THURSDAY, NOVEMBER 18, 1909.

CYTOLOGICAL ASPECTS OF CERTAIN BIOLOGICAL PROBLEMS.

Zeitpunkt der Bestimmung des Geschlechts, Apogamie, Parthenogenesis, und Reduktionsteilung. By E. Strasburger. Heft VII., Der Histologischen Beiträge. Pp. xvi+124. (Jena: Gustav Fischer, 1909.) Price 6.50 marks.

IN the seventh part of his "Histologische Beiträge," Prof. Strasburger records and discusses the results of investigations on a number of cytological problems chiefly related to the nature and distribution of sex. The reader will recognise the facile grasp of wide and complex series of facts, as well as the lucid presentation of the conclusions, which form so strongly marked a feature of the works of this great investigator.

The opening chapter is devoted to an account of studies on the sexual differentiation in the spores of the diœcious liverwort Sphærocarpus. The result of cultures of the spores of this plant brings out the remarkable fact that on the average two spores in each tetrad give rise to male, and the two other ones to female individuals. This distribution does not occur invariably, but it does so in the great majority of cases, and the discovery is of considerable importance and interest. It is clearly in harmony with, and gives greater precision to, the observations already made by others on the distribution of sex in other liverworts and mosses. In the case of the plant in question, it indicates that the sex of the individual to which the spore will give rise is predestined during the meiotic divisions of the spore mother cell—the divisions in which we have good grounds for supposing that many other characters are segregated and distributed. It will be remembered that it is at meiosis that the nuclear chromosomes are *distributed* between the nuclei of two daughter nuclei, so that their number in each of these nuclei is consequently halved. But the coincidence needs to be utilised with caution, and Prof. Strasburger himself fully discusses the difficulties in the way of generalising too freely.

It is obviously necessary to distinguish clearly between the characters appropriate to the sexual cells (or to the gametophytes) themselves, and those sexual *tendencies* of which they are the bearers. The latter, of course, only declare themselves after fertilisation, when the sex of the particular individual of the next generation which springs from them is declared. Whilst it is quite possible, and in certain cases it can be very plausibly argued, that these sexual *tendencies* are decided at meiosis, it appears to be quite certain that the sexual *characters* must be regarded from a different point of view. Thus, notwithstanding the case of Sphærocarpus, where meiosis seems to determine the segregation of the resulting gametophytes into a pair of male and a pair of female plants respectively, a consideration of any heterosporous plant—as, for example, selaginella, suffices to remind one that here, at any rate, the sexual character of the gametophyte is determined by causes which operate before meiosis supervenes. For the difference can be detected in the sporangia. Still more clearly is the same thing apparent in diœcious plants, where the male and female individuals differ from each other, and thus the character of the gametophytes to which they will severally give rise can be foretold at a much earlier stage in the life-history.

With regard to the segregation of the sexual tendencies the matter is otherwise. Although the questions herein involved are very complex, the evidence at present available seems to indicate that the segregation of the opposing sexual tendencies, where it occurs at all, is achieved at the stage and by means of the mechanism of meiosis. The fact that in the interpretations of sex, from this point of view, there exists a lack of unanimity as to the precise constitution of the male and female gametes does not materially affect the position. Thus the question as to whether maleness and femaleness can be regarded as allelomorphic (or alternative, as regards the constitution of the gametes) characters is independent of the views taken as to the heterozygous character, for example, of the male or the female, and it may turn out ultimately that different organisms behave differently in this respect. In this connection it may be mentioned that the alga *Chara crinita* produces only female plants from its parthenogenetically developing eggs, which contain the half number of chromosomes (haploid), whilst in ants, bees, and wasps the corresponding unfertilised, parthenogenetically developing eggs invariably give rise to males.

Intimately bound up with the question of sex are the various instances of eggs which are able to develop into a new individual in the absence of the normal union with a sperm. Strasburger rightly, as we think, criticises those who would include all these cases under the term parthenogenesis. Examples are known of eggs which possess the full premeiotic number of chromosomes owing to the obliteration of the meiotic phase from the life-history. Fertilisation is always absent in such cases, but it is misleading to speak of this as a parthenogenetic development, seeing that the nuclear constitution of such an egg deviates so fundamentally from that of a normal one. Possibly the term "diploid parthenogenesis" might be employed to meet such cases, though we confess to a preference for the word "parthenapogamy" as being more characteristic.

In dealing with the general question of apogamy, the author emphasises the suggestive fact that species which exhibit this feature commonly possess far larger numbers of chromosomes than allied and normal species, and also that they are characterised by a relatively high degree of variability. These two points appear to us to be highly significant, and to merit a closer attention than they have generally received.

Prof. Strasburger holds stoutly to his views as to the omnipotence of the nucleus in determining the course of development. That is to say, the nucleus is regarded as alone bearing the hereditary substance which he believes to consist of distinct bodies responsible for the characters manifested by an individual. He adheres strongly to the view, advanced by Grégoire, that homologous chromosomes (*i.e.* derived from the male and female parent respectively) pair laterally during the prophase of meiosis, and he discounts the speculations which have been based on mitochondrial and such-like cytoplasmic structures. As regards the interpretation of the nuclear transformations which occur during meiosis, Prof. Strasburger admits that he is influenced by theoretical considerations in arriving at his final conclusions. The views he advocates are not shared by all investigators, although at the present time they are rather widely supported. But the available evidence is hardly sufficient as yet to allow of the matter being brought to a decisive issue, and, indeed, the very same preparations have been differently interpreted by the exponents of the divergent views. It is a pity, perhaps, that this should be so, but it is clearly not an unhealthy condition of affairs when the final conclusion on a question of fact is confessedly influenced by other than objective evidence.

The reader will find many other topics treated in this volume by a master hand. Evidence is given to show that the hybrid *Fragaria virginiana* × *F. elatior*, which in the F_1 generation so exactly resembles the latter (male) parent that its hybrid nature has been doubted, does really arise in this way, but that the Elatior parent is completely dominant. Alternation of generations is touched upon, and the book ends with a suggestive speculation as to how the details of nuclear structure, and in particular the meiotic divisions, have come to exhibit so close a resemblance in the higher plants and animals respectively. It is pointed out that so remarkable a fact cannot be otherwise than pregnant with real significance, especially when we reflect that we seek in vain amongst the more primitive animals and plants for the uniformity which on *a priori* grounds we might, perhaps, have anticipated would be found.

It is impossible, in bringing this notice to a close, to refrain from expressing appreciation for the manner in which Prof. Strasburger has handled the more controversial matter in his book. The invariable courtesy with which he treats the opinions of those who happen to differ from himself might well be copied by some who still appear to imagine that scientific discussion should be conducted on the lines of modern politics. Not the least of the qualities which have endeared Prof. Strasburger to a wide circle of friends, in addition to that scrupulous fairness and consideration which he always shows to others, is the open-mindedness with which he is always ready to accept the result of new discoveries, even when, as he himself says, they may involve the sacrifice of long-cherished views.

J. B. FARMER.

METALLIC ALLOYS.

Leçons sur les Alliages métalliques. By Prof. J. Cavalier. Pp. xix+466. Illustrated. (Paris: Vuibert et Nony, 1909.)

DURING the last twenty years a systematic study has been undertaken of the properties of alloys, their chemical nature and constitution, and the relations between that constitution and their useful properties. The work has been made possible by the invention of trustworthy pyrometers, by the application of microscopic examination to opaque substances, and by advances in the knowledge of chemical equilibrium. The investigations have in many cases been carried out with an industrial aim, but by throwing light on the chemistry of solid bodies they have contributed largely to the development of pure science. It is true that the whole subject is still to some extent in a state of flux, and much remains to be done in order to explain apparent contradictions, and to remove the uncertainty and provisional nature of some of the conclusions. Nevertheless, it is time to make the fundamental principles of the science of alloys part of the course of training of students of general chemistry. Prof. Cavalier's book shows a pronounced superiority for this purpose over previous attempts, and is one of the manuals which teachers of chemistry may usefully place in the hands of their students. It is based on a series of lectures delivered by the author at the University of Rennes, and is characterised by clearness of thought and of language, logical arrangement, and perfection of balance.

The first part of the book contains a brief general description of the methods of preparation and study of alloys. Ordinary chemical analysis is not dealt with, but proximate analysis, and the still more important methods of microscopic metallography and thermal study are discussed, and the physical and mechanical properties are also considered. The treatment is elementary, and is hardly full enough to help those engaged in research, but it is sufficient for students to obtain some knowledge of the methods of determining the constitution of alloys. No attempt is made to set up a complete classification of alloys based on their constitution, but perhaps this need not be regretted when the artificial aspect of some of the previous attempts at classification is remembered.

The second part of the book contains the special study of certain alloys, and is intended to show by concrete examples how the general methods have been applied in practice, and what results have been obtained. There is no attempt to make this part complete by describing all alloys, the author referring the reader to Guillet's book, "Les Alliages métalliques," published in 1906, for details of those alloys which he has omitted to mention. However, Prof. Cavalier has chosen his examples from alloys presenting some industrial interest, and has passed in review most of the important groups. He has contented himself with a single example of each case met with in a systematic study, arranging his material as far as possible in the order of increasing complexity. Thus the simple case of alloys of gold and silver is taken first. The more complicated diagrams of equilibrium assigned to lead, tin and antimony are next dealt with, and these are followed by the brasses and bronzes, in which so many solid solutions occur. The relation between constitution and useful properties find a striking example in the antifriction alloys, and the iron-carbon alloys, of which the practical importance is fundamental, present difficulties in their study owing to the existence of a labile system, and are taken last.

In the section devoted to special steels the method of describing only a few typical alloys is discarded, and a catalogue of the steels is given with their composition and properties, as if a comprehensive book of reference were being written.

The faults of the book are the faults of a university professor when dealing with a practical subject. As soon as works-practice is touched on, the information is not to be trusted. Thus, in the chapter on the preparation of alloys, a somewhat misleading diagram is given of a melting furnace for crucibles, and the statement is made that the maximum charge for a crucible in such a furnace scarcely exceeds 100 kilograms. To show the inexactness of this, it is enough to mention that at the Royal Mint crucibles containing more than 180 kilogrammes of standard silver have been in use for many years, and even larger crucibles are used in mints abroad.

The merits of the volume have already been sufficiently indicated. It is a pleasure to read the book. It can hardly fail to fascinate many of the students into whose hands it will come as a task, and it will be useful to those engaged in the industries as an aid in understanding the numerous articles and papers on alloys which appear in scientific periodicals every day.

T. K. R.

OPEN-AIR STUDIES AT HOME AND ABROAD.

(1) *The Young Naturalist*. A Guide to British Animal Life. By W. P. Westell. Pp. xv+476. (London: Methuen and Co., 1909.) Price 6*s*.

(2) *Nature*. By J. H. Crawford. Pp. x+242. (London: Swan Sonnenschein and Co., 1909.) Price 5*s*.

(3) *Victorian Hill and Dale*. A Series of Geological Rambles. By Dr. T. S. Hall. Pp. x+160. (Melbourne: Thomas C. Lothian, 1909.) Price 3*s*.

(1) THE distinguishing feature of this survey of the British fauna is its comprehensiveness. With the exception of marine fish, there is no large order that does not come in for comment. The mammals, birds, fresh-water fish, and Lepidoptera—the most popular groups—are allotted most space, and are evidently more familiar to the author than the remainder. In spite of certain drawbacks, of which we shall have something to say, this book is a most suitable handbook for a boy or girl who is interested in animal life. The contents are arranged in ordinal fashion, and no attempt is made to deal with the associations of animals characterising field, moor, or lake, nor are there practical suggestions for the capture, maintenance, or preservation of specimens. There are, however, accounts of the habits and distinctive features of the commoner British animals that should be read with interest by young naturalists, and the wealth of clear photographs makes the book a most attractive one.

In dealing with the more familiar orders, the author's observations are evidently based on personal observation, but one can scarcely hope to extend this enviable acquaintance to all the groups, and accordingly there are occasions when the experience of others has to be drawn upon. Unfortunately, in these instances the authorities relied upon by Mr. Westell are not unimpeachable, and have been the cause of several misstatements. Thus, on p. 456, in speaking of the severing of a limb or part of the body, the author concludes, "This is known as autonomy." We can hardly believe the author responsible for mistaking the second "t" for an "n." But in other cases the authority is clear. On pp. 291–5 there is a description of the structure and life of fish that bristles with misleading or inaccurate statements:—"the fish's gills are its lungs"; "a fish need only open its mouth and the water pours in"; "the heart has two cavities"; "the fins along the back and the stomach are especially useful in keeping the body upright"; "probably the sense of taste and touch are only very dull"; "fishes (with one or two exceptions of tropical fishes) are hatched from eggs which are laid by the parent in very large number." Why the author should have trusted to such information instead of going to first-hand authorities we do not understand. The account of the mollusca contains several mistakes. Pearls are said to be due to "a grain of sand or other hard substance. Cephalopods "have no outside shell, the principal eight-armed Cephalopod is the Argonaut or Nautilus." This confusion is rendered still more distressing by a later note (p. 439), in which the "Paper Nautilus or Argonaut" is called "Nautilus pompilius," whilst the shell of the "common Nautilus" is figured and described as a distinct structure. There is a similar confusion between the acorn barnacle and Lepas, the goose-barnacle. The nomenclature, in fact, is inconsistent. On p. 49 the Linnean system is justified, and yet throughout the book confusion is continually arising through the want of its use. What are flat burying beetles or museum beetles? What is the Noonday Fly? Even Mr. Westell seems to become confused by this absurd nomenclature, for he tells his readers to look for the "brine shrimp" in the sea; and evidently believes in some abstraction called the *real* shrimp (p. 316). But for thorough confusion of thought, take the statements that the Brittle Star "ably practises (*sic*) this remarkable habit (of fragmentation) for it casts away in regular and methodic manner certain parts of its body during its early life," or this one of the house fly, "accused often unjustly of disseminating disease, it seems that according to Sir James Crichton Browne, there is much truth in a good deal of what has been stated."

The style of the author really needs a little chastening. "Vasty deep"; "Denizens of the deep"; "I having made observations upon the insects but not them upon me" (p. 423); "despite the hue and cry which one hears so frequently as to the dense human population that this country harbours," p. 169 (as though humans were a kind of vermin), are a few expressions that should have been cut out. We know how easy is the task of picking out weak places in the work of others, and direct attention to these flaws in a very useful book in the hope that a new edition (which certainly ought to be called for) may be even better than this one. References might then be given, in the text, to the attractive illustrations. This is a very necessary, even an essential matter, for the adder, *e.g.*, is figured on p. 20, and the description of it is not given until p. 276, where no reference to the foregoing figure occurs. The same dislocation of figures occurs in many groups.

(2) Mr. Crawford is an impressionist, and one who shares the Wordsworthian spirit. In these slight word-pictures of east-coast scenery he sketches, in a very dainty and observant fashion, the picturesque features of animal life as seen against the varying background of nature's moods. He believes, and reiterates his belief in, the value of our response to such beauty. He is an artist.

"We think in pictures. We recall in pictures. We remember more than we see. With this aid, to evolve our artistic sense were easy, to add a touch of imagination were not hard. Thus, simply, might the world be made to seem beautiful and life be filled with gladness."

These essays will perhaps not add to Mr. Crawford's reputation, but they will certainly not detract from it.

(3) This little book is mainly a reprint of articles on the geology of Melbourne and neighbourhood contributed to the *Melbourne Argus*, but also includes a survey of the strata round Port Phillip Bay and up country to Ballarat and Bendigo. The bedrock, of Silurian age, is characterised by rough, dark-barked gum-trees, and is economically of great importance for the making of pottery and bricks. The wearing down of this rock has produced the gravel beds in which the gold of the bedrock is found. These gravel beds have also their characteristic flora, the grass-trees. Intersecting these are granitic rocks which have weathered out, and support a flora of native cherries, white-barked gums, and other trees. The vast blue-stone plains have been formed by eruptions of lava emerging through the bedrock, and are distinguished by their grassy, treeless appearance. In addition there are glacial beds in many districts, and cinder beds in a few others, supporting dense forest and forming rich farm land. The descriptions are very clear, and are illustrated by good photographs.

ELECTROMAGNETIC THEORY.

(1) *Anfangsgründe der Maxwellschen Theorie, verknüpft mit der Elektronentheorie.* By Franz Richards. Pp. ix+245. (Leipzig: B. G. Teubner, 1909.) Price 7 marks.

(2) *The Theory of Electrons, and its Applications to the Phenomena of Light and Radiant Heat.* By H. A. Lorentz. Pp. iv+332. (Leipzig: B. G. Teubner; London: David Nutt and Williams and Norgate, 1909.) Price 8 marks.

(1) THE first of these volumes deals with the foundations of Maxwell's electromagnetic theory. The author is careful to point out that it is not a text-book, but a sketch based on lectures delivered to teachers. For this reason the treatment differs somewhat from what may be regarded as the normal method of presenting the subject to students; although in a branch of physics which appeals to a comparatively limited class, it may be doubted whether there are satisfactory grounds for introducing preferential treatment.

At an early stage the author shows how the two fundamental "circuital relations" are connected by means of the principle of least-action. This is an excellent feature, and the proof would probably have produced greater impression had some definite physical picture, such as that adopted by Larmor, been introduced.

In succession, the author treats of static effects in non-conductors, of conduction, and of magnetic effects of currents. The introduction of Stokes' theorem, which is delayed until this stage, might, with advantage, have been introduced much earlier.

Induction is next discussed, and finally there is a chapter on electromagnetic waves, which closes with a brief and rather imperfect treatment of metallic reflexion.

As a whole the book is somewhat disconnected, but it ought to be judged as a collection of monographs, and from this point of view the treatment is clear and good.

(2) Lorentz' book deals with the latest development of the electromagnetic theory. It contains a series of lectures delivered in Columbia University, New York, in 1906, and will be welcomed as his latest views on a subject which owes its origin and much of its development to Lorentz himself.

There are five chapters and a section of notes, which give calculations too elaborate to be included in the text. Chapter i. treats of general principles and the doctrine of free electrons. It is to Lorentz that we owe the view that the free æther is to be regarded as at rest, and that hence phenomena in it are governed by the two "circuital" and the two "solenoidal" equations of Maxwell.

At discrete points we may have electrical singularities characterised by a certain density. The effect of this at those points is simply to make the electric divergence equal to the density, instead of nil, and to add to the displacement current, a portion due to convection of amount equal to the product of density and velocity. At other points in the æther the effects are sufficiently included in the four fundamental equations. It is of importance to notice that this specification imposes a limitation on the internal character of an electron. Thus if an electron is defined as a shell with a surface charge of electricity, its interior must, on the basis of Lorentz' equations, consist of nothing but æther. The limitation carries important consequences, such as prescribing surface conditions.

In this chapter the author discusses the question of electric inertia on the basis of Kaufmann's experiments; but as he again takes up the question more fully in a later chapter, it will be convenient to reserve our observations.

Chapter ii. is devoted to the question of radiation and absorption of heat. Those who have followed the interesting discussion on this matter in the *Physikalische Zeitschrift* recently, will not be surprised to find that Lorentz devotes some space to the question whether the æther and the radiating body, supposed to consist of electronic radiators, can be regarded as a system to which the law of equipartition of energy can be applied. The result of such an assumption is in flat contradiction to observation. As the law of equipartition has never been proved for purely dynamical systems, and is probably not in general true, it is not surprising that it fails when applied to the æther.

The Zeeman effect is discussed in chapter iii., and the author is chiefly concerned in showing how little progress has been made in elucidating the phenomena, and how much knowledge of atomic structure we may reasonably hope to gain from study of the facts.

The electron theory of dispersion is next dealt with. Probably most readers will regret that the author has not found it possible to enter more fully on the problem of the optical properties of metals.

Optical phenomena in moving bodies forms the subject of the last chapter. The explanation of Fresnel's hypothesis on an electromagnetic basis is one of the most important results contributed by Lorentz to optical theory. The explanation of the result of the Michelson-Morley experiment and of the double refraction experiment by Lord Rayleigh and Brace, forms most interesting reading. The hypothesis of a contracted electron is introduced, and with it the question of electric inertia is again raised. The chapter closes with an exposition of Einstein's principle of relativity.

The book is a most fascinating one, and to those acquainted with Lorentz' former memoirs, it is unnecessary to say that it is written with a lucidity that characterises a master hand.

We venture to offer some observations on the view that negative electrons possess an inertia which is entirely of electric origin. It appears to us that the proof requires considerably more support, both on the experimental and on the theoretical side, than it has yet received.

For many purposes it is unnecessary to define an electron further than to say that it possesses a charge. But when we come to the question of inertia we have to define the size and shape of the electron. Surface conditions are, of course, determined by the fundamental equations. We confine attention to the two cases considered by Lorentz, viz., the "rigidly" electrified sphere of Abraham and the contracted electron of Lorentz. It has been claimed that Kaufmann's experiments agree with the spherical electron formula and the view that the ordinary inertia is *nil*. As a matter of fact, his experiments agree very much better with the contracted electron formula, but make the ordinary inertia quite comparable with the electric inertia for slow speeds. Bucherer's experiments also agree with the contracted electron formula, and make the ordinary inertia *nil*, but the speed was not so high as in Kaufmann's experiments. On the theoretical side it must be remembered that both formulæ are derived from the energy of the steady state, using the "quasi-stationary state" principle. This principle has been acknowledged as quite unsound, and it must in general lead to false results, when, as in the present case, any change of velocity is attended with radiation into the medium. We have reason to believe that any change of velocity is accompanied by a redistribution of the charge on the electron, and this in general leads to an expression for the inertia which differs from that obtained by differentiating the energy of the steady state.

We may well hesitate to sweep away the last scrap of ordinary matter from an electron until the proof rests on some principle more convincing than that of the quasi-stationary state.

OUR BOOK SHELF.

Handbook of Marks on Pottery and Porcelain. By W. Burton and R. L. Hobson. Pp. xii+210. (London: Macmillan and Co., Ltd., 1909.) Price 7*s*. 6*d*. net.

THIS volume supplies a distinct want. Mr. Burton is a practical potter, and the author of numerous works on the history of pottery and porcelain. Mr. Hobson is on the British Museum staff, and there are few men with greater chances of seeing and studying examples of all periods of pottery. The authors, therefore, speak with authority on subjects connected with ceramics, and although they style it a "reliable pocket volume," it is really a valuable and interesting addition to the bookshelves of collectors and students of pottery. Thousands of authentic marks will, of course, not be found in the volume, but those chosen are, on the whole, thoroughly representative, and the elaborate indices make the work of reference easy.

It is interesting to note the influence that one factory had on another, as shown by the marks. The Meissen factory was the father of European porcelain. The Cross Swords from the arms of Saxony, which was used there as their mark, can be seen in Caughley Tournay, Worcester, Derby, and Bristol. Even Meissen itself had in its early days, like so many other factories, marks in imitation of the oriental.

