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TREE-FLORA OF JAVA.

Mikrographie des Holzes der auf Java vorkommenden Baumarten. By Dr. J. W. Moll and H. H. Janssonius. Erste Lieferung (1906), pp. 368; and Zweite Lieferung (1908), pp. 369–568+160. (Leyden: E. J. Brill.) Price 6 marks each.

THIS work, like the earlier tree-flora of Java, was undertaken at the suggestion of Prof. M. Treub, director of the Botanic Garden at Buitenzorg. It will be convenient to begin by making a short reference to this earlier publication.

In the year 1888 Dr. S. H. Koorders began to collect material for a tree-flora of Java. The work connected with the compilation of this flora was carried out in a most careful and methodical manner. More than four thousand trees, many of which were in the primeval forest, were marked, and a special system of numbering the trees, and of indexes and maps, was instituted, so that each tree could be easily found again, and the rate of growth, leaf fall, &c., could be studied. In the course of naming and studying the plants for the tree-flora of Java ("Flora arborea Javanica," by S. H. Koorders and Th. Valeton), a collection of fifteen thousand specimens was made to illustrate the species dealt with in the flora.

This collection included a series of wood-specimens, which were sent in 1904 from Buitenzorg to the University of Gröningen for microscopic examination and description, and this work has been carried out, under the direction of Prof. J. W. Moll, by Herr H. H. Janssonius. The results appear in the present work, which may therefore be described as a counterpart to Koorders and Valeton's flora in the province of the anatomy of the wood. Hence a most important asset in the value of the work lies in the fact that there is no uncertainty as to the origin of the specimens. They have all been obtained from trees which have been carefully studied and determined by an expert, and, moreover, herbarium material from the same trees is to be found in the herbaria at Buitenzorg, Leyden, Berlin, &c.

In this work the authors have adopted a very orderly arrangement of the information. Under each species there are five principal headings, beneath which are given the literature, information on the material, the preparations made, the reagents used, and, lastly, under the name of micrography, a description of the structure of the wood. The section on micrography is generally subdivided into one on topography, dealing chiefly with the distribution of the tissues and elements as seen in transverse section, and another giving descriptions of the individual elements, based on a study of radial, tangential, and transverse sections, sometimes supplemented by macerated preparations. A separate paragraph is devoted to each kind of element, and gives full details of measurements, pitting, contents, &c. The section on topography is elucidated, in cases where this is advisable, by means of a diagrammatic figure showing the distribution of the vessels, wood-parenchyma, medullary rays, &c., in a portion of a transverse section. When several species of a genus are found to differ only slightly in the structure of the wood, one of them is fully described, and the description of the others is shortened by comparative treatment. Under each family, except where only one species is dealt with, there is a description of the structure of the wood, founded on that of the different species described, and an analytical key for distinguishing the species, so far as this is possible by means of the wood, is added.

Part i. contains, first (pp. 5–62), general information, including the history of the material and an exposition of the method adopted in presenting the information in the succeeding pages. The remainder of part i. (pp. 63–368) is occupied by the description of the microscopic structure of the wood in species from Dilleniaceæ to Dipterocarpaceæ. Part ii. (pp. 369–547) continues the same from Dipterocarpaceæ to Tiliaceæ, followed by the index and contents of vol. i., after which pp. 1–160 form a first instalment of vol. ii., extending from Geraniaceæ to Meliaceæ. The last page of part ii. reaches species No. 230, twenty-one families having been dealt with up to this point.

The foregoing description of this work will serve to indicate its value, which lies in the authentic nature of the specimens, the large number of species and families dealt with, the completeness of the description of the microscopic structure, and, lastly, the strict uniformity of treatment adhered to by the authors.

This book will be an important aid in the determination of wood-specimens, and the authors are to be congratulated on the efficient way in which they are carrying out a difficult and laborious task.

L. A. B.

TWO AMERICAN MATHEMATICAL BOOKS.

(1) *Plane and Spherical Trigonometry and Four-place Tables of Logarithms.* By Dr. Wm. A. Granville. Pp. xii+264+38. (London: Ginn and Co., n.d.) Price 5*s*. 6*d*.

(2) *A Course of Mathematics for Students of Engineering and Applied Science.* By Fredk. S. Woods and Fredk. H. Bailey. Vol. II. Pp. xii+410. (London: Ginn and Co., n.d.) Price 10*s*. 6*d*.

(1) THE type and diagrams in this book are models of elegance and excellence; evidently no pains have been spared in making both as clear and perfect as possible, and the logarithm tables at the end of the book add greatly to its completeness. One useful feature in them is the table of circular functions with the angles expressed in degrees and decimals of a degree, in addition to the usual table in degrees and minutes. The author also supplies a neat celluloid combined protractor and scale in a pocket attached to the cover.

In the plane trigonometry the author introduces the student to practical examples in connection with right triangles in the first chapter, but does not proceed to the solution of oblique triangles until chapter vii., after discussion of functions of the generalised angle, the addition theorems, inverse notation, and trigonometric equations, but to a certain extent teachers can choose their own order in taking these chapters.

The proof of the addition theorem is not very satisfactory. The author proves the theorems for sin $(x+y)$ and cos $(x+y)$ for *acute* angles (using a revolving line of unit length, and so denoting the sines and cosines by lengths of lines instead of ratios, which seems a pity), and then says "it is a fact, however, that these formulæ hold for angles of any magnitude, positive or negative." This he illustrates by a couple of cases. Then, in the next section, he says "it was shown" that the formulæ hold good for all angles. The proof by projection now customary in the best English books would have been much more satisfactory.

The directions for solving trigonometrical equations are not altogether satisfactory, and would lead to difficulties in the case of such an equation as $\sin 3x = \cos 4x$. This part of the subject would need amplifying. The similar instructions for proving identities, though sometimes leading to rather heavy work, would always lead to success and be useful in the last resort, though not conducive to elegance.

The solutions of triangles are well explained, and there is a good chapter on the theory and use of logarithms and their applications to nautical and other problems, but one is sorry not to see the value of the characteristic given as the distance of the highest significant figure from the unit's place, plus or minus according as it is to the left or right. It is more fundamental and easier to remember than the old-fashioned method given in the text.

This part of the book finishes with a discussion of acute angles near 0° and 90°, and a collection of miscellaneous practical examples of the usual type, followed by a useful recapitulation of formulæ, with the pages on which they are proved.

The spherical trigonometry assumes some previous knowledge on the part of the reader, as far as the properties of the polar triangle, and one or two of the more advanced formulæ are quoted without proof. The chief features of this part are a good exposition of Napier's rules for right-angled triangles, and the use of the exterior angles (α, β, γ) in all the formulæ for oblique triangles, a most excellent innovation which the reviewer has advocated for many years, but has never before seen in a text-book. By this means all formulæ become dual without any change except the interchance between a, b, c and α, β, γ. It leads, perhaps, to a preponderance of obtuse angles in the practical applications, but the author in his logarithmic work, which is most excellently exemplified, disposes of them by the simple device of putting (n) to the logarithms of negative quantities, a method often used by practical computers, but not often seen in text-books. The book concludes with applications to astronomical and other problems, well explained and illustrated by good diagrams, with a fair number of examples for the student to solve.

(2) This volume completes the authors' plan of a course of mathematics for students of engineering and physics. The first chapter discusses infinitesimals, and defines differentials of functions of a single variable. Then come chapters on integration, with applications to geometry and mechanics, followed by special methods of integration applicable to partial fractions and trigonometric functions, including the use of reduction formulæ. Chapter viii. deals with simple differential equations, with mechanical and geometric examples illustrating their importance. Chapters ix. and x. deal with solid geometry; chapter xi. with partial differentiation; chapters xii. and xiii. treat of multiple integrals and applications, with carefully drawn diagrams well illustrating the building up of such integrals, in rectangular, polar, and cylindrical coordinates. Then follows an introduction to line integrals and their connection with surface integrals (Stokes's theorem). Chapter xv. is devoted to infinite series, giving the easier tests of convergence, followed by Maclaurin's and Taylor's series and an introduction to Fourier's series, and finishing with the evaluation of indeterminate forms. Chapter xvi. contains a short treatment of complex numbers and conjugate functions. The remaining chapters are devoted to differential equations, total and partial.

The whole book is very solid reading, but the explanations are well given, and when proofs are not fully given references are made to other treatises. The intention of the authors evidently is to take the students over as much ground as possible, and introduce them to all the functions and processes which they are likely to need in their scientific work. There are numerous problems for solution throughout the book, and there is an index at the end to facilitate reference.

A. L.

ELEMENTARY PETROLOGY AND ORE FORMATION.

(1) *Rocks and Rock Minerals.* A Manual of the Elements of Petrology without the Use of the Microscope for the Geologist, Engineer, Miner, Architect, &c., or for Instruction in Colleges and Schools. By L. V. Pirsson. Fifth edition. Pp. vi+414. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd., 1908.) Price 10s. 6d. net.

(2) *Genesis of Metallic Ores and of the Rocks which Enclose Them.* By B. Symons. Pp. xxxiii+494. (London: *The Mining Journal*, 1908.)

THE growing recognition of the economic uses of petrology and the increasing complexity of petrographic methods are rendering necessary the development of a less technical rock nomenclature for use in the field and by general geologists. No one who has acquired sufficient knowledge of petrology to determine the approximate chemical composition and qualities of a rock from a short study of a thin section is likely to discontinue the use of the microscope. The increasing number of students of mining, chemistry, engineering, and agriculture who have to study rocks, but have not much time to devote to the subject, is leading to the issue of special text-books on petrography without the microscope, and, thanks to its revelations, much can now be learnt from rocks by the examination of hand specimens.

(1) Prof. Pirsson's "Rocks and Rock Minerals" is the most advanced of the manuals of petrology without the microscope, but it may be recommended even to students who can use that instrument owing to its clear statement of the principles of petrogenesis and of the mode of occurrence of the sedimentary and

igneous rocks. It summarises the characters of the chief rock-forming minerals, and of the origin and classification of rocks, and is illustrated by an admirable series of photographs and diagrams showing the field relations of igneous rocks. The author makes a useful protest against the appropriation by geologists of popular rock names in new and technical meanings. The term granite, for example, is used in the stone trade in its correct historical and etymological sense, which is entirely different from its use in geology. This system is as inconvenient, as Prof. Pirsson points out, as if botanists had re-defined the terms bush, tree, and shrub, limiting each to a particular species. Prof. Pirsson's protest is justified, and though some American geologists are using the familiar terms in their popular meanings, this reform has probably been proposed too late.

(2) Mr. Brenton Symons's "Genesis of Metallic Ores and the Rocks which Enclose Them" is also intended to appeal to the general elementary student, and is an attempt to explain the formation of ore deposits free from unnecessary technicalities. It is a book, however, of very different standard from Prof. Pirsson's; it is written by a practical engineer, who is keenly interested in the theoretical study of mining geology, but whose knowledge of the subject is a little unequal.

The book begins with a general introduction on geological principles, followed by a section on rock metamorphism; the third part of the book deals with the ore deposits. Though the author avoids so far as possible technical scientific terms, his text is often repellent by the abundant use of such Americanisms as cavations for spaces, such reformed spellings as "lentiles" for "lenticles," and vegetal for vegetable, and mining terms of only local value. The most valuable part of the book is its collection of diagrams of ore occurrences; the instances drawn from Cornwall are the most satisfactory, for some of his diagrams and views regarding ores in other parts of the world are a little out of date. Mr. Symons takes, moreover, an extreme position as to the genesis of ores. He has a great belief in the agency of geosynclinals, by which sediments are carried down to depths where they are melted, and then forced to re-ascend as igneous rocks into overlying strata; and though he describes many ores as plutonic, he appears to regard the vast majority of ores as having been derived from the destruction of Archæan rocks and precipitated in the sea. He says, on p. 381, "It has been already observed that nearly all the ores that can come within the reach of man have been derived from the Archean strata"; from these rocks, according to Mr. Symons, the metals are removed in solution and "precipitated on the bottom of the sea by chemical reactions that were principally set up by organic matter." He has no doubt, for example, that the gold in the reefs of Nova Scotia and the copper ores of Mansfeld were deposited in the rocks of those mining fields during their deposition in the sea. His view of the origin of crystalline rocks of most ores is shown by the following quotation.

"The presence of such minute proportions in all formations is natural, since the crystalline rocks, as far as known, were originally deposited as marine strata, and, consequently, retain some part of the minerals that were precipitated during sedimentation from the oceanic waters. The proportion of these metals appears to be just the same, whether districts are metalliferous or not" (p. 363).

This extract shows that the author adopts such an extreme position in regard to the genesis of ores that his book must be read with caution.

ZOOLOGICAL PRIMERS.

(1) *Die Säugetiere Deutschlands.* By Dr. C. Hennings. Pp. 174. (Leipzig: Quelle und Meyer, 1909.) Price 1.25 marks.

(2) *Korallen und andere gesteinsbildende Tiere.* By Dr. Walther May. Pp. iii+122. (Leipzig: B. G. Teubner, 1909.) Price 1.25 marks.

(3) *Die Fortpflanzung der Tiere.* By Dr. R. Goldschmidt. Pp. iv+124. (Leipzig: B. G. Teubner, 1909.) Price 1.25 marks.

(4) *Die Stammesgeschichte unserer Haustiere.* By Prof. Dr. T. Keller. Pp. iii+114. (Leipzig: B. G. Teubner, 1909.) Price 1.25 marks.

(5) *Biology.* By Prof. R. J. Harvey Gibson. Pp. viii+120. (London: J. M. Dent and Co., 1909.) Price 1*s.* net.

(1) THE most useful portion of this sketch of the mammalia of Germany lies in the synoptic tables placed at the head of each order; but these can hardly be considered as complete, since they do not include any account of the subspecies, which are of the greatest interest.

A complete list prefixed to this book would have made comparisons with the fauna of other countries a much easier matter. As it is, one has to search through the index in order to discover what forms are included in this work.

(2) Dr. May is a well-known writer on the anatomy of corals, and in this little work he brings together descriptions of a heterogeneous assemblage of animals, the common feature amongst which is the property of producing a hard exoskeleton, or of contributing otherwise by their remains to the formation of strata.

The question inevitably arising out of this treatment is, What determines the difference between, say, a soft anemone and an encrusted coral? To this Dr. May has, so far as we can see, no answer. Nevertheless, his book contains a good sketch or the various hypotheses accounting for the origin and formation of coral-reefs, and for this, if for nothing else, it is welcome. The corals and lamellibranchs appear to us the best parts of the work.

(3) Dr. Goldschmidt has undertaken to compress into a hundred small pages an account of the methods of animal reproduction, with especial reference to the number of the young, their state on hatching, their habits and adaptations. The work cannot be considered as really up to date, but the treatment is interesting, and the subject is one of such importance that we regret more space could not have been allotted to it. The illustrations are better than those of any other booklet of this series we have so far seen.

(4) In an earlier and larger work, published some

three years ago, Dr. Keller advanced his views on the origin of domesticated animals. The present little work is an abstract of the larger one, and gives only the most meagre outline of the evidence on this difficult subject. The time has not yet arrived when such a work can be successfully written. We know far too little to establish conclusions on the origin of most of our familiar animals, and we can only recommend this work on a most interesting subject with considerable reserve. Prof. Ewart's work on horses appears to be unknown to the author. The book has no index.

(5) The general scheme of this primer is excellently devised. Beginning with a sketch of function, the author passes on to differentiation. The values, transformations, and elaboration of food-stuffs are next dealt with, and a special section is given to "sensitivity." The adaptations of organisms are briefly considered, and a short account of reproduction is given. The primer concludes with a sketch of the theory of natural selection. Such a concise statement of the general principles of animal and plant life should be of considerable use to teachers of elementary science.

