony. Among subjects dealt with are the liming of soils, selection of seeds, merinos, rhubarb and mealie culture, "raising" calves without milk, and wide *versus* narrow waggon tires. The report for 1899 of the Colonial Bacteriologist is also inserted, and in it Dr. Edington describes a method for protective inoculation against horse-sickness, which is as follows:—Animals which have passed through an attack of the disease and have recovered are inoculated at intervals with increasing doses of virulent blood taken from affected horses. After this treatment the animals are bled and the serum preserved. Blood of the highest virulence is likewise obtained, standardised against the serum and preserved. A definite amount of the virulent blood is mixed with 50 c.c. of serum and injected subcutaneously. Some days later 30 c.c. of the same serum, with the same dose of blood, is injected. At a later date the procedure is repeated with a reduced dose of serum, and fourteen days later pure virulent blood is injected. This method is said to afford a perfect and complete solution to the problem of protecting horses which have to live in unhealthy districts in South Africa, and is very similar to that devised by the Imperial Bacteriologist of India against rinderpest, as mentioned in these notes on December 13 (p. 161).

IT is to be feared that it will be a long time before the general public realises what is desirable and what undesirable in artificial lighting. The two principal desiderata are well distributed, but not necessarily very brilliant, illumination, and cheapness, which means high efficiency and consequently high intrinsic brilliancy of the source of light: two characteristics in direct antagonism. The use of some form of diffusing shade is therefore desirable, even with the present electric lamps; and it will be essential when lamps of higher efficiency come on the market, as is sure to occur before long. Mr. W. L. Smith's experiments ("A Study of Certain Shades and Globes for Electric Lights as used in Interior Illumination," *Technology Quarterly*) are a timely and very valuable contribution to our knowledge of the relative merits of various types of shade. For a shade to be satisfactory, it should soften down and distribute evenly the light of the naked lamp, whilst, at the same time, it should not absorb too great a proportion of it. Mr. Smith's experiments show that this problem is solved by very few of the shades in ordinary use. It is worthy of remark that the author finds that the Holophane shades, in which the cutting of the glass is determined on scientific instead of artistic principles, are greatly superior to all others. We have seen a Nernst lamp (which is, with the exception of the arc, the most intense form of artificial illuminant) burning in a Holophane globe, and can fully endorse Mr. Smith's remarks on the excellent manner in which these globes soften and diffuse the light. It is to be regretted that the author has not drawn more distinction between globes designed to cover the lamp and shades merely intended to be hung over it, as direct comparison of the two classes is hardly fair.

The pamphlet, short though it is, contains many suggestive results, and we await with interest the promised account of further experiments.

IN the *Physical Review*, xi. 5, Mr. W. P. Boynton gives an investigation of the form of Gibbs' thermodynamic model for a substance following Van der Waals' equation, and compares this model with that given by Maxwell.

PROF. ANTIGONO RAGGI, writing in the *Rendiconti* del R. Istituto Lombardo, xxxiii. 17, gives a summary of the works of Serafino Biffi, who died on March 27, 1899. Biffi was the author of many valuable contributions to medical and physiological science, and we are glad to learn that his collected works are shortly to be published.

A PHYSICAL theory of nerve is given by Mr. W. M. Strong in the *Journal of Physiology* (xxv. 6). The theory, which is based on the ionic theory of salt solution, assumes all nerves to consist of a semi-solid axis cylinder containing a saline substance in solution. The salt is wholly or partially ionised, so that the axis cylinder is a good electrolytic conductor. Surrounding it is a medullary sheath or outer layer formed of a relatively bad conductor. The negative ion of the salt is supposed to be of a simple nature and to move freely in the semi-solid material of the axis cylinder, while the positive ion only moves with great difficulty. The contraction of a muscle, the author supposes, is directly caused by the arrival of the negative variation at the point where the nerve terminates in the muscle.

THE tenth volume of scientific memoirs edited by Prof. H. Crew and published by the American Book Company, contains reprints of the more important treatises dealing with the "wave theory of light." Beginning with the work of Christian Huygens, the first three chapters of his "Treatise on Light" (1678) are given, describing rectilinear propagation, laws of reflection and refraction; concluding this section is a biographical sketch of the life of Huygens. Next are given three of the historical contributions of Dr. Thomas Young, on the "Theory of Light and Colours," "On the Production of Colours," and "Experiments and Calculations in Physical Optics," followed, also, by a short biographical sketch of the author. The volume is concluded by memoirs of Arago and Fresnel on the "Diffraction of Light" and "Action of Polarised Light," a biography of Fresnel, and a bibliography of the literature at present available on the subject.

WE have received a copy of a report on Hertzian waves drawn up for the recent Physical Congress at Paris by Prof. Augusto Righi, of Bologna. The report deals with the subject from two points of view; the theoretical aspect, which considers the physical identity of Hertzian waves and waves of light, and the practical aspect in connection with wireless telegraphy. Prof. Righi's paper is divided into four sections, the first containing a description of the apparatus used in connection with the production and study of Hertzian waves, the second with radio-conductors, the third with the optical properties of electrical oscillations, and the last with Hertzian telegraphy. Prof. Righi's intimate knowledge of the subject and the important part he himself is known to have played in connection with the invention of wireless telegraphy have eminently qualified him for furnishing physicists with a brief summary of the progress made in this branch of physics since it was first opened up by Hertz.

THE December number of the *Photo-Era*, the American journal of photography, contains many articles of interest. Mr. Yellot reviews the third "Philadelphia Photographic Salon," and evidently does not think very much of it, as he talks of the . . . "dreary monotony about the tier on tier of weak, fuzzy, washed-out-looking photographs. . . ." Landscape composition is another communication worth perusing. Under the heading "Photographing the Aurora," Mr. Stiles describes and illustrates the photograph he obtained at Mount Washington. He used a Ross-Goerz six-inch lens, aperture 7·7, and isochromatic plates, and gave an exposure of 35 minutes. He writes: "What is surprising is the actinic power of the auroral light as compared with the bright moonlight on the snow. Under the aurora is a dark space, which is noted in many displays. This in earlier notes on the aurora was assumed to be dark by contrast, but the photograph shows a quite definite lower boundary."

WE have received from St. Xavier's College Observatory the monthly meteorological results for the months of January to June for the thirty-three years 1868–1900, which we are glad to see will shortly be followed for the other six months, ending December last. The observatory was established in August 1867, and is situated one and a half miles north-east of the Alipore Observatory, and is sufficiently isolated for trustworthy observations. The instruments have been compared with those at either Kew Observatory or the Government Observatory at Alipore, and the observations have been carefully taken several times daily by the fathers in charge, so that the tables form a a very valuable series.

MESSRS. ELSTER AND GEITEL have sent us some further accounts of their interesting experiments on atmospheric electricity. In No. 8, vol. ii. of the *Physikalische Zeitschrift*, papers are communicated on the measurement of electrical leakage in free air, and in closed spaces. Dr. Geitel finds that with regard to the air in a closed vessel, with an initial charge of 240 volts (independently of the sign of electrification) the leakage from an insulated body amounted to about 0·4 per cent. per minute; on the second day the leakage amounted to 1·0 per cent., and on the fourth day to 1·4 per cent. After this period the leakage became slower, and gradually attained a limit of about 2 per cent. per minute. A full description is given of the apparatus employed. He also found that the leakage was not proportional to the charge of electricity, but that for charges varying from 80 to 240 volts the amount remained constant. This phenomenon was pointed out by Matteucci in 1850 (*Annales de Chémie et de Physique*, vol. xxviii.), but the observation remained practically unnoticed. Further, Dr. Geitel found that the influence of daylight, or of artificial illumination, was not perceptible on the results obtained.

THE new number of the *Abhandlungen* of the Vienna Geographical Society consists of an exhaustive paper on the cork-tree, by Eugen Müller. The botany of the cork-tree and the growth and chemical constitution of the cork are first discussed; then follow a lengthy investigation of the geographical distribution of the cork-tree, a history of the production of cork, and a statistical account of the development of the world's trade in cork.

PROF. MITZOPULOS contributes a paper on two of the most remarkable of the seismic disturbances experienced in Greece during the years 1898 and 1899, to *Petermann's Mitteilungen*. The first, the Tripolis earthquake of June 2, 1898, Prof. Mitzopulos believes to have been caused by subterranean falls of rock. The second, or Triphylia earthquake, occurred on January 22, 1899; its epicentrum is located in the Ionian Sea, some 35 to 40 kilometres to the west of the coast of the Peloponnesus, where the bottom goes down in terraces to depths of 2500 to 3500 metres. The epicentrum was probably about 70 kilometres below the sea-bottom.

THE greater part of the December number of the *National Geographic Magazine* is devoted to an account, by Mr. Wilbur C.

Knight, of an expedition to the fossil fields of Wyoming in July 1899. This expedition was organised by the general passenger agent of the Union Pacific Railroad, who issued invitations to every important university, college, and museum in the United States. Each institution was allowed one professor and one or two assistants, who were given free transport from Chicago to Laramie and back. About one hundred men of science joined the expedition, which collected an immense amount of valuable material, including many photographs of geographical interest, some excellent specimens of which illustrate Mr. Knight's article.