The short descriptions and the introduction are models of Precis writing, giving in a page or two the history of potting in each country. There is a little confusion in the use of the terms "hard and soft." Hard paste is fired at a high temperature, and the glaze is fired at the heat at which the porcelain matures. Soft paste, on the other hand, is fired at a lower temperature, and the glaze at a still lower one. The terms hard and soft have nothing to do with the hardness and softness, as usually understood. So far as the body of the piece of ware is concerned, some hard paste may scratch with a file more easily than soft.

The Oriental section is particularly good. It displays very great care, and is a decided advance on anything of a similar kind that has been within the reach of an ordinary collector.

The scheme of the work takes the reader through the various countries, and the period covered extends from the Middle Ages to about 1850, with a selection of modern marks. It is a very great advantage to have the authors' assurance that none but undoubted marks are illustrated in the volume. Great care seem to have been taken with the dates also, but on page 33 the A. R., the cipher of Augustus of Poland, the patron of Bottger, is given by the author as 1725–40. Most authorities, and with reason, place this mark considerably earlier.

The Races of Man and their Distribution. By Dr. A. C. Haddon, F.R.S. Pp. x+126. (London: Milner and Company, Ltd., n.d.) Price 1*s*. net.

THIS book gives a description of the various races of mankind as complete as appears to be possible within the compass of a small volume. The physical characters and culture of each race are described as far as it is at present known, and the author has in many cases to confess that the knowledge is, as yet, very incomplete. In the general classification of mankind the character of the hair is taken as a primary feature. The three great divisions of mankind obtained in this way are subdivided according to stature or the shape of the head. Whether this is the ideal method of classification or not, it serves as a basis for the orderly description of the various known races. The description of the supernatural beliefs, weapons, houses, &c., of the Oceanic peoples is especially full and complete.

The latest views on the African races and their relations to each other are clearly set out. The native races of Asia are described, though an unduly large proportion of the treatise appears to be devoted to Indian races. The description of European races is comparatively superficial. So little appears to be known about the physical characters of the native races of the American continent that the author adopts a geographical classification, which makes it somewhat difficult to realise the physical relations of these races to each other. Some of Dr. Haddon's views on the relations of races to each other would be disputed by the latest authorities; for example, the view that the Tasmanians belonged to the same race as the Papuans would hardly, we think, be accepted by Prof. Sollas.

There are ten plates of representative members of leading races, and a very useful glossary of ethnological terms at the end of the book. The value of the book to a beginner in ethnology would have been considerably enhanced if it had contained a few maps. This little book is a welcome contribution to anthropological literature, and contains much valuable and accurate information not otherwise easily accessible.

(1) *Der menschliche Organismus und seine Gesunderhaltung.* By Dr. A. Menzer. Pp. 159. (Leipzig: Quelle and Meyer, 1909.) Price 1.25 marks.
(2) *Unsere Sinnesorgane und ihre Funktion.* By Dr. E. Mangold. Pp. vii+147. (Leipzig: Quelle and Meyer, 1909.) Price 1.25 marks.
(3) *Die moderne Chirurgie für gebildete Laien.* By Dr. H. Tillmanns. Pp. iv+156. (Leipzig: Quelle and Meyer, 1908.) Price 1.25 marks.
(4) *Die Geschlechtskrankheiten, ihr Wesen, ihre Verbreitung, Bekämpfung und Verhütung.* By Prof. Schumburg. Pp. vi+102. (Leipzig: B. G. Teubner, 1909.) Price 1.25 marks.

THESE four little books are examples belonging to two series of publications, which embrace a number of works on religion, philosophy, literature, art, history, geography, science, &c. They give a clear, concise and popular exposition of the various subjects with which they deal. From our insular standpoint in some instances certain subjects are discussed in a more open manner than we are accustomed to.

In the first book on the list, after a brief description of the anatomy, histology, and physiology of man, the various subjects of the causation of disease, infectious diseases, clothing, food, and general hygiene are simply and adequately described.

In the second book, the various organs of the special senses, sight, hearing, smell, taste, and touch, are described, and the mechanism of their action, so far as is known, is detailed. In "Modern Surgery" the reader is introduced to surgical theory and practice as regards the Röntgen rays, anæsthesia, arrest of hæmorrhage, sterilisation and antiseptics, preparation for operation, microorganisms, and their relation to disease, inflammation, burns, wounds, cancer, &c. The book would form an excellent little text-book for nurses.

The fourth book deals in a very outspoken manner with the subject of venereal diseases, their consequences, spread, and prevention. The diseases are briefly described, the various measures of prevention detailed, and the social evils of prostitution and their remedy are discussed. We should consider it hardly advisable to place such a book in the hands of the general educated public, unless the reader had actual need to study the question with which it deals. All the books are clearly printed and freely and adequately illustrated.

R. T. H.

Plant Galls of Great Britain. A Nature-Study Handbook. By Edward T. Connold. Pp. xii+292. (London: Adlard and Son, 1909.)

THIS volume will certainly prove to be of great use to all students of insect and plant life. The author's previous works, viz., "British Vegetable Galls," published in 1901, and "British Oak Galls," published in 1908, are already well known. The present book is intended for the pocket as a guide in the field to botanists and collectors. The descriptions are condensed and brief, but Mr. Connold has not forgotten the value of good illustrations, and each description is accompanied by an excellent and typical photograph of the gall described. As the author points out, the systematic study of all British plant galls is as yet by no means complete. The subject offers a wide and interesting field for further research. This volume is well adapted to create an interest in these interesting vegetable structures, and to encourage the beginner to pursue his studies further.

The opening chapters give ample directions as regards the time when, the place where, and the manner how, to collect and study the various galls. The gall-producers, their habits and the principles of gall formation, are also adequately dealt with.

The list of English and Latin names of the host plants mentioned in the volume will be found of great use in the field. The various nomenclatures are becoming a vexed question, and a useful list of synonyms of gall producers has, therefore, been included, and at the end a very full index is given. The book cannot fail to serve its purpose as a field companion for the practical student of nature.

The Rhodesian Miner's Handbook. By F. P. Mennell. Second edition. Illustrated. Pp. 167. (Buluwayo: Ellis Allen, 1909.) Price 5*s*.

THIS is the latest of a series of books issued from the Rhodesia Museum. They are presumably intended to interest and instruct the settlers in the country, and to promote the prosperity of the industries of Rhodesia. Looked at in this light it may be that the book under review was well worth producing, and will be useful to its readers, but it is of little interest except to a prospector who has had no scientific training. It contains chapters of an elementary character on geology, mineralogy, ore deposits, prospecting, &c., and a quantity of miscellaneous information as to the present condition of the mining industry in Rhodesia. This is divided into sections, under the heads of precious metals, base metals, precious stones, and coal. The relative importance of the industries is indicated by the fact that in 1907 the gold represented nearly 94 per cent. of the total mineral production, and amounted in value to 148*l*. 15*s*. per head of the white population, as compared, for example, with about 100*l*. per head in the Transvaal, and 26*l*. per head in Western Australia.

Los Métodos de Integracion. By Carlos Wargny. Pp. 234. (Santiago de Chile: Cervantes, 1907.)

IT is interesting to find that Spanish students in Chile study the integral calculus: otherwise this compilation calls for no special remark. It contains a collection of elementary examples of indefinite integration, many of which are worked out in elaborate detail. On pp. 128–9 Gregory's series and the expansion of arc sin x are given, without proper indication of the limits of the integrals from which they are derived.

LETTERS TO THE EDITOR.

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

The Temperature of the Upper Part of Clouds.

At the recent meeting of the British Association, a report of which appeared in NATURE of October 14 (p. 473), Prof. A. L. Rotch gave an account of the highest balloon ascent in America. It is stated he found the remarkable result that on at least two ascents the temperature increased in a cumulus cloud in passing upwards. It is stated that during the discussion of the paper doubt was expressed as to the reality of the phenomenon. The first thing that strikes one on reading Prof. Rotch's result is that it seems rather curious that this phenomenon had not been recorded in previous ascents. When one considers the conditions, it is only what might be expected. The upper part of the cloud is receiving and dealing with the whole solar radiation falling on its surface, as none of it passes through it. Some of this heat penetrates some distance into the cloud, where it undergoes repeated reflections from the cloud particles. One would thus expect that the cloud particles and the saturated air would absorb some of the heat and have their temperature raised, though probably the greater part of the heat is reflected into space.

There is, however, a point to which I wish to direct attention, and that is to the extreme difficulty of getting anything like correct records of temperature and humidity in the conditions existing at the top of cumulus clouds. On one occasion, while making observations on Pilatus Kulm, the top of the mountain being at the time in dense cloud, but evidently near its upper limit, part of the observations consisted in taking readings of wet- and dry-bulb thermometers, but under the conditions it was found to be very difficult to get trustworthy results. All sorts of abnormal and contradictory readings were at first obtained, even to the wet-bulb reading higher than the dry. A few observations of the surroundings cleared up the difficulties. To begin with, one felt as if in an oven. Radiant heat streamed in from every direction, though no sun was visible, not even the direction of it. An examination of the surfaces of surrounding objects showed them to be in a very abnormal condition, though in the midst of dense cloud many of them were perfectly dry, not the usual dripping condition. The heat reflected from the cloud particles was absorbed by the surrounding objects, and their temperature raised far above the dew point. For instance, a thermometer placed on a large piece of wood showed a temperature of 60° F., while if hung up near it only rose to 48°.

Under the conditions the diffused radiation acted on all surfaces and raised their temperature, but, of course, did not raise them all to the same amount, large bodies, as is well known under these conditions, being much more highly heated than small ones. For instance, ordinary pins driven into a wooden post for hanging the thermometers on got wet, while the post was quite dry. All other freely exposed small objects were wet, and all large ones dry. It was while the thermometers were hung on the post that the wet bulb read higher than the dry, the reason being that the dry was not really dry, but had a film of water over it; and it was colder than the wet bulb, because it was a little smaller, and the wet had also the advantage of a better heat-absorbing surface in its muslin covering. The wet- and dry-bulb temperatures could only be obtained after they had been properly protected from all radiation. In ordinary cloud observations no such protection is required.

As bearing on the question of the heat absorbed by clouds, it may be mentioned that while the observations were being made on Pilatus Kulm the atmosphere was in a constant state of boil, so to speak. Vertical currents were constantly surging up on one side or the other, though there was no wind. These vertical currents were probably due to the disturbing effects of the absorbed heat, and they seem to suggest that this heated upper part of the cloud may explain the formation of those pillar-like clouds sometimes seen rising from sunlit cumulus by the hot part breaking away from the body of the cloud and rising high above it.

JOHN AITKEN.

Ardenlea, Falkirk.

Lines of Force and Chemical Action of Light.

THE fact that carbon dioxide is dissociated at the low temperature of the surrounding medium, when green organs of plants are exposed to sunlight, has been often considered as somewhat paradoxical. Count Rumford was the first who tried to account for it by suggesting that this process takes place in spaces so small that the temperature produced by the absorption of light may approach the highest temperatures obtainable in our laboratories. More recently I tried to adduce in support of this ingenious interpretation some considerations, derived from the experimental study of the actual conditions of this photo-chemical process.[1] Still more wonderful is the possibility of its going on, though very slowly, in diffused sunlight. But perhaps in the whole range of photo-chemical phenomena there is no fact more wonderful than the possibility of obtaining photographs of the remotest star or nebula.

All these photo-chemical riddles seem to me to find their full explanation in Sir Joseph Thomson's theory,[2] so eloquently expressed in his recent presidential address to the British Association at Winnipeg.[3]

If "a wave of light may be regarded as made of groups of lines of electric force," if "in the wave front there cannot be uniformity," and "it must be more analogous to bright specks on a dark ground than to a uniformly illuminated surface," then it becomes evident that the chemical effect of light on a single molecule cannot fall off in the same ratio as the dispersion of light in space. A single molecule lying in the path of a line of force may be, with regard to the distant sun or star, in the same condition as another molecule in the nearest proximity of these centres of energy. It will be only the number of molecules attacked that will be reduced with the increasing divergence of the lines of force, and this result can be compensated by prolonging the exposition. It seems to me that Sir Joseph Thomson's theory furnishes for the first time a real explanation for the fact that a ray of light is not deprived of its photo-chemical efficiency, no matter how great the distance between the source of energy and the molecule acted upon.[4] These considerations may give us perhaps a deeper insight into the part played by radiant energy in the chemistry of the universe than we possess until now.

A full discussion of the problem would require, of course, something more than the very modest scientific equipment of a botanist, and I should be very grateful if a more competent reader of NATURE would find it worth while to decide the question whether the conclusions here deduced are really consistent with Sir Joseph Thomson's theory.

University, Moscow. C. TIMIRIAZEFF.

The Position of the Radio-active Elements in the Periodic Table.

MANY arrangements have been suggested, which include the radio-active elements in the periodic table. So far as I am aware, these have all attempted to confine each space in the table to a single element. This restriction has led to unlikely assumptions, on account of the large number of these elements, and the limited number of spaces vacant preceding uranium.

From analogy with organic compounds it seems possible that different internal structures of the atoms of the heavier elements may exist, resulting in elements of the same weight with perhaps very different properties. Similarly,

[1] In my Croonian lecture on "The Cosmical Function of the Green Plant" (Proc. Roy. Soc., vol. lxxii., p. 454).

[2] "Electricity and Matter." (1903.)

[3] NATURE, August 26, p. 253.

[4] For instance, it seems to me that the following lines, though referring to photo-electric, may be as well applied to photo-chemical phenomena: ". . . thus any effect which can be produced by a unit by itself will, when the source of light is removed to a greater distance, take place, less frequently it is true, but when it takes place it will be of the same character as when the intensity of light was stronger." Sir Joseph Thomson, "On the Ionisation of Gases by Ultra-violet Light, &c." (Proceedings of the Cambridge Philosophical Society, vol. xiv., part iv., p. 421).

elements with very nearly the same weight might possess very similar properties. This would allow the truth of the following table, in which only three assumptions are made.

(1) It is possible that two elements of nearly the same atomic weight may occupy the same place in the table.

(2) The emission of an α-particle is accompanied by the production of an element which occupies the adjacent space of lower atomic weight.

(3) The emission of a β-particle, or a rayless change, may or may not be accompanied by a remove to a space of lower atomic weight.

In the table the elements which emit α-particles are printed in thick type, the other radio-active elements in italics.

depends, of course, on the *specific* physical and chemical properties they possess. These are often none too well defined. The mechanism of a rayless change, or one accompanied by the emission of a β-particle, may be compared with a change of frequent occurrence with organic compounds, the formation of one desmotropic substance from another under the influence of heat.

It must be remembered that should the conclusions be correct which are drawn from the recent work of Ramsay and Gray on the boiling point and critical constants of radium emanation, and should the atomic weight of 176 be confirmed, not only are the above arguments invalidated, but the whole theory of disintegration put forward by Rutherford and Soddy will require modification.

University College, London. A. T. CAMERON.

								H 1
He 4	Li 7	Be 9	B 11	C 12	N 14	O 16	Fl 19	
Ne 20	Na 23	Mg 24	Al 27	Si 28	P 31	S 32	Cl 35·5	
Ar 40	*K* 39	Ca 40	Sc 44	Ti 48	V 51	Cr 52	Mn 55	Fe 56, Co 59, Ni 59
	Cu 64	Zn 65	Ga 70	Ge 72	As 75	Se 79	Br 80	
Kr 83	*Rb* 85·5	Sr 88	Y 89	Zr 90	Cb 93·5	Mo 96	Np? 100?	Ru 102, Rh 103, Pd 107
	Ag 108	Cd 112	Am 115	Sn 119	Sb 120	Te 127·5	I 127	
X 131	Cs 133	Ba 137	La 139	Ce, &c. 140–178	Ta 181	W 184		Os 191, Ir 193, Pt 195
	Au 197	Hg 200	Tl 204	Pb 207	Bi 208 ←**RaF**←*E_2*←*E_1*←*D*	?←*Act C* ←**Th C** ←**Ra C**←*Ra B*	←**Act B**←*A* ←**Th B**←*A* ←**RaA**	
←**Act Em** ←**Th Em** ←**Ra Em**	←**ActX′** ← ←**ThX** ← ←	**Radio-Act** ← **Radio-Th** ← **Ra** 226·5 ←	*Act* *Mesoth.2*←*1*← **Ionium** ←	**Th** 232·5 *UrX*	←**Radio-Ur?**	**Ur** 238·5		

In considering this table, if we assume that Rutherford and Soddy's theory, that the loss of an α-particle is accompanied by a corresponding decrease of 4 in the atomic weight, is correct, it seems certainly necessary to confine radium and radio-thorium to the same space in the table. They are both members of the barium series. The atomic weight of radium is 226·5, while that of radio-thorium must be $(232{\cdot}5-4)=228{\cdot}5$. Similarly the thorium and radium emanations resemble each other so closely that it is legitimate to suppose that they occupy the same space. They condense at almost the same temperature, while their rates of diffusion into other gases are very nearly the same. If one case is admitted, the whole is rendered probable. The evidence with the actinium series is not so positive, but the present arrangement satisfies the known facts.

It may be pointed out that there are three α-emitting elements between radium emanation and lead, and only three spaces in the table, and two α-emitting elements between thorium emanation and bismuth, with two spaces corresponding; lead and bismuth were suggested by Rutherford and Boltwood as the respective end-products of these series. Again, it may be emphasised that the anomalous existence of the group of rare earth metals, giving a difference of more than 40 in the atomic weight of the elements which precede and follow them, explains the change of the difference between two elements of a vertical series from about 46 to nearly twice that figure, so that no element of the argon series is to be expected between xenon and one with a weight about 220. *Except in the two spaces in the vertical series below manganese,* and possibly in the rare earth series, *there is no vacant space in the periodic table between hydrogen and uranium.* In this connection it is interesting to recall the suggestion of R. W. Wood (Astrophys. Journ., 1908, vol. xxviii., p. 75), that the green line in the spectrum of the sun's corona is the fluorescent line of some common element, and that the supposed element "coronium" of weight less than hydrogen does not exist.

It is possible that other β-emitting or rayless elements may be discovered. How far these are really *elements*

Radio-activity and the Rocks.

IN the course of some observations which I have recently made with regard to the pleochroic halos sometimes seen round inclusions in various rock-forming minerals, certain points have suggested themselves as possibly of considerable significance. It may be premised that Prof. Joly's suggestion that the halos are due to the α rays emitted by radium appears fully borne out by their remarkable constancy in size and by the fact that they are invariably connected with minerals independently known to be strongly radio-active, that is, comparatively speaking. The only qualification that need be made respecting this view is with regard to the possibility of radio-active substances other than radium producing the observed effects.

So far as my experience goes, the following minerals are capable of producing halos when enclosed in suitable substances like biotite, cordierite, hornblende, tourmaline, &c., zircon, orthite (allanite), epidote, sphene, and apatite. All these are silicates, except apatite, which is a phosphate. The last three are lime compounds, which does not, however, seem to be of any particular import. Zircon contains zirconium, orthite cerium and its allies, and sphene titanium, and it may be noted that orthite always contains thorium in some quantity, while both zircon and sphene may be expected, from a mineralogical point of view, to contain that element as an impurity. Epidote, being isomorphous with orthite, and frequently intergrown with it in rocks, the presence of some traces of thorium may also be generally presumed. As regards apatite, it is obviously significant that the other two phosphates which occasionally occur as rock-formers, namely, monazite and xenotime, always contain thorium in considerable amount; indeed, monazite owes its commercial value to the constant presence of that element. It would appear, therefore, as if the radio-activity of all the minerals cited might, unless other considerations are opposed to the idea, be fairly attributed to the presence of thorium.

There is, however, another feature of these minerals which may be of significance. It will be noticed that one or other of them contains all the elements grouped under carbon in series four of the periodic table, namely, titanium, zirconium, cerium, and thorium. Indeed, "carbonaceous matter" is itself recorded by Prof. Rosenbusch ("Rock-making Minerals," p. 197) as giving rise to pleochroic halos in andalusite. Of course, this might imply nothing more than that chemical similarity leads to similar impurities (*e.g.* thorium), to which the radioactivity may be due. It is not easy to see how such an explanation would fit the case of carbon, but otherwise it would readily account for the fact that halos are not always seen round the minerals mentioned above, and that they may occur round some crystals and yet not round others in the same rock. They are most common, indeed practically constant, round zircon and orthite, but are confined to a few occurrences of the abundant minerals sphene, apatite, and epidote.

Another point which seems to deserve emphasis is the fact that, from a geological point of view, the radioactivity of thorium must surely be a far more potent factor than that of uranium and its derivatives. For there is no mineral which occurs in ordinary rocks which appears to contain uranium in quantities appreciable by chemical methods, whereas, as will be inferred from what has been already said, thorium is of extremely wide distribution.

F. P. MENNELL.

Bulawayo, Rhodesia, October 18.

Magnetic Storms.

IN his letter (NATURE, November 11) Dr. Simpson raises an argument as to the absence of corresponding changes in the electrical potential gradient during magnetic storms which, if admitted, would, I imagine, prove a serious difficulty in the "electron stream" theory of magnetic disturbances. On the assumption that the arriving stream induces an opposite charge which resides at the earth's surface, we can agree with Dr. Simpson's calculation, except that, since there are two current sheets of opposite sign, the potential gradient ought to be half what he finds.

It seems to me most unlikely that the induced charge resides at the earth's surface. The atmosphere is slightly conducting, and it is throughout it that the induced charge distributes itself. It is well known that a very slightly conducting shell will with great rapidity act as a perfect electrostatic screen, but, on the contrary, fails to screen magnetic effects. In his paper (Phil. Trans., A, 1908) on terrestrial magnetism, Dr. Schuster points out that the normal conductivity of air at the earth's surface is about 10^{-24}, while at a height such that the pressure is 1 dyne per sq. cm. the conductivity would be about 10^{-18}. For such a conductivity the time constant of decay would be about 10^{-4} of a second, or, in other words, practically complete electrostatic screening would be established in about one-thousandth part of a second, and correspondingly the slight initial magnetic screening would then cease. We have thus a simple explanation of the absence of direct electrostatic effects at the surface of the earth due to "electron streams" several hundred kilometres above the earth. The earth currents which do accompany magnetic storms are thus referred, not to electrostatic induction, but to change of magnetic induction at the earth's surface.

GEORGE W. WALKER.

Eskdalemuir Magnetic Observatory, November 12.

The Photometric Measurement of the Obliquity Factor of Diffraction.

IN vol. lxxviii. of NATURE (May 21, 1908, p. 55) was published a note on "Secondary Waves of Light," in which I described the diffraction effects produced by an obliquely held rectangular aperture or reflecting surface, and pointed out that the observed distribution of illumination in the pattern was not in accordance with that deduced in the ordinary way. I indicated an explanation of the discrepancy, that it was due to the variation of the obliquity factor of diffraction within the limits of the pattern.