The value of the book would have been increased by better illustrations. Many of those employed (for example, Nos. 8, 9, 18, 19, 37, 40, and 47) are so incompletely described as to lose much of their value. The figure of Padina (Fig. 2) is extremely vague. The text as a whole is what we should expect from such an experienced teacher as Prof. Harvey Gibson, and it has had the benefit of revision from his colleagues. The account of the destruction of life as illustrated by a dinner (p. 114) is perhaps open to criticism. The benefits of cultivation in increasing the number and variety of edible organisms are not pointed out. Moreover, in contrast to wild species, the individuals of cultivated ones have surely not remained "fairly constant" in numbers. Demand has in this case created supply. So far from illustrating natural selection, such an example seems to typify artificial selection. The statement about green Hydra on p. 43 goes beyond our present knowledge.

SOME NEW ELECTRICAL BOOKS.

(1) *The Bell Telephone.* The Deposition of A. G. Bell in the Suit brought by the United States to annul the Bell Patents. Pp. iv+469. (Boston: The American Bell Telephone Co., 1908.)

(2) *How Telegraphs and Telephones Work.* Explained in non-technical language by C. R. Gibson. Pp. vi+156. (London: Seeley and Co., Ltd., 1909.) Price 1*s*. 6*d*. net.

(3) *Technical Electricity.* By H. T. Davidge and R. W. Hutchinson. Second edition. Pp. xi+539. (Cambridge: University Tutorial Press, Ltd., 1909.) Price 4*s*. 6*d*.

(1) THE printing of the full deposition made by Mr. Bell in the suit brought by the United States to annul the Bell telephone patents doubtless furnishes a valuable historical record of the experiments which led to the invention of the telephone, and, since the deposition was never officially printed, the American Bell Telephone Co. has performed a useful service in the publication of this book. To any who may still be interested in the legal aspects of the case the book should also prove valuable. But for the general reader, even when specially interested in telephony, the verbatim report of a legal examination and cross-examination is a very unsatisfactory medium for conveying information. The constant repetitions, the frequent insistence on what must be regarded from the broader point of view as wholly irrelevant details, and, above all, the clumsiness of a dialogue devoid of literary merit, make very poor reading, and one is liable to be overcome with ennui before any salient points have been gleaned.

By judicious, if comprehensive, skipping, however, many facts of both scientific and general interest may be obtained from this volume, and to many the detailed descriptions of the earlier struggles and difficulties leading to an invention of enormous utility and importance will have a particular fascination. It is only to be regretted that the book was not written in consecutive narrative form, though possibly some of its value as a record might have been sacrificed thereby.

(2) That Mr. Gibson has an aptitude for the description in non-technical language of the achievements of modern technology has been amply proved by his earlier books which have been reviewed in these columns. The present small volume shares the merits of its predecessors. The very large degree to which the telegraph and telephone enter into the daily life of the community should make this book particularly useful, and it should find a large circle of readers. The book is more or less an amplification of the chapters dealing with this branch in earlier more general books. The subjects covered are telegraphy and telephony, both with wires and without; there is a short chapter on lightning, the reason for the inclusion of which "by request" does not seem clear, and three concluding chapters of a more general character on electrical units and theory. The volume is well printed and illustrated.

(3) This text-book was originally published in 1906, and the present is the third impression. Advantage has been taken of the new edition to bring some parts of the book more up to date, but the revision has not been very thorough, as reference to the chapter on lamps (in which there has been very marked progress since 1906) will show. The tungsten lamp is allotted seven lines of small print, but the osmium lamp, almost if not quite defunct, remains in possession of what we presume was its original position in the main text. The whole chapter on lamps seems to us poor; the drawing of an arc in Fig. 128 is purely imaginary, and the authors would do well to refer to Mrs. Ayrton's book before they issue their next edition; the section on flame arcs and the reference to the Bremer arc lamp lead us to the conclusion that the authors have no correct idea of the real difference between the flame and the ordinary arc.

It is perhaps somewhat unkind to take exception to such errors in what is only one chapter amongst four-and-twenty. But it is deplorable that a text-book should give incorrect or misleading information; the authors' aim "at spanning the gulf which too often divides pure theory and practical engineering" will not be realised if the student is obliged to unlearn much that they teach him when he becomes a practical engineer. We do not profess to be experts in the whole subject of electrical engineering, and cannot criticise the whole book, therefore, on the same lines as we have criticised the section on lamps; but the authors, by writing such a book, lay claim—at least so far as fundamentals are concerned—to be such experts, and if we find them at fault at one part we are led to suspect the whole.

The book covers the whole electrical field; the arrangement is that usually adopted, opening with electrostatics and magnetism, and passing on to electric currents. The diagrams and illustrations are for the most part good, but the process blocks (fortunately few) come out badly on the class of paper used. There are numerous exercises for the student to work out at the end of each chapter.

M. S.

OUR BOOK SHELF.

Gas-engine Theory and Design. By A. C. Mehrtens. Pp. v+256. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd., 1909.) Price 10*s.* 6*d.* net.

THE writer of this book is an instructor in mechanical engineering in the Michigan Agricultural College. His aim, he tells us, has been to prepare a book for all who are interested in gas engines, whether students, draughtsmen, engineers, or engine operators.

This is an ambitious aim, and we may well doubt the possibility of its being carried out in such a small compass; but there can be no doubt that the cardinal virtues of simplicity and conciseness of language which any such intention must require are here presented in no usual degree. The reviewer does not remember any book hitherto written on the gas engine which presents its subject with such lucidity.

The chief entry to be made on the debit side of the account is that the extent of the field covered is far too great. It will be found, on perusing the volume, that it not only deals with the history and present position of gas-engine invention, and with the properties of the gases and fuels used, but also with such a big subject as the design of engine details and the dimensions of parts. Students usually learn their physics and machine design independently of the steam or gas engine, and a book on the gas engine which includes a great deal of what has already been studied separately is wasting space. The result in so small a book as this is that the truth and applicability of a great number of formulæ are taken for granted, which may account for the poor compliment paid to them by the author on p. 123, where he remarks:—

"A number of formulas will be given in the following paragraphs, but machinery cannot be designed by formulas alone. The author has frequently found that empirical, and other, formulas would sometimes come within 500 per cent. of the correct result."

There are also the inevitable slips of a "first edition," but they are not numerous. The author should, however, make a point in the next edition of correcting his description (on p. 33) of carbon monoxide as an unstable compound; his omission on p. 39, in the discussion of the apparent suppression of heat on explosion, of any reference to the increase of specific heats admitted on p. 25; the error in saying (on p. 44) that it is usual to increase the compression pressure in an engine which is to run on kerosene, and he should also correct the general confusion of the table on p. 167. It is difficult to understand what the author means in his description (on p. 52) of the working of the gas producer by the remark:—"The limit of the ratio of steam to coal by weight is about 1 to 40."

Although, as has been stated, the author has attempted to get too much into so small a volume, it must be acknowledged that he has produced a book at once interesting in treatment and clear in language.

La materia radiante e i raggi magnetici. By Prof. A. Righi. Pp. vii+308. (Bologna: N. Zanichelli, 1909.) Price 8 lire.

IN a recent number of NATURE a brief account was given of Righi's "magnetic rays," this being the name applied to a peculiar luminosity near the kathode of a vacuum tube, when the latter is placed in a longitudinal magnetic field. Righi supposes that this luminous column is due to electrically neutral doublets, which are not in sufficiently stable equilibrium to be looked upon as atoms or molecules, which owe, in fact, such stability as they possess to the action of the magnetic field. Several papers on this subject have been published by the author, and the main object of the present small volume is to give a connected account of the whole research. About one-third of the book is devoted to an extremely lucid and interesting summary of our present knowledge concerning the corpuscular theory of matter, written in a style which, as far as possible, is free from technical terms. The remainder, except for three short mathematical appendices, deals with the evidence for and against the existence of neutral doublets or magnetic rays. Here, while very suggestive, the experiments are not altogether convincing—this is evidently the opinion of Prof. Righi himself—but this is due in great measure to the difficult experimental conditions. While no one experiment can be said to have demonstrated the existence of magnetic rays, the results as a whole certainly tend to support the author's view. One point might have been treated more fully, viz., the conditions under which a magnetic field lowers the potential difference at the terminals of the discharge tube. Experiments are described, in some of which an increase, in others a decrease, of potential is brought about by the magnetic field, but it is not clear to what difference in the conditions this is due.

R. S. W.

Brassolidae. By Dr. H. Stichel. (Das Tierreich, 25 Lieferung.) Pp. xiv+244. (Berlin: R. Friedländer und Sohn, 1909.) Price 15 marks.

THIS is a very elaborate monograph of a comparatively small group of butterflies found only in Tropical America. They form a subfamily of the great family Nymphalidæ, and are most nearly allied to the great blue Morphidæ, but differ from them by their stouter bodies, darker colours, and the closed cell of the hind wings, which are generally ornamented with three large eye-spots on the undersurface. Their flight is crepuscular, while that of the Morphidæ (which are represented in the East Indies as well as in Tropical America), is diurnal.

In 1823, Latreille and Godart, in the second part of "Papillons" in the "Encyclopédie méthodique," were acquainted with only twenty-three species now referred to the Brassolidæ. Of these, twenty-one formed the bulk of the second section of the genus Morpho, while the remaining two species were placed in Brassolis. In Kirby's Catalogue of Diurnal Lepidoptera and Supplement (1871 and 1877) we find eight genera of Brassolidæ and fifty-four species, while Dr. Stichel now enumerates eleven genera and seventy-five species, in addition to a very considerable number of forms treated for the present as subspecies.

Dr. Stichel describes the species at great length, adding tables of the genera, species, and subspecies. The synonymy of the genera and species is very fully given, and the excellent text-illustrations include the neuration of one species of each genus, and also the markings of the wings of a large number of species, both surfaces being usually figured. Descriptions are also given of the eggs, larvæ and pupæ of the insects, as far as known at present, and the range of each species is also indicated. On pp. 3 and 4 we find general information on the habits of the butterflies, and should have liked more detail under the various species; but we presume that there was either no room, or the available information on the subject was too meagre to be worth giving, except in a general manner. W. F. K.

The Volcanic Origin of Coal and Modern Geological Theories: a Plea for Lessening Demands on Geological Time; and for Further Separating the Life Histories of the Aqueous and Volcanic Formations. By Col. A. T. Fraser (late R.E.). Pp. 21. (London: R. Banks and Sons, 1909.)

THE old Wernerians used to account for volcanic action by the supposed combustion of coal within the earth's crust, but the author of this pamphlet turns the tables upon them by making the volcanoes produce the coal! The way in which this feat is performed is as follows:—first by pointing out that in the sides of the active volcano Gedeh in Java the tuffs are seen to be well stratified, and look, *at a distance*, like old red sandstone; then the mud deposits ejected by the eruption of Tarawera in New Zealand are also stratified. Next, we have somewhat of a leap in the advance of the argument. The Java experience showed, *though coal was absent*, another way in which it (coal) might originate; namely, being rained down in a shower of bitumen alternately with sandstones, shales, &c. In support of this view we are told that a visit to "the quarries of Carrara and Parnassus" show that "marble is a volcanic rock," "ejected, accompanied by high-pressure steam, from a fissure and showered down." We must leave our author with the coal and marble, and not attempt to follow his leading among geological theories, old and new. We fear, judging from books advertised on a fly-leaf at the end of the one before us, that the author has been so much occupied with psychical research, occult powers of Eastern nations and the religions of the world, that he has not found time for even a very little elementary chemistry.

Cassell's "Nature" Copies (Wild Flowers). Aids to Nature Study, Brushwork, and Drawing. In twelve packets. (London: Cassell and Co., Ltd., n.d.) Price 6*d*. net per packet.

EACH of these packets of drawing copies contains ten examples of pictures of wild flowers executed in colours on stout plate paper. Though the best plan is to have wild flowers drawn from actual specimens, these copies may serve a useful purpose in town schools, where it is very difficult or impossible to procure the plants themselves; in any case they will add variety to the art work, and familiarise children with the beauty of common wild flowers.

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.]*

August Meteoric Shower.

I HAVE summarised in a form which may be convenient for comparison some of the results of Perseid observations this year. The differences in some cases are remarkable, and sufficiently prove that to arrive at definite conclusions respecting the character of a shower a large number of materials should be consulted and averaged. Weather conditions are dissimilar, the places of observation are not equally well situated (certain positions in towns are much affected by artificial light), and there are other causes which must introduce discordances. Though comparatively few Perseids were observed at Bristol and Meltham on August 10, they were fairly numerous at Blaina and Antwerp, and on the night of August 12, when a rich display of brilliant meteors was remarked at Bristol, there was no striking exhibition witnessed at several other places.

Results of Perseid Observations, 1909.

	Aug.	h. m. h. m.	h. m.	Meteors	Perseids
C. B. Pennington, Notts.	11	9 0–12 0	3 0	50	
Mrs. H. P. Hawkins, Brockham, Surrey	11	10 0–13 0	3 0	80	
Miss Irene Warner, Bristol	11	10 0–11 37	1 37	60	55
	12	10 0–10 30	0 30	9	6
John Hicks, Weston-super-Mare	11	9 30–10 0	0 30	30	
	12	9 30–10 30	1 0	9	
Mrs. R. M. Brook, Meltham, Huddersfield	11	10 0–11 30	1 30	54	
T. K. Jenkins, Blaina	10	10 50–12 5	1 15	30	
	11	9 48–12 10	2 22	78	
	12	9 14–10 43	1 29	12	
C. L. Brook, Meltham	9	10 25–12 15	1 35	15	10
	10	10 25–12 25	1 35	23	14
W. F. Denning, Bristol	8	9 45–11 0	1 30	12	6
	9	9 45–11 30	1 30	8	4
	10	9 15–12 0	1 45	19	12
	11	9 5–11 50	2 45	73	67
	12	9 0–12 52	2 30	65	55
	13	9 5–11 45	1 45	25	11
	14	9 0–11 50	1 45	19	7
C. Birkenstock & another observer, Antwerp	7	11 50–13 0	1 10	3	
	8	11 25–13 0	1 35	19	
	9	11 0–12 20	1 20	15	
	10	10 15–14 0	3 15	113	
	11	10 30–14 0	3 30	129	
	12	10 30–14 0	3 30	96	
Col. E. E. Markwick, Boscombe	11	10 7–11 40	1 33	40	38
Ellison Hawks, Leeds	11	10 30–dawn	—	175	
J. L. Haughton and another, Dublin	10	10 0–11 0	1 0	20	17
	11	9 0–12 0	3 0	57	48
	12	8 30–10 30	2 0	50	35
	13	9 15–10 15	1 0	19	15

Apparently few determinations of the radiant have been made, but so many values have been found for this at previous returns that further estimates are not much needed. Photographic impressions of the trails would be of essential value as giving, not only a very exact position for the radiant, but as indicating its character and the extent of its diffusion. W. F. DENNING.

The Ringing of House-bells without Apparent Cause.

UNTIL I read the two letters in NATURE of July 22 and August 12 I had no idea that the ringing of house-bells without apparent cause was so fascinating a subject, as my own experience of it has been rather prosaic. One of my bells occasionally rings when no one is in the room, but it is entirely due to bad workmanship. The strength of the spring which draws the wire back after it has been pulled is only about equal to the friction of the wires, and the result is that, though it generally draws the wire back immediately after it has been pulled, yet it sometimes fails to do so at the time; but after some time, it may be hours, owing to some change in the conditions, it succeeds in drawing back the wire, when the bell again rings when no one is touching it. The bell thus rings once when it is pulled, and a second time when the spring succeeds in drawing back the wire.