WE have received the first number (January 1, 1901) of the *Geologisches Centralblatt*, which is a new fortnightly geological review intended to give titles and brief abstracts relating to all books, papers, maps and tables that have been published on geology, including palæontology and petrography. Twenty-four numbers of thirty-two pages each will be issued yearly. All works issued since April 1, 1900, will be noticed. In the present number there are notices of 104 works, consequently we may expect about 2500 articles to be recorded during the year. We may remark that in the first volume of Whitaker's "Geological Record" for 1874, there were more than 2000 entries, while in Blake's "Annals of British Geology" for 1893 there were 730 entries. The *Geologisches Centralblatt* will not, however, take notice of articles on pure mineralogy and crystallography. It starts with a good list of supporters and contributors, amongst whom are Barrois, Choffat, Reusch, F. D. Adams, and many others, and we observe that British abstracts are furnished by Mr. C. V. Crook, of the Geological Survey Library in Jermyn Street. Abstracts appear in German, English and French. The titles of works in other languages will be translated into one of the before-mentioned languages, and appear beneath the original titles. The *Centralblatt* is divided into sections, but the authors under these sections are arranged promiscuously. The abstracts extend occasionally to a page or even two pages in length; some occupy but a single line. New species of fossils are printed in distinct type, and other species specially referred to are in different type. The work cannot fail to be of the greatest service to geologists in all parts of the world, if only it appears punctually. Messrs. Dulau and Co. act as London agents, and the subscription price is thirty shillings.

THE *Transactions* of the Leicester Literary and Philosophical Society (vol. v., part 10, October 1900) contains three excellent pictorial plates of the pre-Cambrian rocks of Charnwood Forest to illustrate an excursion conducted by Prof. W. W. Watts. The reports of other geological excursions are illustrated by remarkably clear maps and sections prepared by Mr. Fox-Strangways. There are also notes on the botany of the Beaumont Leys Sewage Farm, by Mr. A. B. Jackson, and an address to Section E (Zoology) by Mr. F. R. Rowley. Curiously enough, the entomologists form a section by themselves apart from the zoologists, who are urged by Mr. Rowley to take up the neglected groups of "Rhizopoda, Heliozoa, Infusoria, Turbellaria, Oligochæta, Rotifera, Acarina and Polyzoa."

WE have received from the author, Dr. S. Kaestner, a copy of his inaugural address delivered at the Leipzig Academy on the methods of preparation employed in embryological investigation.

THE excellence of the illustrations forms a striking feature of the latest issue (vol. v. No. 2) of *Indian Museum Notes*. Mr. G. B. Buckton describes one new insect injurious to forest trees, and a second to betel; while the other contributors treat of many kinds of insect pests.

TO the January number of the *Entomologist*, Dr. A. G. Butler contributes some highly interesting observations with regard to the seasonal phases of certain South African butterflies. For instance, the form described as *Precis simia* proves to be the wet season phase of *P. antilope*, and *P. trimeni* that of *P. cuama*. Since these phases are not absolutely confined to season, the indiscriminate use of the term "seasonal form" is deprecated.

ACCORDING to the *American Museum Journal* for November, active steps are being taken for the further zoological exploration of Alaska, Mr. A. J. Stone having already started on a preliminary collecting trip. There is, however, a proposal on foot to start an "Arctic Mammal Club," and it is hoped that the 2000 dollars left conditionally by the late Mr. Constable for the exploration of Alaska will be shortly available. The condition is that the amount should be raised to 5000 dollars by other contributors—and in a rich country like the United States there ought to be little difficulty in getting this sum subscribed.

To the *Proceedings* of the Washington Academy (vol. ii. pp. 661-676), Dr. Merriam contributes a preliminary revision of the red foxes of North America, of which no less than twelve species and races are recognised. The author regards all these forms as specifically distinct from the common fox of Europe and Northern Asia, although he states that the one described as *Vulpes alascensis* is closely related to the latter, which it connects with the more southern American types. To many zoologists this admission would indicate that all the American red foxes are nothing more than local phases of their Old World prototype. In another part of the same journal (pp. 631-649), Mr. G. S. Miller describes a collection of small mammals from Liberia, among which several are new.

WE have received Prof. Herdman's fourteenth annual *Report* of the Liverpool Marine Biological Committee, and their biological station at Port Erin (Isle of Man). The editor observes that although there is nothing remarkable to record in regard to the educational work of the station, yet all lines of research have been continued and all investigations advanced a stage, while several important publications have been issued. Detailed reports of the laboratory, aquarium and dredging operations are given, and seven plates are appended showing the distribution of the marine fauna at the south-western extremity of the Isle of Man and of particular groups of the same in Port Erin Bay. The preparation of these last must have entailed a vast amount of labour on the part of the staff.

AMONG several other papers, vol. xii., part 2, of the *Proceedings* of the Royal Society of Victoria contains a note by Mr. R. H. Walcott relating to the cast of a fossil tree-trunk in basalt. It was found at Footscray, and shown at the Melbourne Exhibition of 1866. Unlike ordinary fossil stems, in which the wood has been replaced, atom by atom, by mineral matter, the whole of the woody matter in the specimen in question was first destroyed, leaving a cavity which was subsequently filled by liquid trap. A necessary condition for the preservation of the tree-form at the time of the entombment of the specimen seems to have been its rapid inclusion in the molten rock, so that the carbonised remains would be inaccessible to the air, and maintain the mould in its proper shape until the trap had cooled sufficiently to prevent it from closing in. A subsequent flow filled the cavity. The author is of opinion that the specimen cannot be a concretion, and, if he is right, it appears to be unique.

MR. J. E. S. MOORE's account of his researches and explorations in Lake Tanganyika and the countries to the northward, published in the January number of the *Geographical Journal*, will be read with interest both by geologists and zoologists, as well as by the members of the society before which it was presented. After relating the history of the discovery of the remarkable molluscan fauna of the great lake, and pointing out how it differs essentially in its marine *facies* from that of all the other African lakes, the author refers to the Tanganyika jelly-fish, and concludes that the evidence in favour of the marine origin of the "halolimnic" fauna is overwhelming and irresistible. He then discusses the objections that have been raised against his theory on the ground that, according to an opinion advanced years ago by Sir R. Murchison, no part of the interior of Africa has ever been beneath the sea. This opinion was in part based upon the presumed absence of evidence of volcanic activity in Africa south of the equator. The discovery of volcanoes, both active and passive, in this area, as well as of huge lava-flows, discounts the latter part of the objection, while the evidence of the Tanganyika fauna itself is considered to outweigh the other part.

As regards the outlet by which Tanganyika (presumably as far back as Jurassic times) communicated with the ocean, Mr. Moore adduced evidence to show that, instead of being northwards by way of the other great lakes and the Nile valley, this must apparently have taken place by way of the Congo. The author, from the physical features of the country, was led to believe "that the lake had at some former time extended far to the west of its present site, in the neighbourhood of the Lukuga. It is only necessary for such extension to cover some eighty miles to bring it into communication with the great circular basin of the Congo itself." It is true that the evidence against the original northward extension of the lake is mainly of a negative nature, that is to say, the absence of the halolimnic fauna in the northern lakes; but, as Prof. Lankester observed, negative evidence "has its distinct importance and value as much as positive evidence, and we are in a position to say certainly that the marine fauna of which Mr. Moore has so fully established the existence in Tanganyika did not arise from a northward extension of the lake."

PART iv., completing vol. xxi., of the *Transactions* of the Botanical Society of Edinburgh, contains a second article by Mr. C. E. Hall on tree measurements, from which it would appear that in the tropics, as with us, the chief factor in the growth of trees is rain.

A NEW text-book of botany ("Cours de Botanique," published by Dupont, Paris) is announced, by Profs. Bonnier and Leclerc du Sablon, in two vols. (25 fr.), with upwards of 3000 illustrations, mostly drawn from nature. A new departure is claimed, in the item that the description and anatomy of the organs are taken from a certain number of type-species chosen from widely spread plants.

WE have received the Report of the Moss Exchange Club for the years 1899–1900. Associations of this kind are obviously useful in promoting an interest in their particular branch of science, and the study and determination of critical species. Their danger lies in the destruction of rare and local species, and we should have liked to have seen a hint to this effect in the Report. The honorary secretary of the club, to whom communications are to be addressed, is Mr. C. H. Waddell; but we do not find his address in the Report, which is printed at Stroud.

THE volume of *Knowledge* for 1900 contains numerous splendid collotype plates and other illustrations accompanying articles on subjects belonging to most branches of science.

DR. OLIVER LODGE's presidential address on the controversy concerning Volta's Contact Force, delivered to the Physical Society at the annual general meeting in February last, is published, with other papers, in the December number of the *Proceedings* of the Society.

THE six monthly numbers of the *Geographical Journal*, from July to December 1900, make up volume xvi., which has just been published by the Royal Geographical Society. The volume contains 766 pages, as well as numerous coloured maps, and is full of matter of interest to the student of geography in all its aspects. Among the many important papers are Dr. C. Hose's account of the natives of Borneo, Captain Deasy's "Journeys in Central Asia," Mr. E. S. Grogan's "Through Africa from the Cape to Cairo," Prof. Haddon's "Studies in the Anthropogeography of British New Guinea," Mrs. Ogilvie Gordon's "Origin of Land-Forms through Crust Torsion," Mr. Borchgrevink's description of the *Southern Cross* Antarctic expedition, and Dr. Donaldson Smith's "Expedition between Lake Rudolf and the Nile." Most of the papers are accompanied by reproductions of photographs of the regions or peoples visited.