The interest of the observations lay in the fact that such an effect had never been noticed before, and that the observations enabled us actually to trace the variation of the amplitude of vibration from point to point on Huygens's secondary waves. A full description of the effect and a mathematical investigation were published in the *Philosophical Magazine* for January.

The effect observed was that the intensities of illumination in corresponding bands on opposite sides of the central band in the unsymmetrical pattern were unequal. A photometric investigation of this difference in illumination has been carried out. The method was to use revolving sectors to reduce the illumination in one of the two bands to be compared, so as to make them both of equal brightness. The following table illustrates the comparisons made:—

No. of expt.	Ratio of illumination according to ordinary theory	Ratio of illumination actually determined	Ratio of illumination calculated from obliquity
1	1·00	1·66	1·61
2	1·00	1·81	1·98
3	1·00	2·66	2·43
4	1·00	3·25	3·27

The obliquity law demonstrated by these measurements is that, in the hemispherical wavelets emitted by each element of a transmitting aperture or reflecting surface upon which waves are incident at any angle, the amplitude of the light vector is, at any point in the plane of incidence, proportional to the cosine of the angle made by the line joining that point and the element, with the normal to the plane of the element.

C. V. RAMAN.

Post-Box 59, Rangoon.

Mendelian Heredity: A Correction.

I SHOULD be glad of an opportunity of correcting the following errors in my book "Mendel's Principles of Heredity":—

On p. 35, Davenport's result regarding rumplessness in fowls is accidentally inverted. The character, according to him, is recessive, not dominant as stated by me. I have to thank Prof. Arnold Lang for this correction.

The other, and more serious, error is in the description of Fig. 34 of the second impression of the book (p. 231). In giving a tentative scheme for the descent of colour-blindness, I there stated that a male homozygous for colour-blindness could be produced by the mating of two colour-blind parents; but if the scheme is right, it evidently follows that such a male cannot be formed even from that mating.

W. BATESON.

November 12.

The Functions of the Martian Canals.

WITH reference to the recent paper by Dr. Pocklington before the Royal Society, on the functions of the Martian canals, a notice of which appeared in NATURE of November 11 (p. 58), I should like to suggest that these canals may perhaps be used for power-storage purposes. In Mars, possibly, there are seasons of winds or monsoons during which the upper reaches of the canals would be pumped full by innumerable windmills, and the power thus stored utilised during calm seasons, and transmitted electrically for lighting, heating, and general power purposes. For a population which had exhausted all its mineral fuel, which possessed no extensive ocean, and whose soil and climate were unsuitable for the growth of fuel, this would indeed appear to be the only means of obtaining heat and power. The same canals could serve the triple purposes of communication, power, and irrigation.

H. F. HUNT.

7 Officers' Row, Pembroke Dock, Wales,
November 13.

GRAVITY SURVEY.[1]

THE two publications described below afford a remarkable example of the value of an International Bureau worked in the right spirit and used in the right way. The sumptuous institute upon the Telegraphenberg at Potsdam is the home of the

1 "Survey of India: Professional Paper, No. 10. The Pendulum Operations in India, 1903–7." By Major G. P. Lenox-Conyngham, R.E.; with an appendix by A. Strahan, F.R.S. Pp. ix+196. (Dehra Dun, 1908.)
"Deutsche Südpolar Expedition, 1901–3." Band i., Geographie; Heft iii., Die Schwerkraftsbestimmungen der Deutschen Südpolar Expedition. By E. von Drygalski und L. Haasemann. Pp. 285–363. (Berlin: Georg Reimer, 1909.) Price 12.80 marks.

Prussian Geodetic Institute and of the Central Bureau of the International Geodetic Association. The same chief directs them both, and a visitor sees no obvious line of demarcation between the two. There is, however, no need to inquire minutely how much is Prussian and how much is international; the resources and experience of both are freely available when advice and cooperation are desired.

The last series of pendulum operations in India had been brought to a close in 1871 with the tragic death of Captain Basevi, who lost his life from exposure while working with the Royal Society pendulums at great altitudes in the Himalayas. When the Government of India resolved to undertake a new and more extensive series, they began by asking the advice of Prof. Helmert, chief of the Central Bureau. He recommended the use of half-second pendulums of the von Sterneck pattern, offered to obtain them from the makers in Vienna who had supplied the Potsdam instruments, and to standardise them at Potsdam. In 1902 Major Burrard and Captain Lenox-Conyngham went to Potsdam to study the use of the pendulums, and Prof. Haasemann, to whom the standardisation had been entrusted, gave up the whole of his time to their instruction. The pendulums were then swung at Kew and at Greenwich, were taken to India, and set to work; and, lastly, it was arranged that Dr. Hecker, of Potsdam, returning from his second "gravity-voyage," should join the Indian pendulum party wherever they might happen to be, and swing his Potsdam pendulums in India, to provide a final control of the circuit Potsdam—Kew—Dehra Dun—Potsdam.

The admirable results of this cooperation are visible on every page of Major Lenox-Conyngham's memoir. He started with an equipment already well tried. He could face the peculiar difficulties of Indian pendulum work with the confidence that he knew all about the ordinary troubles; and, by no means least, he can describe his work in a way which makes it perfectly easy to read in conjunction with German work, for they are written in the same language, though in a different tongue.

It is well known that an exceptional difficulty has embarrassed the survey of India for many years. How much does the enormous mass of the Himalayas and the Tibet plateau to the north, how much does the enormous deficiency of mass in the deep ocean to the south, affect the direction of gravity in India? India was the birthplace of Pratt's celebrated hypothesis of "compensation." The general principle, that an excess of matter above the sea-level is compensated by a deficiency of density below, has been established in the Caucasus and the Tyrol. The fact that gravity is normal, not deficient, over the deep oceans was strongly suggested by Faye when he showed that on solitary islands gravity is in excess by an amount corresponding to the mass of the island above the ocean floor; it has recently been established by Dr. Hecker's elegant application of Mohn's method—the comparison of the mercurial barometer and the boiling-point thermometer at sea.

Only in India has the establishment of the principle of compensation suffered a series of small reverses. Colonel Burrard's series of latitude determinations, published a few years ago, showed that a hidden chain of excessive density runs parallel to the Himalayas to the south, which very much complicates the situation. Major Lenox-Conyngham's pendulums confirm the existence of this chain, and bring to light a new feature—that between it and the Himalayas there is a "ditch" along which gravity is in defect; and, lastly, along the fringe of the mountains their attraction is by no means completely compensated. Five stations in the Himalayas and two in the Baluchistan hills were occupied. "At all these points a deficiency of density is revealed, but in no case does it amount to total compensation. . . . Under all the submontane and mountain stations there appears to be a deficiency which is nearly constant in amount, and is not proportional to the height of the station."

But these interesting results touch only the fringe of the Himalayas, and they are not to be taken as indicating a general failure of complete compensation for the mountain mass as a whole. Before this can be either affirmed or denied it will be necessary to get observations further north; and it is interesting to note that, as Major Lenox-Conyngham points out, it is more important to get well in among the mountains than to climb to excessive altitudes, where the conditions make accurate work almost impossible. Unfortunately, access to Tibet is forbidden to British subjects, including its own scientific servants, by the Indian Government; nor is it easy to disguise a pendulum equipment as a praying-wheel.

The technical details of modern pendulum work are highly interesting, in particular the correction for the flexure of the pendulum support. The present practice is a development of Captain Kater's method of the inverted pendulum initially at rest, which is set swinging by the motion of the stand. In its actual shape it is the invention of Prof. Schumann, of the Prussian Geodetic Institute. An auxiliary pendulum is mounted with its knife-edges parallel to those of one of the set; it has an adjustable weight on the bob by which the times of vibration can be made equal. If one is set swinging, the pull of its knife-edges on the agate plates will rock the stand and set the other swinging; over a considerable range the ratio of the amplitudes of the driven and the driving pendulum increases proportionally to the time, and a simple relation connects this ratio with the virtual increase in the length of the pendulum due to the flexure. It is thus a simple matter to determine the correction for flexure of the stand and pillar at each station, and a pretty illustration of the need of the correction is given by those series which were begun upon a concrete pillar newly cast, and show unmistakably the gradual stiffening of the pillar as the concrete hardened.

The pendulum observations are differential, and it is necessary to choose a base. Kew Observatory was selected, because it had been the base for the earlier Indian series, and the National Physical Laboratory gave valuable assistance in the observation of the base series and a re-determination of the constants of the pendulums for verification. At the suggestion of the Astronomer Royal, Greenwich was chosen as a secondary base. A remarkable feature of the report is the exhaustive appendix by Mr. A. Strahan on the geological strata underlying Kew and Greenwich, and their height above the "Palæozoic floor." With these refinements of observation and discussion the observed differences in the value of g at Kew and Greenwich become fairly accordant with the theoretical differences, and warrant the conclusion that "henceforward the pendulum may prove as satisfactory in practice as it has always been attractive in theory."

Dr. Drygalski's Antarctic expedition had the bad fortune to be frozen in just outside the Antarctic circle, and he was unable to reach Antarctic land. His pendulum operations were therefore confined to the island of Saint Vincent in the Cape Verdes, to Kerguelen Island, and to a station on the ice near the winter quarters of the *Gauss*. At the two former gravity was in excess, as is usual on oceanic islands; upon the ice it was nearly normal, which confirms the results of Dr. Hecker's recent determinations of gravity at sea. The observations on the ice were of the heroic order, from difficulty, not with the pendulums, but with the clocks. An ice pillar proved nearly as stable as concrete for the pendulums, but the chronometer stopped at a temperature of −35° C., and the clock was filled with snow in the rather inadequate observing hut. The clock was then removed to the ship and connected with the "flash box" by cable; but the ship heeled over in an Antarctic gale, and again the clock stopped. Finally, after six months' work, it was installed in an ice house, when it went creditably.

The discussion of the observations, largely due to Prof. Haasemann, is full of interest, but the interest lies, unfortunately, in the details of the struggle against adverse circumstances rather than in the wealth of results. It is much to be regretted that Dr. Drygalski's pendulums failed to reach land within the Antarctic circle, for it may be long before so complete an equipment and so accomplished an observer travels again to that sector of the Antarctic.

A. R. H.

A NEW OCEANOGRAPHICAL EXPEDITION.

THE *Times* of November 9 announces the organisation of an important expedition for the investigation of the eastern part of the North Atlantic Ocean, with a possible extension westward to Newfoundland. By an Order in Council, dated October 16, his Majesty the King of Norway has granted permission, subject to certain conditions, for the Norwegian Government steamer *Michael Sars* "to be placed gratuitously at disposal for a scientific expedition in the Atlantic Ocean from the Canary islands to the Færöes, in the spring of 1910, proposed by a British subject, Sir John Murray," and also for "the Fishery Director, Dr. Hjort, Assistant Koefoed, and Mr. Helland-Hansen, as well as the ship's captain and engineer . . . to take part in the expedition while continuing to draw their salaries."

The *Michael Sars* is to sail under the Norwegian flag during the expedition, which is to extend over not more than four months, and Sir John Murray has undertaken to pay all expenses not provided for by the Order in Council.

The chief purpose of the forthcoming expedition, which must necessarily contribute results of first-rate importance to the science of oceanography, is to apply the new instruments and methods of research developed during the last few years, more particularly by the International Council for the Study of the Sea, to the deeper regions of the open ocean. It is believed that the use of large nets and trawls is practicable in deep water, and that, should this prove to be the case, zoological discoveries of great interest and importance will be made. The application of methods of high precision to the determination of the temperature and salinity of sea water has yielded results which have raised considerable doubt in the minds of some investigators as to the validity of the earlier observations made by the *Challenger* and other expeditions, and the cruise of the *Michael Sars* should not only afford much entirely new information, but provide a means of valuing the earlier work. Specially valuable data may be expected from the use of Ekman's new current-meter, which makes it possible for the first time to obtain direct measurements of the currents in the depth.

THE REV. W. H. DALLINGER, F.R.S.

IN the history of "Protozoology"—a department which has advanced of late so rapidly that it has journals, laboratories, and professorial chairs devoted to it—an honoured place, in one of the earlier chapters, must be given to the late Dr. Dallinger, for to him and to his fellow-worker, the late Dr. Drysdale, we owe the first complete record of a complex Protistan life-history, and at the same time a fine example of careful investigation.

William Henry Dallinger was born in 1842 at Devonport. He entered the Wesleyan ministry in 1861, and travelled various circuits, much esteemed as an impressive and weighty preacher. A serious illness is said to have driven him from theology to biology, for in his convalescence he took up the study of open-air natural history, and became fascinated with microscopic work. In 1880 he was appointed principal of the Wesley College, Sheffield, but he resigned this position in 1888 to devote himself more exclusively to scientific work, the Wesleyan Conference allowing him to retain his status and prerogatives as a minister, though without pastoral charge or any other office. Dallinger did much effective work as a lecturer on the staff of the Gilchrist Educational Trust, and his popular lectures on such subjects as "The Infinitely Little," "An Hour with the Microscope," and "Spiders," were models of clear exposition. He had a vivid and careful style, and give his delighted audiences a sound mixture of accurate facts and suggestive ideas. A good instance was the lecture on "The Lowest and Smallest Forms of Life," which he delivered on the occasion of the Montreal meeting of the British Association in 1884. For many years Dr. Dallinger was secretary of the Royal Microscopical Society, and he occupied the presidential chair from 1883 to 1887. He took a great interest in this society and in its valuable journal. It is said that during his presidency he travelled to attend the meetings a distance equal to about half the circumference of the globe, and it was characteristic of his conscientiousness that he usually journeyed back from London to Sheffield by the early mail train so as to be in time for his college duties in the morning.

Dallinger's scientific work began about 1870, and in 1873-6 he published, along with Drysdale, a series of papers on the life-history of monads in the *Monthly Microscopical Journal*. The characteristic feature of the patient labours of the two friends was continuity of observation. By means of a delicate mechanical stage and other devices they were able to keep their eye on one particular specimen of *Bodo saltans*, or whatever the flagellate might be, and follow it from phase to phase. By using a binocular they were able to change places without losing sight of the particular creature the life-cycle of which was being traced. On one occasion Dr. Dallinger kept up continuous observation for nine hours. The result was that some complete life-histories were worked out—spore-formation, growth of spores into flagellates, repeated fission of flagellates, conjugation, encysting, and spore-formation again. This was interesting in itself, it was prophetic of much that has followed in recent years, and it exposed one of the pitfalls in which believers in present-day abiogenesis are apt to come to grief.

In connection with the spontaneous generation question—which has had so many fruitful results—Drysdale and Dallinger made some interesting studies, showing, for instance, that although boiling the water killed monads in an active condition, it did not kill the spores. For the spores, indeed, the fatal temperature is very much higher, up to 268° F.

in water, up to 300° F. or more when dry. This led on to one of Dallinger's best known researches (Proc. Roy. Soc., xxvii., 1878), in which he showed that flagellates could gradually adapt themselves to tolerate extremely high temperatures. Starting with a medium at 60° F., in which three selected species (*e.g. Dallingeria Drysdalei*) flourished, he very gradually raised the temperature to 158° F., without killing off the organisms. That scalding heat would, indeed, have been fatal to the original stocks, but there had been, of course, myriads of generations, and the power of resistance to heat had been gradually augmented. The adapted forms showed marked vacuolation. Dallinger seems to have thought that this was a case of the inheritance of "acquired characters," but it is obviously out with Weismann's category of "somatic modifications." It is interesting to recall that Darwin was much interested in Dallinger's experiment because of its bearing on the adaptation of living creatures to hot springs. He wrote:—"The fact which you mention about their being adapted to certain temperatures, but becoming gradually accustomed to much higher ones, is very remarkable. It explains the existence of algæ in hot springs."

So far as we know, Dallinger's microscopical studies did not extend beyond monads and the like except by way of recreation, and his output of work was not great. It was thorough, however, as the man himself, and the lesson of his patience has still to be learned by some of the too impetuous workers of to-day. In 1886 he published the "Fernley Lecture" on "The Creator, and What we may Know about Creation," and he wrote many scientific articles for the *Wesleyan Methodist Magazine*. He wrote also a number of papers on spontaneous generation and heterogenesis, both of which he profoundly disbelieved in, on the ultimate limit of microscopic vision and kindred questions, and on the thermal death-point of microbes. A characteristic deliverance was an address to the Literary and Philosophical Society in Liverpool entitled "Life-histories and their Lessons: a Defence of the Uniformity and Stability of Vital Processes as Controlled by the Laws of Evolution." But his *magnum opus*, apart from monads, was his edition and re-edition (1891 and 1901) of "Carpenter's Microscope," which he brought up to date, and with the aid of specialists developed into a most valuable encyclopædia of the whole science and art of microscopy.

Dallinger was elected a Fellow of the Royal Society in 1880, and he received the honorary degrees of LL.D. from Victoria University in 1884, of D.Sc. from Dublin in 1892, of D.C.L. from Durham in 1896. He enjoyed the respect and esteem of scientific workers, and he has left his successors a pattern of thoroughness, patience, and enthusiasm.

THE STUDY OF GERMAN IN SCHOOLS.

TWELVE months ago an influentially signed letter, dealing with the study of German in secondary schools, was sent to the President of the Board of Education. That letter pointed out the serious neglect into which the study of the German language is falling in secondary schools, and urged the Board to take steps to encourage and foster the teaching of German. It was made clear that the decline of German as a secondary-school subject is a matter of grave national importance from the points of view of general literary culture, the public services, practical utility, and of rendering a good understanding between the peoples of two great nations less easy.

About six months after the receipt of this letter, the Board of Education issued a memorandum (circular 705) on language-teaching in State-aided secondary schools in England, in which an optimistic view of the condition of German teaching in England was taken, and it appeared to be argued that an advance was in progress in the number of pupils studying the language.

The various associations interested in the teaching of modern languages have had the Board's circular in particular, and the whole question generally, under consideration again, and a second letter has been sent to the President of the Board of Education, signed by representatives of the Modern Language Association, the Society of University Teachers, the Teachers' Guild of Great Britain and Ireland, and the British Science Guild.

The letter conveys the sense of disappointment of the associations generally with the "Memorandum on Language Teaching in Secondary Schools in England" (circular 705), and dissents in particular from several of the doctrines and statements laid down in it. It appears that

The Board of Education has not obtained, and cannot obtain, the materials required for making the return on the time allotted to modern language teaching in schools in the exact form that the motion in the House of Lords made on February 5, 1908, demanded, but there seems no good reason why the Board should not furnish Parliament and the public, in whatever shape it thought good, with the information suggested by the motion. What we desire to know, and what the Board has full power and opportunity for ascertaining, is the present condition of modern language teaching in secondary schools, the place assigned to it in the curriculum by headmasters and governing bodies, the relation in which it stands to the teaching of Classics and of English, the qualifications, emoluments, and status of its teachers. On these points the memorandum throws no light.

The remark in the Board's memorandum that "the advance in the study of German is not at the present moment as rapid as the advance in the study of French, or even of Latin," scarcely represents the facts. All the evidence available shows that, not only has there been no advance in the study of German, but rather a rapid and decided retrogression. Sympathetic action is required to arrest this decline.

The letter continues:—

As regards the contention that "the curriculum of schools is necessarily guided by the course of the Universities to which it is to lead," we would observe that only a fraction of the pupils in State-aided schools proceed to the university, and no curriculum can be deemed satisfactory which does not satisfy the needs of the bulk of the scholars. The majority of the pupils in these schools leave school before the age of seventeen, and it is allowed that for such pupils, "both practically and educationally, German is a language of the first importance"; yet the Board throws the whole weight of its influence into the scale of Latin as against German, apparently out of consideration for the one boy in a hundred who will go on to the university; and in this case what would be confessedly good for the many would be no less good for the favoured few. The number at Oxford and Cambridge taking medicine, science, and modern subjects is rapidly on the increase, and it is a constant cause of complaint among the professors and teachers of these subjects that their pupils come to them heavily handicapped by their ignorance of German. It is hardly necessary to insist on the value of a knowledge of German to honour students in every faculty.

Our suggestion that the Board should encourage and foster schools of the type of the German Realschule and Ober-Realschule is not noticed, but it is indirectly negatived by the insistence on Latin as one of two foreign languages where two are taught.

We would reiterate our conviction that a sound and thorough literary training can be given through English, German, and French without a knowledge of Latin. If, in the words of the memorandum, English can serve as "the backbone of a humanistic education," surely a combination of English, German, and French would constitute a valuable type of humanistic education.

We greatly regret that the Board has not, as yet, seen its way to lead public opinion on so vital a matter as the study of modern languages, and we express a hope that the memorandum is not its last word.

NOTES.

THE following is a list of those to whom the Royal Society has this year awarded medals. The awards of the Royal medals have received the King's gracious approval:—the Copley medal to Dr. G. W. Hill, For.Mem.R.S., for his researches in mathematical astronomy; a Royal medal to Prof. A. E. H. Love, F.R.S., for his researches in the theory of elasticity and cognate subjects; a Royal medal to Major Ronald Ross, F.R.S., for his researches in connection with malaria; the Davy medal to Sir James Dewar, F.R.S., for his researches at low temperatures; and the Hughes medal to Dr. R. T. Glazebrook, F.R.S., for his researches on electrical standards.

WE regret to see the announcement of the death, on November 12, of Dr. W. J. Russell, F.R.S., in his eightieth year.

THE death is announced, at sixty-six years of age, of Sir William Thomson, C.B., honorary surgeon to the King in Ireland, and the author of several publications on surgical subjects.

SIR T. H. HOLLAND, K.C.I.E., F.R.S., professor of geology and mineralogy in the Manchester University, will deliver the Wilde lecture of the Manchester Literary and Philosophical Society for 1910.

THE death is announced, on November 13, of Dr. C. Graham, formerly professor of chemical technology at University College, London, at seventy-four years of age. Dr. Graham was a vice-president of the Institute of Chemistry in the years 1882–4, and served on the council for several years.

THE specimens illustrating the manufacture of high-class lenses, shown by Messrs. J. H. Dallmeyer, Ltd., at the Franco-British Exhibition last year and the Imperial International Exhibition this year, have been presented to the Board of Education. This collection, which was awarded a Grand Prix, is now housed in the western galleries of the Science Museum, South Kensington.

AT the annual general meeting of the Cambridge Philosophical Society on October 25, the following were elected officers of the society for the ensuing session, 1909–10:—*President*, Prof. Bateson; *vice-presidents*, Dr. Hobson, Dr. Fenton, Prof. Seward; *treasurer*, Prof. Newall; *secretaries*, Mr. A. E. Shipley, Dr. Barnes, Mr. A. Wood; *new members of the council*, Sir J. Larmor, Prof. Biffen, Prof. Pope, Mr. R. H. Rastall, and Mr. K. Lucas.