The electrical explanation of any mysterious ringings seems hopeless in any conditions, save possibly in a thunderstorm, when we remember that all the bells and wires are in good electric contact with each other, and in more or less indifferent contact at many places with pipes, walls, &c. Further, only the bell at the end of a row could be rung by electrical attraction to the opposite wall, because the bells swing parallel to the wall on which they are fixed, and considerable force is required to make them move in a direction at right angles to their free swing.

In the case referred to by Mr. C. L. Tweedale, it might have been worth while to see if the wire attached to the lively bell he mentions did not come in contact with any other wires at any part of its length. What makes me suggest this is that in one of my rooms I can tell when the front-door bell is rung by a sympathetic movement of the bell-pull in the room, due to the wires rubbing against each other at some part and the wire to the door bell pulling the wire to the room.

When one considers the class of workmanship put into bell-hanging, one need not be surprised at the vagaries of the bells. Like plumber work, it is mostly out of sight, and as the work has often to be done in very imperfect light and under cramped conditions, anything that will work is considered good enough.

JOHN AITKEN.

Ardenlea, Falkirk, August 21.

FLYING ANIMALS AND FLYING MACHINES.

UNTIL quite recently human flight was considered by the mass of mankind as so impracticable that "I can no more do that than fly" was a phrase used to denote something not to be accomplished. It is no wonder, then, that the fact that several people (probably some dozens at the present moment) have actually flown should appeal to the popular imagination, and the appeal is especially strong in such a case as M. Blériot's flight over the English Channel, although there is nothing really more formidable in a flight over water than over land. It may be of some interest to show briefly how it is that what was formerly looked on as a typical impossibility has now become a matter of everyday occurrence.

It will be a help to take first the case of such animals as have wings, and to see why it is that no creature the height of which approaches even one-quarter that of a man has been able to fly either in present or former times. In order that the wings may support the body, their movement must generate a downward current of air of which the momentum per unit of time is equivalent to the downward momentum which the body and wings would acquire in the same time under the influence of gravity. This does not necessarily involve a large expenditure of work. For instance, when a weight is attached to a parachute and is dropped from a height the speed of descent soon becomes constant, and the work done in the air by the parachute is then just equal to the product of the weight into the distance fallen. The resistance of the parachute is proportional to its area, and the speed of descent can be made as small as we please if the area is made large enough. The work, therefore, expended in a given time, that is, the power delivered to the air, is diminished in the same proportion.

Suppose now that instead of an inanimate weight an animal is suspended from the parachute by a long rope ladder. When the speed of descent is slow enough, the animal will have no difficulty in climbing the ladder at such a rate that the centre of gravity of the "system" may remain stationary in the air, and this by an expenditure of work which can be diminished indefinitely by increasing the area of the parachute.

This case is analogous to the hovering of a bird in the air without horizontal velocity during the down-stroke of the wings, and as no means are here provided for restoring the wing to its primitive position the time of support is limited. The illustration suffices, however, to show that the work required in order to maintain a stationary position in the air by means of wings is equal to the work required to raise the total weight involved at the same rate as that at which it would fall were no work to be expended.

Of the total weight supported, namely, the animal and the parachute, the animal only is a source of power. Thus, while in "dynamically similar" combinations the total weight varies as the cube of the linear dimensions, the supporting area varies as the square, and the living power available varies, not as the total weight, but as the total weight less the weight of the supporting wing. It will be readily seen that if the animal can only deliver a certain amount of power per unit weight of body these conditions lead to an absolute limit to the weight of an animal which can sustain itself stationary in the air. For, suppose the total weight is $w = w_a + w_s$ (the weights, namely, of the animal and the parachute of area s), w_s must vary as $s^{\frac{3}{2}}$, and if the downward velocity is to be constant s must be proportional to w. From this it can be shown that the greatest weight an animal (incapable of climbing faster than some given speed) can have is $2b^3/3c^2$, where $b = w'/s'$ and $c = w_s'/s'^{\frac{3}{2}}$, w_s' and s' being known values of wing weight and wing area fulfilling the condition of falling with the required velocity when the total weight is w'. If we take $w_s' = w'/n$, the expression $2b^3/3c^2$ becomes $\frac{2}{3}w'n^2$.

As an example, suppose that 30 feet per minute is the limiting velocity at which an animal can continue to climb, and that the area of the parachute which will drop at the appropriate speed when the total weight of parachute and load is 1 lb. is 100 square feet, and also that the weight of the parachute alone is $\frac{1}{4}$ lb., then it appears that no animal could maintain itself stationary in the air by means of a parachute the weight of which exceeded $\frac{2}{3}(4)^2$ (or about $10\frac{1}{2}$ lb.), and the area required for this weight would be more than 1600 square feet. Thus, if no more favourable way of supporting a weight was available than the down stroke of a wing in still air, flight would be impossible for all except the very smallest animals.

As is well known, however, the vertical reaction on a slightly inclined plane moving rapidly in a horizontal direction enormously exceeds that which it would experience in dropping through still air, and although the proportionalities between the weights and the supporting area still remain, viz. $s \propto w$ and $w_s \propto s^{\frac{3}{2}}$, the actual weight which can be supported by a given area increases indefinitely as the horizontal speed increases.

If there were no such thing as air friction, the work expended in supporting a given load might also be reduced indefinitely, for the resistance to the horizontal motion (which, when the inclination of the plane is small, may be regarded as the horizontal component of the normal force) could be diminished indefinitely by decreasing the inclination.

Air friction, however, fixes a limit beyond which the inclination of the plane to the direction of motion cannot be advantageously reduced. Experiments have shown that this inclination is about 5°, and that then the ratio of the supporting force to the resistance lies between 5 and 7 (depending partly on the shape of the plane). A knowledge of the best angle of inclination and the ratio of the resistance to the force on the plane at right angles to its path afford means of determining the possible efficiency (see "Experiments on

Model Screws," R. E. Froude, F.R.S., Proc. Naval Architects, 1908).

Among birds, those which fly continuously seldom have the ratio of weight to wing area more than 1 lb. per square foot, and in many cases, such as hawks and swallows, the ratio is something like ½ lb. per square foot; but whatever the ratio may be, so long as the animal can only give out a limited amount of power proportional to its weight, a definite limit can be assigned to the size and weight of the body which can sustain itself in flight by muscular action.

If the weight of the wing increased directly as its area such a limit would not exist. The weight of a flock of birds, for example, is limited simply by the numbers in the flock, and we only have to suppose the individuals to be connected by a light framework to convert the flock into a flying machine the wing weight of which is proportional to the wing area. To a certain extent, the biplane flying machine carries out the same idea, but in most of the existing types the weight of the connecting framework must to a great extent neutralise the reduction of weight which should accompany the reduced linear dimensions.

From what has been said it will be seen that so long as no engine was available which, with all adjuncts, such as fuel supply, framing, and wings, could raise the total weight much faster than could an animal of the weight of the engine only, there was no chance for the addition of flight to human accomplishments, and it is due to the advent of the internal-combustion engine that it is now possible to carry air-borne loads of more than 1000 lb. To carry heavy loads with a moderate wing area requires large horizontal velocities, and in such machines as have succeeded the load per square foot generally exceeds 2 lb.

The high velocity requisite is advantageous when the machine is launched and is pursuing a straight course, but it adds to the difficulties of starting and stopping, and is a restriction on manœuvring power: that is, it increases the radius of the circle in which the machine can turn. When a flying machine of weight w travels in a circle of radius r with velocity v the centrifugal force, F, is wv^2/rg, and if the plane of the circle is horizontal the upward component of the normal force on the wings is w, and hence the normal force is $(w^2+F^2)^{\frac{1}{2}}$ (nearly), and the inclination (β) of the wings to the horizontal in the direction of r is F/w.

The normal force on a straight course differs little from w. In flying in a horizontal curve, therefore, the normal force must be increased in the ratio $(w^2+F^2)^{\frac{1}{2}}/w$ if the velocity is to remain constant. To effect this the engine revolutions must be quickened and the fore and aft trim of the wings altered. In other words, it requires more power to fly in a curve than in a straight course at the same speed, although the increase is not important so long as F/w is small.

For example, if $v=50$ f.s. and $r=200$ feet, $F/w=0{\cdot}256$, the increase of power required is about 3 per cent., and $\beta=14°$. For the same radius if $v=100$ f.s., $F/w=1{\cdot}56$. The power required is 1·86 times that for the straight course, and $\beta=56°$ about.

I am not aware that any exact experiments have yet been made on the manœuvring capacity of flying machines, but the subject will have to be carefully investigated.

The three most important lines along which the development of flying machines should be pursued are those relating to intrinsic stability, ease of starting and stopping, and manœuvring capacity. It is improbable that any form is intrinsically stable at all speeds, but automatic devices may be introduced (as mentioned in my letters to NATURE of January 30 and December 24 1908) which will relieve the aëronaut of responsibility in this respect. Ease in starting and stopping implies the power of flying (at any rate, for a short time) at low velocities; while manœuvring capacity demands ready control of the angles at which the various supporting surfaces are presented to the air.

A. MALLOCK.

THE BRITISH ASSOCIATION AT WINNIPEG.

As we go to press the seventy-ninth annual meeting of the British Association is being opened at Winnipeg, under the presidency of Sir J. J. Thomson, F.R.S., whose inaugural address is reprinted below. Following our usual custom, the addresses of presidents of most of the sections will be published in future issues of NATURE, and also accounts of the scientific proceedings of the sections.

This is the fourth time the association has met outside the British Isles, the previous occasions being Montreal (1884), Toronto (1897), and South Africa (1905). The last meeting of the association in Canada was very successful, the number of members and associates present being 1362. During the twelve years that have since elapsed, great progress has been made in all branches of science, and, though the people of Western Canada do not expect to contribute a very large part to the scientific proceedings of the sections, they anticipate interest in many of the subjects to be dealt with or discussed. Much interest in the meeting has been manifested in Canada and the United States, as well as on this side of the Atlantic. It is estimated that between 400 and 500 members have gone to Winnipeg from Europe, and it is hoped that the total number of members and associates attending the meeting will be at least 1500.

Generous financial support towards the expenses of the meeting has been given by the Dominion Government, the Government of Manitoba, and the city of Winnipeg, while the western provinces and cities have agreed to defray the expenses of an excursion to the Pacific Coast of a party of about two hundred office-bearers and distinguished guests of the association.

Excursions have been arranged for Saturday, August 28, to points of interest in the vicinity of Winnipeg, including Stony Mountain and the municipal stone quarries; Lake Winnipeg, St. Andrew's Rapids, and Selkirk; the wheat fields of Manitoba; the hydro-electric plant on the Winnipeg River. Members have also the opportunity of visiting various industrial works in the city of Winnipeg.

Evening receptions will be held by the Lieutenant-Governor at Government House, and by the local executive committee. Garden-parties have been arranged for several afternoons during the meeting including those to be given at the historic Lower Fort Garry by the Commissioner of the Hudson's Bay Company, at the Provincial Agricultural College, and by the Hon. Chief Justice Howell.

INAUGURAL ADDRESS BY PROF. SIR J. J. THOMSON, M.A., LL.D., D.Sc., F.R.S., PRESIDENT OF THE ASSOCIATION.

TWENTY-FIVE years ago a great change was made in the practice of the British Association. From the foundation of our Society until 1884 its meetings had always been held in the British Isles; in that year, however, the Association met in Montreal, and a step was taken which changed us from an Insular into an Imperial Association. For this change, which now I think meets with nothing but approval, Canada is mainly responsible. Men of science welcome it for the increased opportunities it gives them of studying under the most pleasant and favourable conditions different parts of our Empire, of making new friends; such meetings as these not only promote the progress of science, but also help to strengthen the bonds which bind together the different portions of the King's Dominions.

This year, for the third time in a quarter of a century, we are meeting in Canada. As if to give us an object lesson in the growth of Empire, you in Winnipeg took the opportunity at our first meeting in Canada in 1884 to invite our members to visit Manitoba and see for themselves the development of the Province at that time. Those who were fortunate enough to be your guests then as well as now are confronted with a change which must seem to them unexampled and almost incredible. Great cities have sprung up, immense areas have been converted from prairies to prosperous farms, flourishing industries have been started, and the population has quadrupled. As the President of a scientific association I hope I may be pardoned if I point out that even the enterprise and energy of your people and the richness of your country would have been powerless to effect this change without the resources placed at their disposal by the labours of men of science.

The eminence of my predecessors in the chair at the meetings of the British Association in Canada makes my task this evening a difficult one. The meeting at Montreal was presided over by Lord Rayleigh, who, like Lord Kelvin, his colleague in the chair of Section A at that meeting, has left the lion's mark on every department of physics, and has shown that, vast as is the empire of physics, there are still men who can extend its frontiers in all of the many regions under its sway. It has been my lot to succeed Lord Rayleigh in other offices as well as this, and I know how difficult a man he is to follow.

The President of the second meeting in Canada—that held in 1897 at Toronto—was Sir John Evans, one of those men who, like Boyle, Cavendish, Darwin, Joule, and Huggins, have, from their own resources and without the aid derived from official positions or from the universities, made memorable contributions to science: such men form one of the characteristic features of British science. May we not hope that, as the knowledge of science and the interest taken in it increase, more of the large number of men of independent means in our country may be found working for the advancement of science, and thereby rendering services to the community no less valuable than the political, philanthropic, and social work at which many of them labour with so much zeal and success?

I can, however, claim to have some experience of, at any rate, one branch of Canadian science, for it has been my privilege to receive at the Cavendish Laboratory many students from your universities. Some of these have been holders of what are known as the 1851 scholarships. These scholarships are provided from the surplus of the Great Exhibition of 1851, and are placed at the disposal of most of the younger universities in the British Empire, to enable students to devote themselves for two or three years to original research in various branches of science. I have had many opportunities of seeing the work of these scholars, and I should like to put on record my opinion that there is no educational endowment in the country which has done or is doing better work.

I have had, as I said, the privilege of having as pupils students from your universities as well as from those of New Zealand, Australia, and the United States, and have thus had opportunities of comparing the effect on the best men of the educational system in force at your universities with that which prevails in the older English universities. Well, as the result, I have come to the conclusion that there is a good deal in the latter system which you have been wise not to imitate. The chief evil from which we at Cambridge suffer and which you have avoided is, I am convinced, the excessive competition for scholarships which confronts our students at almost every stage of their education. You may form some estimate of the prevalence of these scholarships if I tell you that the colleges in the University of Cambridge alone give more than 35,000*l.* a year in scholarships to undergraduates, and I suppose the case is much the same at Oxford. The result of this is that preparation for these scholarships dominates the education of the great majority of the cleverer boys who come to these universities, and indeed in some quarters it seems to be held that the chief duty of a schoolmaster, and the best test of his efficiency, is to make his boys get scholarships. The preparation for the scholarship too often means that about two years before the examination the boy begins to specialise, and from the age of sixteen does little else than the subject, be it mathematics, classics, or natural science, for which he wishes to get a scholarship; then, on entering the university, he spends three or four years studying the same subject before he takes his degree, when his real life-work ought to begin. How has this training fitted him for this work? I will take the case in which the system might perhaps be expected to show to greatest advantage, when his work is to be original research in the subject he has been studying. He has certainly acquired a very minute acquaintance with his subject—indeed, the knowledge possessed by some of the students trained under this system is quite remarkable, much greater than that of any other students I have ever met. But though he has acquired knowledge, the effect of studying one subject, and one subject only, for so long a time is too often to dull his enthusiasm for it, and he begins research with much of his early interest and keenness evaporated. Now there is hardly any quality more essential to success in research than enthusiasm. Research is difficult, laborious, often disheartening. The carefully designed apparatus refuses to work, it develops defects which may take months of patient work to rectify, the results obtained may appear inconsistent with each other and with every known law of Nature, sleepless nights and laborious days may seem only to make the confusion more confounded, and there is nothing for the student to do but to take for his motto "It's dogged as does it," and plod on, comforting himself with the assurance that when success does come, the difficulties he has overcome will increase the pleasure—one of the most exquisite men can enjoy—of getting some conception which will make all that was tangled, confused, and contradictory clear and consistent. Unless he has enthusiasm to carry him on when the prospect seems almost hopeless and the labour and strain incessant, the student may give up his task and take to easier, though less important, pursuits.