THE "Guide to the Babylonian and Assyrian Antiquities" in the British Museum, which has just been published, is a marvel of interest and cheapness, the price being only one shilling. The guide provides notes, interpretations, and thirty-four excellent plates, referring to Babylonian and Assyrian antiquities covering a period of about five thousand years, ranging from about B.C. 4500 to A.D. 500. "In them," Dr. Wallis Budge remarks in the preface, "are comprised by far the largest portion of available material for reconstructing the history of Western Asia, inscribed in the cuneiform character." Dr. Budge's numerous contributions to the science of antiquities have had a profound influence upon intellectual progress; and this new guide, though small in comparison with the works which stand as a monument to his vast knowledge of the past, give students an additional reason for being grateful to him. By the publication of the Guide the Trustees of the British Museum have rendered available a mass of information of interest to students and the public alike.

THE publication of a great work on systematic botany has been commenced by Mr. Englemann, of Leipzig (London: Williams and Norgate), under the title "Das Pflanzenreich." The work has been undertaken by Prof. A. Engler, and is to be a complete record of the plant kingdom. Particulars of the plan of the work, two fascicules of which have been received, are given in Messrs. Williams and Norgate's Book Circular for December. Every one of the 280 families is to form a monograph by itself, with a separate and complete index, the larger families each formin g a separate fascicule. Each family begins with the enumeration of the literature, including monographs, which are restricted to genera, provided they deal with general morphological points, while the purely systematic treatises on genera are quoted with the latter. To each family is attached a complete list of its groups, genera and species, with the generic and specific synonyms. The work is amply illustrated by original drawings, with especial reference to the generic and sectional characters of the plants. This gigantic undertaking will, of course, require many years for its completion; but this is guaranteed, to a great extent, by subventions from the Prussian Government and the Imperial Academy of Sciences. The editor is anxious that it should be known that the present "Pflanzenreich" is not a second edition of the "Natürliche Pflanzenfamilien," supplements to which will continue to be published every few years.

THE much-debated question of the existence of an ammonium amalgam would appear to be finally settled in the affirmative as the result of recent researches. The fact that the volumes of ammonia and hydrogen evolved from ammonium amalgam are in the ratio of 2 : 1 has been regarded as evidence in favour of Berzelius' ammonium theory, but the inability of ammonium amalgam to effect the reduction of the heavy metals from their salt solutions, in opposition to potassium and sodium amalgam, spoke strongly against the theory. The investigation of the electrolytic tension of decomposition of the ammonium salts with a mercury cathode, by Coehn and Dannenberg (*Zeitschrift für anorganische Chemie*, 25, 430), has given results perfectly analogous to those obtained with salts of the alkali metals, a result only explicable on the assumption of the ammonium theory. Experiments carried out under varying conditions to ascertain the possibility of reducing the heavy metals from their solutions, show that the negative results previously obtained are due to the great instability of the ammonium amalgam. By preparing the amalgam electrolytically at low temperatures (0° C.), when it appears to be much more stable and does not exhibit, to any great extent, the spongy appearance peculiar to the amalgam prepared under ordinary conditions, and allowing it to act on cold solutions of copper, cadmium and zinc salts, the formation of the corresponding heavy metal amalgams is easily observed. In the case of the copper, it might be possible to explain the reduction by attributing it to the nascent hydrogen generated in the decomposition of the ammonium amalgam; but this explanation is not possible in the case of the cadmium and zinc salts.

THE additions to the Zoological Society's Gardens during the past week include a Bonnet Monkey (*Macacus sinicus*) from India, presented by Mr. R. F. Wilson; a Polecat (*Mustela putorius*), British, presented by Mr. Hett; three Painted Snipe (*Rhynchaea capensis*) from India, presented by the Hon. Walter Rothschild, M.P.; a Tawny Owl (*Syrnium aluco*), European, presented by Mr. F. Medcalf; a Deville's Tamarin (*Midas devillii*) from Peru, a —— Conure (*Conurus ocularis*), an Orange-winged Amazon (*Chrysotis amazonica*), a Brazilian Tortoise (*Testudo tabulata*) from South America, three Japanese Pheasants (*Phasianus versicolor*) from Japan, two Pennant's Parrakeets (*Platycercus elegans*), a King Parrot (*Aprosmictus cyanopygius*) from Australia, deposited.

OUR ASTRONOMICAL COLUMN.

ORIGIN OF TERRESTRIAL MAGNETISM.—The *Observatory* for January contains a translation by Prof. L. A. Bauer, of the U.S. Geodetic Service, of an article in *Ciel et Terre*, December 16, 1900, containing the results obtained by Dr. Schmidt from an important harmonic analysis of the permanent magnetic field of the earth. This work has been practically an amplification of Gauss' "Théorie générale du magnétisme terrestre."

In Schmidt's analysis he does not assume the existence of an interior potential function governing the entire magnetic force; but adjusting separately each of the three rectangular components, obtains three expressions in place of the one determined by Gauss; moreover, the computations have been carried to the terms of sixth order instead of the fourth. He concludes that the magnetic force of the earth consists of three parts:—

(1) *The greatest part*, attributed to causes situated in the terrestrial crust, and having a potential.

(2) *The smallest part* (about one-fortieth the whole), due to causes exterior to the crust, and also possessing a potential.

(3) A part, somewhat greater than (2), not represented by a potential, and therefore indicating the existence of *vertical* terrestrial electric currents.

Dr. Schmidt has also made careful examinations of the records of magnetic storms. In that of February 28, 1896, which was observed at fifteen observatories, and lasted from 6-7 o'clock, he finds that the directions of disturbance vary considerably, at times converging to a point, at others radiating from a point; while at certain periods of comparative calm the lines of force were practically parallel, suggesting a distant centre of force. Taking these facts in consideration with the vertical component disturbances, he concludes that the causes producing terrestrial magnetic storms are for the most part exterior to the surface of the earth.

OPPOSITION OF MARS IN 1888.—Signor G. V. Schiaparelli has recently published a sixth volume of observations of Mars, containing the discussion of his determinations on the topography and constitution of the planet during the opposition of 1888, made with the 18-inch Merz refractor at the Milan Observatory. After preliminary notes of instrumental details and tables showing varying size of the disc, atmospheric quality, &c., about eighty pages are devoted to the detailed description of the aspects of the many markings recognised during the period, very many comparisons with the work of other observers being included; the remainder of the volume is occupied with the discussion of observations bearing on the constitution of the surface, giving detailed measures and descriptions of the varying polar caps, and a comparative analysis of the gemination of the principal "*canali*." Reproductions of drawings of the surface markings on successive dates are included, and two polar charts showing the whole of the observed phenomena in their relative longitudes.

DOUBLE STAR MEASURES.—In the *Astronomische Nachrichten* (Bd. 154, No. 3679) Mr. J. Comas Sola gives a series of measures of seventy-five double stars observed at Barcelona.

SCIENTIFIC DEVELOPMENTS OF BIOLOGY AND MEDICINE.

AN interesting monograph is just to hand in the shape of a lecture, delivered by Dr. Oscar Hertwig upon the occasion of the congress of German naturalists at Aix la Chapelle (Aachen). The subject is the development of biology in the nineteenth century. Many interesting points, forming landmarks in the progress of biological science, are discussed by the lecturer. The microscope, from the inestimable service it has rendered to morphology, must rank high in the discoveries of the century. Before morphological method had been enriched by it, the cellular hypothesis, which is the foundation stone of all biology, was impossible. Dr. Hertwig accentuates the fact that progress consists, not only in adding facts to our treasury of knowledge, but also in stamping out error, and that some of the biological energy of the nineteenth century has been consumed in annihilating the doctrine of spontaneous generation; it was, indeed, only Pasteur's researches that established irrefutably the dictum *Omne vivum e vivo*, and much later still did the corollary of this, namely *Omnis cellula e cellula*, firmly plant itself upon biology, never to be uprooted.

A further factor of transcendental importance in the progress of biology during the nineteenth century was the birth and growth of the study of embryology. Its chief result was the theory of evolution and the accompanying doctrines of natural selection and the survival of the fittest. The lecturer enters fully into the literature of this subject, which has moved the biological world perhaps more than any preceding one. The concluding part of the discourse is devoted to the progress made in that department of biology which we know as physiology. The attempt in this direction during the latter part of the century has been to reduce, by means of physico-chemical technique, biological phenomena to physico-chemical law. This attempt, although it has given us an enormous insight into the processes of life and has enabled us to formulate laws of the highest abstract and utilitarian value, has been, in its absolute sense, unsuccessful. It is doubtful if chemical and physical law can ever explain fully the phenomena of life, and while physiological chemistry and physics have destroyed the old vitalism, we are, to some extent, compelled to take refuge in a new one. From the practical standpoint, great progress has been made in the development of pharmacology and experimental pathology. The former, going hand in hand, as it ever must, with the practical treatment of disease, has not only thrown light upon many problems of pathology and physiology, but has greatly increased the possibilities of therapeutics, and given distinct hope for the future in this direction. Under experimental pathology serum therapy is included, and the immense field for research this has opened up.