AT the annual general meeting of the London Mathematical Society on November 11 the following were elected as the council and officers for the session 1909–10:—*President*, Sir William Niven, K.C.B., F.R.S.; *vice-presidents*, Mr. A. Berry, Dr. W. Burnside, F.R.S., Major P. A. MacMahon, F.R.S.; *treasurer*, Sir Joseph Larmor, F.R.S.; *secretaries*, Dr. A. E. H. Love, F.R.S., Mr. J. H. Grace, F.R.S.; *other members of the council* (names of members not on the retiring council are in italics), Dr. H. F. Baker, F.R.S., Mr. G. T. Bennett, *Dr. T. J. I'A. Bromwich, F.R.S., Mr. E. Cunningham*, Mr. A. L. Dixon, Dr. L. N. G. Filon, Dr. E. W. Hobson, F.R.S., Mr. H. W. Richmond, and Mr. A. E. Western.

SIR ERNEST SHACKLETON was officially received by the Paris Geographical Society on Monday, November 15, in the Grand Amphitheatre of the Sorbonne, and gave an account of his Antarctic expedition. From the *Times* we learn that after the address Prince Roland Bonaparte, the president of the society, rose and said:—"Since its foundation in 1827 our Geographical Society, which is the *doyenne* of all similar societies, has always desired to recognise the labours of the most illustrious travellers by bestowing upon them its grand gold medal. Among those to whom it has been given were the Polar explorers Sir John Franklin, Sir James Clark, Ross, Dumont d'Urville, and Nansen. To the list of these great names the Geographical Society is happy to add yours by offering you its grand gold medal, which is the highest recompense that is in its power to bestow."

THE first session of the seventeenth International Congress of Americanists will be held in Buenos Ayres, Argentine Republic, on May 16–21, 1910. The general and sectional meetings will be held in the hall of the National University in Buenos Ayres. A second session will take place in Mexico in September of the same year. A commission of organisation has been formed, the president of which is Dr. José Nicolas Matienzo, dean of the faculty of philosophy and letters in the National University. Communications, which may be either oral or written, may be made in English, French, German, Italian, Portuguese, or Spanish. The conference will deal with questions relating to the ethnology, archæology, and history of the New World, and a detailed programme will be published towards the end of the present year. For further information application should be made to the general secretary of the committee of organisation, Dr. Lehmann-Nitsche, Calle Viamonte 430, Buenos Ayres.

THE annual report of the Liverpool Marine Biology Committee and the Port Erin Biological Station was submitted by Prof. Herdman at a meeting of the Liverpool Biological Society on November 12. In the course of his address Prof. Herdman gave an account of the work, both scientific and economic, carried out during the past year, such as the curator's report upon the hatching and setting free of more than seven millions of young plaice, making a total of 25½ millions during the six years the hatching has been in operation; the experiments in lobster rearing; Dr. Ward's investigations on the eggs and young larvæ of the plaice (illustrated by many very beautiful enlarged photographs); Mr. Gravely's work on the development of the brittle-starfish; Dr. Herbert Roaf's researches on digestion in marine animals; Mr. Dakin's physico-chemical observations on the condition of the sea-water at different times in connection with the migrations of the food of fishes; Mr. Edwin Thompson's photomicrographs of various types of minute organisms in the sea; and Prof. Herdman's own investigations into the detailed distribution of life in the sea. Some of the biological stations and establishments for fish culture in Canada and the United States were also described, and attention was directed to the American system of providing dormitories and dining halls for the students and researchers, and to the manner in which men of wealth in the States advance science by making large donations to such laboratories in order to defray the expenses of special investigations or marine and other explorations.

DR. D. S. JORDAN, president of Stanford University, contributes to *Science* an appreciation of the work of Dr. Kakichi Mitsukuri, dean of the college of science in the Imperial University of Tokio, who died on September 16. Dr. Mitsukuri was the author of numerous papers on zoological subjects, and was largely responsible for the establishment of the seaside laboratory at Misaki, where much excellent work has been done by Japanese, as well as by American and European naturalists. Dr. Mitsukuri was born in Edo, Japan, on December 1, 1857. He went to America in 1873, and received the degree of Ph.D. in zoology from Yale University in 1879. Returning to Japan, he was appointed a professor of zoology, in 1882, in the science department of the University of Tokio. In 1883 he received the degree of Ph.D. in zoology from Johns Hopkins University. In 1893 he was appointed councillor of the Imperial University. In 1896 he was made head of a commission for the investigation of the fur seal, and in 1897 he signed on behalf of Japan a treaty whereby Japan agreed for a certain length of time to consent to any adjustment of this matter which might be made by Great Britain and the United States. Dr. Mitsukuri was made dean of the College of Science of the Imperial University of Tokio in 1901, and six years later was awarded the Order of the Sacred Treasure in recognition of his public services. Of late years Dr. Mitsukuri was engaged in the special study of the turtles, and was also largely occupied with matters of administration.

TWENTY-FOUR delegates, representing Great Britain, France, Germany, Austria-Hungary, Russia, Spain, United States, Canada, and Australia, met at the Foreign Office on Tuesday to consider the steps to be taken for constructing a map of the world on the scale of 1 : 1,000,000 (16 miles to the inch), on a uniform system. The conference was opened by Sir Charles Hardinge, Permanent Under-Secretary of State for Foreign Affairs. In opening the congress Sir Charles Hardinge summarised the history of the movement. The *Times* reports him to have said that it was in the year 1891 that the question of an international map was first raised at the International Geographical Congress at Berne. Two years later several distinguished German men of science met at Stuttgart, where the question was again seriously discussed, and upon that occasion Prof. Brudener contributed a very valuable report upon the subject. Two years later the matter was taken up by several geographical societies both in Paris and London, and it was fully discussed at a meeting of the Geographical Congress in London in 1895. In various countries the preparation of maps on the scale of 1 : 1,000,000 was then commenced. These maps were chiefly of Asia and Africa, and though uniform in size, sheets, and scale, were wanting in uniformity in other details. The next step of any importance took place in 1908, when it was proposed by the delegates of the United States of America, at the International Geographical Congress at Geneva, that an international map should be definitely standardised. This was agreed to by the members of the congress, and a system of detailed resolutions was universally voted by them. It was felt, however, that unofficial proceedings of this description had no positive result, and were somewhat of the nature of pious aspirations. It was considered necessary, therefore, that the Governments interested should invite official delegates to meet in conference and to arrive at an agreement, which they would be able to submit to their respective Governments for approval and adoption.

THE greater portion of the combined first to fifth parts of vol. xviii. of *Actes de la Société scientifique du Chili* is devoted to an article, by Mr. C. E. Porter, on myriopods, which concludes with a classified list of the known Chilian species.

IN order to obtain sufficient material for an inquiry as to the degree of variation in the wings of beetles of the family Carabidæ, Dr. Sharp asks in the November number of the *Entomologist's Monthly Magazine* for fresh and unmounted specimens of these insects. The inquiry, it is stated, promises to yield results of considerable interest.

AMONG other articles included in the August number of the Annals of the Transvaal Museum, attention may be directed to a check-list of the butterflies of the Transvaal, with notes on certain species, by Mr. C. J. Swiestra. The author has been enabled to raise the number of known species from the 238 or 239 (for both these numbers are mentioned), recorded by Mr. W. L. Distant in 1898, to 316.

IN the October number of the *Museums Journal* Mr. H. Bolton directs attention to a representative series of insects recently installed in the Bristol Museum with the object of displaying the essential features and character of the different orders and their mutual relations, while in a second article the same author emphasises the value and importance attaching to exhibits of injurious insects.

WE have to acknowledge the receipt of the *Scientific Monthly* for October, containing abbreviated reports of some of the presidential addresses at the Winnipeg meeting of the British Association; also of part i. of a catalogue of books on natural history offered for sale by Mr. Quaritch, of Grafton Street. This part includes scientific voyages and the publications of learned societies.

CONSIDERABLE interest attaches to the account, by Mr. C W. Gilmore, of a new generic type (*Opisthias rarus*) of rhynchocephalian reptile from the Jurassic of Wyoming, published as No. 1698 (vol. xxxvii., pp. 35–42) of the Proceedings of the U.S. National Museum. The genus is established on the evidence of a left dentary bone of the lower jaw, which appears to approximate to the corresponding element in the existing Sphenodon and the Kimeridgian Homœosaurus. Opisthias is the first terrestrial rhynchocephalian hitherto obtained from American strata.

WE have received a copy of the report on the scientific investigations of the Northumberland Sea-fisheries Committee for 1908–9, from which it appears that additional trawlings have been conducted in order to standardise the previous results. A number of marked fish—notably a turbot, after four years—were recovered, while, out of 100 lobsters marked in 1907, thirty-six, none of which had migrated from their native grounds, were re-taken within nine months. An account of the marine laboratory opened at Cullercoats in 1908 is appended. The committee strongly recommends the establishment of a close time for crabs from October to January, during which period many of these crustaceans are changing their shells and out of condition.

To Mr. W. B. Helland-Hansen, the author, we are indebted for a copy of a report on a recent statistical research into the biology of the cod and the haddock in the North Sea, published in vol. x. of "Rapports et Procès-verbaux du Conseil international pour l'Exploration de la Mer," 1909. The report is based on trawlings carried out to a great extent for the purpose of ascertaining the individual dimensions and weights of the haddock and cod frequenting the fishing-grounds at different seasons and in different years, in order to determine whether the grounds are being over-fished. The investigations are, however, only in a preliminary stage, and before they can be regarded as anything like complete will have to be extended so as to embrace surface-fishing at seasons when the cod are in pursuit of the shoals of herrings.

OUR knowledge of Peruvian barnacles has been but slightly increased since the appearance of Darwin's monograph, and considerable interest attaches, therefore, to the report, by Dr. A. Pilsbry, published as No. 1700 of the Proceedings of the U.S. National Museum, on a collection recently made by Dr. R. E. Coker and Dr. W. H. Jones, of the U.S. Navy. The apparent absence of parasitic species or of forms commensural on crabs is a remarkable feature of the cirripede fauna of Peru. A new species of Balanus is described, and the opportunity has been taken to publish figures sufficiently large to exhibit the details of the plates of the previously known Peruvian forms.

IN Bulletin No. 67 of the U.S. National Museum, comprising 135 pages of text and a large number of illustrations, Mr. Nathan Banks supplies entomologists with very full and detailed directions for collecting and preserving insects according to modern methods. A bulletin on the same subject, prepared under the direction of the late Dr. C. V. Riley, was published in 1892, but since that date new methods of collecting have been devised and studies are conducted on entirely new lines, so that it has been deemed advisable to re-write the pamphlet from beginning to end. Many notes on the preparation of insects for the cabinet have been copied from various entomological journals, while special information has been supplied in regard to particular groups by members of the Bureau of Entomology. The work commences with a general review of the different orders of insects and their developmental history, after which come directions for capture and preservation in the field and mounting and storing in the museum. Figures of apparatus of all kinds are given, accompanied by full descriptions of the cabinets employed in the U.S. Museum. The scope of the work likewise includes directions for rearing live insects and maintaining them in captivity, while the collection and preservation of spiders, scorpions, and centipedes also come within its purview.

A REPORT by Dr. Newsholme and Sir Malcolm Morris, K.C.V.O., the British delegates to the International Conference on Leprosy held at Bergen in August last, has been issued as a Parliamentary Paper (Cd. 4916). They, together with several delegates from British colonies, formulated several resolutions for the control of the disease, the chief of which are as follows:—(1) Leprosy is spread by direct and indirect contagion from persons suffering from the disease. The possibility that indirect contagion may be effected by fleas, bugs, lice, the itch parasite, &c., has to be bôrne in mind. (2) Leprosy is not due to the eating of any particular food, such as fish. (3) There is no evidence that leprosy is hereditary. (4) In leprosy an interval of years may elapse between infection and the first recognised appearance of disease. (5) The danger of infection from leprous persons is greater when there is discharge from mucous membranes or from ulcerated surfaces. (6) Compulsory notification of every case of leprosy should be enforced. (7) The most important administrative measure is to separate the leprous from the non-leprous by segregation in settlements or asylums. (8) In settlements home life may be permitted under regulation by the responsible authorities.

A SELECTION of new or noteworthy Philippine plants described by Mr. Merrill, forming the seventh series, is published in the *Philippine Journal of Science* (August). The majority of the determinations refer to tree specimens, and include new species of Diospyros and Cryptocarya, also additions to the families Meliaceæ and Flacourtiaceæ. In the latter family the author finds a similarity between Philippine and Ceylonese species. A new genus, Embolanthera, allied to Maingaya, is created in the Hamamelidaceæ, and Everettiodendron in the Euphorbiaceæ. A noteworthy new species is *Chonemorpha elastica*, an asclepiad, which promises to be the best native rubber-producing vine.

WITH the view of making the best use of their local museums, the Essex Museum of Natural History, Stratford, and the Epping Forest Museum, Chingford, the Essex Field Club held during the previous winter two conferences to discuss the use of museums for promoting nature-study in schools, which are reported in a small pamphlet recently published. At Stratford educational facilities are provided in the form of mounted specimens, drawings, and explanatory labels, while at Chingford the exhibition of seasonal plants and branches is made a special feature. Nevertheless, it was agreed that a museum is not the place to hold nature-study classes for children, although well adapted for classes of teachers. Prof. R. Meldola, in testifying to the value of nature-study, expressed the opinion that it should be regarded as a method of training, not as a subject for teaching, and that it should include the study of the inorganic world; he also emphasised the necessity for nature-taught teachers.

THE dispersal of plants was a subject to which the late Prof. Errera devoted much attention, and among the problems which came under his notice was the manner in which plants manage to reach rocks isolated by glaciers. In this connection he visited the isolated peaks, Aguagliouls, by the side of the Roseg glacier, and Isla Persa, flanked by the Morteratsch glacier. A posthumous paper published in the *Recueil de l'Institut botanique Léo Errera* (vol. viii.) contains a list of the plants collected on these rocks and on the moraine adjoining the former. There is a remarkable contrast between the species growing on the peak Aguagliouls and the moraine; on the moraine three species of Trifolium and *Anthyllis vulneraria* were taken, and Primulas were wanting, while on the peak the Leguminosæ were represented by one Trifolium, but six species of Primula were collected.

THE vigorous efforts made by the American agricultural colleges to get into touch with the practical man are well exemplified by the large numbers of bulletins they issue dealing with every phase of agriculture and every problem about which it is supposed the farmer requires help. We have received a series of bulletins from the Colorado Agricultural College which are quite typical of their kind; the subjects dealt with are the cultivation of fruit trees, pig production, and the manufacture of gate-posts out of cement. The bulletins are drawn up by experts, are clearly written, and well illustrated. The cost of production and distribution must be considerable.

THE United States Department of Agriculture has recently issued a popular bulletin by Mr. Milner on the use of milk as food. It is stated that about one-sixth of the total food of the average American family is furnished by milk and its products. A simple account is given of its properties and of the effects of bacteria; a number of milk products are described, and comparison is instituted between these and other nutrients. It is further shown that milk is quite as economical as other animal foods, but dearer than most vegetable products; as a source of protein it is especially economical.

WE have received from the Michigan State Agricultural College Experiment Station a bulletin describing a local cattle disease known as the Grand Traverse or Lake Shore disease. At the outset the head is carried low with drooping ears, the coat stares, and the appetite falls off. The animals drink less and less as the disease advances, until finally they refuse to drink at all. As the appetite fails it becomes depraved, and such materials as bones, wood, leather, rope, or bark are eaten. The animals become extremely emaciated. The seat of the disease appears to be in the third stomach, where extensive lesions are often found. The cause of the disease is obscure, but some evidence was obtained that showed it lay in the methods of feeding. Experiments to test this view are in progress.

AMONG some miscellaneous publications to hand from the United States Department of Agriculture is one on the method of winter fumigation for the white fly infesting citrus trees. The tree is covered with a sufficiently large tent in which hydrocyanic acid is being generated; by careful attention to certain details the fly can, it is said, be exterminated at a small cost. A Farmers' Bulletin gives a short summary of the results obtained at some of the agricultural experiment stations. No fewer than ten different subjects are dealt with, and references are given to the original sources, from which farmers who wish to do so can readily obtain fuller information. Another bulletin describes the card-index sets now being made up and sold, in which are catalogued the publications of the Departments of Agriculture, the Geological Survey, and the State Surveys. Such an index is indispensable in the United States, where an enormous number of official publications are issued every year.

THE *Geographical Journal* for November contains a short report, by Sir Ernest Shackleton, on some results of the British Antarctic Expedition of 1907–9. The paper gives a summary of the routes of the chief expeditions from the headquarters at Cape Royds, and a brief narrative of the most important events which occurred during each. It is announced that most of the volumes containing the scientific records and results of the expedition will probably be issued within the next twelve or eighteen months. The contribution is accompanied by three maps.

DR. WARREN DU PRÉ SMITH, chief of the Division of Mines, Bureau of Science, Manila, contributes a paper to the November number of the *Geographical Journal* on geographical work in the Philippines. The work under the American *régime* is carried on primarily by the United States Coast and Geodetic Survey, which is responsible for the most accurate surveys, but mapping is also done by the United States Army, the Bureau of Constabulary, the Bureau of Lands (cadastral surveys), and the Division of Mines. The land area of the Philippines is approximately 115,000 square miles, and of this about 14,000 square miles had been covered by triangulation, and the topography of 1500 square miles mapped up to June 30, 1908.

THE *Revue des Idées* for October contains an article, by Prof. Jacques Loeb, of California, entitled "Les Tropismes et la Psychologie." The writer refuses to accept the common view that a physical interpretation, however complete, of a psychical phenomenon can never afford an explanation of its psychical character. He maintains that the "will" of an animal is merely a term useful to cloak our ignorance of the forces determining its movements, and that the scientific solution of the problem of volition consists solely in discovering those forces and the laws according to which they act. He adduces evidence in favour of attributing to positive or negative heliotropism the reactions of aphides, bees, ants, &c., to light. He combats the experimental work of Jennings and others who claim to have established the inadequacy of mechanical processes to account for the behaviour of even the lowest organisms.

MR. G. L. GOMME contributes to the *Sociological Review* for October an important paper treating of sociology as the basis of inquiry into primitive culture. He lays down as the fundamental proposition of anthropological research "that inquiry into the culture and condition of primitive man as he is represented by modern savages, in the remains of decayed civilisations, or in the ancient records of the beginnings of modern civilisations, can only be conducted by considering each item of culture which is the subject of inquiry in association with all the other items of culture in the same social group." The original social unit consists of the tribal rulers and the tribal village, representing the one a conquering, the other a conquered, race. Slavery in Indo-European society means, not personal servitude, but the status of a class springing from the conquered people. Indo-European tribalism is not only a polity, but a religion, and it was indestructible. The tribe is founded, not alone on blood kinship, but also on common worship. He perhaps goes too far in extending Robertson Smith's theory of sacramental kinship with the deity to non-Semitic communities; but, with this reservation, his study of early tribal origins is interesting and suggestive.

PEOPLE who are seriously interested in aërial navigation will regret that the weekly *Ila*, issued in connection with the Frankfurt Exhibition, terminated on October 16. The seventeen issues contain many important and well-written articles dealing with various aspects of aërotechnics. Among the subjects treated are aërial motors, by E. Rumpler; materials and machinery, by August Bauschlicher; measurements of air resistance at Lindenberg, by Dr. F. Bendemann; aërial electricity, by O. Voigt; wind statistics, by W. Peppler; bird flight, by F. W. Lanchester (translated by H. Hochschild); the special steel industry, by W. Eilender; meteorological statistics for airships, by W. Peppler; balloon photography, by Captain Scheimpflug (abstract); aërodynamical researches, by Prof. Ahlborn (some of whose photographs of stream lines closely resemble those recently obtained by W. E. Williams in this country); besides unsigned articles on vehicles for transport of hydrogen, lamps for hangars, the Parseval balloon, and technical notes. The seventeen numbers of *Ila* will preserve their place in the literature of aërotechnics long after the great majority of journals of mushroom growth have passed into oblivion.

SEVENTY out of the hundred and eighty pages of the August number of the Proceedings of the American Philosophical Society of Philadelphia are devoted to papers dealing with seismological subjects, some of which have been mentioned already (June 10, vol. lxxx., p. 444). The first, on the causes and effects of earthquakes, by Mr. E. O. Hovey, treats the subject in a popular manner, and contains descriptions of the Charleston (1886), the California (1906), the Kingston (1907), and the Messina (1908) earthquakes. The second, by Mr. W. H. Hobbs, deals with the evolution and outlook of seismic geology, and advocates two lines of advance:—first, to make practical use of the knowledge already gained, and second, to refine our instruments until we are capable of forecasting the time, place, and severity of the next earthquake. He points out the importance, as a means of forecasting, of the principle of immunity from shock for a long period of a region which has just experienced one, and suggests that more refined instruments may show that slight tremors precede all shocks. A third paper, by Mr. H. F. Reid, urges the United States Government to found a seismological bureau for the study of earthquakes, particularly in the United States.

MARINE steam turbines show generally a lower efficiency as compared with corresponding land turbines on account of the compromise which has to be made regarding speeds of revolution. This is owing to the fact that the propeller has best efficiency at comparatively low speeds, while the turbine gives best results at high speeds. In *Engineering* for November 5 is described one of the several methods which have been tried for securing a reduction of speed from the turbine to the propeller, thus enabling both to be worked at their best speeds. The arrangement is due to Dr. Föttinger, of the Vulcan Company, of Stettin, and consists of a differential water-turbine transmitter in which the primary water-wheel is driven by the steam-turbine shaft, and transmits water with a certain velocity through guide blades or directly to a secondary wheel or wheels mounted on the secondary or propeller shaft in the same axial plane. Transmission ratios of from 3/1 up to 12/1 can be provided, and reversal can be obtained by means of a reversing water-turbine transmitter of somewhat similar design on the same shafts. With an experimental installation at the works in which the primary shaft runs at 1600 revolutions per minute and the propeller shaft at about 270 ahead, reversal to 250 revolutions astern can be obtained in nineteen seconds. The efficiency of power transmission rises rapidly to 78 per cent. at 600 revolutions per minute of the primary shaft, and remains constant at 83 per cent. at 1250 revolutions. This installation has a transmission ratio of 4·5 to 1. The Vulcan Company have built a special steamer for trials with this arrangement, and it will also be probably tried on warships. The arrangement seems to be valuable and likely to come into extensive use.

WE have received from Mr. Bernard Quaritch, 11 Grafton Street, New Bond Street, London, a copy of his current issue of rare and valuable books now offered for sale. The list includes many interesting volumes concerned with America and Australasia.