I am convinced that no greater evil can be done to a young man than to dull his enthusiasm. In a very considerable experience of students of physics beginning research, I have met with more—many more—failures from lack of enthusiasm and determination than from any lack of knowledge or of what is usually known as cleverness.

This continual harping from an early age on one subject, which is so efficient in quenching enthusiasm, is much encouraged by the practice of the colleges to give scholarships for proficiency in one subject alone. I went through a list of the scholarships awarded in the University of Cambridge last winter, and, though there were 202 of them, I could only find three cases in which it was specified that the award was made for proficiency in more than one subject.

The premature specialisation fostered by the preparation for these scholarships injures the student by depriving him of adequate literary culture, while when it extends, as it often does, to specialisation in one or two branches of science, it retards the progress of science by tending to isolate one science from another. The boundaries between the sciences are arbitrary, and tend to disappear as science progresses. The principles of one science often find most striking and suggestive illustrations in the phenomena of another. Thus, for example, the physicist finds in astronomy that effects he has observed in the laboratory are illustrated on the grand scale in the sun and stars. No better illustration of this could be given than Prof. Hale's recent discovery of the Zeeman effect in the light from sun-spots; in chemistry, too, the physicist finds in the behaviour of whole series of reactions illustrations of the great laws of thermodynamics, while if he turns to the biological sciences he is confronted by problems, mostly unsolved, of unsurpassed interest. Consider for a moment the problem presented by almost any plant—the characteristic and often exquisite detail of flower, leaf, and habit—and remember that the mechanism which controls this almost infinite complexity was once contained in a seed perhaps hardly large enough to be visible. We have here one of the most entrancing problems in chemistry and physics it is possible to conceive.

Again, the specialisation prevalent in schools often prevents students of science from acquiring sufficient knowledge of mathematics; it is true that most of those who study physics do some mathematics, but I hold that, in general, they do not do enough, and that they are not as efficient physicists as they would be if they had a wider knowledge of that subject. There seems at present a tendency in some quarters to discourage the use of mathematics in physics; indeed, one might infer, from the statements of some writers in quasi-scientific journals, that ignorance of mathematics is almost a virtue. If this is so, then surely of all the virtues this is the easiest and most prevalent.

I do not for a moment urge that the physicist should confine himself to looking at his problems from the mathematical point of view; on the contrary, I think a famous French mathematician and physicist was guilty of only slight exaggeration when he said that no discovery was really important or properly understood by its author unless and until he could explain it to the first man he met in the street.

But two points of view are better than one, and the physicist who is also a mathematician possesses a most powerful instrument for scientific research with which many of the greatest discoveries have been made; for example, electric waves were discovered by mathematics long before they were detected in the laboratory. He has also at his command a language clear, concise, and universal, and there is no better way of detecting ambiguities and discrepancies in his ideas than by trying to express them in this language. Again, it often happens that we are not able to appreciate the full significance of some physical discovery until we have subjected it to mathematical treatment, when we find that the effect we have discovered involves other effects which have not been detected, and we are able by this means to duplicate the discovery. Thus James Thomson, starting from the fact that ice floats on water, showed that it follows by mathematics that ice can be melted and water prevented from freezing by pressure. This effect, which was at that time unknown, was afterwards verified by his brother, Lord Kelvin. Multitudes of similar duplication of physical discoveries by mathematics could be quoted.

I have been pleading in the interests of physics for a greater study of mathematics by physicists. I would also plead for a greater study of physics by mathematicians in the interest of pure mathematics.

The history of pure mathematics shows that many of the most important branches of the subject have arisen from the attempts made to get a mathematical solution of a problem suggested by physics. Thus the differential calculus arose from attempts to deal with the problem of moving bodies. Fourier's theorem resulted from attempts to deal with the vibrations of strings and the conduction of heat; indeed, it would seem that the most fruitful crop of scientific ideas is produced by cross-fertilisation between the mind and some definite fact, and that the mind by itself is comparatively unproductive.

I think, if we could trace the origin of some of our most comprehensive and important scientific ideas, it would be found that they arose in the attempt to find an explanation of some apparently trivial and very special phenomenon; when once started the ideas grew to such generality and importance that their modest origin could hardly be suspected. Water vapour we know will refuse to condense into rain unless there are particles of dust to form nuclei; so an idea before taking shape seems to require a nucleus of solid fact round which it can condense.

I have ventured to urge the closer union between mathematics and physics, because I think of late years there has been some tendency for these sciences to drift apart, and that the workers in applied mathematics are relatively fewer than they were some years ago. This is no doubt due to some extent to the remarkable developments made in the last few years in experimental physics on the one hand and in the most abstract and metaphysical parts of pure mathematics on the other. The fascination of these has drawn workers to the frontiers of these regions who would otherwise have worked nearer the junction of the two. In part, too, it may be due to the fact that the problems with which the applied mathematician has to deal are exceedingly difficult, and many may have felt that the problems presented by the older physics have been worked over so often by men of the highest genius that there was but little chance of any problem which they could have any hope of solving being left.

But the newer developments of physics have opened virgin ground which has not yet been worked over, and which offers problems to the mathematician of great interest and novelty—problems which will suggest and require new methods of attack, the development of which will advance pure mathematics as well as physics.

I have alluded to the fact that pure mathematicians have been indebted to the study of concrete problems for the origination of some of their most valuable conceptions; but though no doubt pure mathematicians are in many ways very exceptional folk, yet in this respect they are very human. Most of us need to tackle some definite difficulty before our minds develop whatever powers they may possess. This is true for even the youngest of us, for our schoolboys and schoolgirls, and I think the moral to be drawn from it is that we should aim at making the education in our schools as little bookish and as practical and concrete as possible.

I once had an illustration of the power of the concrete in stimulating the mind which made a very lasting impression upon me. One of my first pupils came to me with the assurance from his previous teacher that he knew little and cared less about mathematics, and that he had no chance of obtaining a degree in that subject. For some time I thought this estimate was correct, but he happened to be enthusiastic about billiards, and when we were reading that part of mechanics which deals with the collision of elastic bodies I pointed out that many of the effects he was constantly observing were illustrations of the subject we were studying. From that time he was a changed man. He had never before regarded mathematics as anything but a means of annoying innocent undergraduates; now, when he saw what important results it could obtain, he became enthusiastic about it, developed very considerable mathematical ability, and, though he had already wasted two out of his three years at college, took a good place in the Mathematical Tripos.

It is possible to read books, to pass examinations without the higher qualities of the mind being called into play. Indeed, I doubt if there is any process in which the mind is more quiescent than in reading without interest. I might appeal to the widespread habit of reading in bed as a prevention of insomnia as a proof of this. But it is not possible for a boy to make a boat or for a girl to cook a dinner without using their brains. With practical things the difficulties have to be surmounted, the boat must be made watertight, the dinner must be cooked, while in reading there is always the hope that the difficulties which have been slurred over will not be set in the examination.

I think it was Helmholtz who said that often in the course of a research more thought and energy were spent in reducing a refractory piece of brass to order than in devising the method or planning the scheme of campaign. This constant need for thought and action gives to original research in any branch of experimental science great educational value even for those who will not become professional men of science. I have had considerable experience with students beginning research in experimental physics, and I have always been struck by the quite remarkable improvement in judgment, independence of thought and maturity produced by a year's research. Research develops qualities which are apt to atrophy when the student is preparing for examinations, and, quite apart from the addition of new knowledge to our store, is of the greatest importance as a means of education.

It is the practice in many universities to make special provision for the reception of students from other universities who wish to do original research or to study the more advanced parts of their subject, and considerable numbers of such students migrate from one university to another. I think it would be a good thing if this practice were to extend to students at an earlier stage in their career; especially should I like to see a considerable interchange of students between the universities in the Mother Country and those in the Colonies.

I am quite sure that many of our English students, especially those destined for public life, could have no more valuable experience than to spend a year in one or other of your universities, and I hope some of your students might profit by a visit to ours.

I can think of nothing more likely to lead to a better understanding of the feelings, the sympathies, and, what is not less important, the prejudices, of one country by another, than by the youths of those countries spending a part of their student life together. Undergraduates as a rule do not wear a mask either of politeness or any other material, and have probably a better knowledge of each other's opinions and points of view—in fact, know each other better than do people of riper age. To bring this communion of students about there must be cooperation between the universities throughout the Empire; there must be recognition of each other's examinations, residence, and degrees. Before this can be accomplished there must, as my friend Mr. E. B. Sargant pointed out in a lecture given at the McGill University, be cooperation and recognition between the universities in each part of the Empire. I do not mean for a moment that all universities in a country should be under one government. I am a strong believer in the individuality of universities, but I do not think this is in any way inconsistent with the policy of an open door from one university to every other in the Empire.

It has usually been the practice of the President of this Association to give some account of the progress made in the last few years in the branch of science which he has the honour to represent.

I propose this evening to follow that precedent and to attempt to give a very short account of some of the more recent developments of physics, and the new conceptions of physical processes to which they have led.

The period which has elapsed since the Association last met in Canada has been one of almost unparalleled activity in many branches of physics, and many new and unsuspected properties of matter and electricity have been discovered. The history of this period affords a remarkable illustration of the effect which may be produced by a single discovery; for it is, I think, to the discovery of the Röntgen rays that we owe the rapidity of the progress which has recently been made in physics. A striking discovery like that of the Röntgen rays acts much like the discovery of gold in a sparsely populated country; it attracts workers who come in the first place for the gold, but who may find that the country has other products, other charms, perhaps even more valuable than the gold itself. The country in which the gold was discovered in the case of the Röntgen rays was the department of physics dealing with the discharge of electricity through gases, a subject which, almost from the beginning of electrical science, had attracted a few enthusiastic workers, who felt convinced that the key to unlock the secret of electricity was to be found in a vacuum tube. Röntgen, in 1895, showed that when electricity passed through such a tube, the tube emitted rays which could pass through bodies opaque to ordinary light; which could, for example, pass through the flesh of the body and throw a shadow of the bones on a suitable screen. The fascination of this discovery attracted many workers to the subject of the discharge of electricity through gases, and led to great improvements in the instruments used in this type of research. It is not, however, to the power of probing dark places, important though this is, that the influence of Röntgen rays on the progress of science has mainly been due; it is rather because these rays make gases, and, indeed, solids and liquids, through which they pass conductors of electricity. It is true that before the discovery of these rays other methods of making gases conductors were known, but none of these was so convenient for the purposes of accurate measurement.

The study of gases exposed to Röntgen rays has revealed in such gases the presence of particles charged with electricity; some of these particles are charged with positive, others with negative electricity.

The properties of these particles have been investigated; we know the charge they carry, the speed with which they move under an electric force, the rate at which the oppositely charged ones recombine, and these investigations have thrown a new light, not only on electricity, but also on the structure of matter.

We know from these investigations that electricity, like matter, is molecular in structure, that just as a quantity of hydrogen is a collection of an immense number of small particles called molecules, so a charge of electricity is made up of a great number of small charges, each of a perfectly definite and known amount.

Helmholtz said in 1880 that in his opinion the evidence in favour of the molecular constitution of electricity was even stronger than that in favour of the molecular constitution of matter. How much stronger is that evidence now, when we have measured the charge on the unit and found it to be the same from whatever source the electricity is obtained. Nay, further, the molecular theory of matter is indebted to the molecular theory of electricity for the most accurate determination of its fundamental quantity, the number of molecules in any given quantity of an elementary substance.

The great advantage of the electrical methods for the study of the properties of matter is due to the fact that whenever a particle is electrified it is very easily identified, whereas an uncharged molecule is most elusive; and it is only when these are present in immense numbers that we are able to detect them. A very simple calculation will illustrate the difference in our power of detecting electrified and unelectrified molecules. The smallest quantity of unelectrified matter ever detected is probably that of neon, one of the inert gases of the atmosphere. Prof. Strutt has shown that the amount of neon in 1/20th of a cubic centimetre of the air at ordinary pressures can be detected by the spectroscope; Sir William Ramsay estimates that the neon in the air only amounts to one part of neon in 100,000 parts of air, so that the neon in 1/20th of a cubic centimetre of air would only occupy at atmospheric pressure a volume of half a millionth of a cubic centimetre. When stated in this form the quantity seems exceedingly small, but in this small volume there are about ten million million molecules. Now the population of the earth is estimated at about fifteen hundred millions, so that the smallest number of molecules of neon we can identify is about 7,000 times the population of the earth. In other words, if we had no better test for the existence of a man than we have for that of an unelectrified molecule we should come to the conclusion that the earth is uninhabited. Contrast this with our power of detecting electrified molecules. We can by the electrical method, even better by the cloud method of C. T. R. Wilson, detect the presence of three or four charged particles in a cubic centimetre. Rutherford has shown that we can detect the presence of a single α particle. Now the α particle is a charged atom of helium; if this atom had been uncharged we should have required more than a million million of them, instead of one, before we should have been able to detect them.

We may, I think, conclude, since electrified particles can be studied with so much greater ease than unelectrified ones, that we shall obtain a knowledge of the ultimate structure of electricity before we arrive at a corresponding degree of certainty with regard to the structure of matter.

We have already made considerable progress in the task of discovering what the structure of electricity is. We have known for some time that of one kind of electricity—the negative—and a very interesting one it is. We know that negative electricity is made up of units all of which are of the same kind; that these units are exceedingly small compared with even the smallest atom, for the mass of the unit is only 1/1700th part of the mass of an atom of hydrogen; that its radius is only 10^{-13} centimetre, and that these units, "corpuscles" as they have been called, can be obtained from all substances. The size of these corpuscles is on an altogether different scale from that of atoms; the volume of a corpuscle bears to that of the atom about the same relation as that of a speck of dust to the volume of this room. Under suitable conditions they move at enormous speeds, which approach in some instances the velocity of light.

The discovery of these corpuscles is an interesting example of the way Nature responds to the demands made upon her by mathematicians. Some years before the discovery of corpuscles it had been shown by a mathematical investigation that the mass of a body must be increased by a charge of electricity. This increase, however, is greater for small bodies than for large ones, and even bodies as small as atoms are hopelessly too large to show any appreciable effect; thus the result seemed entirely academic. After a time corpuscles were discovered, and these are so much smaller than the atom that the increase in mass due to the charge becomes not merely appreciable, but so great that, as the experiments of Kaufmann and Bucherer have shown, the whole of the mass of the corpuscle arises from its charge.

We know a great deal about negative electricity; what do we know about positive electricity? Is positive electricity molecular in structure? Is it made up into units, each unit carrying a charge equal in magnitude though opposite in sign to that carried by a corpuscle? Does, or does not, this unit differ, in size and physical properties, very widely from the corpuscle? We know that by suitable processes we can get corpuscles out of any kind of matter, and that the corpuscles will be the same from whatever source they may be derived. Is a similar thing true for positive electricity? Can we get, for example, a positive unit from oxygen of the same kind as that we get from hydrogen?