An address delivered by Dr. Naunyn, of Strassburg, at the same congress, is of considerable interest. He chose for his subject the development of medicine, hygiene and bacteriology during the nineteenth century. To show the condition of medical thought at the beginning of the century, he quotes from the work of Prof. Kieser, of Jena, in 1812. At that time the exanthemata were regarded as necessary stages in the growth of mankind, and as essential to his perfect development, just as the pupa stage is essential to the butterfly. The scientific development of medicine, according to Prof. Naunyn, took its first real impetus from the work of Johannes Müller. His text-book of physiology was a book which focussed the work of preceding generations for the purpose of pointing out the direction which the work of succeeding generations should take. This, and the subsequent discoveries of Laennec, formed the first scientific basis of medicine. The next step forward was the founding and development of morbid anatomy, going hand in hand with clinical medicine; in fact, any further progress of the latter without the former was impossible. In this respect the Vienna School, as exemplified by the clinician Skoda, working in connection with the pathologist Rokitansky, did giant service. Subsequently the researches of Pasteur, upon fermentation, and the antiseptic work of Lister form striking monuments in the century's progress. The latter was of value, according to the author, in a somewhat unanticipated direction, in that it rendered explorative operations possible, and thus enabled clinicians to observe disease in a stage short of that which it presented at the post-mortem examination. Last, but not least, Prof. Naunyn refers to the rise and the progress made by pharmacology, and points out the brilliant therapeutical results which have issued from pharmacological research.

THE DISTRIBUTION OF VERTEBRATE ANIMALS IN INDIA, CEYLON AND BURMA.[1]

THE completion of the seven volumes containing descriptions of all the vertebrata, in the "Fauna of British India," affords an opportunity of reviewing generally the distribution of terrestrial vertebrate animals throughout the British possessions in India, Ceylon and Burma.

For the study of zoological distribution there are few, if any, regions on the earth's surface that exceed British India and its dependencies in interest. The area is about 1,800,000 square miles, and although the vertebrate fauna is by no means thoroughly explored, it is well known throughout the greater part of the area and fairly known throughout the whole, better, probably, than in any other tropical and sub-tropical tract of approximately equal extent. The variety of climate is remarkable; within the area are included the almost rainless deserts of Sind and the locality on the Khási Hills, distinguished by the heaviest rainfall known, the cold, arid plateau of the Upper Indus drainage, and the damp tropical forests of Malabar and Tenasserim. The country is bounded on the north by the highest mountain range in the world and on the south by an ocean extending to the Antarctic regions. Another element of interest lies in the fact that the peninsula of India is a land of great geological antiquity, there being no evidence that it has ever been submerged, although the greater part of the Himalayas and Burma have at times been beneath the sea.

The plan adopted for the study has been to divide the whole country into nineteen tracts, distinguished by physical characters—such as rainfall, temperature, presence or absence of forests, and prevalence of hilly ground, and to construct tables showing the distribution of each genus of land or fresh-water vertebrate in the tracts. Genera have been selected for consideration because families and sub-families are too few in number and too wide in range, whilst species are too numerous and too unequal in importance. In the demarcation of regions and sub-regions, terrestrial mammalia are regarded as of primary importance.

The tracts are the following:—

A. *Indo-Gangetic Plain.*

1. Punjab, Sind, Baluchistan and Western Rajputana.
2. Gangetic Plain from Delhi to Rajmahal.
3. Bengal from Rajmahal to the Assam Hills.

B. *Indian Peninsula.*

4. Rajputana and Central India as far south as the Nerbudda.
5. Deccan from the Nerbudda to about 16° N. lat. and from the Western Ghats to long. 80° E.
6. Behar, Orissa, &c., from the Gangetic Plain to the Kistna.
7. Carnatic and Madras, south of 5 and 6, and east of the Western Ghats.
8. Malabar Coast, Concan and Western Ghats or Sahyádri range from the Tapti River to Cape Comorin.

[1] Abridged from a paper read at the Royal Society, on December 13, 1900, by Dr. W. T. Blanford, F.R.S.

C. *Ceylon.*

9. Northern and Eastern Ceylon.
10. Hill Ceylon, the Central, Western and Southern Provinces.

D. *Himalayas.*

11. Western Tibet and the Himalayas above forest.
12. Western Himalayas from Hazára to the western frontier of Nepal.
13. Eastern Himalayas, Nepal, Sikhim, Bhutan, &c.

E. *Assam and Burma.*

14. Assam and the hill ranges to the south with Manipur and Arrakan.
15. Upper Burma, north of about 19° N. lat.
16. Pegu from the Arrakan Yoma to the hill ranges east of the Sittang.
17. Tenasserim as far south as the neighbourhood of Mergui.
18. South Tenasserim, south of about 13° N. lat.
19. Andaman and Nicobar Islands.

A review of the fauna of these tracts leads to the following conclusions:—

(1) The Punjab tract differs greatly in its fauna from the Indian Peninsula and from all countries to the eastward, so greatly that it cannot be regarded as part of the Indo-Malay or Oriental region. Of terrestrial mammals, bats excluded, 30 genera are met with, of which 8 or 26½ per cent. are not Indian, whilst of reptiles (omitting crocodiles and chelonians) 46 genera occur, and of these 20 or 43½ per cent. are unknown further east. Of the corresponding orders of mammalia 46, and of reptiles 80 genera occur in the Peninsula, and 24 or 52 per cent. of the former and 57 or 64 per cent. of the latter are not found in the Punjab tract. All the genera met with in the Punjab tract and wanting further east are either Holarctic forms or peculiar, but with Holarctic affinities.

The Punjab, Sind and Western Rajputana are in fact the eastern extremity of the area known as the Eremian or Tyrrhenian or Mediterranean sub-region, generally regarded as part of the Holarctic region, but by some classed as a region by itself corresponding to the Sonoran in North America.

(2) The Himalayas above the forests and such portions of Tibet as come within Indian political limits (Gilgit, Ladák, Zanskar, &c.) belong to the Tibetan sub-region of the Holarctic region. Of twenty-five mammalian genera hitherto recorded from No. 11 (the Tibetan) tract, 11 or 44 per cent. are not found in the Indo-Malay region. That Tibet forms a distinct mammalian sub-region has already been shown in other papers.

(3) India proper from the base of the Himalayas to Cape Comorin, and from the Arabian Sea and the eastern boundary of the Punjab tract to the Bay of Bengal and the hills forming the eastern limit of the Gangetic alluvium, should, with the addition of the island of Ceylon, be regarded as a single sub-region, and may be conveniently entitled the Cisgangetic sub-region. The forests of the Sahyádri range and of the western, or Concan and Malabar, coast and the hill area of Southern Ceylon have a far richer fauna than the remaining area, but are not sufficiently distinct to require sub-regional separation.

The Cisgangetic sub-region is distinguished from the Transgangetic by the presence amongst mammals of Hyænidæ, Erinaceinæ, Gerbillinæ, of three peculiar genera of antelopes and of some other types; amongst birds by the occurrence of Pterocletes (sand grouse), Phœnicopteri (flamingoes), Otididæ (bustards) and Cursoriinæ; amongst reptiles by the possession of the families Eublepharidæ, Chamæleontidæ and Uropeltidæ, together with many peculiar Geckonidæ, Agamidæ, Lacertidæ and Scincidæ, and amongst batrachians by about one-half of the genera found in each sub-region being absent in the other. The difference between the reptiles and batrachians by itself would justify the classification of the two areas as distinct regions, a view adopted by several writers.

The difference between the Cisgangetic vertebrate fauna and that inhabiting the rest of the Indo-Malay or Oriental region is partly due to the absence in the former of numerous Eastern types, and partly to the presence of two constituents besides the Oriental genera, which, especially in forest, form a majority of the animals present. One of these two constituents consists of mammals, birds and reptiles having a distinct relationship with Ethiopian and Holarctic genera, and with the Pliocene

Siwalik fauna. This constituent of the Cisgangetic fauna it is proposed to distinguish by the term Aryan. The other constituent is composed of reptiles and batrachians and may be termed the Dravidian element. The latter is well developed in the south of the Peninsula and especially along the south-west or Malabar coast, and in Ceylon, but it gradually disappears to the northward, its northern limit, so far as is known at present, not extending to the 20th parallel of north latitude. It is probable that this is the oldest part of the Cisgangetic fauna, and it may have inhabited the country since India was connected by land with Madagascar and South Africa, across what is now the Indian Ocean, in Mesozoic and early Cenozoic times. The other two elements, the Indo-Malay or Oriental and the Aryan, are probably later immigrants, and its wider diffusion may indicate that the Indo-Malay element has inhabited the Indian Peninsula longer than the Aryan has. There appears some reason for regarding the Indo-Malay portion of the fauna as dating in India from Miocene times and the Aryan from Pliocene, whilst in the Pleistocene epoch the proportion of Aryan to Indo-Malay types of mammals in India, as shown by the fossil faunas of the Nerbudda and the Karnul caves, was much larger than at the present day.