MESSRS. LONGMANS, GREEN AND CO. will publish in a few days "Beasts and Men: being Carl Hagenbeck's Experiences for Half a Century among Wild Animals," an abridged translation by H. S. R. Elliot and A. G. Thacker, with an introduction by Dr. P. Chalmers Mitchell. Carl Hagenbeck is the founder of the famous Zoological Park at Stellingen, near Hamburg.

REFERENCE has been made before in these columns to the convenience of the circulating library of Mr. H. K. Lewis, Gower Street, London, to students of science and others. The most recent list of new books and new editions added to the library during July, August, and September of the present year shows that great pains are being taken to keep the library complete and up to date.

THE Cambridge University Press announces as in the press "Mathematical and Physical Papers," by the late Lord Kelvin, vol. iv., hydrodynamics, containing vortex motion, tides, and waves on water, collected and arranged by Sir J. Larmor, secretary of the Royal Society. The same publishers have in preparation "Lord Kelvin: Scientific Remains," including excerpts from early diaries and from his scientific correspondence, together with a reprint of the historical account of his scientific career prepared for the obituary notices of the Royal Society. This work is also by Sir J. Larmor.

OUR ASTRONOMICAL COLUMN.

A BRILLIANT METEOR.—A magnificent meteor was observed, at 11h. 59m., at the Solar Physics Observatory, South Kensington, on November 15. The observed path was from about 114½°, +27½° to 87½°, +6°, *i.e.* from immediately below Pollux to immediately below Betelgeuse, the path being nearly horizontal.

The meteor was very bright, exhibited striking red and greenish tints, and travelled with a medium velocity. It did not explode, but the large bright head simply faded away, leaving a definite trail, which endured for some two or three seconds.

ELEMENTS OF HALLEY'S COMET.—The following five elements of Halley's comet are those calculated by Mr. P. H. Cowell, F.R.S., and Mr. A. C. D. Crommelin, from the perturbations since 1835:—

Longitude of ascending node	57° 16′ 12″
Node to perihelion	111 42 16
Inclination of orbit	162 12 42
Semi-major axis of ellipse	17·94527
Eccentricity	0·967281

The above elements have not yet been re-determined from recent observations.

The predicted date of perihelion passage was 1910 April 16·6.

The observed positions in 1909 September and October can be satisfied, both in right ascension and declination, by altering the date of perihelion passage to 1910 April 19·7 and retaining the predicted values of the other elements.

RECENT OBSERVATIONS OF MARS.—In No. 4367 of the *Astronomische Nachrichten* M. Jonckheere gives 24·325″ as the mean diameter of Mars from several observations near opposition; at unit distance this would be 9·533″, which means that if the diameter of the earth be taken as 1·0, that of Mars is 0·540. The observed flattening of the polar diameter was 1 : 270·8. A list of nine probably new canals is given, names being proposed for six of them which are certainly novel.

In No. 4368 of the same journal M. Jonckheere gives two drawings, made on September 30, 11h. 30m. (long. 210°), and October 5, 10h. 10m. (long. 145°), respectively. On the former date a number of "lands" and thirty-four canals, four probably new, were seen, and on the latter date forty-nine canals, six probably new, and seven "lands" were recorded. Among the latter were the two new ones, Stella, near the polar cap, and Thaumas, in the Aonius Sinus.

No. 4367 also contains a note, by M. Jarry Desloges, recording the observation and disappearance of a terminator projection in the region of Daedalia, variations in the Lacus Solis, the Auroræ Sinus and Deucalionis Regio, and the discovery of two new canals.

A paper by M. Desloges also appears in No. 17 of the *Comptes rendus* (October 26), in which the author divides the canaliform markings into three types:—(1) broad greyish bands; (2) lines of medium breadth, very dark, and with definite edges; (3) fine lines near the limit of visibility. He suspects that some features of the first type have, at times, been resolved into finer details, whilst among those of the second type changes have undoubtedly taken place. The finer markings, type 3, appear to have become greatly augmented in number. His collaborators, MM. Fournier, saw Araxes, type 1, single, then double, and finally triple, but M. Desloges himself has never been certain of seeing a canal doubled. Two charts given in the paper show the Martian features in spring (southern hemisphere), and later at the beginning of summer, and it is seen that at the later epoch the markings were more numerous and better defined.

PERRINE'S COMET, 1909*b*.—From the recent observations (August–October) of Perrine's periodical comet Dr. Kobold has calculated a set of elements, which he gives in No. 4368 of the *Astronomische Nachrichten* (p. 405, November 10); this gives the perihelion passage as 1909 October 31·865 (M.T. Berlin). An ephemeris is also published showing that the comet is apparently travelling, nearly due south, through Gemini, as shown by the following positions:—November 18, 7h. 3·8m., $+17^\circ$ 46·8'; November 30, 7h. 11·9m., $+5^\circ$ 45·5'. On November 19 the comet will be some minutes west of λ Geminorum, and of about magnitude 12·3.

THE LIVERPOOL ASTRONOMICAL SOCIETY.—The annual report of the Liverpool Astronomical Society shows that its activity and membership are being well maintained. In the presidential address Mr. W. E. Plummer gives an interesting paper on satellites, and other notes, by Mr. Thorp and Father Cortie respectively, deal with diffraction gratings and sun-spot spectra. There is also a paper on Morehouse's comet, illustrated by a frontispiece reproducing photographs taken by four of the society's members.

THE PARALLAX OF THE DOUBLE STAR Σ 2398.—In these columns on September 16 we directed attention to Dr. Bohlin's re-determination of the parallax of the double star Σ, from which it followed that this star, with a parallax of 0·484", is the nearest to us in the northern hemisphere.

Since Dr. Bohlin's publication several observers have directed attention to the discordance of the above value from several previously determined, Prof. Schlesinger pointing out (*Astronomische Nachrichten*, No. 4365, p. 359) that it is probably 0·15" too high.

Dr. Bohlin now states (*ibid.*) that an error crept into his calculations, and that, on correcting this, the parallax derived from his observations is +0·251"; there are, at least, eight or nine stars in the northern hemisphere for which greater parallaxes than this have been found.

THE MEASUREMENT OF SOLAR RADIATION.[1]

IN the long memoir referred to below Dr. Bemporad discusses a variety of problems relating to the measurement of solar radiation, a subject to which he has made previous contributions. The material employed consists mainly of observations made with pyrheliometers of the now common Ångström pattern at the peak of Teneriffe during five days in June and July, 1896. Prof. Ångström and an assistant observed at two different heights, the two stations simultaneously occupied being one at a level of 3252 metres, the other at one or other of the three levels 3683, 2125, and 360 metres.

On an average day there were about sixteen observations at each of the two stations occupied. The observations were scattered over the day, the zenith distances of the sun usually ranging from a little more than 5° to between 80° and 90°. The pyrheliometer reading on reduction gives q, the heat received in unit time by a unit of surface placed orthogonally to the sun's rays. As the sun's zenith distance alters, there is at any station a change in the length of the path of the sun's rays through the atmosphere. The longer the path, the greater the loss by absorption, and the first problem considered by Bemporad is which of several formulæ, due to Crova, Bartoli, Pouillet, and himself, best represents the variation of q with zenith distance. The formulæ all contain a quantity e defined as the "mass" of air traversed by the rays (for this purpose a ray may be regarded as a tube of unit section), unity representing the value of e for a vertical ray. The author refers to a previous memoir, in which he has tabulated e as a function of z, the zenith distance, at sea-level. Treating the morning and afternoon observations of each day at each station separately, he calculates the best values for the constants q_0 and m in a formula of Crova's type $q = q_0(1+e)^{-m}$. The average difference between the individual observed and calculated values is usually well under 1 per cent. The author seems, however, to prefer a three-constant formula of the type $\log q = a - be^n$, and makes numerous comparisons with formulæ of this type.

If we neglect the earth's curvature and the small variation in z at different levels due to refraction, and regard the atmosphere as formed of "layers" bounded by parallel planes, an increase of z increases the length of path in all layers in the same proportion. Thus the formulæ involving e do not really assume that the absorption in travelling through a given "mass" of air is the same at all levels. With the view of ascertaining the variation in absorption with height, the author proceeds to calculate the "mass" of air traversed by rays, having different values of z, in passing from the level of one of Ångström's stations to another. This is got by a slight modification of the difference between the air "masses" from sea-level up to each of the two heights, as given in a table previously published by the author. One assumption in the process which rather invites criticism—though there is no obvious means of avoiding it in the absence of direct observations—is that the temperature gradient was the same at all levels and deducible from the observations at the two stations. Having found M, the "mass" of air traversed between the levels of the two stations, the author assumes that the simultaneous values q and q' of q at the two stations are connected by a formula of the type $\log(q'/q) = c\mathrm{M}$, where c is the mean absorption per unit mass of air for the layer between the two heights. Ångström's four stations supply, of course, three layers, though the data for the three refer really to different days. Thus three values of c—answering to three different layers or to three different mean heights in the atmosphere—are obtained for a series of different values of z. One noteworthy feature is the tendency of c, for a given value of z, to be greater in the afternoon than in the forenoon. The author finds c to diminish notably with the altitude of the layer, and he concludes in favour of the empirical law that the absorption at different heights varies as the fourth power of the density of the air. This conclusion was derived primarily from Ångström's observations alone, but the author tests it by reference to results obtained by Millochau at Mont Blanc, Langley at Mount Whitney, and Rizzo at Rocciamelone. On p. 97 he considers the relationship of his formula to the law of variation with height usually proposed for aqueous vapour.

In an earlier paper the author had tabulated the value M of the "mass" of air traversed by a ray between sea-level and heights varying up to 5000 metres for different values of z. His calculations assumed the temperature gradient β to be 6·2° C. per km. In an appendix to the present memoir he gives the corrections to be applied to the previous table when the value of β is not 6·2°, but 6°, 5° . . . 0°. By a curious oversight the table for $\beta = 2^\circ$ is printed twice over on p. 103, that for $\beta = 1^\circ$ being omitted.

The author refers in various places to the fact that the absorption by the atmosphere is selective, the presence of aqueous vapour in the lower strata being specially important; but Ångström's observations in 1896 dealt only with the total radiation. He also recognises that the presence of a mountain may disturb the atmospheric conditions in its immediate neighbourhood. He apparently ascribes to this—and with good reason—certain anomalous results derived from Ångström's two highest stations, according to which the absorption in the intervening layer was at times negative. One cannot but entertain some doubt whether the subject is yet quite ripe for mathematical calculations of so elaborate a type as the author's. There would certainly have been a much more suitable field for their application if he had had at his disposal absolutely synchronous data from seven or eight stations—preferably in the free atmosphere—at heights differing by regular intervals of, say, 500 metres, results being obtained, not merely for the total radiation, but for the portions passed by a series of filters after the method recently proposed by Ångström.

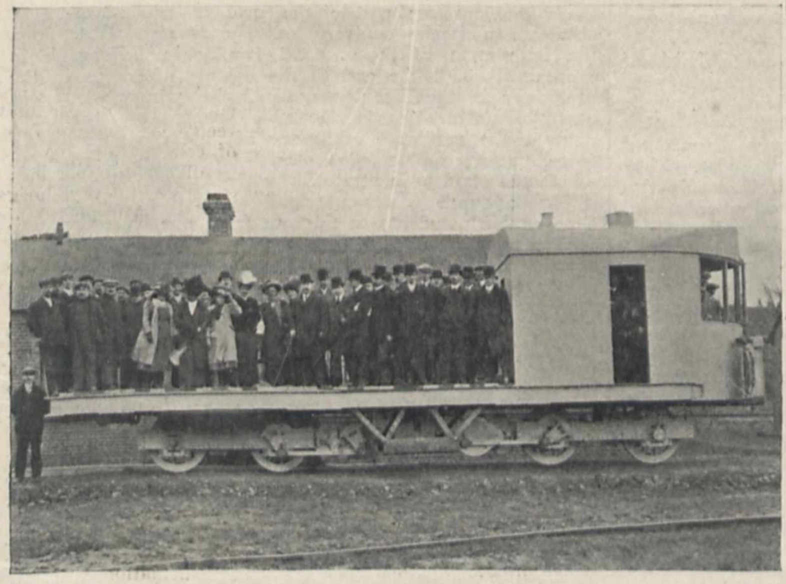
C. CHREE.

[1] "L'Assorbimento selettivo della Radiazione solare nell' Atmosfera terrestre e la sua variazione coll' altezza." By Dr. A. Bemporad. Pp. 111. From Reale Accademia dei Lincei, anno cccv., 1908. (Roma: Tipografia della R. Accademia dei Lincei, 1908.)

THE BRENNAN MONO-RAIL SYSTEM.

IT will be remembered that Mr. Louis Brennan exhibited a model mono-rail vehicle at the Royal Society soirée in May, 1907. Aided by grants from the War Office, the India Office, and the Cashmir Government, Mr. Brennan has developed the system, and we have now to record public trials of a full-sized vehicle which were made at the Brennan Torpedo Works, near Chatham, on Wednesday, November 10. A full account of the gyroscopic principles involved was given in NATURE of March 12, 1908.

The track consists of a single-rail circular portion of 105 feet radius, a straight portion 440 yards in length, and sidings. The rails are of the Vignoles section, 5$\frac{3}{4}$ inches high, 70 lb. to the yard, and have the heads rounded to a radius of 5 inches. These are laid on sleepers 3 feet 6 inches long at about 3-foot centres on soft made ground, the rails being spiked to the sleepers. The points consist of two short lengths of rails fixed together and capable of sliding sideways so as to bring whichever is required into line with the fixed rails. The car is a platform 40 feet in length and 10 feet in width, having the machinery cab at one end, and is supported on two bogies, the centres of which are 20 feet apart. Each bogie has two double-flanged wheels 3 feet in diameter, of wheel base 5 feet 4 inches. To obtain flexibility in rounding curves, the bogies have their centre pins connected to the body by means of ball bearings. The empty car weighs 22 tons, and is designed to carry a load of from 10 to 15 tons.



Four-wheel self-propelling mono-rail car.

The power required is derived from two petrol-electric sets of 80 and 20 horse-power respectively, the petrol engines being direct-coupled to dynamos. It is, of course, possible to collect current from an overhead wire, or to use steam or other motive power. Current is supplied from the generating sets to two 40 to 50 horse-power motors on the bogies for propulsion, the motors being geared to an intermediate shaft, from which the wheels are driven by balanced cranks and coupling rods. Current is also supplied to the gyroscopic motors, to a compressor for operating the Westinghouse brake and the gyroscopic control gear, and to a small motor driving an oil pump.

Each of the two gyroscopic wheels is 3 feet 6 inches in diameter, and weighs three-quarters of a ton; the axes are normally horizontal, and perpendicular to the direction of the rail. Each is driven at 3000 revolutions per minute by a direct-current shunt motor, having the field magnets on the frame and the armature on the gyrostat shaft. The whole is cased in, and a vacuum is maintained of $\frac{1}{2}$-inch to $\frac{5}{8}$-inch of mercury for the purpose of minimising the air resistance. Although the vacuum will last several hours, a pump is kept running in order to keep it as low as possible. Mr. Brennan has noticed that, while the motors run cool under a good vacuum, they become hot directly air is admitted to the casing. The shafts have steel journals running in white-metal bearings under forced lubrication, the oil being cooled before being returned to the bearings.

During the trials on November 10 the smaller generating set alone was in operation, giving a speed of seven miles per hour. At this speed there was no difficulty in carrying forty persons round the circular track, on to the straight, and over reverse curves of 35 feet radius without material disturbance of the level of the car floor. Loaded on one side, the car-level first rises on that side and then gradually recovers; the steadiness is admirably shown by one of the photographs taken, showing thirty-six persons standing as close as possible to one edge of the platform with the car at rest. Mr. Brennan states that a load of two tons can be placed on the edge of the platform and then removed without danger of non-recovery of the level. The car at present can negotiate grades of 1 in 13, and, with an additional generating set, grades of 1 in 6$\frac{1}{2}$ could be surmounted. Finality in design cannot be said to be reached as yet, and Mr. Brennan thinks that development will proceed in the direction of high-speed passenger trains having speeds up to 150 miles per hour.

THE RISE OF SCIENTIFIC STUDY IN SCOTLAND.[1]

AS the Royal Society is now about to open a fresh page in its history, it may not be regarded as an inopportune moment to sketch the rise of scientific study in Scotland, the means and opportunities afforded for that purpose, the formation of societies and institutions for the encouragement and diffusion of science in Edinburgh; also to put in the form of a continuous narrative the chief incidents in the growth of the society during the century and a quarter that has elapsed since its foundation.

Prior to the eighteenth century, and indeed during a considerable part of its course, Latin was the language in use for the interchange of thought and information amongst educated people at home and abroad. Treatises were composed in this language, lectures were delivered in the universities in Latin, and the theses presented for graduation were written and defended in the same tongue. Readiness to speak and understand Latin was a common bond of union amongst the learned, and distinguished them from the unlettered classes, whether of higher or lower social degree. Scotland participated in the revival of letters during the sixteenth century, and the names of George Buchanan, the representative Scottish humanist and historian of his time, of Andrew Melville, humanist and theologian, of James Crichton, surnamed the Admirable, were familiar to scholars throughout Europe. Contemporaneous with Andrew Melville was John Napier, the laird of Merchiston, the inventor of logarithms, a man of a different order of mind from the famous divine, one who by the publication of his great treatises, which were written in Latin, created a fresh era in the science of numbers, and provided mathematicians with a new and powerful instrument. To be conversant with Latin was a necessity for all who aspired to take rank in their respective professions. Those whose means enabled them to travel and to study in foreign universities could avail themselves of the instruction imparted therein, without requiring to have, as a preliminary, a good acquaintance

[1] Abridged from an address delivered before the Royal Society of Edinburgh on the occasion of the opening of the new home of the society, November 8, by Sir William Turner, K.C.B., F.R.S., president of the society.

with the language of the people. To cite an illustrious example from the south of the Tweed. William Harvey, the son of a Kentish yeoman, was educated in classics and physics at Gonville-Caius College, Cambridge. In 1598 he went to the University of Padua, where he studied under Fabricius, at that time the most eminent professor of anatomy in Italy. Profiting by the best means of instruction available at that time, and as a result of his own subsequent and independent observations and experiments, he discovered the circulation of the blood, and wrote his treatise "De motu Cordis et Sanguinis," which has made his name immortal, and has entitled him to be called the founder of exact physiological science, and the father of modern medicine.

Ambitious young Scotsmen did not lag behind in the desire to extend and perfect their studies by residence at schools of learning on the Continent. Literature, philosophy, and theology at first were the subjects of attraction; but later on medicine and science were cultivated with great zeal, and instruction and training in their application were obtained abroad of a quality surpassing that procurable in the universities of their native land.

In the latter half of the seventeenth century, three Edinburgh physicians, Sir Robert Sibbald, Sir Andrew Balfour, and Dr. Archibald Pitcairne, all of whom had studied abroad, took a leading part in the development and cultivation of medicine and science in Edinburgh.

Sibbald, Balfour, and Patrick Murray, the laird of Livingstone, being desirous of encouraging the study of botany, were bent on founding a medicine or physic garden, and, acting in conjunction with some other physicians, obtained a lease from the Town Council of the garden of Trinity Hospital for that purpose. They imported plants and seeds from abroad, obtained subscriptions from the nobility, the Exchequer, and members of the College of Justice, and established the garden which was the precursor of our world-famed Royal Botanic Garden.

In 1680 Drs. Balfour, Archibald Pitcairne, Sir Thomas Burnett, and other physicians met once a fortnight or so in Sibbald's house, to confer on "what was most remarkable a doing by the learned, some rare cases that had happened in our practice, and ane account of Bookes that tended to the improvement of medicine or natural history, or any other curious learning." So far as I have been able to ascertain, these conferences marked the first attempt in Scotland to bring together at regular intervals, for purposes of discussion and mutual improvement, those who had common interests in science and medicine. On St. Andrew's Day, 1681, after much negotiation, conducted principally by Drs. Sibbald, Balfour, and Stevenson, and with the aid of H.R.H. James, Duke of York, and Sir Charles Scarborough, His Majesty's first physician, a patent was granted by King Charles II. to found the Royal College of Physicians of Edinburgh, and in 1684 Sibbald was elected president of the college. After its institution the meetings for discussion and interchange of ideas were discontinued in Sibbald's hause, and were held monthly in the college.

In granting a charter in July, 1662, to the Royal Society of London, and one in 1681 to the Royal College of Physicians of Edinburgh, Charles did two wise actions, which have encouraged science, medicine, and learning, and therein have redounded to his honour and to that of his kingdom.

The scientific spirit and foresight shown by Balfour and Sibbald more than two centuries ago gave an impetus to the study of the natural sciences in Scotland, which as time went on resulted in the establishment of two institutions of which Edinburgh may well be proud, the Royal Botanic Garden and the Royal Scottish Museum.

Early in the eighteenth century, and during its continuance, a remarkable intellectual awakening took place in Scotland. Public affairs, with the exception of the abortive Jacobite risings in 1715 and 1745, had by this time become more settled. Through the development of agriculture, mining, manufactures, and commerce, Scotland had begun to emerge from being a poor country to a state of comparative affluence. Men found it possible to direct their thoughts to the arts of peace and to study letters, philosophy, and science. Within the universities, as well as in cultured society outside them, men of marked ability came prominently to the front, many of whom acquired, and have retained, a world-wide reputation.

An important change took place within the universities themselves in connection with the methods of instruction imparted in the faculty of arts. The old system of regents, under which it was the duty of each regent to act as tutor to a group of pupils from entrance to laureation, in all the subjects of a prescribed curriculum, began to be abolished, and a special subject was allotted to a particular teacher, who became a professor in that subject.[1] Encouragement was in this way given to a more profound study and fuller exposition of the subjects entrusted to the professors. Mathematics and philosophy, both natural and mental, especially commended themselves to the Scottish intellect. Great developments also took place in medicine and in the sciences on which it is based. The incorporation of the physicians of Edinburgh into a Royal College in 1681, the severance in 1722 of the corporate interests of the surgeons from those of the barbers, and the granting a new charter in 1778 to the surgeons, which incorporated them as a Royal College, greatly improved the tone and status of the medical profession in Edinburgh and in the adjoining counties.

As an indication of the value attached in Scotland during the eighteenth century to the medical education to be obtained in foreign universities, I may state that, from the foundation of the medical faculty in Edinburgh in 1726 until about the end of the century, fourteen of the professors in that faculty studied, either in whole or in part, in universities in Holland, France, or Italy, and many took the degree of Doctor of Medicine abroad. Of these, ten were educated at the University of Leyden, to which they had been attracted by the fame of Boerhaave.