For my own part, I think the evidence is in favour of the view that we can, although the nature of the unit of positive electricity makes the proof much more difficult than for the negative unit.

In the first place we find that the positive particles—"canalstrahlen" is their technical name—discovered by our distinguished guest, Dr. Goldstein, which are found when an electric discharge passes through a highly rarefied gas, are, when the pressure is very low, the same, whatever may have been the gas in the vessel to begin with. If we pump out the gas until the pressure is too low to allow the discharge to pass, and then introduce a small quantity of gas and restart the discharge, the positive particles are the same whatever kind of gas may have been introduced.

I have, for example, put into the exhausted vessel oxygen, argon, helium, the vapour of carbon tetrachloride, none of which contain hydrogen, and found the positive particles to be the same as when hydrogen was introduced.

Some experiments made lately by Wellisch, in the Cavendish Laboratory, strongly support the view that there is a definite unit of positive electricity independent of the gas from which it is derived; these experiments were on the velocity with which positive particles move through mixed gases. If we have a mixture of methyl-iodide and hydrogen exposed to Röntgen rays, the effect of the rays on the methyl-iodide is so much greater than on the hydrogen that, even when the mixture contains only a small percentage of methyl-iodide, practically all the electricity comes from this gas, and not from the hydrogen.

Now if the positive particles were merely the residue left when a corpuscle had been abstracted from the methyl-iodide, these particles would have the dimensions of a molecule of methyl-iodide; this is very large and heavy, and would therefore move more slowly through the hydrogen molecules than the positive particles derived from hydrogen itself, which would, on this view, be of the size and weight of the light hydrogen molecules. Wellisch found that the velocities of both the positive and negative particles through the mixture were the same as the velocities through pure hydrogen, although in the one case the ions had originated from methyl-iodide and in the other from hydrogen; a similar result was obtained when carbon tetrachloride, or mercury methyl, was used instead of methyl-iodide. These and similar results lead to the conclusion that the atom of the different chemical elements contains definite units of positive as well as of negative electricity, and that the positive electricity, like the negative, is molecular in structure.

The investigations made on the unit of positive electricity show that it is of quite a different kind from the unit of negative, the mass of the negative unit is exceedingly small compared with any atom, the only positive units that up to the present have been detected are quite comparable in mass with the mass of an atom of hydrogen; in fact they seem equal to it. This makes it more difficult to be certain that the unit of positive electricity has been isolated, for we have to be on our guard against its being a much smaller body attached to the hydrogen atoms which happen to be present in the vessel. If the positive units have a much greater mass than the negative ones, they ought not to be so easily deflected by magnetic forces when moving at equal speeds; and in general the insensibility of the positive particles to the influence of a magnet is very marked, though there are cases when the positive particles are much more readily deflected, and these have been interpreted as proving the existence of positive units comparable in mass with the negative ones. I have found, however, that in these cases the positive particles are moving very slowly, and that the ease with which they are deflected is due to the smallness of the velocity and not to that of the mass. It should, however, be noted that M. Jean Becquerel has observed in the absorption spectra of some minerals, and Prof. Wood in the rotation of the plane of polarisation by sodium vapour, effects which could be explained by the presence in the substances of positive units comparable in mass with corpuscles. This, however, is not the only explanation which can be given of these effects, and at present the smallest positive electrified particles of which we have direct experimental evidence have masses comparable with that of an atom of hydrogen.

A knowledge of the mass and size of the two units of electricity, the positive and the negative, would give us the material for constructing what may be called a molecular theory of electricity, and would be a starting-point for a theory of the structure of matter; for the most natural view to take, as a provisional hypothesis, is that matter is just a collection of positive and negative units of electricity, and that the forces which hold atoms and molecules together, the properties which differentiate one kind of matter from another, all have their origin in the electrical forces exerted by positive and negative units of electricity, grouped together in different ways in the atoms of the different elements.

As it would seem that the units of positive and negative electricity are of very different sizes, we must regard matter as a mixture containing systems of very different types, one type corresponding to the small corpuscle, the other to the large positive unit.

Since the energy associated with a given charge is greater the smaller the body on which the charge is concentrated, the energy stored up in the negative corpuscles will be far greater than that stored up by the positive. The amount of energy which is stored up in ordinary matter in the form of the electrostatic potential energy of its corpuscles is, I think, not generally realised. All substances give out corpuscles, so that we may assume that each atom of a substance contains at least one corpuscle. From the size and the charge on the corpuscle, both of which are known, we find that each corpuscle has 8×10^{-7} ergs of energy; this is on the supposition that the usual expressions for the energy of a charged body hold when, as in the case of a corpuscle, the charge is reduced to one unit. Now in one gram of hydrogen there are about 6×10^{23} atoms, so if there is only one corpuscle in each atom the energy due to the corpuscles in a gram of hydrogen would be 48×10^{16} ergs, or 11×10^{9} calories. This is more than seven times the heat developed by one gram of radium, or than that developed by the burning of five tons of coal. Thus we see that even ordinary matter contains enormous stores of energy; this energy is fortunately kept fast bound by the corpuscles; if at any time an appreciable fraction were to get free the earth would explode and become a gaseous nebula.

The matter of which I have been speaking so far is the material which builds up the earth, the sun, and the stars, the matter studied by the chemist, and which he can represent by a formula; this matter occupies, however, but an insignificant fraction of the universe, it forms but minute islands in the great ocean of the æther, the substance with which the whole universe is filled.

The æther is not a fantastic creation of the speculative philosopher; it is as essential to us as the air we breathe. For we must remember that we on this earth are not living on our own resources; we are dependent from minute to minute upon what we are getting from the sun, and the gifts of the sun are conveyed to us by the æther. It is to the sun that we owe, not merely night and day, springtime and harvest, but it is the energy of the sun, stored up in coal, in waterfalls, in food, that practically does all the work of the world.

How great is the supply the sun lavishes upon us becomes clear when we consider that the heat received by the earth under a high sun and a clear sky is equivalent, according to the measurements of Langley, to about 7000 horse-power per acre. Though our engineers have not yet discovered how to utilise this enormous supply of power, they will, I have not the slightest doubt, ultimately succeed in doing so; and when coal is exhausted and our water-power inadequate, it may be that this is the source from which we shall derive the energy necessary for the world's work. When that comes about, our centres of industrial activity may perhaps be transferred to the burning deserts of the Sahara, and the value of land determined by its suitability for the reception of traps to catch sunbeams.

This energy, in the interval between its departure from the sun and its arrival at the earth, must be in the space between them. Thus this space must contain something which, like ordinary matter, can store up energy, which can carry at an enormous pace the energy associated with light and heat, and can, in addition, exert the enormous stresses necessary to keep the earth circling round the sun and the moon round the earth.

The study of this all-pervading substance is perhaps the most fascinating and important duty of the physicist.

On the electromagnetic theory of light, now universally accepted, the energy streaming to the earth travels through the æther in electric waves; thus practically the whole of the energy at our disposal has at one time or another been electrical energy. The æther must, then, be the seat of electrical and magnetic forces. We know, thanks to the genius of Clerk Maxwell, the founder and inspirer of modern electrical theory, the equations which express the relation between these forces, and although for some purposes these are all we require, yet they do not tell us very much about the nature of the æther.

The interest inspired by equations, too, in some minds is apt to be somewhat Platonic; and something more grossly mechanical—a model, for example, is felt by many to be more suggestive and manageable, and for them a more powerful instrument of research, than a purely analytical theory.

Is the æther dense or rare? Has it a structure? Is it at rest or in motion? are some of the questions which force themselves upon us.

Let us consider some of the facts known about the æther. When light falls on a body and is absorbed by it, the body is pushed forward in the direction in which the light is travelling, and if the body is free to move it is set in motion by the light. Now it is a fundamental principle of dynamics that when a body is set moving in a certain direction, or, to use the language of dynamics, acquires momentum in that direction, some other mass must lose the same amount of momentum; in other words, the amount of momentum in the universe is constant. Thus when the body is pushed forward by the light some other system must have lost the momentum the body acquires, and the only other system available is the wave of light falling on the body; hence we conclude that there must have been momentum in the wave in the direction in which it is travelling. Momentum, however, implies mass in motion. We conclude, then, that in the æther through which the wave is moving there is mass moving with the velocity of light. The experiments made on the pressure due to light enable us to calculate this mass, and we find that in a cubic kilometre of æther carrying light as intense as sunlight is at the surface of the earth, the mass moving is only about one-fifty-millionth of a milligram. We must be careful not to confuse this with the mass of a cubic kilometre of æther; it is only the mass moved when the light passes through it; the vast majority of the æther is left undisturbed by the light. Now, on the electromagnetic theory of light, a wave of light may be regarded as made up of groups of lines of electric force moving with the velocity of light: and if we take this point of view we can prove that the mass of æther per cubic centimetre carried along is proportional to the energy possessed by these lines of electric force per cubic centimetre, divided by the square of the velocity of light. But though lines of electric force carry some of the æther along with them as they move, the amount so carried, even in the strongest electric fields we can produce, is but a minute fraction of the æther in their neighbourhood.

This is proved by an experiment made by Sir Oliver Lodge in which light was made to travel through an electric field in rapid motion. If the electric field had carried the whole of the æther with it, the velocity of the light would have been increased by the velocity of the electric field. As a matter of fact, no increase whatever could be detected, though it would have been registered if it had amounted to one-thousandth part of that of the field.

The æther carried along by a wave of light must be an exceedingly small part of the volume through which the wave is spread. Parts of this volume are in motion, but by far the greater part is at rest; thus in the wave front there cannot be uniformity, at some parts the æther is moving, at others it is at rest—in other words, the wave front must be more analogous to bright specks on a dark ground than to a uniformly illuminated surface.

The place where the density of the æther carried along by an electric field rises to its highest value is close to a corpuscle, for round the corpuscles are by far the strongest electric fields of which we have any knowledge. We know the mass of the corpuscle, we know from Kaufmann's experiments that this arises entirely from the electric charge, and is therefore due to the æther carried along with the corpuscle by the lines of force attached to it.

A simple calculation shows that one-half of this mass is contained in a volume seven times that of a corpuscle. Since we know the volume of the corpuscle as well as the mass, we can calculate the density of the æther attached to the corpuscle; doing so, we find it amounts to the prodigious value of about 5×10^{10}, or about 2000 million times that of lead. Sir Oliver Lodge, by somewhat different considerations, has arrived at a value of the same order of magnitude.

Thus around the corpuscle æther must have an extravagant density: whether the density is as great as this in other places depends upon whether the æther is compressible or not. If it is compressible, then it may be condensed round the corpuscles, and there have an abnormally great density; if it is not compressible, then the density in free space cannot be less than the number I have just mentioned.

With respect to this point we must remember that the forces acting on the æther close to the corpuscle are prodigious. If the æther were, for example, an ideal gas the density of which increased in proportion to the pressure, however great the pressure might be, then if, when exposed to the pressures which exist in some directions close to the corpuscle, it had the density stated above, its density under atmospheric pressure would only be about 8×10^{-16}, or a cubic kilometre would have a mass less than a gram; so that instead of being almost incomparably denser than lead, it would be almost incomparably rarer than the lightest gas.

I do not know at present of any effect which would enable us to determine whether æther is compressible or not. And although at first sight the idea that we are immersed in a medium almost infinitely denser than lead might seem inconceivable, it is not so if we remember that in all probability matter is composed mainly of holes. We may, in fact, regard matter as possessing a bird-cage kind of structure in which the volume of the æther disturbed by the wires when the structure is moved is infinitesimal in comparison with the volume enclosed by them. If we do this, no difficulty arises from the great density of the æther; all we have to do is to increase the distance between the wires in proportion as we increase the density of the æther.

Let us now consider how much æther is carried along by ordinary matter, and what effects this might be expected to produce.

The simplest electrical system we know, an electrified sphere, has attached to it a mass of æther proportional to its potential energy, and such that if the mass were to move with the velocity of light its kinetic energy would equal the electrostatic potential energy of the particle. This result can be extended to any electrified system, and it can be shown that such a system binds a mass of the æther proportional to its potential energy. Thus a part of the mass of any system is proportional to the potential energy of the system.

The question now arises, Does this part of the mass add anything to the weight of the body? If the æther were not subject to gravitational attraction it certainly would not; and even if the æther were ponderable, we might expect that as the mass is swimming in a sea of æther it would not increase the weight of the body to which it is attached. But if it does not, then a body with a large amount of potential energy may have an appreciable amount of its mass in a form which does not increase its weight, and thus the weight of a given mass of it may be less than that of an equal mass of some substance with a smaller amount of potential energy. Thus the weights of equal masses of these substances would be different. Now, experiments with pendulums, as Newton pointed out, enable us to determine with great accuracy the weights of equal masses of different substances. Newton himself made experiments of this kind, and found that the weights of equal masses were the same for all the materials he tried. Bessel, in 1830, made some experiments on this subject which are still the most accurate we possess, and he showed that the weights of equal masses of lead, silver, iron, brass did not differ by as much as one part in 60,000.

The substances tried by Newton and Bessel did not, however, include any of those substances which possess the marvellous power of radio-activity; the discovery of these came much later, and is one of the most striking achievements of modern physics.

These radio-active substances are constantly giving out large quantities of heat, presumably at the expense of their potential energy; thus when these substances reach their final non-radio-active state their potential energy must be less than when they were radio-active. Prof. Rutherford's measurements show that the energy emitted by one gram of radium in the course of its degradation to non-radio-active forms is equal to the kinetic energy of a mass of 1/13th of a milligram moving with the velocity of light.

This energy, according to the rule I have stated, corresponds to a mass of 1/13th of a milligram of the æther, and thus a gram of radium in its radio-active state must have at least 1/13th of a milligram more of æther attached to it than when it has been degraded into the non-radio-active forms. Thus if this æther does not increase the weight of the radium, the ratio of mass to weight for radium would be greater by about one part in 13,000 than for its non-radio-active products.

I attempted several years ago to find the ratio of mass to weight for radium by swinging a little pendulum, the bob of which was made of radium. I had only a small quantity of radium, and was not, therefore, able to attain any great accuracy. I found that the difference, if any, in the ratio of the mass to weight between radium and other substances was not more than one part in 2000. Lately we have been using at the Cavendish Laboratory a pendulum the bob of which was filled with uranium oxide. We have got good reasons for supposing that uranium is a parent of radium, so that the great potential energy and large æthereal mass possessed by the radium will be also in the uranium; the experiments are not yet completed. It is, perhaps, expecting almost too much to hope that the radio-active substances may add to the great services they have already done to science by furnishing the first case in which there is some differentiation in the action of gravity.

The mass of æther bound by any system is such that if it were to move with the velocity of light its kinetic energy would be equal to the potential energy of the system. This result suggests a new view of the nature of potential energy. Potential energy is usually regarded as essentially different from kinetic energy. Potential energy depends on the configuration of the system, and can be calculated from it when we have the requisite data; kinetic energy, on the other hand, depends upon the velocity of the system. According to the principle of the conservation of energy the one form can be converted into the other at a fixed rate of exchange, so that when one unit of one kind disappears a unit of the other simultaneously appears.

Now in many cases this rule is all that we require to calculate the behaviour of the system, and the conception of potential energy is of the utmost value in making the knowledge derived from experiment and observation available for mathematical calculation. It must, however, I think, be admitted that from the purely philosophical point of view it is open to serious objection. It violates, for example, the principle of continuity. When a thing changes from a state A to a different state B, the principle of continuity requires that it must pass through a number of states intermediate between A and B, so that the transition is made gradually, and not abruptly. Now, when kinetic energy changes into potential, although there is no discontinuity in the quantity of the energy, there is in its quality, for we do not recognise any kind of energy intermediate between that due to the motion and that due to the position of the system, and some portions of energy are supposed to change *per saltum* from the kinetic to the potential form. In the case of the transition of kinetic energy into heat energy in a gas, the discontinuity has disappeared with a fuller knowledge of what the heat energy in a gas is due to. When we were ignorant of the nature of this energy, the transition from kinetic into thermal energy seemed discontinuous; but now we know that this energy is the kinetic energy of the molecules of which the gas is composed, so that there is no change in the type of energy when the kinetic energy of visible motion is transformed into the thermal energy of a gas—it is just the transference of kinetic energy from one body to another.