There are some other peculiarities of the Indian Peninsula fauna to which attention may be called. One of these is the presence of genera and sometimes of species which are found on both sides of the Bay of Bengal, but not in the Himalayas or Northern India. A good example is afforded by the genus *Tragulus*, of which one species inhabits Ceylon and India south of about 22° N. lat., whilst two others are found in Southern Tenasserim and the Malay Peninsula. In Pliocene times the genus inhabited Northern India. Another instance is the lizard *Liolepis guttatus*, found in Burma and Arrakan and also in South Canara on the west coast of India. Examples amongst reptiles are rather numerous. Moreover, whilst there are numerous alliances between the animals of Peninsular India and those of Africa, there are also some curious connections between India and Tropical America, but these are chiefly amongst invertebrates. Some, however, are found in reptiles. It is probable that such Indo-American connections are vestiges of older life than the Indo-African. They are, of course, generally speaking, instances of animal groups once more widely distributed, but now only preserved in a few favourable tropical localities.

(4) The forest area of the Himalayas belongs to the same sub-region as Assam, Burma (except South Tenasserim), Southern China, Tonquin, Siam and Cambodia, and to this sub-region the term Transgangetic may be applied. It is distinguished from the Cisgangetic sub-region by the absence of the animals already specified as characteristic of that area and by the presence of the following, which are wanting in the Indian Peninsula—Mammals: the families Simiidæ, Procyonidæ, Talpidæ and Spalacidæ, and the sub-family Gymnurinæ, besides numerous genera such as *Prionodon*, *Helictis*, *Arctonyx*, *Atherura*, *Nemorhaedus* and *Cemas*. Birds: the families Eurylæmidæ, Indicatoridæ and Heliornithidæ, the sub-family Paradoxornithinæ. Reptiles: Platysternidæ and Anguidæ. Batrachians: Discophidæ, Hylidæ, Pelobatidæ and Salamandridæ.

The relations of the Himalayan fauna to that of Assam and Burma on the one hand, and to that inhabiting the Peninsula of India on the other, may be illustrated by the mammals with bats omitted. Of forty-one genera occurring in the Himalayas, three are not found in the hills south of Assam or in Burma, whilst sixteen are wanting in the Cisgangetic region. It should be remembered that a large number of the genera are widespread forms. As the result is not in agreement with the views of some who have written on the subject, the relations of species have been examined. It results that eighty-one species of mammalia, belonging to the orders Primates, Carnivora, Insectivora, Rodentia and Ungulata, are recorded from the forest regions of the Himalayas. Of these two are doubtful, twenty-two are not known to occur south of the Himalayan range in India or Burma, twenty-one are wide ranging forms and are found in both Burma and the Indian Peninsula, one only (*Hystrix leucura*) is common to the Himalayan forests and the Indian Peninsula, but does not range east of the Bay of Bengal, whilst thirty-five are found in the countries east of the Bay of Bengal but not in the Peninsula south of the Ganges. Of the thirty-five, eight only range as far as the hills south of the Assam Valley, sixteen to Burma proper, and eleven to the Malay Peninsula and Archipelago. Of the twenty-two species not ranging south of the Himalayas a large majority are either Holarctic species or belong to Holarctic genera.

The fauna of the Himalayan forest area is partly Holarctic, partly Indo-Malay. It is remarkably poor, when compared with the Cisgangetic and Burmese faunas, in reptiles and batrachians. It also contains but few peculiar genera of mammals and birds, and almost all the peculiar types that do occur have Holarctic affinities. The Indo-Malay element in the fauna is very richly represented in the Eastern Himalayas, and gradually diminishes to the westward until in Kashmir and farther west it ceases to be the principal constituent. These facts are consistent with the theory that the Indo-Malay constituent of the Himalayan fauna, or the greater portion of it, has migrated into the mountains from the eastward at a comparatively recent period. It is an important fact that this migration appears to have been from Assam and not from the Peninsula of India.

(5) Southern Tenasserim agrees best in its vertebrata with the Malay Peninsula, and should be included in the Malayan sub-region of the Indo-Malay region.

There are several points left which require explanation. There is the much greater richness of the Oriental constituent in the Cisgangetic fauna to the southward in Malabar and Ceylon, although this is far away from the main Oriental area, and the ocurrence also in the southern part of the Peninsula of various mammalian, reptilian and batrachian genera, such as *Loris*, *Tragulus*, *Draco*, *Liolepis* and *Ixulus*, which are represented in Burma and the Malay countries but not in the Himalayas or Northern India. In connection with this the limitation of the Dravidian element to the south of India should also be remembered. Then there is the occurrence of certain Himalayan species on the mountains of Southern India and Burma and even farther south, but not in the intervening area. There is also the predominance of the Western, or what I have proposed to call the Aryan, element in the Pleistocene fauna of the Nerbudda Valley, and of Karnul in the north of the Carnatic tract. Lastly, we have to account for the apparently recent immigration of Oriental types into the Himalayas.

Whilst it is quite possible that other explanations may be found, it is evident that all these peculiarities of the Indian fauna may have been due to the Glacial epoch. The great terminal moraines occurring at about 7000 feet in Sikhim and the occurrence of similar moraines and other indications of ice action at even lower levels in the Western Himalayas clearly show that the temperature of the mountain range must have been much lower than at the present day, when no glacier in Sikhim is known to descend below about 14,000 feet.

During the coldest portion of the Glacial epoch, a large part of the higher mountains must have been covered by snow and ice, and the tropical Indo-Malay fauna which had occupied the range, and which may have resembled that of the Indian Peninsula more than is the case at present, must have been driven to the base of the mountains or exterminated. The Holarctic forms apparently survived in larger numbers. The Assam Valley and the hill ranges to the southward would afford in damp, sheltered, forest-clad valleys and hill slopes a warmer refuge for the Oriental fauna than the open plains of Northern India and the much drier hills of the country south of the Gangetic plain. The Oriental types of the Peninsula generally must have been driven southwards, and some of them, such as *Loris* and *Tragulus*, which must originally have been in touch with their Burmese representatives, have never returned. It was probably during this cold period that the ossiferous Nerbudda beds and the deposits in the Karnul caves were accumulated. The tropical damp-loving Dravidian fauna, if it inhabited Northern India, must have been driven out of the country. Unless the temperature of India and Burma generally underwent a considerable diminution, it is not easy to understand how plants and animals of temperate Himalayan types succeeded in reaching the hills of Southern India and Ceylon, as well as those of Burma and the Malay Peninsula.

When the whole country became warmer again after the cold epoch had passed away, the Transgangetic fauna appears to have poured into the Himalayas from the eastward. At the present day the comparatively narrow Brahmaputra plain in Assam is far more extensively forest-clad, especially to the eastward, than is the much broader Gangetic plain of Northern India, and if, as is probable, the same difference between the two areas existed at the close of the Glacial epoch, it is easy to see how much greater the facilities for the migration of a forest-haunting fauna must have been across the Brahmaputra Valley than over the great plain of the Ganges. This difference alone would give the Transgangetic fauna of Burma an advantage over the Cisgangetic fauna in a race for the vacant Himalayas, even if the latter had not been driven farther to the southward than the former, as it probably was during the Glacial epoch.

The theory, however, is only put forward as a possible explanation of some remarkable features in the distribution of Indian vertebrates. At the same time it does serve to account for several anomalies of which some solution is necessary. If thus accepted, it will add to the evidence, now considerable, in favour of the Glacial epoch having affected the whole world, and not having been a partial phenomenon induced by special conditions, such as local elevation.

SCIENCE TEACHERS IN CONFERENCE.

FOR the third time the Technical Education Board of the London County Council has arranged and held a conference of teachers of science from all parts of the kingdom. Since their inauguration, these annual meetings have steadily grown in popularity. At the first conference, in 1899, there was an attendance of eighty persons, in 1900 the number had grown to 200, while at the meetings held last week the attendance reached the total of 350. These satisfactory results are largely due to the efforts of Mr. C. A. Buckmaster, of the Board of Education, and Dr. Kimmins, the Inspector to the Technical Education Board, who have steadily worked during the three years in encouraging lecturers, demonstrators and inspectors to meet together for the discussion of methods of teaching different branches of science. The addresses and papers brought before the conference at the South-Western Polytechnic, Chelsea, on January 10 and 11, dealt with subjects of great importance in an interesting and instructive manner; but the discussions were not entirely satisfactory. It is useless to expect teachers to contribute anything valuable to a discussion at a moment's notice. It should be possible at future meetings to obviate in a large measure the desultory speeches on more or less general topics which this year followed the addresses and papers. If half a dozen well-known, practical teachers were given an abstract of the paper before the meeting, they would be able, with a few days' preparation, to place succinctly before the meeting the results of their own practice, and besides putting the discussion on right lines, they would lead other teachers with experience of the matter in hand to help forward a complete presentation of the subject.

One more preliminary remark is necessary. Too much was attempted at separate meetings, at some of which as many as three papers were read and put down to be discussed in two hours. The consequences were unfortunate. To name one instance only: at the third meeting, not only was Prof. Armstrong unable to deliver the whole of the paper he had prepared on the teaching of domestic science, but though the discussion was continued some fifteen minutes after the proper time, he was not called upon to reply to the points raised by different speakers. It is to be hoped that next year fewer subjects will be taken up at each meeting, and more pains taken to secure an ample discussion, rigidly kept to the matter in hand.