The language common to all cultured people at that time enabled students to migrate from one European university to another, and to converse and receive instruction through one of the noblest of tongues, without having to resort to such mongrel forms of speech, to facilitate general intercourse amongst the nations, as have recently been devised by some ingenious persons. In the quality and range of their education and intellectual attainments, professors of science and the leaders in medicine were on an equal footing with the members of the Church and Bar, and with those who cultivated philosophy and literature. Members of the several professions acquired the habit of meeting together on a friendly footing, and were often joined by country gentlemen living in proximity to Edinburgh. Clubs and societies of various kinds, literary, social, medical, scientific, and legal, became the fashion.

In 1731 the leading physicians and surgeons in Edinburgh instituted a Medical Society for the improvement of medical knowledge. Monro *primus* acted as secretary, and under his supervision six volumes of "Medical Essays and Observations" communicated to the society were published. The "Essays" reached a fifth edition in 1771. They were translated into some foreign languages, were highly commended, and assisted in making the medical school of the University known throughout Europe. Shortly after the formation of the Medical Society several of the leading lawyers, professors in Edinburgh, Glasgow, and St. Andrews, country gentlemen, William Adams the architect, and others, formed a Society for Improving Arts and Science, particularly Natural Knowledge. Colin Maclaurin was the moving spirit; he and Andrew Plummer were secretaries, and the first president was James Douglas, fourteenth Earl of Morton, who became in 1764 president of the Royal Society of London.

(It may not be out of place to refer to the part taken by Scotsmen in the early history of the Royal Society of London. In the original charter appear the names of Sir

[1] During the incumbency of the regents, Latin was the medium of intercourse between teachers and students. After the introduction of professorships the lectures in many subjects were delivered in Latin well into the eighteenth century. Sir Alexander Grant says that St. Clair, professor of medicine, lectured in Latin (1726–1747), as indeed was the practice with all the faculty of medicine, except anatomy. In Glasgow, Cullen lectured (1748) on botany in Latin, but his lectures on medicine were delivered in English. Sir Robert Christison relates in his "Autobiography" that in 1810 his oral examination for the degree of Doctor of Medicine was conducted in Latin. The theses presented for graduation in medicine in Edinburgh were written and printed in Latin down to 1833, and an occasional thesis in the same language was presented as late as 1844.

Robert Moray, Secretary to the Privy Council in Scotland, and William Aerskine (Erskine), a son of the Earl of Mar, one of the cupbearers to King Charles. They had been his companions in exile, and after the Restoration they were attached to his court and person. Moray had scientific tastes and pursuits, which led to his election as president of a society for the promotion of physico-mathematical experimental learning, which met in Gresham College, London, 1661–2. This society became, on the receipt of a Royal charter in July, 1662, the Royal Society of London, under the presidency of William, Viscount Brouncker. Moray had without doubt been the King's adviser in the granting of the charter. About a century later James Douglas, Earl of Morton, a mathematician and astronomer, a friend of Colin Maclaurin, and a former president of the Philosophical Society of Edinburgh, was in 1764 elected president of the Royal Society of London. Eight years later Sir John Pringle, of the family of Stichel, was made president. He had graduated as M.D. at Leyden in 1730, and settled in Edinburgh, where he held the chair of moral philosophy in the University from 1734 to 1742. He then joined the army as a surgeon, ultimately became Physician-General to His Majesty's forces, wrote a famous book on "Diseases of the Army," resided in London, and in 1772 was appointed president. After a long interval Lord Kelvin occupied the chair, 1890–5, and last year Sir Archibald Geikie was made president. Although not of Scottish birth or parentage, Scotland may claim to have participated in the training of Sir J. Dalton Hooker, president 1873–8, who was educated at the High School and University of Glasgow during his father's tenure of the regius chair of botany in the University; also of Lord Lister, president 1895–1900, who carried out his far-reaching researches when he held the chair of systematic surgery in the University of Glasgow, and subsequently that of clinical surgery in the University of Edinburgh.)

It does not appear that any of the communications made to the society in its early years were immediately published, as the troubles which arose in connection with the Jacobite rising in 1745, and the death of Maclaurin in the following year, suspended for a time its work. Proposals had been, however, made to the Medical Society to form along with it a conjoined society, which should carry its disquisitions into other parts of nature than those which immediately related to medicine, on the understanding that theology, morals, and politics were to be excluded. The larger society formed by this combination became the Philosophical Society of Edinburgh, and it published between 1754 and 1771 three volumes of "Essays and Observations, Physical and Literary," which had been read before the society, the last two of which appeared when David Hume and Monro *secundus* were secretaries. The "Essays" embraced a wide range of subjects, mathematical, physical, anatomical, botanical, medical, and surgical. Vol. i. is of interest in containing two papers by Alex. Monro, jun., afterwards *secundus*, then a student of medicine; and in vol. iii. a letter to David Hume is printed, dated 1762, in which Benjamin Franklin described his method of securing houses from the effects of lightning. To quote the words of Principal Forbes, the Philosophical Society of Edinburgh was the immediate parent of the Royal Society. As the Philosophical Society was a voluntary association, liable to be interrupted in its work, or even to be dissolved, it was considered advisable that an attempt should be made to form a society on a more permanent basis. A meeting of the professors of the University, many of whom were likewise members of the Philosophical Society, was called in 1782, when Principal Robertson proposed a scheme "for the establishment of a new society on a more extended plan, and after the model of some of the foreign academies, which have for their object the cultivation of every branch of science, erudition, and taste." As in the formation of the Royal Society of London, the patronage of the King had been solicited, and a charter of incorporation by the Crown obtained; a similar course in this instance was proposed and agreed to, and in March, 1783, King George III. granted a charter under the name of the Royal Society of Edinburgh.

The charter provided "ut Societas Literaria Edinburgi institueretur, ad Statum illius partis Imperii nostri quæ Scotia vocatur accommodata," from which it is obvious that its scope was not limited to the city after which it was named, and in which it had its seat, any more than the corresponding Royal Society in the southern division of the kingdom was exclusively a society for London itself. The charter defined the range of study and research to be included in the work of the society, and specifically named along with the sciences of mathematics, physics, chemistry, and natural history, also archæology, philology, and literature.

The first meeting of the society was held on June 23, 1783, in the University library, with Principal Robertson in the chair, when it was resolved that all the members of the Philosophical Society should be assumed as members of the Royal Society, and that the judges of the Supreme Court and a number of other gentlemen should be invited to join it. The society in its first year had as president Henry, third Duke of Buccleuch, and numbered 102 resident and 71 non-resident members. It is interesting to note that the Senatus of the University of St. Andrews was represented by ten members, King's and Marischal's Colleges, Aberdeen, by sixteen, whilst fifteen members of the Senatus of the University of Glasgow were original fellows, so that its national character was emphasised from its foundation.

The fellows were divided into two classes, physical and literary, and a short time after the foundation of the society the physical class numbered 101, whilst the literary class contained 114 fellows. In the first four volumes of the Transactions of the Royal Society, from 1783 to 1797, the papers were grouped into two classes. In vol. i. twelve physical papers were published and eight literary; in vol. iv. thirteen physical papers and only two literary. It became obvious, therefore, at an early date that the physical or scientific work of the society would dominate the literary. In vol. v. (1805) it was not thought necessary to divide the published memoirs into these groups, and two papers on literary subjects and two biographies were printed without being classified apart from those relating to science. In the course of time communications on literary subjects became so few in number that they formed only a small part of the work of the society.

The society commenced to publish its Transactions in 1788, and up to the present date forty-six quarto volumes have appeared. Vols. i. to v. contained chapters entitled "History of the Society," which included its Proceedings from 1783 to 1805. The publication of the Proceedings was then suspended for nearly thirty years, but in December, 1832, the society began to issue the Proceedings independently, from which date to May, 1844, they were collected, and published in 1845 in an octavo volume, to be followed by twenty-five similar volumes up to 1907, when they were enlarged to a super-royal octavo.

The scheme for the encouragement of research, recently inaugurated by the Carnegie trustees, by the institution of fellowships and scholarships, has made a provision to aid in the maintenance of men of science of the younger generation during their years of probation. The conferring of grants of money to meet the expenses of research and publication has rendered valuable assistance to scientific and other investigators, and has enabled our society to provide more complete and finished illustrations to some of the memoirs than would otherwise have been possible.

Those of us who commenced scientific work fifty or more years ago cannot but recognise the enormous advance which has been effected in recent years in providing means and facilities for exact inquiry. Natural objects were present and visible to us and to our predecessors then as now. But the present methods of study are more exact, and opportunities for its pursuit are more easily obtained; instruments of research have become more powerful and more capable of assisting in penetrating deeper into the secrets of nature; novel phenomena have been disclosed to view and call for interpretation by men of science. The field of research is far from being barren and exhausted, for it is, and will continue to be, capable of producing ever-ripening fruit. It will be for the younger fellows and for those who may succeed them to bear their share in the extension of natural knowledge, to undertake the responsibility of continuing the work of the society, and to preserve the place which it has gained in the forefront of kindred institutions.

EXPERIMENTS AT HIGH TEMPERATURES AND PRESSURES.[1]

WITHIN a few miles of this lecture-room there is an unexplored region—to approach it we should have to move vertically downwards. It has been suggested by Mr. Parsons[2] that it would be worth while to make a short expedition in this direction, but the journey would be slow and the cost high—for instance, to bore a hole twelve miles deep was estimated to be a labour which would occupy eighty-five years and cost 5,000,000*l*. A well-to-do man desiring to benefit his fellow creatures could not do better than undertake this project, but until he comes forward we must perforce be content to try to imitate in our laboratories the temperature and pressure conditions which would be met with deep down in the earth.

Information, attainable from experiments under these conditions, is essential to the development of any exact concept of the structure and evolution of the earth. One of the most important questions in connection with the study of bodies under high pressures and at various temperatures is as to whether any particular body is solid or liquid under specified conditions, and, if solid, whether it is amorphous, glassy, or crystalline. That pressure would influence the melting point of solids was clearly put forward by Clapeyron in 1834, but it was not until after the establishment of the mechanical theory of heat in the "forties" of the last century that the exact numerical relations could be established, as was done by Prof. James Thomson in 1851, when he calculated, for the first time, the amount by which the temperature of fusion of ice would be reduced by a given increase of pressure. The ideas underlying such calculations are based on a consideration of the way in which heat is converted into mechanical work in any prime mover depending on a heat-supply, and were first formulated by Carnot in 1824, before the true nature of heat was understood. As the matter is fully dealt with in every text-book, I will merely remind you that Prof. James Thomson was able to obtain an equation between the mechanical work actually produced under stated conditions and the work which, according to Carnot's principle, must be developed by a reversible engine operating between fixed temperature limits upon a given amount of heat.

The general relation for a substance undergoing a change of state at absolute temperature T, such change involving a change of volume Δv and an absorption or emission of heat at constant pressure Q_p, is, reserving the question of sign,

$$\frac{dT}{dp} = \frac{\Delta v T}{Q_p}$$

or, in words, the change of melting point produced by unit change of pressure equals the product of the absolute temperature, and the ratio of the change of volume of unit mass on melting to the quantity of heat absorbed or emitted by unit mass in the process.

Now the greater number of substances when they pass from the liquid to the solid state evolve heat and contract in volume. An increase of volume is, of course, a positive quantity, and if heat is absorbed during this increase it is reckoned positive also. In the case of water, heat is evolved during freezing as in other cases, but the mixture of ice and water has a smaller volume than the solid ice. Accordingly, the change of volume in this case is negative, and the melting point falls as the pressure rises.

The first fairly exact confirmation of the theory appears to be due to De Visser,[3] who selected acetic acid most carefully purified as a test substance, though valuable experiments up to much higher pressures had been previously made by many others, particularly by Dewar on water,[4] Ferche on benzol,[5] and Damien[6] on a variety of substances.

It is necessary to work with a pure substance in order to test the theory, or at all events with one the solid phase of which has the same constitution as its liquid phase. If the acetic acid had not been pure, the probability is that the frozen part would have contained more or less of the impurity than the unfrozen, and consequently a state of affairs not contemplated in the theory would have arisen. From the experimental point of view, it is obvious that a sharp melting point is a necessary condition for its accurate observation.

A quantity of acetic acid—rather more than 40 c.c.—is confined by mercury in a closed apparatus based on a previous design by Bunsen, which also contains air in a graduated tube. When the acetic acid melts it expands, and compresses the air through the intermediary of the mercury, whereby the pressure can be inferred. The part of the apparatus containing the acetic acid is immersed in a bath which can be kept at any desired temperature. As the melting progresses a pressure is set up by the expansion, and finally attains such a value that no further melting can take place. We then have a mixture of solid and liquid acetic acid in presence of each other under a measured pressure and at a known temperature. The quantities entering into the calculation are ascertained from other experiments—notably the ratio of the change of volume to heat absorbed was ingeniously ascertained by a modification of Bunsen's ice calorimeter. The final result was that the rate of variation of temperature of melting point with increasing pressure was calculated to be 0·02421° C. per atmosphere as against 0·02435° C. found by experiment, a difference of 0·57 per cent. I have dwelt on this work at some length in the hope that it may make the nature of the problem clear. It is to be noted that the experimental difficulties are considerable, and are enhanced by the fact that we have no *a priori* reason to suppose that the rate of change of melting point with pressure is a constant quantity independent of the pressure. In fact, it was shown by Sir Joseph Thomson about 1886[1] that in calculating the change of melting point we ought to take into consideration "the difference between the energy due to strains produced by the pressure in unit mass before and after solidification." Sir Joseph Thomson's reasoning, based as it is on a generalised Lagrangian method of treating problems involving energy changes, is unsuited for discussion in a non-mathematical address, but it is easy to see that if the compressibilities of liquid and solid are different, then the change of volume accompanying the change of state of unit mass must itself depend on the pressure, and therefore the pressure change of melting point, which is proportional to the change of volume, must depend on the square of the actual pressure so far as this part of the effect is concerned. This anticipation was realised by Damien in 1891, who showed that the melting points of substances in terms of the pressure could be expressed by a formula of the kind

$$t = t_0 + a(p-1) - b(p-1)^2,$$

t_0 being m.p. under 1 atmosphere pressure.

I think we may add that there will also be a small effect depending on changes of energy in the capillary layer separating the phases.

The first adequate investigation of the change of m.p. under pressure over a wide range of pressures was made by Barus.[2] Time does not permit me to do more than exhibit the results obtained, though the apparatus employed was most cleverly designed. It requires great experimental knowledge and ingenuity to infer with accuracy changes of volume of a few per cent. of the original volume at pressures of 1500 atmospheres, nearly ten tons per square inch. If we note the pressures and temperatures of melting, and plot the result as a curve against the pressure and temperature, we obtain what is called a melting-point curve, and this divides the field into two parts, so that on one side of the curve the temperature and pressure at each point have such values that the substance is solid, while on the other side their values are such that the substance is liquid. It is instructive, therefore, to regard the melting-point curve as the line separating the region of solid from the region of liquid. Along the line, and along it only, *i.e.* at the pressures and temperatures indicated by points on the line, the solid and liquid phases can exist in equilibrium together. Such a diagram is called a "diagram of condition."

[1] Discourse delivered at the Royal Institution on Friday, March 19, by Richard Threlfall, F.R.S.
[2] B.A. Reports, Cambridge, 1904, 672.
[3] Recueil des Travaux Chimiques des Pays Bas xiii., 1893, 101.
[4] Proc. R.S., xxx., 1880, 533.
[5] Wied. Ann., xliv., 1891, 265.
[6] C. R., cxii., 1891, 785.

[1] Applications of Dynamics to Physics and Chemistry, 259.
[2] Bulletin No. 96 of the U.S.A. Geological Survey, 1892.

By far the greater part of our information as to the quantitative relations of bodies at high pressures we owe to Prof. Gustave Tammann, who has collected his results in a book entitled "Kristallisieren und Schmelzen," the advent of which (1903) must be regarded as an important event in the history of the subject.

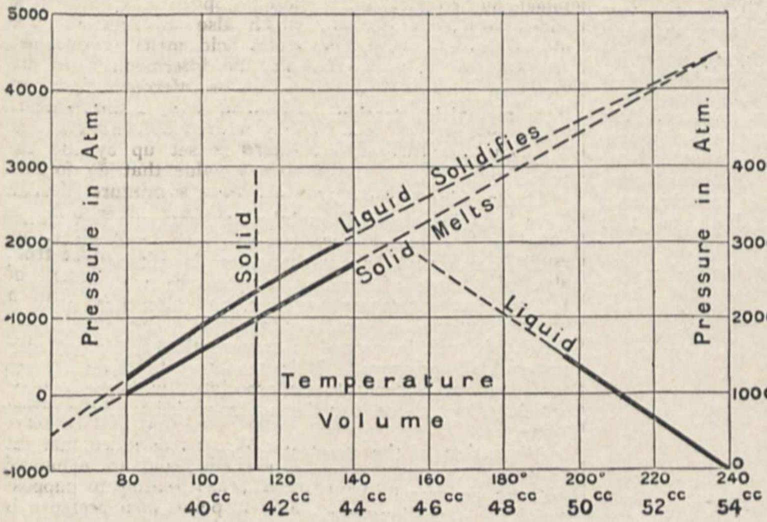


FIG. 1.—Full lines indicate part of field actually explored. Dotted lines indicate extrapolations.

The complete thermodynamic specification of a body involves a knowledge of its mass, volume, pressure, temperature, energy, entropy, surface tension, and nature, whether liquid, solid, glassy, crystalline, or amorphous.

Prof. Tammann has simultaneously measured the pressure, temperature, volume, and mass of many substances under high pressure, and at temperatures extending from 80° C. to 200° C.—taking cognisance of the physical state—and has thus been able to plot out many interesting diagrams of condition. The apparatus consists of a screw press by which a piston of ebonite is driven down a steel cylinder of small known cross-section. The cylinder is filled with oil, and the ebonite piston fits practically oil-tight. The oil communicates with the oil contained in a strong steel vessel, which also encloses a glass tube open at the lower end, containing the substance and dipping below the level of mercury contained in a dish. The oil occupies the rest of the space. The steel vessel is placed in a thermostat so that its temperature can be ascertained. The oil pressure is measured by a Bourdon gauge, which it was possible to standardise, thanks to the previous work of Amagat and Tait. In order to construct a diagram of condition, it is necessary and sufficient to find a number of points separating the liquid from the solid area, or separating the areas corresponding to different crystalline forms in the case where the transformation of one sort of crystal into another is under investigation. To understand how this is done, it is best to take a special case. If we have a quantity of a substance under a known pressure and temperature in the piezometer, and suddenly increase the pressure, so that there is not time for heat to pass in or out to any appreciable extent before the pressure gauge can be read, we have practically adiabatic compression. If the apparatus be then left to itself, the heat which we may suppose to be liberated by the pressure will slowly diffuse outwards, and the pressure will fall as time goes on. If we happen to start from a point on the m.p. curve before the pressure is raised, then the final result will be that we shall thaw or freeze more or less of the material, and the original pressure will be exactly regained, the change of state compensating the impressed change of volume. If, however, the increase of pressure has been so great that a change of state of the whole mass has been brought about, then the after variation of pressure will be so much greater that it is easy to distinguish this case from the previous one.

The accompanying diagram (Fig. 2), taken from Prof. Tammann's book, shows how the equilibrium curve can be located in the case of carbon dioxide and naphthalene. In the former case the temperature was 0·31° C. The pressure was 3800 kilograms per sq. cm., or 24·13 tons per sq. inch. (157·49 kilograms per sq. cm. = 1 ton per sq. inch = 152·38 atmospheres.)

The pressure was raised adiabatically to 4400 kg./cm.² (27·93 tons/sq. inch), and the subsequent fall of pressure plotted against a time scale for ten minutes. The pressure was then adiabatically reduced to 3550 kg./cm.², and the recovery curve again plotted. The equilibrium pressure must lie between the pressures approached asymptotically on the diagram, *i.e.* between 3825 and 3792 kg./cm.². A repetition between narrower pressure limits enables the pressure to be fixed at between 3808 and 3797 kg./cm.². A similar procedure fixed the pressure of the m.p. of naphthalene between 3090 and 3080 kg./cm. at the temperature considered, a difference which corresponds to 0·2° C., the actual temperature possibly differing from the thermostat temperature by 0·1° C.

We may now pass on to the consideration of some of the results obtained, which refer, not only to change of melting points, but to changes in the temperatures of transformation of isomorphic forms.

As illustrations of such changes, I show here the transformation of yellow to red mercuric iodide, which shows well in the projection microscope; also Mitscherlich's transformation of potassium bichromate, and sulphur in two forms.[1]

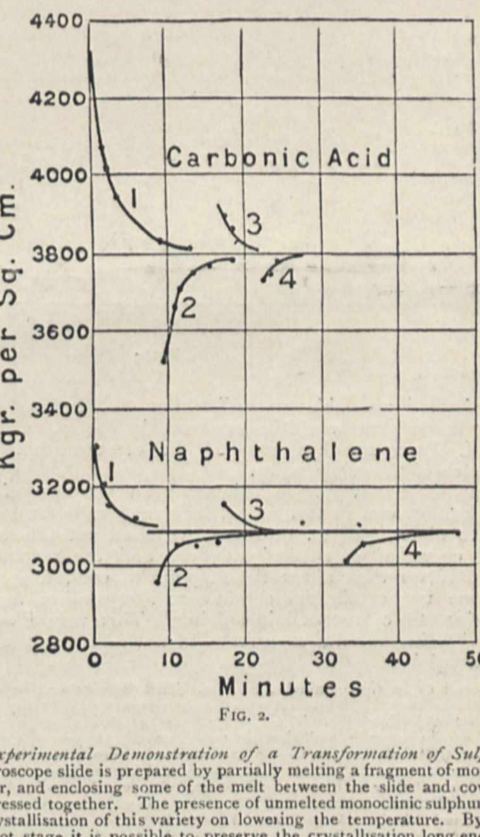


FIG. 2.