If we regard potential energy as the kinetic energy of portions of the æther attached to the system, then all energy is kinetic energy, due to the motion of matter or of portions of æther attached to the matter. I showed, many years ago, in my "Applications of Dynamics to Physics and Chemistry," that we could imitate the effects of the potential energy of a system by means of the kinetic energy of invisible systems connected in an appropriate manner with the main system, and that the potential energy of the visible universe may in reality be the kinetic energy of an invisible one connected up with it. We naturally suppose that this invisible universe is the luminiferous æther, that portions of the æther in rapid motion are connected with the visible systems, and that their kinetic energy is the potential energy of the systems.

We may thus regard the æther as a bank in which we may deposit energy and withdraw it at our convenience. The mass of the æther attached to the system will change as the potential energy changes, and thus the mass of a system the potential energy of which is changing cannot be constant; the fluctuations in mass under ordinary conditions are, however, so small that they cannot be detected by any means at present at our disposal. Inasmuch as the various forms of potential energy are continually being changed into heat energy, which is the kinetic energy of the molecules of matter, there is a constant tendency for the mass of a system such as the earth or the sun to diminish, and thus as time goes on for the mass of æther gripped by the material universe to become smaller and smaller; the rate at which it would diminish would, however, get slower as time went on, and there is no reason to think that it would ever get below a very large value.

Radiation of light and heat from an incandescent body like the sun involves a constant loss of mass by the body. Each unit of energy radiated carries off its quota of mass, but as the mass ejected from the sun per year is only one part in 20 billionths (1 in 2×10^{13}) of the mass of the sun, and as this diminution in mass is not necessarily accompanied by any decrease in its gravitational attraction, we cannot expect to be able to get any evidence of this effect.

As our knowledge of the properties of light has progressed, we have been driven to recognise that the æther, when transmitting light, possesses properties which, before the introduction of the electromagnetic theory, would have been thought to be peculiar to an emission theory of light and to be fatal to the theory that light consists of undulations.

Take, for example, the pressure exerted by light. This would follow as a matter of course if we supposed light to be small particles moving with great velocities, for these, if they struck against a body, would manifestly tend to push it forward, while on the undulatory theory there seemed no reason why any effect of this kind should take place.

Indeed, in 1792, this very point was regarded as a test between the theories, and Bennet made experiments to see whether or not he could find any traces of this pressure. We now know that the pressure is there, and if Bennet's instrument had been more sensitive he must have observed it. It is perhaps fortunate that Bennet had not at his command more delicate apparatus. Had he discovered the pressure of light, it would have shaken confidence in the undulatory theory and checked that magnificent work at the beginning of the last century which so greatly increased our knowledge of optics.

As another example, take the question of the distribution of energy in a wave of light. On the emission theory the energy in the light is the kinetic energy of the light particles. Thus the energy of light is made up of distinct units, the unit being the energy of one of the particles.

The idea that the energy has a structure of this kind has lately received a good deal of support. Planck, in a very remarkable series of investigations on the Thermodynamics of Radiation, pointed out that the expressions for the energy and entropy of radiant energy were of such a form as to suggest that the energy of radiation, like that of a gas on the molecular theory, was made up of distinct units, the magnitude of the unit depending on the colour of the light; and on this assumption he was able to calculate the value of the unit, and from this deduce incidentally the value of Avogadro's constant—the number of molecules in a cubic centimetre of gas at standard temperature and pressure.

This result is most interesting and important, because if it were a legitimate deduction from the Second Law of Thermodynamics, it would appear that only a particular type of mechanism for the vibrators which give out light and the absorbers which absorb it could be in accordance with that law.

If this were so, then, regarding the universe as a collection of machines all obeying the laws of dynamics, the Second Law of Thermodynamics would only be true for a particular kind of machine.

There seems, however, grave objection to this view, which I may illustrate by the case of the First Law of Thermodynamics, the principle of the Conservation of Energy. This must be true whatever be the nature of the machines which make up the universe, provided they obey the laws of dynamics, any application of the principle of the Conservation of Energy could not discriminate between one type of machine and another.

Now, the Second Law of Thermodynamics, though not a dynamical principle in as strict a sense as the law of the Conservation of Energy, is one that we should expect to hold for a collection of a large number of machines of any type, provided that we could not directly affect the individual machines, but could only observe the average effects produced by an enormous number of them. On this view, the Second Law, as well as the First, should be incapable of saying that the machines were of any particular type: so that investigations founded on thermodynamics, though the expressions they lead to may suggest—cannot, I think, be regarded as proving—the unit structure of light energy.

It would seem as if in the application of thermodynamics to radiation some additional assumption has been implicitly introduced, for these applications lead to definite relations between the energy of the light of any particular wave-length and the temperature of the luminous body.

Now a possible way of accounting for the light emitted by hot bodies is to suppose that it arises from the collisions of corpuscles with the molecules of the hot body, but it is only for one particular law of force between the corpuscles and the molecules that the distribution of energy would be the same as that deduced by the Second Law of Thermodynamics, so that in this case, as in the other, the results obtained by the application of thermodynamics to radiation would require us to suppose that the Second Law of Thermodynamics is only true for radiation when the radiation is produced by mechanism of a special type.

Quite apart, however, from considerations of thermodynamics, we should expect that the light from a luminous source should in many cases consist of parcels, possessing, at any rate to begin with, a definite amount of energy. Consider, for example, the case of a gas like sodium vapour, emitting light of a definite wave-length; we may imagine that this light, consisting of electrical waves, is emitted by systems resembling Leyden jars. The energy originally possessed by such a system will be the electrostatic energy of the charged jar. When the vibrations are started, this energy will be radiated away into space, the radiation forming a complex system, containing, if the jar has no electrical resistance, the energy stored up in the jar.

The amount of this energy will depend on the size of the jar and the quantity of electricity with which it is charged. With regard to the charge, we must remember that we are dealing with systems formed out of single molecules, so that the charge will only consist of one or two natural units of electricity, or, at all events, some small multiple of that unit, while for geometrically similar Leyden jars the energy for a given charge will be proportional to the frequency of the vibration; thus, the energy in the bundle of radiation will be proportional to the frequency of the vibration.

We may picture to ourselves the radiation as consisting of the lines of electric force which, before the vibrations were started, were held bound by the charges on the jar, and which, when the vibrations begin, are thrown into rhythmic undulations, liberated from the jar and travel through space with the velocity of light.

Now let us suppose that this system strikes against an uncharged condenser and gives it a charge of electricity, the charge on the plates of the condenser must be at least one unit of electricity, because fractions of this charge do not exist, and each unit charge will anchor a unit tube of force, which must come from the parcel of radiation falling upon it. Thus a tube in the incident light will be anchored by the condenser, and the parcel formed by this tube will be anchored and withdrawn as a whole from the pencil of light incident on the condenser. If the energy required to charge up the condenser with a unit of electricity is greater than the energy in the incident parcel, the tube will not be anchored and the light will pass over the condenser and escape from it. These principles that radiation is made up of units, and that it requires a unit possessing a definite amount of energy to excite radiation in a body on which it falls, perhaps receive their best illustration in the remarkable laws governing Secondary Röntgen radiation, recently discovered by Prof. Barkla. Prof. Barkla has found that each of the different chemical elements, when exposed to Röntgen rays, emits a definite type of secondary radiation whatever may have been the type of primary; thus lead emits one type, copper another, and so on; but these radiations are not excited at all if the primary radiation is of a softer type than the specific radiation emitted by the substance; thus the secondary radiation from lead being harder than that from copper, if copper is exposed to the secondary radiation from lead the copper will radiate, but lead will not radiate when exposed to copper. Thus, if we suppose that the energy in a unit of hard Röntgen rays is greater than that in one of soft, Barkla's results are strikingly analogous to those which would follow on the unit theory of light.

Though we have, I think, strong reasons for thinking that the energy in the light waves of definite wave-length is done up into bundles, and that these bundles, when emitted, all possess the same amount of energy, I do not think there is any reason for supposing that in any casual specimen of light of this wave-length, which may subsequent to its emission have been many times refracted or reflected, the bundles possess any definite amount of energy. For consider what must happen when a bundle is incident on a surface such as glass, when part of it is reflected and part transmitted. The bundle is divided into two portions, in each of which the energy is less than the incident bundle, and since these portions diverge and may ultimately be many thousands of miles apart, it would seem meaningless still to regard them as forming one unit. Thus the energy in the bundles of light, after they have suffered partial reflection, will not be the same as in the bundles when they were emitted. The study of the dimensions of these bundles, for example, the angle they subtend at the luminous source, is an interesting subject for investigation; experiments on interference between rays of light emerging in different directions from the luminous source would probably throw light on this point.

I now pass to a very brief consideration of one of the most important and interesting advances ever made in physics, and in which Canada, as the place of the labours of Profs. Rutherford and Soddy, has taken a conspicuous part. I mean the discovery and investigation of radio-activity. Radio-activity was brought to light by the Röntgen rays. One of the many remarkable properties of these rays is to excite phosphorescence in certain substances, including the salts of uranium, when they fall upon them. Since Röntgen rays produce phosphorescence, it occurred to Becquerel to try whether phosphorescence would produce Röntgen rays. He took some uranium salts which had been made to phosphoresce by exposure, not to Röntgen rays, but to sunlight, tested them, and found that they gave out rays possessing properties similar to Röntgen rays. Further investigation showed, however, that to get these rays it was not necessary to make the uranium phosphoresce, that the salts were just as active if they had been kept in the dark. It thus appeared that the property was due to the metal and not to the phosphorescence, and that uranium and its compounds possessed the power of giving out rays which, like Röntgen rays, affect a photographic plate, make certain minerals phosphoresce, and make gases through which they pass conductors of electricity.

Niepce de Saint-Victor had observed some years before this discovery that paper soaked in a solution of uranium nitrate affected a photographic plate, but the observation excited but little interest. The ground had not then been prepared, by the discovery of the Röntgen rays, for its reception, and it withered and was soon forgotten.

Shortly after Becquerel's discovery of uranium, Schmidt found that thorium possessed similar properties. Then M. and Mme. Curie, after a most difficult and laborious investigation, discovered two new substances, radium and polonium, possessing this property to an enormously greater extent than either thorium or uranium, and this was followed by the discovery of actinium by Debierne. Now the researches of Rutherford and others have led to the discovery of so many new radio-active substances that any attempts at christening seem to have been abandoned, and they are denoted, like policemen, by the letters of the alphabet.

Mr. Campbell has recently found that potassium, though far inferior in this respect to any of the substances I have named, emits an appreciable amount of radiation, the amount depending only on the quantity of potassium, and being the same whatever the source from which the potassium is obtained or whatever the elements with which it may be in combination.

The radiation emitted by these substances is of three types, known as α, β, and γ rays. The α rays have been shown by Rutherford to be positively electrified atoms of helium, moving with speeds which reach up to about one-tenth of the velocity of light. The β rays are negatively electrified corpuscles, moving in some cases with very nearly the velocity of light itself, while the γ rays are unelectrified, and are analogous to the Röntgen rays.

The radio-activity of uranium was shown by Crookes to arise from something mixed with the uranium, which differed sufficiently in properties from the uranium itself to enable it to be separated by chemical analysis. He took some uranium, and by chemical treatment separated it into two portions, one of which was radio-active and the other not.

Next Becquerel found that if these two portions were kept for several months, the part which was not radio-active to begin with regained radio-activity, while the part which was radio-active to begin with had lost its radio-activity. These effects and many others receive a complete explanation by the theory of radio-active change which we owe to Rutherford and Soddy.

According to this theory, the radio-active elements are not permanent, but are gradually breaking up into elements of lower atomic weight; uranium, for example, is slowly breaking up, one of the products being radium, while radium breaks up into a radio-active gas called radium emanation, the emanation into another radio-active substance, and so on, and that the radiations are a kind of swan's song emitted by the atoms when they pass from one form to another; that for example, it is when a radium atom breaks up and an atom of the emanation appears that the rays which constitute the radio-activity are produced.

Thus, on this view, the atoms of the radio-active elements are not immortal; they perish after a life the average value of which ranges from thousands of millions of years in the case of uranium to a second or so in the case of the gaseous emanation from actinium.

When the atoms pass from one state to another they give out large stores of energy; thus their descendants do not inherit the whole of their wealth of stored-up energy; the estate becomes less and less wealthy with each generation; we find, in fact, that the politician, when he imposes death duties, is but imitating a process which has been going on for ages in the case of these radio-active substances.

Many points of interest arise when we consider the rate at which the atoms of radio-active substance disappear. Rutherford has shown that whatever be the age of these atoms, the percentage of atoms which disappear in one second is always the same; another way of putting it is that the expectation of life of an atom is independent of its age—that an atom of radium one thousand years old is just as likely to live for another thousand years as one just sprung into existence.

Now this would be the case if the death of the atom were due to something from outside which struck old and young indiscriminately; in a battle, for example, the chance of being shot is the same for old and young; so that we are inclined at first to look to something coming from outside as the cause why an atom of radium, for example, suddenly changes into an atom of the emanation. But here we are met with the difficulty that no changes in the external conditions that we have as yet been able to produce have had any effect on the life of the atom; so far as we know at present, the life of a radium atom is the same at the temperature of a furnace as at that of liquid air—it is not altered by surrounding the radium by thick screens of lead or other dense materials to ward off radiation from outside, and, what to my mind is especially significant, it is the same when the radium is in the most concentrated form, when its atoms are exposed to the vigorous bombardment from the rays given off by the neighbouring atoms, as when it is in the most dilute solution, when the rays are absorbed by the water which separates one atom from another. This last result seems to me to make it somewhat improbable that we shall be able to split up the atoms of the non-radio-active elements by exposing them to the radiation from radium; if this radiation is unable to affect the unstable radio-active atoms, it is somewhat unlikely that it will be able to affect the much more stable non-radio-active elements.

The evidence we have at present is against a disturbance coming from outside breaking up the radio-active atoms, and we must therefore look to some process of decay in the atom itself; but if this is the case, how are we to reconcile it with the fact that the expectation of life of an atom does not diminish as the atom gets older? We can do this if we suppose that the atoms when they are first produced have not all the same strength of constitution, that some are more robust than others, perhaps because they contain more intrinsic energy to begin with, and will therefore have a longer life. Now if when the atoms are first produced there are some which will live for one year, some for ten, some for a thousand, and so on; and if lives of all durations, from nothing to infinity, are present in such proportion that the number of atoms which will live longer than a certain number of years decreases in a constant proportion for each additional year of life, we can easily prove that the expectation of life of an atom will be the same whatever its age may be. On this view the different atoms of a radio-active substance are not, in all respects, identical.