INSTRUMENT MAKING.

At the first meeting of the conference, Mr. T. A. Organ, the Chairman of the Technical Education Committee of the London County Council, presided. In his introductory remarks the Chairman insisted on the need there is still for improved science teaching in our schools, and directed attention to a growing danger of doing too much for students. What has been called in America "peptonised" education seems to be on the increase, and is much to be deprecated. Addresses were given on "Instrument-making for schools and technical classes," by Mr. W. Hibbert, of Regent Street Polytechnic; and on the "Co-ordination of workshop and laboratory instruction," by Mr. T. P. Nunn, of William Ellis's School, and Mr. A. G. Hubbard, of Raine's School. During the course of his remarks, Mr. Hibbert described, with the aid of lantern slides, a large number of simple pieces of apparatus for use in the teaching of electricity and magnetism, amongst which his magnetometer, which can be easily converted into an astatic galvanometer, his electroscope, capable of detecting one-tenth the potential difference recognisable by the ordinary forms of instrument, and his standard magnets are particularly worth mention. The remaining addresses described successful attempts to make the work of the manual instruction teacher assist the practical study of physics. In the subsequent discussion, Dr. Gladstone, F.R.S., referred to the efforts he had made on the London School Board in the direction of supplying the teachers of the schools of the Board with simple, inexpensive apparatus which would satisfactorily demonstrate the elementary principles of physics and chemistry.

THE FITTING UP OF LABORATORIES.

Sir W. de W. Abney, K.C.B., F.R.S., took the chair at the second meeting, and lectures were given by Messrs. J. B. Coleman, A. Schwartz and W. W. Pullen, describing the fittings and apparatus of the chemical, physical and mechanical laboratories, of which they respectively have charge at the South-Western Polytechnic. After the addresses, which were profusely illustrated with lantern slides, a discussion was opened by Prof. Armstrong, F.R.S. Referring to the provision which Mr. Coleman has made for the proper writing of notes in the laboratory itself at the time the practical exercise in science is actually performed, Prof. Armstrong urged that one of the most valuable results from intelligent science teaching is the excellent progress the pupil makes in his ability to express himself in a literary manner when called upon to systematically describe the work he has performed. He also urged that it is a great mistake to suppose that palatial establishments, such as those described by the lecturers, are really necessary for teaching science to boys and girls. Pretentious "drawing-room" laboratories are by no means desirable; what is wanted is not so much a laboratory as a workshop, which need be little more than a shed, such as a contractor about to put up a large building erects for the use of his workmen. Students who work in the sumptuously-fitted places now provided are not suitably trained for the work of life; nobody in commercial undertakings gets a place anything like as good as a school laboratory in which to do his professional work. The thing of importance is the spirit with which the work is undertaken, not the number of appliances at the disposal of the teacher and pupil.

In acknowledging a vote of thanks, and at the same time summarising the papers and discussion, Sir W. Abney explained that his experience in connection with the Board of Education at South Kensington has shown him what a great deal can be done with very simple apparatus. He had, he said, again and again met, in different parts of the country, teachers using the simple pieces of physical apparatus they had made in the laboratories of the Royal College of Science during the courses of instruction arranged for them there during the summer vacation. The teacher of science who has learnt how to make and devise these simple pieces of apparatus can, with the aid of his pupils, easily turn out apparatus quite suitable for satisfactorily demonstrating the important laws of chemical and physical science.

DOMESTIC SCIENCE.

The third meeting, over which Mr. Bousfield, Chairman of the Girls' Public Day School, presided, was devoted to a consideration of the science teaching in girls' schools, especially as to what form of instruction in domestic science is desirable. The first paper was read by Miss Aitken, of the North London Collegiate School, who gave it as her opinion that the best practical teaching in science for girls is given in the now well-known schools of science held in connection with the South Kensington branch of the Board of Education. The generality of girls' schools are not, Miss Aitken finds, properly provided with necessary and suitable accommodation for the pupils to themselves make experiments with simple apparatus, the classes in science are too large, and the amount of time placed at the disposal of the science mistress is ludicrously inadequate.

Prof. Armstrong, in a paper on the teaching of domestic science, laid it down that the object of their instruction should be the formation of habits, not the accumulation of knowledge. Elementary work, in what Prof. Armstrong prefers to call *νοῦς* or "knowingness" rather than science, should throughout aim at developing and strengthening a young pupil's mother wit. Anything may be taught and in any way, provided it leads to the cultivation of *νοῦς*. All teaching in domestic science must be guided by considerations of this kind, and the fundamental subjects of a suitable course will be measuring work, which will not be unduly prolonged, but give place at an early stage to continued exercises with the balance; the study of the properties of water will follow, after which the effects of heat can with advantage be taken up, and so prepare the way for the final stage of the preliminary course—namely, the study of the air, more particularly in relation to the part it plays in the combustion of food and fuel. But throughout the course constant work with the balance must take a prominent part. The balance inculcates thrift and morality generally, and weighing should be so constantly resorted to that it becomes an absolute habit. If Rudyard Kipling could but be persuaded to write a song with the refrain "Weigh, weigh, weigh," which could be hummed by girls during their lessons in practical work in science, as well as sung on State occasions, he would be doing education a great service.

Prof. Tilden, F.R.S., opened a discussion and referred to the neglect of book-keeping in household management, and directed attention to the fact that a sound education must take notice of other subjects than science.

PSYCHOLOGY AND SCIENCE TEACHING.

Sir Henry Roscoe, F.R.S., took the chair at the concluding meeting, at which Prof. Earl Barnes gave an address on nature teaching for young children, and Principal Lloyd Morgan, F.R.S., lectured on psychology and science teaching. Prof. Morgan said a lecturer in psychology had been defined thus by a pupil—" He tells us what every one knows in language which nobody can understand," but he hoped to avoid the dangers mentioned in the definition. It is easier to indicate what is not education than to give a satisfactory account of what it is: " when one fellow talks about what he doesn't understand to other fellows who don't understand him, that's *not* education." The teacher ignorant of psychology is somewhat of a quack, the honest and earnest instructor must have some practical knowledge of mental processes. In fact, all science teachers ought to take a course in psychology as part of their recognised curriculum in training for their life-work. But such work in psychology should have an experimental basis; the professor and his students must participate in an investigation together. Prof. Morgan then described, with a series of practical demonstrations, the research he was assisting his own students to carry out. In all such practical work it is borne in mind that the first stage in a normal course of mental sequence is that of observation presenting facts which demand explanation; the second that of discovery; and the third that of testing and applying the principles. A discussion followed in which the chairman and Dr. Gladstone took part.

A collection of home-made apparatus for science teaching in schools was on view during the days of the conference, and the chemical, physical and mechanical laboratories of the Polytechnic were open for inspection. A. T. SIMMONS.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Sedgwick prize in geology has been awarded to Mr. F. R. C. Reed, M.A., of Trinity College.

At Peterhouse the following entrance scholarships in Natural Science have been awarded: Blackie, Tonbridge School, 50*l.*; King, City of London School, 40*l.*

THE University of Cincinnati was re-organised in the latter part of last year, and an account of the changes, with photographs and short biographical sketches of the Faculty as now constituted, is given in *Chic.* The most distinctive change is the introduction of the elective system, which permits the student to follow the course of study which best suits his needs for the profession or business he intends to follow after leaving the University. A college of commerce and administration is in contemplation, which will have for its object practical instruction in methods of business in conformity with modern demands. The endowment fund of the University, through the bequests of a number of generous benefactors, amounts to the substantial sum of 3,357,308 dollars, or more than 700,000*l.* The president of the University is Dr. H. Ayres, formerly professor of biology in the University of Missouri.

Literature remarks:—The close of the term for the Christmas vacation has shown the interest of the American millionaire in the advancement of learning. Mr. J. D. Rockefeller gives 300,000*l.* to the University of Chicago and 3000*l.* to the Vermont Academy. Wellesley College, Mass., receives 20,000*l.* from various donors, and Ripon College, Wisconsin, comes into possession of a handsome building for scientific study, the gift of Mr. O. H. Ingram. The Universities have, on the whole, done well by the millionaires. Here is a summary of the largest endowments and their givers:—

Chicago University ...	J. D. Rockefeller ...	$9,133,874 ...	£1,902,848
Gerard College	Stephen Gerard	7,000,000 ...	1,458,333
Pratt Institute	Charles Pratt	3,600,000 ...	750,000
Johns Hopkins Univ. ...	Johns Hopkins	3,000,000 ...	625,000
Drexel Institute	A. J. Drexel...	3,000,000 ...	625,000
L. Stanford University...	Leland Stanford, jun...	2,500,000 ...	520,833
Cornell University	Ezra Cornell...	1,500,000 ...	312,500
Vanderbilt University ...	The Vanderbilts	1,100,000 ...	229,166
Columbia University ...	Seth Low	1,000,000 ...	208,333

But there are millionaires outside of America, and the list may at any rate be taken as an example *pour encourager les autres.*

SCIENTIFIC SERIALS.