[1] *Experimental Demonstration of a Transformation of Sulphur.*—A microscope slide is prepared by partially melting a fragment of monoclinic sulphur, and enclosing some of the melt between the slide and cover-slip, well pressed together. The presence of unmelted monoclinic sulphur insures the crystallisation of this variety on lowering the temperature. By means of a hot stage it is possible to preserve the crystallisation long enough to exhibit it by means of a projection polarising microscope. The appearance is very characteristic. Another slide is prepared, but this time all the sulphur is melted, and can generally be undercooled so far that it crystallises in what

The case of sulphur is one of great interest. It has long been known that sulphur can exist in at least three solid forms. It crystallises from some solvents in octahedral crystals, from others or from its liquid state in monoclinic crystals. In the latter case some amorphous sulphur is generally dissolved in the crystals, and the amorphous variety itself is formed in tough vitreous masses when molten sulphur, heated until it becomes very viscous, is poured into cold water. At ordinary temperatures the octahedral form alone is stable. It has been found that at atmospheric pressure octahedral sulphur is converted into monoclinic at 95·4° C., and in the process 2·7 gram-calories per gram of sulphur are evolved. The density of octahedral sulphur is about 2·03 and of monoclinic about 1·98 at ordinary temperatures. In accordance with the principles developed previously, the transformation temperature of rhombic to monoclinic sulphur must rise with increase of pressure. So far back as 1887

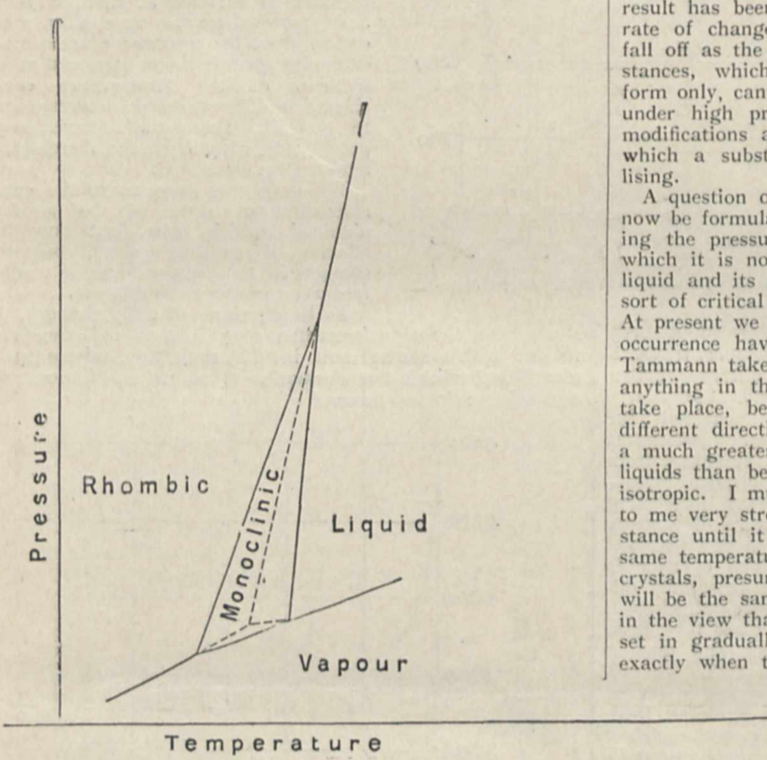


FIG. 3

Roozeboom[1] was able to predict that the diagram of condition for sulphur would be as shown in Fig. 3.

Prof. Tammann has supplied the corroboration of the existence of the triple point.

Suppose that we have sulphur at a pressure of about 1500 kg./sq. cm. (9·52 tons/sq. inch) and raise its temperature to about 160° C. or more, we shall cut the melting-point curve of octahedral sulphur, and the sulphur will melt. If we then allow the sulphur to cool, keeping the pressure up, octahedral sulphur will crystallise from the melt instead of monoclinic sulphur. This very likely has some bearing on the occurrence of native crystals of octahedral sulphur.

is believed to be the octahedral system. This slide is then placed in the projection microscope, when it is seen that its appearance is totally different from that of the first slide. The preparation of octahedral sulphur is then heated on the hot stage, and when the transformation temperature is reached it is seen that the structure begins to change—the crystallisation breaks up and becomes granular, the granules showing in general much more colour than the original crystallisation. These granules are taken to be monoclinic sulphur. The temperature is now raised until about half the preparation has melted, and it is then allowed to cool back a little so as to crystallise. The crystals now show the characteristic monoclinic crystallisation with brilliant colours, since unmelted monoclinic sulphur is present.

[1] Rec. Trav. Chim. Pays-Bas, vi., 1887, 314.

It is not every substance which has such sharply defined properties as sulphur, though even these are not so sharp as they might be, owing to the constant presence of amorphous sulphur. An instructive case is afforded by phenol. As the diagram shows, there is a considerable region of the field in which two kinds of crystals of different density can exist together, the curves forming the boundary of this region of pseudo-equilibrium.

It may be that the two crystalline forms of carbon which apparently can exist together indefinitely at ordinary temperatures and pressures are an illustration of the same property.

As a final illustration we may note the results for water down to −80° C., from which it appears that it possesses three allotropic crystalline forms with at least two melting points.

The melting curves of from thirty to forty substances have been investigated, mainly by Tammann, up to about 3000 kg./sq. cm. = 19·05 tons/sq. inch, and the general result has been to show that there is a tendency for the rate of change of melting temperature with pressure to fall off as the temperature rises, and also that many substances, which at ordinary pressures crystallise in one form only, can be caused to assume allotropic modifications under high pressure. This tendency to form allotropic modifications appears to be associated with the extent to which a substance can be under-cooled without crystallising.

A question of the greatest interest and importance may now be formulated, What will happen if we go on increasing the pressure? Will a state of affairs be reached in which it is no longer possible to distinguish between the liquid and its crystalline form? Will there be, in fact, a sort of critical point at which the melting curve will end? At present we can only say that no indications of such an occurrence have been observed experimentally, and Prof. Tammann takes the point that it is highly improbable that anything in the nature of continuous transformation can take place, because a crystal has different properties in different directions related to its axes, and there is thus a much greater qualitative difference between crystals and liquids than between liquids and gases, both of which are isotropic. I must admit that this argument does not appeal to me very strongly. If it be possible to compress a substance until it reaches a state in which, at one and the same temperature, the liquid has the same density as the crystals, presumably the mean distance of the molecules will be the same in both cases. I see nothing monstrous in the view that in these circumstances crystallisation may set in gradually, and that it may not be possible to say exactly when the liquid ceases to be a fluid and becomes a crystalline solid. There are no theoretical or other grounds for supposing that the phenomena of crystal growth, as observed when there is a change of volume accompanying the crystal formation, will necessarily hold when no such change of volume occurs.

If we refer to the theory of the change of m.p. by pressure it is obvious that if either the change of volume or the latent heat of melting vanish at any temperature or pressure on the melting curve, then in the neighbourhood of this pressure the curve must degenerate to a point, or small pressure changes will not affect the m.p. It was pointed out, however, that there is a term or terms depending on the square of the pressure, and if these were relatively important the only thing we should notice would be a change of curvature at the point under consideration. It does not follow that there is no maximum or minimum to the melting temperature of any particular substance because the term in P^2 may be vanishingly small; it may be (and generally is) of opposite sign to the term in P, and in this case it is only a question of the relative importance of the terms where the maximum or minimum melting point lies. Damien's empirical formula expresses precisely the effect to which I refer. The practical result which is of importance in questions affecting the condition of the inner layers of the earth is that we are not entitled—in fact, it is wrong—to suppose that pressure must necessarily go on raising the melting point indefinitely; everything depends on the substance under consideration. It is therefore necessary to make such experiments as those of Tammann at vastly higher temperatures and pressures than those we have been considering, up to probably more than 10,000 kilograms per sq. cm. (or 63·5 tons per sq. inch).

In 1893 some experiments were described by Parsons[1] in which carbon rods were heated by electricity under a pressure usually of 15 tons per sq. inch, but rising in one case to 30 tons per sq. inch. The pressure was obtained by means of a hydraulic press, but no detail is given.

I have been desirous for many years of making some experiments at high temperatures and pressures, but for a long time could think of no way of ascertaining the pressure at temperatures over a red heat except by the use of compressed gases. In 1902 Sir Andrew Noble was kind enough to have some drawings prepared for a wire-wound steel pressure vessel to carry a pressure of 50 tons per sq. inch. The pressure was to be supplied by a compressed gas, and some details of the heating arrangements were designed, when a calculation of the cost of the gas compressors, vessel and appurtenances, made it clear that the undertaking would be beyond my means. I then endeavoured to find a simpler form of apparatus, and finally was led to contemplate the substitution of graphite for compressed gas, Spring having pointed out that crystalline graphite flows very easily at high pressures. A simple trial made it clear that the graphite of Ceylon does, in fact, possess the property of flowing like a liquid under high pressure to a sufficient degree to allow of pressure being transmitted by it. Graphite can be used, with some reservations, to transmit a pressure just like water or oil, though it is, of course, inferior in fluidity, and, as I have now discovered, occasions a loss of "head" which is not independent of the pressure itself. My former statement in the Chemical Society's Journal, 1908, is erroneous, though the results of the experiments are, I believe, hardly, or not at all, affected by the mistake, for a reason which will be clear later on. After several trials, the apparatus which I have here to-night was evolved, and some experiments were made with it. These experiments are not of any great importance, and, indeed, I feel almost ashamed of bringing them to your notice—I can only say, in excuse, that everything must have a beginning.

I believe, however, that the apparatus is sufficiently simple, cheap, and effective to enable others with more leisure at their disposal to make a beginning of an investigation of the properties of matter up to 100 tons per sq. inch, and at temperatures up to about 2000° C. At present, however, it is not possible to infer with accuracy the volume of the substance under these extreme conditions, nor can its physical condition be more than approximately and indirectly inferred—we must content ourselves with the production of transformations which we can make persist down to ordinary temperatures and pressures.

If we refer again to the sulphur diagram, we shall see how this possibility may arise. If sulphur is melted and cooled slowly, monoclinic crystals are found—when the temperature sinks below 98° C. these crystals undergo spontaneous transformation to the rhombic form—but all that we see is that the monoclinic crystals become opaque; the external form of the crystals is still monoclinic, but they are merely pseudomorphs of the original crystals.

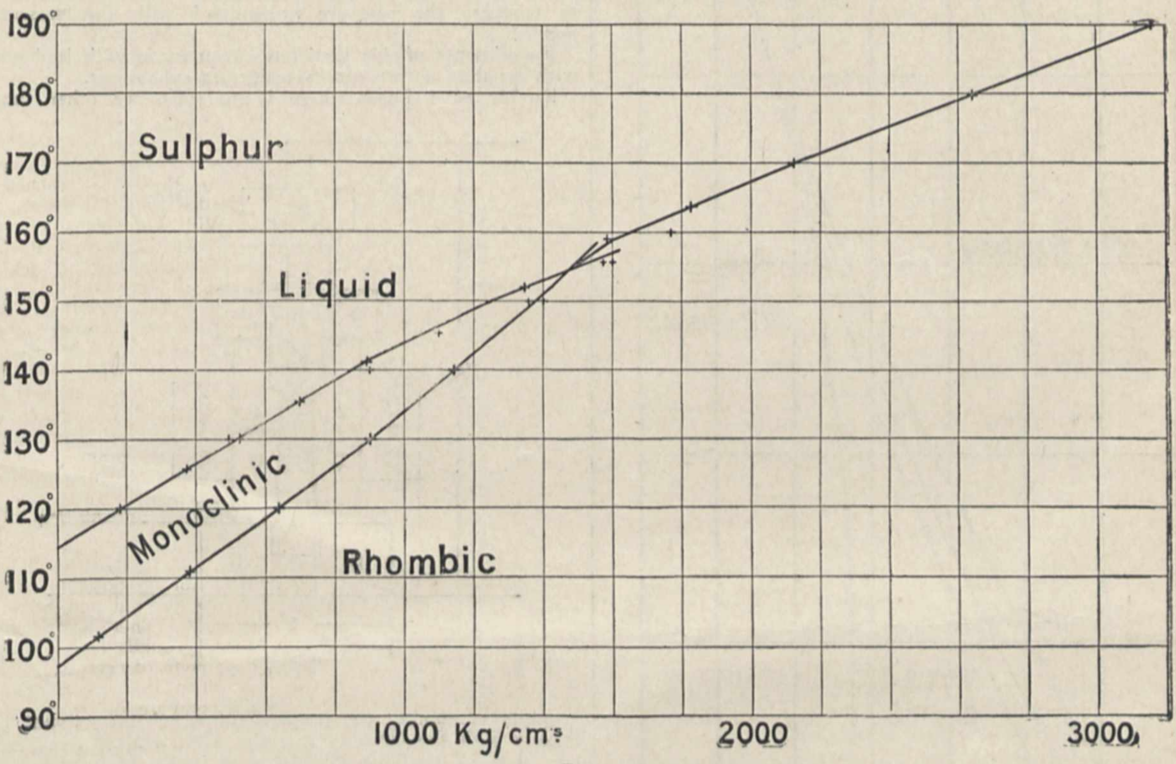


FIG. 4.

To obtain large octahedral crystals we may suppose that we begin by melting sulphur and raising the temperature and pressure until the former stands at 160° C. or over, and the latter at not less than 1600 kg./cm.^{2} (10·16 tons/sq. inch).

If we then slightly reduce the temperature or raise the pressure, we shall have the crystallisation of the sulphur in the rhombic form. By maintaining the pressure as the mass cools, and when it is cold releasing the pressure, we should finally extract rhombic crystals. To this we may, of course, add that we need not expect crystals of any size unless we cool at the proper rate. It appears that there are at least two phenomena requiring attention in relation to the production of crystals—one is the relation between the amount of undercooling necessary to induce spontaneous crystallisation, and the other is the rate at which the crystals will grow when they have once started. If we want large crystals we must not have an excessive number of points of spontaneous crystallisation, nor must we have too high a rate of crystal growth, or the crystals will by all experience

[1] Phil. Mag., xxxvi., 304.

tend to be felted together. The temperature condition giving birth to the most favourable number of spontaneous centres is not necessarily the temperature at which crystals grow to the largest size, so there is really no escape from finding by direct trial the most effective way to go to work.

Another possibility is brought to light by an examination of a case of pseudo-equilibrium, such as that of phenol. Here we have three regions—in one No. 1 alone is stable, in another No. 2, and in the third both Nos. 1 and 2 are stable. The case of iodide of silver is similar but more complicated. If in the area C we change the pressure, the temperature remaining constant and the

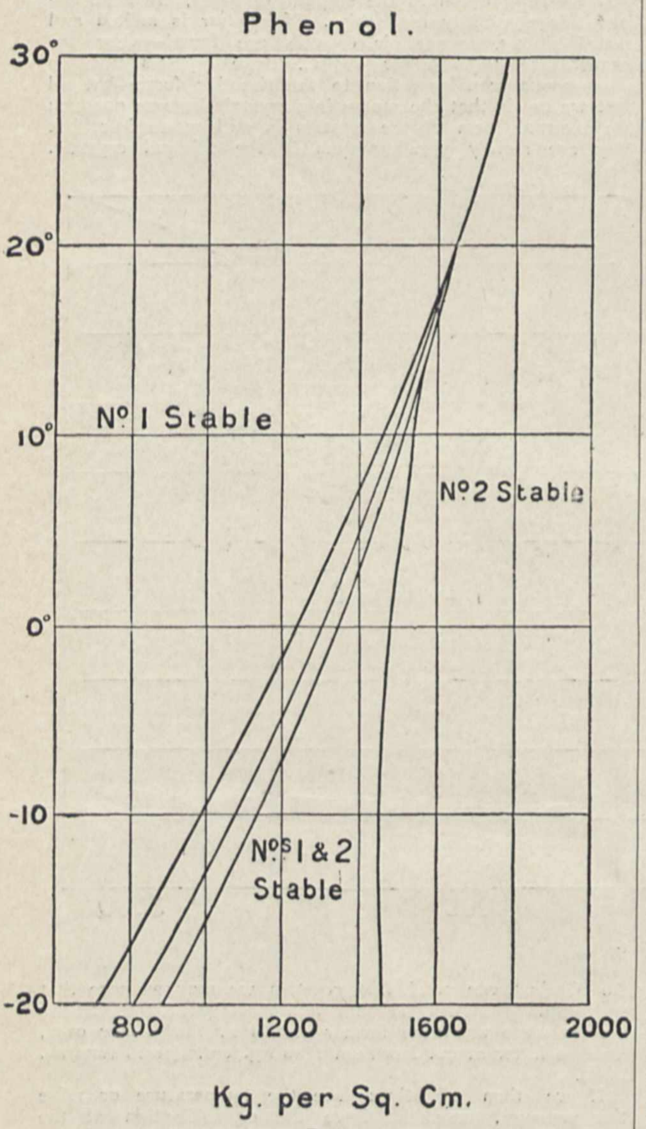


FIG. 5.

material consisting of a mixture of the two stable phases, we can alter the proportions in which these phases exist, but we cannot cause either of them to disappear.

A notable case of this kind is that of graphite and diamond, both perfectly stable in presence of each other at atmospheric pressure up to a temperature nearly that of the electric arc, say about 3000° C. If there be any similarity between the carbon and phenol diagrams, diamond would correspond to variety No. 2 of phenol and graphite to variety No. 1, heat being evolved in both cases when the less dense modification changes into the denser. If we desire to obtain phenol 2 from phenol 1, we note that, down to a temperature of −20° C., we should require to keep the pressure always above about 600 kg./cm.², otherwise the operations would be similar to those described in the case of rhombic sulphur.

Similarly, to convert graphite to diamond on this analogy we should have to raise the temperature and pressure together to some unknown values, and then let the product cool, keeping up the pressure meanwhile.

The apparatus which I have used in making the experiment is based on the transmission of pressure by crystalline graphite or the softer metals. In order to ascertain how much pressure is lost during transmission, I have arranged an apparatus in which the material to be tested is exposed to a known pressure, tending to force it through a cylindrical space, identical in figure with the space in which the heating is intended to be carried out. The pressure transmitted is transferred by a simple device to a piston with a hard steel point, and this is forced by the pressure to penetrate a soft steel plate. In a subsequent experiment the same piston is forced by a known pressure into the same steel plate so as to penetrate to the same depth as in the main experiment. It is then possible to compare the pressure transmitted with the pressure applied.

Experiments of this kind have been made with lead and with graphite as pressure-transmitting substances.

So far as I know, there is no substance other than

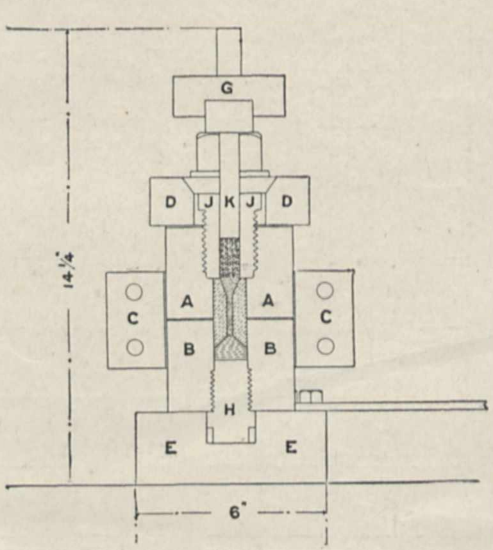


FIG. 6.

graphite combining the property of a certain amount of fluidity with the capacity to resist high temperatures, and our hope of studying chemistry at really high pressures and temperatures appears at present to depend largely upon it. It is true that some attempts have been made to use compressed gases, but the apparatus is vastly more complicated, and the experiments themselves become really dangerous in view of the immense potential energy possessed by gases at pressures of 100 tons per square inch. As illustrating this, I may mention that 100 tons per square inch is about the highest instantaneous pressure noted by Sir Andrew Noble in his well-known experiments on the exploding of cordite in closed vessels. The density of nitrogen at 100 tons per square inch is, taking Boyle's law as a very rough approximation, 15,240 times its density under standard conditions. This works out to rather more than 19, *i.e.* about the same as gold, and the energy stored is of the same order as that contained in an equal volume of cordite, though its availability is lower.

The construction of the apparatus I have used can be easily followed from the drawings. It consists essentially of a steel cylinder divided perpendicular to the longitudinal axis by a thin plate of mica, the two halves being clamped tightly together by an insulated ring and clamps at top and bottom. Pressure can be applied by an ordinary hydraulic lifting jack—the one I have used will lift fifty or sixty tons—the bore of the hydraulic cylinder being about 4½ inches. In order to operate at a high temperature it is necessary to line the cylinder with some refractory substance, and I have generally used magnesia for this purpose, though zirconia or thoria might be better. Purified magnesia is first melted in an electric furnace, and then ground in an iron mortar until it is very fine. The powder is freed from iron as well as possible by a strong magnet, and after being sifted is pressed into the cylinder little by little by hydraulic pressure so as to form a solid plug. This is then bored out with a hard steel drill to the required diameter. In pressing magnesia I have found that it is not possible to thoroughly consolidate the powder in greater thickness than a few millimetres, even under a pressure of 50 tons per square inch. In fact, magnesia is a substance which appears to be almost devoid of the fluid properties so marked in graphite—an essential condition for its use in the apparatus. I have tried various other linings, ground flint, alumina, &c., but they have no advantage over magnesia, and are even more difficult to drill out. Alumina prepared from the crystalline hydroxide is very easily compressed into cakes, and makes a good lining, but it is too fusible for experiments on carbon, and is probably more easily reduced. The

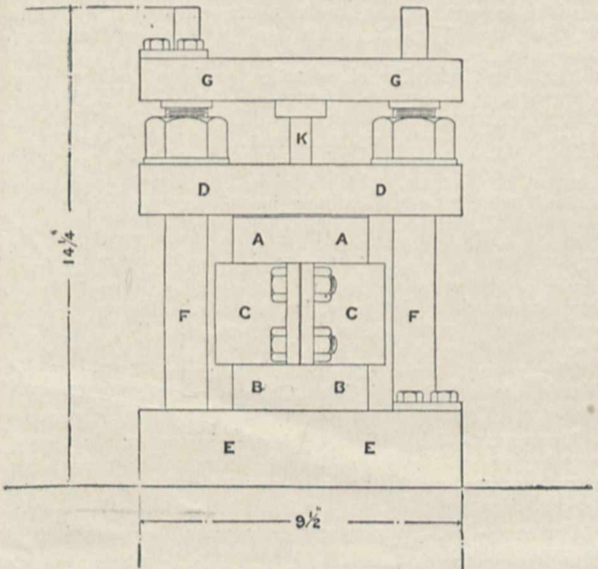


Fig. 7.

cylinder having been lined, the bottom is filled in with Acheson graphite in electrical communication with the base of the apparatus. The substance to be operated upon is placed in the narrow part of the bore, and packed in with graphite or lead if that is suitable. The pressure is applied by a ram of hardened high-speed steel working upon a reservoir of graphite or lead contained in the plug closing the cylinder at the top and electrically connected to the other terminal of the supply. The chief uncertainty in regard to the pressure which actually reaches the subject of the experiment lies in the possibility of the ram being held to some extent by friction against the sides of the cylindrical hole in which it works, and in the consolidation of the graphite, with reduced fluidity, before it actually flows. One has to trust either to the hardness of the ram or to leave a space round it sufficient to allow graphite to escape, when the apparatus follows the lines of Amagat's standard pressure gauge, but the duration of the experiment is curtailed by the exhaustion of the graphite supply. A correction has to be applied for the pressure absorbed by the lead or graphite in accordance with the results of the preliminary trial. It is fair to say that no tendency of the ram to stick has ever been noticed—on the contrary, changes of volume brought about by heating have made themselves evident at once on the pressure gauge of the hydraulic press.