The energy developed by radio-active substances is exceedingly large, one gram of radium developing nearly as much energy as would be produced by burning a ton of coal. This energy is mainly in the α particles, the positively charged helium atoms which are emitted when the change in the atom takes place; if this energy were produced by electrical forces it would indicate that the helium atom had moved through a potential difference of about two million volts on its way out of the atom of radium. The source of this energy is a problem of the deepest interest; if it arises from the repulsion of similarly electrified systems exerting forces varying inversely as the square of the distance, then to get the requisite amount of energy the systems, if their charges were comparable with the charge on the α particle, could not when they start be further apart than the radius of a corpuscle, 10^{-13} cm. If we suppose that the particles do not acquire this energy at the explosion, but that before they are shot out of the radium atom they move in circles inside this atom with the speed with which they emerge, the forces required to prevent particles moving with this velocity from flying off at a tangent are so great that finite charges of electricity could only produce them at distances comparable with the radius of a corpuscle.

One method by which the requisite amount of energy could be obtained is suggested by the view to which I have already alluded—that in the atom we have electrified systems of very different types, one small, the other large; the radius of one type is comparable with 10^{-13} cm., that of the other is about 100,000 times greater. The electrostatic potential energy in the smaller bodies is enormously greater than that in the larger ones; if one of these small bodies were to explode and expand to the size of the larger ones, we should have a liberation of energy large enough to endow an α particle with the energy it possesses. Is it possible that the positive units of electricity were, to begin with, quite as small as the negative, but while in the course of ages most of these have passed from the smaller stage to the larger, there are some small ones still lingering in radio-active substances, and it is the explosion of these which liberates the energy set free during radio-active transformation?

The properties of radium have consequences of enormous importance to the geologist as well as to the physicist or chemist. In fact, the discovery of these properties has entirely altered the aspect of one of the most interesting geological problems, that of the age of the earth. Before the discovery of radium it was supposed that the supplies of heat furnished by chemical changes going on in the earth were quite insignificant, and that there was nothing to replace the heat which flows from the hot interior of the earth to the colder crust. Now when the earth first solidified it only possessed a certain amount of capital in the form of heat, and if it is continually spending this capital and not gaining any fresh heat it is evident that the process cannot have been going on for more than a certain number of years; otherwise the earth would be colder than it is. Lord Kelvin in this way estimated the age of the earth to be less than 100 million years. Though the quantity of radium in the earth is an exceedingly small fraction of the mass of the earth, only amounting, according to the determinations of Profs. Strutt and Joly, to about five grams in a cube the side of which is 100 miles, yet the amount of heat given out by this small quantity of radium is so great that it is more than enough to replace the heat which flows from the inside to the outside of the earth. This, as Rutherford has pointed out, entirely vitiates the previous method of determining the age of the earth. The fact is that the radium gives out so much heat that we do not quite know what to do with it, for if there was as much radium throughout the interior of the earth as there is in its crust, the temperature of the earth would increase much more rapidly than it does as we descend below the earth's surface. Prof. Strutt has shown that if radium behaves in the interior of the earth as it does at the surface, rocks similar to those in the earth's crust cannot extend to a depth of more than forty-five miles below the surface.

It is remarkable that Prof. Milne from the study of earthquake phenomena had previously come to the conclusion that rocks similar to those at the earth's surface only descend a short distance below the surface; he estimates this distance at about thirty miles, and concludes that at a depth greater than this the earth is fairly homogeneous.

Though the discovery of radio-activity has taken away one method of calculating the age of the earth it has supplied another.

The gas helium is given out by radio-active bodies, and since, except in beryls, it is not found in minerals which do not contain radio-active elements, it is probable that all the helium in these minerals has come from these elements. In the case of a mineral containing uranium, the parent of radium in radio-active equilibrium, with radium and its products, helium will be produced at a definite rate. Helium, however, unlike the radio-active elements, is permanent, and accumulates in the mineral; hence if we measure the amount of helium in a sample of rock and the amount produced by the sample in one year we can find the length of time the helium has been accumulating, and hence the age of the rock. This method, which is due to Prof. Strutt, may lead to determinations, not merely of the average age of the crust of the earth, but of the ages of particular rocks and the date at which the various strata were deposited; he has, for example, shown in this way that a specimen of the mineral thorianite must be more than 240 million years old.

The physiological and medical properties of the rays emitted by radium is a field of research in which enough has already been done to justify the hope that it may lead to considerable alleviation of human suffering. It seems quite definitely established that for some diseases, notably rodent ulcer, treatment with these rays has produced remarkable cures; it is imperative, lest we should be passing over a means of saving life and health, that the subject should be investigated in a much more systematic and extensive manner than there has yet been either time or material for. Radium is, however, so costly that few hospitals could afford to undertake pioneering work of this kind; fortunately, however, through the generosity of Sir Ernest Cassel and Lord Iveagh a Radium Institute, under the patronage of his Majesty the King, has been founded in London for the study of the medical properties of radium, and for the treatment of patients suffering from diseases for which radium is beneficial.

The new discoveries made in physics in the last few years, and the ideas and potentialities suggested by them, have had an effect upon the workers in that subject akin to that produced in literature by the Renaissance. Enthusiasm has been quickened, and there is a hopeful, youthful, perhaps exuberant, spirit abroad which leads men to make with confidence experiments which would have been thought fantastic twenty years ago. It has quite dispelled the pessimistic feeling, not uncommon at that time, that all the interesting things had been discovered, and all that was left was to alter a decimal or two in some physical constant. There never was any justification for this feeling, there never were any signs of an approach to finality in science. The sum of knowledge is at present, at any rate, a diverging, not a converging, series. As we conquer peak after peak we see in front of us regions full of interest and beauty, but we do not see our goal, we do not see the horizon; in the distance tower still higher peaks, which will yield to those who ascend them still wider prospects, and deepen the feeling, the truth of which is emphasised by every advance in science, that "Great are the Works of the Lord."

SECTION A.

MATHEMATICS AND PHYSICS.

OPENING ADDRESS BY PROF. E. RUTHERFORD, M.A., D.Sc., F.R.S., PRESIDENT OF THE SECTION.

IT is a great privilege and pleasure to address the members of this Section on the occasion of the visit of the British Association to a country with which I have had such a long and pleasant connection. I feel myself in the presence of old friends, for the greater part of what may be called my scientific life has been spent in Canada, and I owe much to this country for the unusual facilities and opportunity for research so liberally provided by one of her great Universities. Canada may well regard with pride her Universities, which have made such liberal provision for teaching and research in pure and applied science. As a physicist, I may be allowed to refer in particular to the subject with which I am most intimately connected. After seeing the splendid home for physical science recently erected by the University of Toronto, and the older but no less serviceable and admirably equipped laboratories of McGill University, one cannot but feel that Canada has recognised in a striking manner the great value attaching to teaching and research in physical science. In this, as in other branches of knowledge, Canada has made notable contributions in the past, and we may confidently anticipate that this is but an earnest of what will be accomplished in the future.

It is my intention to-day to say a few words upon the present position of the atomic theory in physical science, and to discuss briefly the various methods that have been devised to determine the values of certain fundamental atomic magnitudes. The present time seems very opportune for this purpose, for the rapid advance of physics during the last decade has not only given us a much clearer conception of the relation between electricity and matter and of the constitution of the atom, but has provided us with experimental methods of attack undreamt of a few years ago. At a time when, in the vision of the physicist, the atmosphere is dim with flying fragments of atoms, it may not be out of place to see how it has fared with the atoms themselves, and to look carefully at the atomic foundations on which the great superstructure of modern science has been raised. Every physicist and chemist cannot but be aware of the great part the atomic hypothesis plays in science to-day. The idea that matter consists of a great number of small discrete particles forms practically the basis of the explanation of all properties of matter. As an indication of the importance of this theory in the advance of science it is of interest to read over the Reports of this Association and to note how many addresses, either wholly or in part, have been devoted to a consideration of this subject. Amongst numerous examples I may instance the famous and oft-quoted lecture of Maxwell on Molecules, at Bradford in 1873; the discussion of the Kinetic Theory of Gases by Lord Kelvin, then Sir William Thomson, in Montreal in 1884; and the Presidential Address of Sir Arthur Rücker in 1901, which will be recalled by many here to-day.

It is far from my intention to discuss, except with extreme brevity, the gradual rise and development of the atomic theory. From the point of view of modern science, the atomic theory dates from the work of Dalton about 1805, who put it forward as an explanation of the combination of elements in definite proportions. The simplicity of this explanation of the facts of chemistry led to the rapid adoption of the atomic theory as a very convenient and valuable working hypothesis. By the labour of the chemists matter was shown to be composed of a number of elementary substances which could not be further decomposed by laboratory agencies, and the relative weights of the atoms of the elements were determined. On the physical side, the mathematical development of the kinetic or dynamical theory of gases by the labours of Clausius and Clerk Maxwell enormously extended the utility of this conception. It was shown that the properties of gases could be satisfactorily explained on the assumption that a gas consisted of a great assemblage of minute particles or molecules in continuous agitation, colliding with each other and with the walls of the containing vessel. Between encounters the molecules travelled in straight lines, and the free path of the molecules between collisions was supposed to be large compared with the linear dimensions of the molecules themselves. One cannot but regard with admiration the remarkable success of this statistical theory in explaining the general properties of gases and even predicting unexpected relations. The strength and at the same time the limitations of the theory lie in the fact that it does not involve any definite conception of the nature of the molecules themselves or of the forces acting between them. The molecule, for example, may be considered as a perfectly elastic sphere or a Boscovitch centre of force, as Lord Kelvin preferred to regard it, and yet on suitable assumptions the gas would show the same general statistical properties. We are consequently unable, without the aid of special subsidiary hypotheses, to draw conclusions of value in regard to the nature of the molecules themselves.

Towards the close of the last century the ideas of the atomic theory had impregnated a very large part of the domain of physics and chemistry. The conception of atoms became more and more concrete. The atom in imagination was endowed with size and shape, and unconsciously in many cases with colour. The simplicity and utility of atomic conceptions in explaining the most diverse phenomena of physics and chemistry naturally tended to enhance the importance of the theory in the eyes of the scientific worker. There was a tendency to regard the atomic theory as one of the established facts of nature, and not as a useful working hypothesis for which it was exceedingly difficult to obtain direct and convincing evidence. There were not wanting scientific men and philosophers to point out the uncertain foundations of the theory on which so much depended. Granting how useful molecular ideas were for the explanation of experimental facts, what evidence was there that the atoms were realities and not the figments of the imagination? It must be confessed that this lack of direct evidence did not in any way detract from the strength of the belief of the great majority of scientific men in the discreteness of matter. It was not unnatural, however, that there should be a reaction in some quarters against the domination of the atomic theory in physics and in chemistry. A school of thought arose that wished to do away with the atomic theory as the basis of explanation of chemistry, and substitute as its equivalent the law of combination in definite proportions. This movement was assisted by the possibility of explaining many chemical facts on the basis of thermodynamics without the aid of any hypothesis as to the particular structure of matter. Everyone recognises the great importance of such general methods of explanation, but the trouble is that few can think, or at any rate think correctly, in terms of thermodynamics. The negation of the atomic theory has not, and does not, help us to make new discoveries. The great advantage of the atomic theory is that it provides, so to speak, a tangible and concrete idea of matter which serves at once for the explanation of a multitude of facts and is of enormous aid as a working hypothesis. For the great majority of men of science it is not sufficient to group together a number of facts on general abstract principles. What is wanted is a concrete idea, however crude it may be, of the mechanism of the phenomena. This may be a weakness of the scientific mind, but it is one that deserves our sympathetic consideration. It represents an attitude of mind that appeals, I think, very strongly to the Anglo-Saxon temperament. It has no doubt as its basis the underlying idea that the facts of nature are ultimately explicable on general dynamical principles, and that there must consequently be some type of mechanism capable of accounting for the observed facts.

It has been generally considered that a decisive proof of the atomic structure of matter was in the nature of things impossible, and that the atomic theory must of necessity remain an hypothesis unverifiable by direct methods. Recent investigations have, however, disclosed such new and powerful methods of attack that we may well ask the question whether we do not now possess more decisive evidence of its truth.

Since molecules are invisible, it might appear, for example, an impossible hope that an experiment could be devised to show that the molecules of a fluid are in that state of continuous agitation which the kinetic theory leads us to suppose. In this connection I should like to direct your attention for a short time to a most striking phenomenon known as the "Brownian movement," which has been closely studied in recent years. Quite apart from its probable explanation the phenomenon is of unusual interest. In 1827 the English botanist Brown observed by means of a microscope that minute particles like spores of plants introduced into a fluid were always in a state of continuous irregular agitation, dancing to and fro in all directions at considerable speeds. For a long time this effect, known as the Brownian movement, was ascribed to inequalities in the temperature of the solution. This was disproved by a number of subsequent investigations, and especially by those of Gouy, who showed that the movement was spontaneous and continuous, and was exhibited by very small particles of whatever kind when immersed in a fluid medium. The velocity of agitation increased with decrease of diameter of the particles and increased with temperature, and was dependent on the viscosity of the surrounding fluid. With the advent of the ultra-microscope it has been possible to follow the movements with more certainty and to experiment with much smaller particles. Exner and Zsigmondy have determined the mean velocity of particles of known diameter in various solutions, while Svedberg has devised an ingenious method of determining the mean free path and the average velocity of particles of different diameter. The experiments of Ehrenhaft in 1907 showed that the Brownian movement was not confined to liquids, but was exhibited far more markedly by small particles suspended in gases. By passing an arc discharge between silver poles he produced a fine dust of silver in the air. When examined by means of the ultra-microscope the suspended particles exhibited the characteristic Brownian movement, with the difference that the mean free path for particles of the same size was much greater in gases than in liquids.

The particles exhibit in general the character of the motion which the kinetic theory ascribes to the molecules themselves, although even the smallest particles examined have a mass which is undoubtedly very large compared with that of the molecule. The character of the Brownian movement irresistibly impresses the observer with the idea that the particles are hurled hither and thither by the action of forces resident in the solution, and that these can only arise from the continuous and ceaseless movement of the invisible molecules of which the fluid is composed. Smoluchowski and Einstein have suggested explanations which are based on the kinetic theory, and there is a fair agreement between calculation and experiment. Strong additional confirmation of this view has been supplied by the very recent experiments of Perrin (1909). He obtained an emulsion of gamboge in water which consisted of a great number of spherical particles nearly of the same size, which showed the characteristic Brownian movement. The particles settled under gravity, and when equilibrium was set up the distribution of these particles in layers at different heights was determined by counting the particles with a microscope. The number was found to diminish from the bottom of the vessel upwards according to an exponential law—*i.e.* according to the same law as the pressure of the atmosphere diminishes from the surface of the earth. In this case, however, on account of the great mass of the particles, their distribution was confined to a region only a fraction of a millimetre deep. In a particular experiment the number of particles per unit volume decreased to half in a distance of 0·038 millimetre, while the corresponding distance in our atmosphere is about 6000 metres. From measurements of the diameter and weight of each particle, Perrin found that, within the limit of experimental error, the law of distribution with height indicated that each small particle had the same average kinetic energy of movement as the molecules of the solutions in which they were suspended; in fact, the particles in suspension behaved in all respects like molecules of very high molecular weight. This is a very important result, for it indicates that the law of equipartition of energy among molecules of different masses, which is an important deduction from the kinetic theory, holds, at any rate very approximately, for a distribution of particles in a medium the masses and dimensions of which are exceedingly large compared with that of the molecules of the medium. Whatever may prove to be the exact explanation of this phenomenon, there can be little doubt that it results from the movement of the molecules of the solution, and is thus a striking if somewhat indirect proof of the general correctness of the kinetic theory of matter.

From recent work in radio-activity we may take a second illustration which is novel and far more direct. It is well known that the α rays of radium are deflected by both magnetic and electric fields. It may be concluded from this evidence that the radiation is corpuscular in character, consisting of a stream of positively charged particles projected from the radium at a very high velocity. From the measurements of the deflection of the rays in passing through magnetic and electric fields the ratio e/m of the charge carried by the particle to its mass has been determined, and the magnitude of this quantity indicates that the particle is of atomic dimensions.