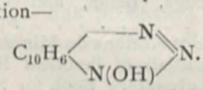
American Journal of Science, January.—The stereographic projection and its possibilities, from a graphical standpoint, by S. L. Penfield. Two stereographic protractors devised by the author are described, and detailed instructions given for their use. These protractors are especially adapted to crystallographic problems, but this branch of the subject is postponed for special consideration in a further communication.—On the mode of occurrence of topaz near Ouro Preto, Brazil, by Orville A. Derby. The yellow Brazilian topaz of the Ouro Preto district was stated by Eschwege to occur in association with talcose or chlorite schist, and this was confirmed to some extent by Mawe, Spix and Martius. This view was contested by Gorceix, who found that the unctuous schists of this region are essentially micaceous. The results of the author's researches in this district show that the occurrence of the topaz here does not differ so materially from the other known ones as has hitherto been supposed. The mineral does not occur in an essentially magnesian rock, nor is its matrix of presumably sedimentary rather than of eruptive origin.—A chemical study of the glaucophane schists, by Henry S. Washington. Analyses of glaucophanes from Syra, Oregon, Croatia, Anglesey, California, Japan and Piedmont, sixteen analyses in all. The glaucophane schists are found to belong to two classes. The larger one is basic, and consists chiefly of glaucophane and epidote, and scarcely differs in chemical composition from the amphibolites and eclogites. A smaller, but widely spread group, is acid in composition, and these are composed largely of quartz and glaucophane.—On the nature of the metallic veins of the Farmington meteorite, by O. C. Farrington. The question of the origin of the metallic veins in a meteorite is of interest as throwing light on the origin, terrestrial or pre-terrestrial, of the meteorite. Preston's views on the veins in the Farmington meteorite are discussed and shown to be improbable.—*Erigenia bulbosa*, by Theo. Holm. An examination of the question as to whether the globular underground part of this plant is a true tuber or a tuberous root. After some trouble, specimens of the plant were obtained in the seedling stage, and the bulb was found to be a tuberous root.—New species of Merycochœrus, in Montana, by Earl Douglass. This species, described as *M. altiramus*, found in the Madison Lake beds of the Loup Fork epoch, is represented by a right mandibular ramus which only lacks the posterior border and some other small fragments. The paper is illustrated by five diagrams of the dentition, accompanied by careful measurements.

Bulletin of the American Mathematical Society, December, 1900.—Prof. F. N. Cole gives an account of, with abstracts of the papers read at, the October meeting of the Society. As these papers will be printed *in extenso* in the *Bulletin*, or in the *Transactions*, we omit the consideration of them here. Prof. M. Bôcher devotes a page to a note on linear dependence of functions of one variable. Report on the groups of an infinite order, by Dr. G. A. Miller, was read before Section A of the American Society for the Advancement of Science, which met at New York in June last. This is a useful *résumé* of recent work done upon the theory of groups, with copious references to original memoirs. Two reviews follow, viz., of Ewing's "The Strength of Materials," by Dr. C. Chree, and of the "Anwendung der Differential- und Integralrechnung auf Geometrie" of Dr. G. Scheffers (Bd. i. "Einführung in die Theorie der Curven in der Ebene und im Raum"), by Prof. J. M. Page. Notes and new publications close the number.

SOCIETIES AND ACADEMIES.

LONDON.

Chemical Society, December 13, 1900.—Prof. Thorpe, President, in the chair.—Prof. H. A. Miers delivered the Rammelsberg Memorial Lecture.—December 20, 1900, Prof. Thorpe, President, in the chair.—On the union of hydrogen and chlorine, by J. W. Mellor. The mixture of hydrogen and chlorine obtained by the electrolysis of hydrochloric acid always contains measurable quantities of oxygen. A slight contraction occurs on mixing gaseous chlorine and hydrogen chloride.—The nitration of the three tolueneazophenols, by J. T. Hewitt and J. H. Lindfield. The three tolueneazophenols are nitrated by warm dilute nitric acid, and in each case the nitro-group enters the phenol ring in the ortho-position relatively to the hydroxyl group.—The bromination of the ortho-oxyazo-compounds and its bearing on their constitution, by J. T. Hewitt and H. A. Phillips. Ortho-oxyazo-compounds appear to react towards bromine as true oxyazo-compounds, and not as orthoquinone-hydrazones.—On the use of pyridine for molecular weight determinations by the ebullioscopic method, by W. R. Innes. Molecular weight determinations show that pyridine does not favour the association of dissolved substances; its molecular rise in boiling point is 29·5.—The influence of the methyl group on ring formation, by A. W. Gilbody and C. H. G. Sprankling. The authors have determined the stability of phenylsuccinimide and its alkyl derivatives in alcoholic solution. It is found that the stability of the succinimide ring is decreased by introducing methyl groups into the fatty ring, whilst Miolati has found that the introduction of fatty groups into the aromatic ring increases the stability.—Experiments on the production of optically active compounds from inactive substances, by F. S. Kipping.—A lecture table experiment for the preparation of nitric oxide, by A. Senier.—The action of ethylene dibromide on xylidine and pseudocumidine, by A. Senier and W. Goodwin.—The action of phenylcarbimide on diphenyl-, dialphyl- and dinaphthyl-diamines, by A. Senier and W. Goodwin.—Note on the action of nitrous acid on β-nitroso-α-naphthylamine, by A. Harden and J. Okell. On treating β-nitroso-α-naphthylamine in alcoholic solution with potassium nitrite and hydrochloric acid, a salt of the composition $C_{10}H_6O_2N_3K$ is obtained; this and the corresponding sodium salt, when treated with stannous chloride and acid, yield a substance which is probably an imidazole of the following constitution—



—1:2:4-Metaxylidine-6-sulphonic acid, by H. E. Armstrong and L. P. Wilson. In accordance with the views previously published by Armstrong, it is found that although excess of fuming sulphuric acid converts 1:2:4-metaxylidine into the 5-sulphonic acid, the 6-sulphonic acid is readily obtainable by heating the sulphate of the base.—The preparation of acetylchloraminobenzene and related compounds, by F. D. Chattaway and K. J. P. Orton.

Geological Society, December 19, 1900.—J. J. H. Teall, F.R.S., President, in the chair.—On the igneous rocks associated with the Cambrian beds of the Malvern Hills, by Prof. T. T. Groom. The Cambrian beds of the Southern Malverns are associated with a series of igneous rocks which have commonly been regarded as volcanic, but are probably all intrusive. They consist of a series of bosses, dykes, sills and small laccolites intruded into the Upper Cambrian Shales and into the Hollybush Sandstone. The dykes appear to be confined to the sandstones, the sills and laccolites chiefly to the shales, while the bosses are found in both. All the rocks have a local stamp, but are probably most nearly related to the camptonitic rocks of the Central English Midlands. Intrusion took place at a period not earlier than the Tremadoc, and probably not later than that of the May Hill Sandstone.—On the Upper Greensand and Chloritic Marl of Mere and Maiden Bradley in Wiltshire, by A. J. Jukes-Browne and John Scanes. The district dealt with is on the borders of Wiltshire and Somerset. The general succession is as follows, the numbers being given in feet:—Lower Chalk, with Chloritic Marl at the base, 200; sands with calcareous concretions, 3 to 8; sands with siliceous concretions (cherts), 20 to 24; Coarse Greensand, 15; fine grey and buff sands, about 120; sandy marlstone, 15; grey marl and clay (Gault), 90.

Royal Microscopical Society, December 19, 1900.—Mr. Wm. Carruthers, F.R.S., President, in the chair.—Mr. Barton exhibited some new forms of lanterns which could be used for ordinary projection purposes either with or without the microscope. The first was a lantern constructed so as to exclude all light from the room except what passed through the lenses; the manner of using this in connection with a microscope was shown. Another lantern exhibited was larger and more complete, and could be used for all purposes, including enlargements. The excellent definition of this lantern was demonstrated by the exhibition on the screen of photomicrographs of mounted preparations of insects, and of whole insects mounted in balsam. Mr. Barton also exhibited and described several new forms of microscope, with detachable circular stage, &c., and a new form of electric arc lamp for lantern use. A new form of lime-light was also exhibited of great brilliancy, steadiness and silence. Mr. Nelson said he was very much struck with the perfection to which the last-mentioned lamp had been brought, and inquired if the gases had been enriched in any way, and how the light was produced with such complete absence of noise. Mr. Barton said nothing was used but the two gases, and the effect was produced by causing them to impinge upon each other previous to their entrance to the mixing chamber, and by the construction of the chamber itself.

MANCHESTER.

Literary and Philosophical Society, January 8.—Prof. Horace Lamb, F.R.S., President, in the chair.—A discussion was introduced by Mr W. H. Johnson upon the method of navigation employed by the Norsemen on their voyages between Northern Europe and Greenland and Iceland before the mariner's compass was known. Mr. W. E. Hoyle communicated a note on D'Orbigny's figure of *Onychoteuthis dussumieri*, in which he pointed out the resemblance which it bore to a species of Loligo in the Hamburg Museum. The skin of this specimen was partly covered by convex tubercles, giving it a shagreen-like appearance, which was due to its having undergone partial maceration in the stomach of some cetacean. It was further shown that this appearance might perhaps explain the true nature of a cephalopod described by Prof. Joubin, which he stated to be covered with scales resembling those of a ganoid fish. Dr. Lönnberg had found a similar appearance in a specimen of Onychoteuthis from Magellan's Straits, which on investigation proved not to be due to scales at all, but to a swelling of subcutaneous papillæ in consequence of the maceration to which the animal had been subjected. It seemed, therefore, a reasonable hypothesis that all these scalelike appearances were due to a similar cause.