When working with any form of carbon there has been no trouble in arranging to heat the body which is being compressed by electrical means. It has been found most convenient to adjust the current to about the value required by means of a resistance—large compared with that of the pressure vessel—the latter being short-circuited meanwhile. In making an experiment, the hydraulic press is worked until the desired pressure is attained, and then by opening the switch the current is thrown on to the apparatus. When the magnesia lining begins to melt, the pressure, as shown by the pump gauge, is seen to fall, graphite flows into the magnesia tube, and the pump is worked so as to compensate for this. Under these conditions the pressure is probably transmitted without appreciable loss, as the narrow part of the cylinder is now in a fluid bath. After a sufficient time has been allowed the switch is closed, and the pressure kept up by pumping until the apparatus is cold. Originally an apparatus with a cylinder made in one piece was employed, and in this case there was a considerable voltage between the graphite entering the apparatus and the steel walls of the pressure vessel. After a few seconds of intense heating it frequently happened that an explosion took place, due (as could be seen by subsequent examination) to filaments of graphite being driven through the magnesia and

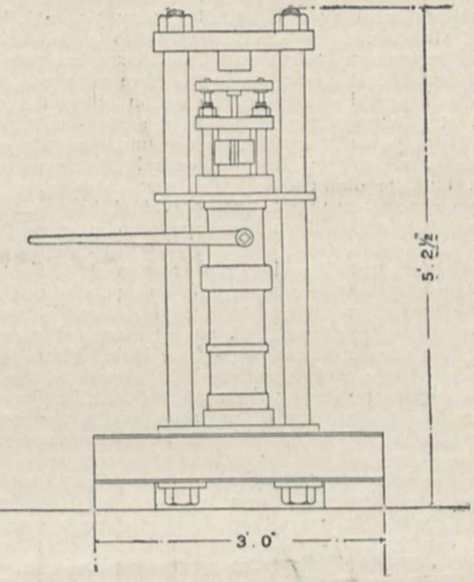


Fig. 8.

producing short circuits against the steel vessel. With the construction above described these explosions do not occur, and there is the additional and very real advantage that when an experiment is over the apparatus can be opened in the middle and everything exposed to view.

A large number of experiments were made on different kinds of carbon and graphite. The weight of material in the highly heated part was generally from 1 to 2 grams, and the energy supply was at a rate of 5 to 10 kilowatts for from three to six seconds. The pressure in a successful experiment lay at from 50 to 100 tons per square inch throughout. The magnesia lining was usually melted for a distance up to 1 centimetre round the graphite. Now magnesia melts at ordinary pressures at about 2000° C., but the energy supply is sufficient to render it possible that temperatures of from 3000° to 4000° C. may have been reached; it is possible that about 3000° C. was actually attained at the centre of the charge. The results obtained were uniform. No matter what form of carbon (excluding diamond, which was not tried) was packed originally in the apparatus, the final product was soft, well-crystallised graphite, which agrees with some results of similar experiments described by Mr. Parsons,[1] but not with the results claimed by Dr. Ludwig.[2]

In several experiments the crystalline mass of graphite

[1] Proc. R.S., 79. [2] Zeits. f [illegible] 1902, 273

was tested in regard to its porosity, and this was found to be considerable—a remarkable result, having in view the conditions under which it had been formed.

Another point of interest was that where the soft graphite had been driven into the Acheson graphite plug at the bottom of the apparatus it became extremely hard, so much so that a hard steel file made little or no impression upon it.

The main difference in treatment of this part of the graphite as compared with the remainder is that it was cooled much more quickly, thanks to the high heat conductivity of the Acheson graphite plug. The cause of hardening has hitherto not met with any satisfactory explanation.

No appreciable quantity of carbide of magnesia was formed in the experiments. The magnesia close to the graphite core contained traces of carbides, but as there were always traces of iron left from the drilling-out process, this may be plausibly accounted for by the formation of carbide of iron.

The graphite was finally systematically searched for microscopic diamonds by Staudenmaier's modification of Brodie's method of conversion of graphite into graphitic acid,[1] or else by Moissan's modification of the same method.[2] A convenient means of distinguishing diamond in fine powder from most or all of the substances which are not separated by a liquid of density 3·34 at 4° C. is to heat the powder in a silver spoon to a dull red heat in fused potassium hydroxide. Check experiments showed that diamond dust easily passing a sieve with 100 threads to the inch would withstand the action of molten caustic potash at a temperature at which the edges of the silver spoon began to melt for five or ten minutes. Crystals of alumina or of carborundum are entirely destroyed by this fusion, but the diamond particles seemed to have undergone no change. In fact, the individual fragments could be recognised under the microscope after passing through the ordeal.

I am led to consider that my experiments indicate that no wholesale transformation of amorphous carbon or graphite into diamond can be brought about by temperatures of the order of 2000° C. and pressures of more than 50 and less than 100 tons per square inch. There is some uncertainty, as already mentioned, in regard to the actual pressures operative during the trials. Prof. Tammann has, however, obligingly directed my attention to the fact that the equilibrium curve graphite-diamond may nevertheless have been crossed, but that no diamond was formed because time for crystallisation was not allowed under the conditions of the experiment. I confess my idea in making the trials was that the amorphous carbon or graphite might be forced to melt, and then that the conditions would require it to re-crystallise as diamond—not, of course, in the form of large clear crystals, but rather in the form of bort or black diamond.

The experiments described have only been rendered possible by the invention of high-speed steel, which keeps its hardness up to nearly, or quite, a red heat, and any further advance—mainly in the direction of the allowance of more time—must wait for improvements in that material. It may very well be, however, that the limits of temperature within which crystallisation in diamond form can take place are really very narrow at any pressure; and in this case it will be a matter of very great difficulty to make an apparatus in which the conditions could be kept constant for a sufficient length of time, and the difficulty would be greater the higher the temperature.

It is noteworthy from this point of view that in Moissan's artificial production of diamond very much lower pressures and temperatures were used than those just described. I have shown[3] that, using iron as a solvent, it is highly improbable that Moissan attained a pressure of more than 20 tons/sq. inch, and when silver was employed the pressure must have been much lower. A similar criticism places the effective temperature of formation of diamond in iron or silver spheroids at something of the order of 1500° C. Comparing the experiments of Moissan with those described above, it looks as if Roozeboom's opinion is at present the most probable, viz. that solvents are necessary in order to depress the crystallisation point of diamond to a temperature at which the transformation to graphite is slow enough for rapid cooling to interrupt it. In this case the next step would be to repeat the experiments I have described at the highest possible pressure in the presence of iron, though Mr. Parsons[1] has already made some trials in this direction with negative results. We have, however, many metals which have never been tried in this connection, and one or other of them may turn out to have the requisite properties.

[1] Ber., 1898, xxxi., 1485. [2] Electric Furnace, 49, translation.
[3] Journ. Chem. Soc., xciii., 1908, 1351.

[1] *Loc. cit*

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The board of anthropological studies has elected Mr. A. R. Brown, fellow of Trinity College, to the Anthony Wilkin studentship in ethnology and archæology. The John Winbolt prize has been awarded to Mr. E. T. Busk, of King's College.

A university lectureship in zoology, recently held by Prof. Gardiner, is now vacant. The general board of studies will shortly proceed to appoint a lecturer to hold office from January 1, 1910, until September 30, 1914. The annual stipend is 50*l*. Candidates are requested to send their applications, with testimonials if they think fit, to the Vice-Chancellor on or before Saturday, November 27.

The Vice-Chancellor gives notice, on behalf of the board of geographical studies, that the Rev. T. G. Bonney, F.R.S., has consented to deliver a lecture in Cambridge on Thursday, November 25, at 5 p.m., on "A Desert Phase in the Development of Britain." By permission of Prof. Hughes the lecture, which will be illustrated by lantern-slides, will be given in the large lecture-room of the Sedgwick Museum of Geology.

The professor of botany also gives notice that Dr. H. H. W. Pearson, of Gonville and Caius College (professor of botany in the South African College, Cape Town), has consented to deliver a lecture at the Botany School on Friday, November 19, at 5 p.m., on "A Botanical Journey in South-west Africa."

The general board of studies has approved Dr. C. S. Myers, of Gonville and Caius College, and A. E. Western, of Trinity College, for the degree of Doctor in Science.

LIVERPOOL.—Mr. W. S. Abell, instructor in naval architecture at the Royal Naval College, Greenwich, has been appointed to the chair of naval architecture endowed by Mr. Alexander Elder.

OXFORD.—Mr. Balfour will deliver the Romanes lecture in the Sheldonian Theatre on Wednesday, November 24. Lord Curzon of Kedleston, Chancellor of the University, will preside.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, November 11.—Sir Archibald Geikie, K.C.B., president, in the chair.—H. C. **Ross**: The vacuolation of the blood-platelets: an experimental proof of their cellular nature.—H. G. **Plimmer** and Captain W. B. **Fry**: Further results of the experimental treatment of trypanosomiasis, being a progress report to a committee of the Royal Society.—G. S. **West** and B. M. **Griffiths**: *Hillhousia mirabilis*, a giant sulphur bacterium.—Dr. H. B. **Fantham** and Miss Annie **Porter**: The modes of division of *Spirochaeta recurrentis* and *S. duttoni* as observed in the living organisms. The observations recorded were made on living Spirochætes. The examination of living material is imperative, as results based only on stained preparations are not always trustworthy. Both longitudinal and transverse division occur in Spirochætes, as seen in *S. recurrentis, S. duttoni, S. anodontae*, and *S. balbianii*. There is a periodicity in the direction of division exhibited by *S. recurrentis* and *S. duttoni*. At the onset of infection longitudinal division occurs. This is followed by transverse division of the

Spirochætes when the infection is at its height. As the infection draws to an end, and there is a diminution in numbers of the parasites, there is a reappearance of longitudinal division. Naturally there are times when both forms of division occur together. The observations relating to periodicity were made on peripheral blood of the host. The actual processes of division, and the movements of the parasites meanwhile, are set forth in detail in the paper.—G. A. **Buckmaster** and J. A. **Gardner**: The supposed presence of carbon monoxide in normal blood, and in the blood of animals anæsthetised with chloroform. In a paper published in 1898, Desgrez and Nicloux stated that the normal blood of Paris dogs contains about 1·6 c.c. of carbon monoxide per litre, and that when the animals are anæsthetised by chloroform the amount increases to 2·5 to 6 c.c., according to the duration of anæsthesia. Their method of estimating carbon monoxide consisted in passing the blood gases over iodine pentoxide at 150° C., and determining the iodine liberated by the method of Rabourdin. The authors have carefully re-investigated the question, making use of Haldane's method of estimating carbon monoxide by means of diluted blood, after having previously ascertained that far smaller quantities of this gas than those found by the French observers in normal blood gases could be readily detected. They find that *neither normal cats' blood nor the blood of cats anaesthetised by chloroform contains any detectable trace of carbon monoxide.* They also find that most of the chloroform in the blood comes off with the gases when extracted at 40° C. In order to arrive at an explanation of Nicloux's results, the authors (1) repeated his experiments with variations, investigated (2) the effect of heat on iodine pentoxide, (3) the effect of chloroform vapour on iodine pentoxide, and (4) the effect of chloroform vapour on alkalis. The latter experiments show that chloroform vapour is readily decomposed by passing over solid potash, and also by the reagents used in gas analysis, with the production of carbon monoxide. It is concluded from the experiments (1) that chloroform is not decomposed in the blood with formation of carbon monoxide; (2) the iodine liberated in the experiments of Nicloux was due, to some extent, to the direct decomposition of the iodine pentoxide by the chloroform vapour in his blood gases, but mainly to the carbon monoxide produced by *the action of this chloroform on the solid potash over which he passed the blood gases* in order to free them from carbon dioxide.—G. W. **Ellis** and J. A. **Gardner**: The origin and destiny of cholesterol in the animal organisms. Part vi., the excretion of cholesterol by the cat. In this paper the results of a number of estimations of the cholesterol content of the fæces of cats fed on a variety of diets—animal and vegetable—of known cholesterol content, are described. It was found that cats behave similarly to dogs when fed on meat diets, but the tendency for the change of cholesterol into coprosterol appears to be greater in the case of cats. The change is, however, never complete unless the diet contains a considerable amount of fat. In all these experiments the total cholesterol and coprosterol excreted was considerably less than that taken in with the food. Without considering the cholesterol poured into the gut with the bile, the percentage deficit was 50–60, an average loss of about 0·08 gram per day. In the case of vegetable diets free from cholesterol or phytosterol, the weights of food necessary to keep the animals in condition were larger, and the amounts of fæces very much larger, than in the case of meat diets. Small amounts of cholesterol were excreted, averaging about 0·03 gram per day, but no change into coprosterol took place. In the case of artificial diets to which measured quantities of cholesterol or phytosterol were added, no excess of cholesterol above that administered was recovered from the fæces. The bearing of these results on hypotheses advanced in former papers of the series is discussed.—Prof. W. A. **Osborne**: The elasticity of rubber balloons and hollow viscera (with a note by W. Sutherland).

MANCHESTER.

Literary and Philosophical Society, October 19.—Mr. Francis Jones, president, in the chair.—L. E. **Adams**: Some notes on the breeding habits of the common mole. An account was given of observations on the length of time the young of the mole spend in the nest, and their rate of growth. Special breeding nests, sometimes as large as, but generally simpler than, the winter fortresses, from which they are further distinguished by the absence of a "bolt-run," are made by the female for the accommodation of the young. These are usually born about the middle of May, though they have been observed as early as April 24, the latest date on which they were found in the nest being June 25. The author thinks that, considering their subterranean existence, climatic changes have little influence on their pairing early or late. Fresh observations confirm the statement made in a former paper that only one litter is produced annually by each pair. In any given season all the litters were born within a period of three weeks, and, as the young remain four weeks in the nest, there could not have been time to rear two litters. In order to ascertain the rate of growth of the young, the author took one, for measurement and reference, from each of several litters, and, after replacing the nest as carefully as possible, repeated the operation at intervals of a few days. The tabulated results showed that head and body measured at birth 40 mm., and at the end of the third week 117 or 118 mm., at which limit they evidently remained for some weeks before growth recommenced. The young begin to leave the nest at the end of the fourth week, and the process is a gradual one, requiring for its accomplishment six or seven days.

PARIS.

Academy of Sciences, November 8.—M. Bouchard in the chair.—G. **Bigourdan**: A means of removing astronomical clocks from the influence of the variations of atmospheric pressure. The apparatus described and figured maintains the pressure round the clock constant, this pressure being fixed so that it is always higher than any possible atmospheric pressure.—L. **Maquenne** and M. **Demoussy**: The influence of the ultra-violet rays on the growth of green plants. The ultra-violet rays were produced by means of a Heraeus quartz mercury lamp. It was found that the ultra-violet rays determine the death of plant cells in a relatively short space of time, comparable with that required for the sterilisation of a contaminated liquid. The action is especially on the surface.—A. **Calmette** and L. **Massol**: The precipitation of the tuberculins by the serum of animals immunised against tuberculosis. In a preceding note a description has been given of a method of immunising cattle against tuberculosis by the injection of bovine bacilli cultivated on glycerinated ox bile. This method furnishes a serum of extraordinary agglutinating power. In the present note the precipitation of tuberculin from physiological saline solutions by this serum is described, and the properties of the precipitated tuberculin discussed.—M. **Giacobini**: Observations of Halley's comet, made at the Paris Observatory with the 38-cm. equatorial. Details of the observations on November 5, 6, and 7 are given. The comet is at the extreme limit of visibility; a small nucleus of the fourteenth magnitude can be distinguished, surrounded by a nebulosity of about 5″ to 6″.—Arthur R. **Hinks**: The mass of the moon deduced from photographic observations of the planet Eros, made in the years 1900 and 1901.—Eugène **Fabry**: The modulus of a Taylor's series.—E. **Vessiot**: The groups of rationality of systems of ordinary differential equations.—Demetrius **Gravé**: An identity in the theory of binary quadratic forms.—H. **Pellat**: A compound pendulum of very simple construction giving immediately the length of the synchronous pendulum. A new method of determining g. A description of a bifilar pendulum the bob of which contains a cavity. Two determinations of the time of oscillation are made, in one of which the mass is altered by the addition of mercury to the cavity. A simple calculation gives the length of the equivalent simple pendulum.—L. **Bloch**: The phosphorescence and oxidation of arsenic. The phosphorescence of arsenic is always accompanied by the production of the oxide. No ozone is produced, and there are no phenomena of ionisation. Both the oxides of arsenic are produced, and this is the case during both phosphorescence and during combustion with flame.—C. **Féry** and C. **Chéneveau**: The total and monochromatic radiation of incandescent lamps. A study of the relation between temperature of the filament and watts consumed by the carbon and tungsten incandescent lamps.—Georges **Claude**: The frigorific recuperation of volatile liquids lost in various industries. In many industries, especially in the manufacture of artificial silk, smokeless powder and celluloid, considerable quantities of alcohol and ether are lost owing to the enormous dilution with air. A practical system is described in which the air containing these volatile vapours is compressed and gradually cooled by expansion to a temperature of $-100°$ C., a special device being necessary for the preliminary separation of the water. The method is shown to be capable of effecting large economies in practice.—E. **Rengade**: The theoretical form of the cooling curves of binary mixtures.—Marcel **Delépine**: The metallic iridio-sulphates.—A. **Guyot**: New general methods for the synthesis of aromatic aldehydes. The method is based on the condensation of a phenol, hydrocarbon, or amine with the $\alpha\beta$-diketonic esters of the type X—CO—CO—CO_2R.—Charles **Mauguin**: The acid properties of the halogen amides: the Hofmann migration. The sodium derivative of bromacetamide, $CH_3CO.NaBr$, has been isolated and its decompositions studied.—N. **Danaila**: The oxidation of the dimethylanilinisatins.—H. **Masson**: The composition of essence of cloves. To the principal constituents already known of essence of cloves it is necessary to add methyl salicylate and two aldehydes, α-methylfurfural and a dimethylfurfural.—P. A. **Dangeard**: The photographic properties of *Chlorella vulgaris*.—M. **Biot**: Concerning *Trypanosoma lewisi*.—M. **Glover**: The examination of the respiration and the graphical analysis of speech in special schools. The radioscopic examination of the thorax has been found of great value in examining the mode of breathing.—Paul **Hallez**: The biological cycle of a form nearly related to Otoplana.—P. **Hachet-Souplet**: The psychology of the Artiozoa.—Mlle. L. **Chevroton** and F. **Vlès**: The kinematics of the segmentation of the egg and the chronophotography of the development of the sea-urchin. An application of the method of Marey to the study of the embryonic development of an animal. A series of photographs is taken at equal intervals of time, and the long film, containing 7000 to 8000 images, examined in the kinematograph.—M. **Sarthou**: The presence in milk of an anæroxydase and a catalase.—M. **Billon-Daguerre**: A mode of integral sterilisation of liquids by radiations of very short wave-length. Geissler tubes, made of quartz, containing rarefied gases, give out rays of short wavelength which are twenty-five times more powerful in producing sterilisation than ordinary ultra-violet rays. Such tubes are more economical than mercury vapour lamps, requiring a primary current of 2 amperes at 4 to 6 volts.—E. **Gley**: The action of toxic serums and their antitoxins on the nervous system. Contribution to the study of the mechanism of immunity.—E. **Gley** and V. **Pachon**: The action of toxic serums on the isolated heart of animals immunised against these serums.

DIARY OF SOCIETIES.

THURSDAY, NOVEMBER 18.

ROYAL SOCIETY, at 4.30.—Bakerian Lecture: The Statistical and Thermodynamical Relations of Radiant Energy: Sir J. Larmor, Sec.R.S.

LINNEAN SOCIETY, at 8.—A New Tipulid Subfamily: W. Wesché.—Freshwater Rhizopods from the English Lake District: J. W. Brown.

INSTITUTION OF MINING AND METALLURGY, at 8.—The Development of Heavy Gravitation Stamps: W. A. Caldecott.—Experiments in Reverberatory Practice at Cananea, Mexico: L. D. Ricketts.

FRIDAY, NOVEMBER 19.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—An Internal-combustion Pump and other Applications of a New Principle: Herbert A. Humphrey.

MONDAY, NOVEMBER 22.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—A Naturalist's Travels on the Congo-Zambezi Watershed: S. A. Neave.

TUESDAY, NOVEMBER 23.

INSTITUTION OF CIVIL ENGINEERS, at 8.—*Further discussion*: The Single-phase Electrification of the Heysham, Morecambe and Lancaster Branch of the Midland Railway: J. Dalziel and J. Sayers.—The Equipment and Working-results of the Mersey Railway under Steam and under Electric Traction: J. Shaw.—The Effect of Electrical Operation on the Permanent-way Maintenance of Railways, as Illustrated on the Tynemouth Branches of the North-Eastern Railway: Dr. C. A. Harrison.

ZOOLOGICAL SOCIETY, at 8.30.

WEDNESDAY, NOVEMBER 24.

ROYAL SOCIETY OF ARTS, at 8.—Photo-Telegraphy: T. Thorne Baker.

BRITISH ASTRONOMICAL ASSOCIATION, at 5.

THURSDAY, NOVEMBER 25.

ROYAL SOCIETY, at 4.30.—*Probable Papers*: On the Change in Hue of Spectrum Colours by Dilution with White Light: Sir William de W. Abney, K.C.B., F.R.S.—On the Nature of the Hydrogen Flocculi and their Structure at Different Levels in the Solar Atmosphere: Prof. G. E. Hale, For.Mem.R.S. and F. Ellerman.—The Boiling Point of Sulphur corrected by Reference to New Observations on the Absolute Expansion of Mercury: Prof. H. L. Callendar, F.R.S., and H. Moss.—(1) On the Refraction and Dispersion of Neon; (2) On the Refraction and Dispersion of Air, Oxygen, Hydrogen, and Nitrogen; (3) On the Refraction and Dispersion of Sulphur Dioxide and Hydrogen Sulphide, and their Relation to those of their Constituents: C. Cuthbertson and M. Cuthbertson.—On Flapping Flight: Prof. M. F. Fitzgerald.—The Crystalline Structure of Iron at High Temperatures: W. Rosenhain and J. C. W. Humfrey.—The Relation of Thallium to the Alkali Metals: a Study of Thallium-zinc Sulphate and Selenate: Dr. A. E. H. Tutton, F.R.S.—And other papers.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—The Present Aspects of Electric Lighting: H. W. Handcock and A. H. Dykes.

FRIDAY, NOVEMBER 26.

PHYSICAL SOCIETY, at 5.—The Effective Resistance and Inductance of a Helical Coil: Dr. J. W. Nicholson.—Ductile Materials under Combined Stress: W. A. Scoble.—The Recoil of Radium C from Radium B: Dr. W. Makower and Dr. Sidney Russ.—The Sun's Motion with Respect to the Æther: Dr. C. V. Burton.

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