EDINBURGH.

Mathematical Society, January 11.—Mr. Geo. Duthie, Vice-President, in the chair.—Prof. Allardice read a paper on the nine-point conic, and notes were given by Prof. Steggall, Mr. D. B. Mair and Prof. Jack.

PARIS.

Academy of Sciences, January 7.—M. Fouqué in the chair.—M. Bouquet de la Grye was elected Vice-President for the year 1901.—M. Maurice Lévy, the retiring President, announced the changes in the members and correspondents for the past year.—The President announced the death of Dr. Potain, member in the section of Medicine and Surgery.—On the integrals of total differentials of the third species in the theory of algebraic functions of two variables, by M. Émile Picard.—Observations of the comet 1900*c* (Giacobini), made at the Observatory of Algiers, by MM. Rambaud and Sy. The observations, which were made with the 31·8 cm. equatorial on the nights of December 26 and 27, 1900, show that the comet is a nebulosity of 1′ to 2′ diameter with a feeble central nucleus comparable in intensity with a star of the 13th magnitude.—Observations of the comet 1900*c* (Giacobini) made with the equatorial of the Observatory of Besançon, by M. P. Chofardet. The observations were made on December 25, 1900, and show the comet as a rounded nebula without a tail, with a central stellar nucleus of about the 12th magnitude.—On convex closed surfaces, by M. H. Minkowski.—On the theorem of active forces, by M. H. Duport.—On linear equations with indeterminate points, by M. Ludwig Schlesinger.—On the theory of the equations of mathematical physics, by M. S. Zaremba.—On the absolute value of the magnetic elements on

January 1, by M. Th. Moureaux. The absolute values of the magnetic elements is given for four stations, Parc Saint-Maur, Nice, Perpignan and Val Joyeux. The removal of the magnetic instruments to this last station from Parc Saint-Maur was rendered necessary during the year by the increasing disturbances caused by the development of the electrical tramway system of Paris.—On a new phosphide of tungsten, by M. Ed. Defacqz. All attempts to prepare the tungsten phosphide, WP, at the temperature of the electric furnace were unsuccessful, owing to the fact that at the temperature of boiling copper phosphide the tungsten phosphide is dissociated. By working at the highest attainable temperature of a wind furnace, however, in presence of a large excess of copper phosphide, a well crystallised phosphide was obtained having the composition WP. This forms prismatic crystals of a grey metallic lustre, density 8·5, not attacked by air at the ordinary temperature, but converted into tungstic acid at a red heat.—On some properties of sodium peroxide, by M. George F. Jaubert. Sodium peroxide is commonly described as a white substance which deliquesces slowly when exposed to the air. The author now finds that the colour of this substance when prepared in a perfectly pure state is yellow, and further that it does not liquefy when exposed to the air.—Composition of the hydride and nitride of thorium, by MM. C. Matignon and M. Delépine. At a dull red heat metallic thorium burns in a current of hydrogen forming the hydride ThH. With nitrogen, if the metal be heated somewhat more strongly, the nitride Th_3N_4 is formed, which is rapidly decomposed by hot water with the formation of thoria and ammonia.—Some new reactions of the organo-metallic derivatives, by M. E. E. Blaise. A description of a new general method for the preparation of ketones and ketonic acids. The reagent used is the alkyl magnesium iodide obtained by the action of magnesium upon an alkyl iodide, and this is allowed to react with either a nitrile or an isocyanic ester. Thus in this way the author has obtained propionoacetic ester from cyanacetic ester, diethyl ketone from cyanogen, and substituted anilides from phenyl isocyanate.—Action of methyl-acetylacetone and ethyl-acetylacetone on the diazoic chlorides, by M. G. Favrel. The diazo-chlorides react with methyl- or ethyl-acetylacetone with the elimination of a molecule of acetic acid and formation of a hydrazone. This reaction resembles that of the cyanacetic esters containing substituted acid radicles, and also the reaction between the alkyl-acetylacetic esters and diazobenzene chloride.—On the embryology of *Taenia serrata*, by M. G. Saint-Remy. The author gives reasons for believing that the description given by van Beneden of the young egg, not segmented, is not quite exact, and that this description belongs in reality to a slightly more advanced stage.—On the discovery of an origin of the Swiss Pre-alps, by M. Maurice Lugeon.

DIARY OF SOCIETIES.

THURSDAY, JANUARY 17.

ROYAL SOCIETY, at 4.30.—Total Eclipse of the Sun, January 22, 1898. Observations at Viziadrug. Part IV. The Prismatic Cameras: Sir N. Lockyer, K.C.B., F.R.S.—Wave-length Determinations and General Results obtained from a Detailed Examination of Spectra photographed at the Solar Eclipse of January 22, 1898: J. Evershed.—The Thermo-Chemistry of the Alloys of Copper and Zinc: T. J. Baker.

ROYAL INSTITUTION, at 3.—The Origin of Vertebrate Animals: Dr. Arthur Willey.

SOCIETY OF ARTS (Indian Section), at 4.30.—Metalliferous Mining in India: Dr. John W. Evans.

LINNEAN SOCIETY, at 8.—On the Affinities of *Aelurofus melanoleucus*, Prof. E. Ray Lankester, F.R.S., with a Description of the Skull and some of the Limb-bones: R. Lydekker, F.R.S.—On the Natural History and Artificial Cultivation of the Pearl Oyster: Dr. H. Lyster Jameson.

CHEMICAL SOCIETY, at 8.—The Preparation of Esters from other Esters of the same Acid: T. S. Patterson and Cyril Dickinson.—Tecomin: a Colouring Matter derived from *Bignonia tecoma*: T. H. Lee.—A New Method for the Measurement of Ionic Velocities in Aqueous Solution: B. D. Steele.—Metal-Ammonia Compounds in Aqueous Solution. II. The Absorptive Powers of Dilute Solutions of Salts of the Alkali Metals: H. M. Dawson and J. McCrae.

FRIDAY, JANUARY 18.

ROYAL INSTITUTION, at 9.—Gases at the Beginning and End of the Century: Prof. J. Dewar, F.R.S.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Annual General Meeting.—*Possible* discussion upon Mr. H. A. Humphrey's paper on Power Gas and Large Gas-Engines for Central Stations.

MONDAY, JANUARY 21.

VICTORIA INSTITUTE, at 4.30.—Evolution: Rev. G. F. Whidborne.

TUESDAY, JANUARY 22.

ROYAL INSTITUTION, at 3.—Practical Mechanics: Prof. J. A. Ewing, F.R.S.

ANTHROPOLOGICAL INSTITUTE, at 8.30.—On Malay Metal-working (illustrated by Lantern Slides and Experiments): W. Rosenhain.—Slides illustrative of the damage to Stonehenge will also be shown.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Present Condition and Prospects of the Panama Canal Works: J. T. Ford.

MINERALOGICAL SOCIETY, at 8.—Note on an Occurrence of Mirabilite: Dr. Trechmann.—On a Question relative to Extinction-Angles in Rock-Slices: Mr. Harker.—On the Arrangement of the Chemical Atoms in Calc Spar and in some other Crystals: Mr. Barlow.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Imitative *versus* Creative (a Comparison): W. Edwin Tindall.

WEDNESDAY, JANUARY 23.

GEOLOGICAL SOCIETY, at 8.—The Glacial Geology of Victoria, Australia: Prof. J. W. Gregory.—The Origin of the Dunmail Raise (Lake District): R. D. Oldham.

THURSDAY, JANUARY 24.

ROYAL SOCIETY, at 4.30.—*Probable* papers: The Boiling Point of Liquid Hydrogen, determined by Hydrogen and Helium Gas Thermometers: Prof. J. Dewar, F.R.S.—Investigations on the Abnormal Outgrowths or Intumescences on *Hibiscus vitifolius*, Linn.: a Study in Experimental Plant Pathology: Miss Elizabeth Dale.—On the Proteid Reaction of Adamkiewicz, with Contributions to the Chemistry of Glyoxylic Acid: F. Gowland Hopkins and S. W. Cole.

ROYAL INSTITUTION, at 3.—Origin of Vertebrate Animals: Dr. Arthur Willey.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Adjourned Discussion: Capacity in Alternate Current Working: W. M. Mordey.

FRIDAY, JANUARY 25.

PHYSICAL SOCIETY, at 5.—The New Physical Laboratories of the Royal College of Science: Prof. A. W. Rücker, Sec.R.S.—Note on an Absolute Method for determining the Hygrometric State of the Atmosphere: E. B. H. Wade.—Exhibition of an Experiment on the Migration of the Ions: S. W. J. Smith.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Sewage Treatment: C. Johnston.

SATURDAY, JANUARY 26.

ROYAL INSTITUTION, at 3.—The Government and People of China: Prof. R. K. Douglas.

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