Rutherford and Geiger have recently developed a direct method of showing that this radiation is, as the other evidence indicated, discontinuous, and that it is possible to detect by a special electric method the passage of a single α particle into a suitable detecting vessel. The entrance of an α particle through a small opening was marked by a sudden movement of the needle of the electrometer which was used as a measuring instrument. In this way, by counting the number of separate impulses communicated to the electrometer needle, it was possible to determine by direct counting the number of α particles expelled per second from one gram of radium. But we can go further and confirm the result by counting the number of α particles by an entirely distinct method. Sir William Crookes has shown that when the α rays are allowed to fall upon a screen of phosphorescent zinc sulphide, a number of brilliant scintillations are observed. It appears as if the impact of each α particle produced a visible flash of light where it struck the screen. Using suitable screens, the number of scintillations per second on a given area can be counted by means of a microscope. It has been shown that the number of scintillations determined in this way is equal to the number of impinging α particles when counted by the electric method. This shows that the impact of each α particle on the zinc sulphide produces a visible scintillation. There are thus two distinct methods—one electrical, the other optical—for detecting the emission of a single α particle from radium. The next question to consider is the nature of the α particle itself. The general evidence indicates that the α particle is a charged atom of helium, and this conclusion was decisively verified by Rutherford and Royds by showing that helium appeared in an exhausted space into which the α particles were fired. The helium, which is produced by radium, is due to the accumulated α particles which are so continuously expelled from it. If the rate of production of helium from radium is measured, we thus have a means of determining directly how many α particles are required to form a given volume of helium gas. This rate of production has recently been measured accurately by Sir James Dewar. He has informed me that his final measurements show that one gram of radium in radioactive equilibrium produces 0·46 cubic millimetre of helium per day, or $5{\cdot}32\times10^{-6}$ cubic millimetres per second. Now from the direct counting experiments it is known that $13{\cdot}6\times10^{10}$ α particles are shot out per second from one gram of radium in equilibrium. Consequently it requires $2{\cdot}56\times10^{19}$ α particles to form one cubic centimetre of helium gas at standard pressure and temperature.

From other lines of evidence it is known that all the α particles, from whatever source, are identical in mass and constitution. It is not, then, unreasonable to suppose that the α particle, which exists as a separate entity in its flight, can exist also as a separate entity when the α particles are collected together to form a measurable volume of helium gas, or, in other words, that the α particle on losing its charge becomes the fundamental unit or atom of helium. In the case of a monatomic gas like helium, where the atom and molecule are believed to be identical, no difficulty of deduction arises from the possible combination of two or more atoms to form a complex molecule.

We consequently conclude from these experiments that one cubic centimetre of helium at standard pressure and temperature contains $2{\cdot}56\times10^{19}$ atoms. Knowing the density of helium, it at once follows that each atom of helium has a mass of $6{\cdot}8\times10^{-24}$ grams, and that the average distance apart of the molecules in the gaseous state at standard pressure and temperature is $3{\cdot}4\times10^{-7}$ centimetres.

The above result can be confirmed in a different way. It is known that the value of e/m for the α particle is

5070 electromagnetic units. The positive charge carried by each α particle has been deduced by measuring the total charge carried by a counted number of α particles. Its value is 9.3×10^{-10} electrostatic units, or 3.1×10^{-20} electromagnetic units. Substituting this number in the value of e/m, it is seen that m, the mass of the α particle, is equal to 6.1×10^{-24} grams—a value in fair agreement with the number previously given.

I trust that my judgment is not prejudiced by the fact that I have taken some share in these investigations; but the experiments, taken as a whole, appear to me to give an almost direct and convincing proof of the atomic hypothesis of matter. By direct counting, the number of identical entities required to form a known volume of gas has been measured. May we not conclude that the gas is discrete in structure, and that this number represents the actual number of atoms in the gas?

We have seen that under special conditions it is possible to detect easily by an electrical method the emission of a single α particle—*i.e.* of a single charged atom of matter. This has been rendered possible by the great velocity and energy of the expelled α particle, which confers on it the power of dissociating or ionising the gas through which it passes. It is obviously only possible to detect the presence of a single atom of matter when it is endowed with some special property or properties which distinguishes it from the molecules of the gas with which it is surrounded. There is a very important and striking method, for example, of visibly differentiating between the ordinary molecules of a gas and the ions produced in the gas by various agencies. C. T. R. Wilson showed in 1897 that under certain conditions each charged ion became a centre of condensation of water vapour, so that the presence of each ion was rendered visible to the eye. Sir Joseph Thomson, H. A. Wilson, and others have employed this method to count the number of ions present and to determine the magnitude of the electric charge carried by each.

A few examples will now be given which illustrate the older methods of estimating the mass and dimensions of molecules. As soon as the idea of the discrete structure of matter had taken firm hold, it was natural that attempts should be made to estimate the degree of coarse-grainedness of matter, and to form an idea of the dimension of molecules, assuming that they have extension in space. Lord Rayleigh has directed attention to the fact that the earliest estimate of this kind was made by Thomas Young in 1805, from considerations of the theory of capillarity. Space does not allow me to consider the great variety of methods that have later been employed to form an idea of the thickness of a film of matter in which a molecular structure is discernible. This phase of the subject was always a favourite one with Lord Kelvin, who developed a number of important methods of estimating the probable dimensions of molecular structure.

The development of the kinetic theory of gases on a mathematical basis at once suggested methods of estimating the number of molecules in a cubic centimetre of any gas at normal pressure and temperature. This number, which will throughout be denoted by the symbol N, is a fundamental constant of gases; for, according to the hypothesis of Avogadro, and also on the kinetic theory, all gases at normal pressure and temperature have an identical number of molecules in unit volume. Knowing the value of N, approximate estimates can be made of the diameter of the molecule; but in our ignorance of the constitution of the molecule, the meaning of the term diameter is somewhat indefinite. It is usually considered to refer to the diameter of the sphere of action of the forces surrounding the molecule. This diameter is not necessarily the same for the molecules of all gases, so that it is preferable to consider the magnitude of the fundamental constant N. The earliest estimates based on the kinetic theory were made by Loschmidt, Johnstone Stoney, and Maxwell. From the data then at his disposal, the latter found N to be 1.9×10^{19}. Meyer, in his "Kinetic Theory of Gases," discusses the various methods of estimating the dimensions of molecules on the theory, and concludes that the most probable estimate of N is 6.1×10^{18}. Estimates of N based on the kinetic theory are only approximate, and in many cases serve merely to fix an inferior or superior limit to the number of the molecules. Such estimates are, however, of considerable interest and historical importance, since for a long time they served as the most trustworthy methods of forming an idea of molecular magnitudes.

A very interesting and impressive method of determining the value of N was given by Lord Rayleigh in 1899 as a deduction from his theory of the blue colour in the cloudless sky. This theory supposes that the molecules of the air scatter the waves of light incident upon them. This scattering for particles, small compared with the wave-length of light, is proportional to the fourth power of the wave-length, so that the proportion of scattered to incident light is much greater for the violet than for the red end of the spectrum, and consequently the sky which is viewed by the scattered light is of a deep blue colour. This scattering of the light in passing through the atmosphere causes alterations of brightness of stars when viewed at different altitudes, and determinations of this loss of brightness have been made experimentally. Knowing this value, the number N of molecules in unit volume can be deduced by aid of the theory. From the data thus available, Lord Rayleigh concluded that the value of N was not less than 7×10^{18}. Lord Kelvin in 1902 re-calculated the value of N on the theory by using more recent and more accurate data, and found it to be 2.47×10^{19}. Since in the simple theory no account is taken of the additional scattering due to fine suspended particles which are undoubtedly present in the atmosphere, this method only serves to fix an inferior limit to the value of N. It is difficult to estimate with accuracy the correction to be applied for this effect, but it will be seen that the uncorrected number deduced by Lord Kelvin is not much smaller than the most probable value 2.77×10^{19} given later. Assuming the correctness of the theory and data employed, this would indicate that the scattering due to suspended particles in the atmosphere is only a small portion of the total scattering due to molecules of air. This is an interesting example of how an accurate knowledge of the value of N may possibly assist in forming an estimate of unknown magnitudes.

It is now necessary to consider some of the more recent and direct methods of estimating N which are based on recent additions to our scientific knowledge. The newer methods allow us to fix the value of N with much more certainty and precision than was possible a few years ago.

We have referred earlier in the paper to the investigations of Perrin on the law of distribution in a fluid of a great number of minute granules, and his proof that the granules behave like molecules of high molecular weight. The value of N can be deduced at once from the experimental results, and is found to be 3.14×10^{19}. The method developed by Perrin is a very novel and ingenious one, and is of great importance in throwing light on the law of equipartition of energy. This new method of attack of fundamental problems will no doubt be much further developed in the future.

It has already been shown that the value $N = 2.56 \times 10^{19}$ has been obtained by the direct method of counting the particles and determining the corresponding volume of helium produced. Another very simple method of determining N from radio-active data is based on the rate of transformation of radium. Boltwood has shown by direct experiment that radium is half transformed in 2000 years. From this it follows that initially in a gram of radium 0.346 milligram breaks up per year. Now it is known from the counting method that 3.4×10^{10} α particles are expelled per second from one gram of radium, and the evidence indicates that one α particle accompanies the disintegration of each atom. Consequently the number of α particles expelled per year is a measure of the number of atoms of radium present in 0.346 milligram. From this it follows that there are 3.1×10^{21} atoms in one gram of radium, and taking the atomic weight of radium as 226, it is simply deduced that the value of N is 3.1×10^{19}.

The study of the properties of ionised gases in recent years has led to the development of a number of important methods of determining the charge carried by the ion, produced in gases by α rays or the rays from radio-active substances. On modern views, electricity, like matter, is supposed to be discrete in structure, and the charge carried by the hydrogen atom set free by the electrolysis of water is taken as the fundamental unit of quantity of electricity. On this view, which is supported by strong evidence, the charge carried by the hydrogen atom is the smallest unit of electricity that can be obtained, and every quantity of electricity consists of an integral multiple of this unit. The experiments of Townsend have shown that the charge carried by a gaseous ion is, in the majority of cases, the same and equal in magnitude to the charge carried by a hydrogen atom in the electrolysis of water. From measurement of the quantity of electricity required to set free one gram of hydrogen in electrolysis, it can be deduced that $Ne=1\cdot29\times10^{10}$ electrostatic units, where N, as before, is the number of molecules of hydrogen in one cubic centimetre of gas, and e the charge carried by each ion. If e be determined experimentally, the value of N can at once be deduced from this relation.

The first direct measurement of the charge carried by the ion was made by Townsend in 1897. When a solution of sulphuric acid is electrolysed, the liberated oxygen is found in a moist atmosphere to give rise to a dense cloud composed of minute globules of water. Each of these minute drops carries a negative charge of electricity. The size of the globules, and consequently the weight, was deduced with the aid of Stokes's formula by observing the rate of fall of the cloud under gravity. The weight of the cloud was measured, and, knowing the weight of each globule, the total number of drops present was determined. Since the total charge carried by the cloud was measured, the charge e carried by each drop was deduced. The value of e, the charge carried by each drop, was found by this method to be about $3\cdot0\times10^{-10}$ electrostatic units. The corresponding value of N is about $4\cdot3\times10^{19}$.

We have already referred to the method discovered by C. T. R. Wilson of rendering each ion visible by the condensation of water upon it by a sudden expansion of the gas. The property was utilised by Sir Joseph Thomson to measure the charge e carried by each ion. When the expansion of the gas exceeds a certain value, the water condenses on both the negative and positive ions, and a dense cloud of small water-drops is seen. J. J. Thomson found $e=3\cdot4\times10^{-10}$, H. A. Wilson $e=3\cdot1\times10^{-10}$, and Millikan and Begeman $4\cdot06\times10^{-10}$. The corresponding values of N are 3·8, 4·2, and $3\cdot2\times10^{19}$ respectively. This method is of great interest and importance, as it provides a method of directly counting the number of ions produced in the gas. An exact determination of e by this method is, however, unfortunately beset with great experimental difficulties.

Moreau has recently measured the charge carried by the negative ions produced in flames. The values deduced for e and N were respectively $4\cdot3\times10^{-10}$ and $3\cdot0\times10^{19}$.

We have referred earlier in the paper to the work of Ehrenhaft on the Brownian movement in air shown by ultra-microscopic dust of silver. In a recent paper (1909) he has shown that each of these particles carries a positive or negative charge. The size of each particle was measured by the ultra-microscope, and also by the rate of fall under gravity. The charge carried by each particle was deduced from the measured mass of the particle, and its rate of movement in an electric field. The mean value of e was found to be $4\cdot6\times10^{-10}$, and thus N becomes $2\cdot74\times10^{19}$.

A third important method of determination of N from radio-active data was given by Rutherford and Geiger in 1908. The charge carried by each α particle expelled from radium was measured by directly determining the total charge carried by a counted number of α particles. The value of the charge on each α particle was found to be $9\cdot3\times10^{-10}$. From consideration of the general evidence, it was concluded that each α particle carries two unit positive charges, so that the value of e becomes $4\cdot65\times10^{-10}$, and of N $2\cdot77\times10^{19}$. This method is deserving of considerable confidence, as the measurements involved are direct and capable of accuracy.

The methods of determination of e, so far explained, have depended on direct experiment. This discussion would not be complete without a reference to an important determination of e from theoretical considerations by Planck. From the theory of the distribution of energy in the spectrum of a hot body, Planck found that $e=4\cdot69\times10^{-10}$, and $N=2\cdot80\times10^{19}$. For reasons that we cannot enter into here, this theoretical deduction must be given great weight.

When we consider the great diversity of the theories and methods which have been utilised to determine the values of the atomic constants e and N, and the probable experimental errors, the agreement among the numbers is remarkably close. This is especially the case in considering the more recent measurements by very different methods, which are far more trustworthy than the older estimates. It is difficult to fix on one determination as more deserving of confidence than another; but I may be pardoned if I place some reliance on the radio-active method previously discussed, which depends on the charge carried by the α particle. The value obtained in this way is not only in close agreement with the theoretical estimate of Planck, but is in fair agreement with the recent determinations by several other distinct methods. We may consequently conclude that the number of molecules in a cubic centimetre of any gas at standard pressure and temperature is about $2\cdot77\times10^{19}$, and that the value of the fundamental unit of quantity of electricity is about $4\cdot65\times10^{-10}$ electrostatic units. From these data it is a simple matter to deduce the mass of any atom the atomic weight of which is known, and to determine the values of a number of related atomic and molecular magnitudes.

There is now no reason to view the values of these fundamental constants with scepticism, but they may be employed with confidence in calculations to advance still further our knowledge of the constitution of atoms and molecules. There will no doubt be a great number of investigations in the future to fix the values of these important constants with the greatest possible precision; but there is every reason to believe that the values are already known with reasonable certainty, and with a degree of accuracy far greater than it was possible to attain a few years ago. The remarkable agreement in the values of e and N, based on so many different theories, of itself affords exceedingly strong evidence of the correctness of the atomic theory of matter and of electricity, for it is difficult to believe that such concordance would show itself if the atoms and their charges had no real existence.

There has been a tendency in some quarters to suppose that the development of physics in recent years has cast doubt on the validity of the atomic theory of matter. This view is quite erroneous, for it will be clear from the evidence already discussed that the recent discoveries have not only greatly strengthened the evidence in support of the theory, but have given an almost direct and convincing proof of its correctness. The chemical atom as a definite unit in the subdivision of matter is now fixed in an impregnable position in science. Leaving out of account considerations of etymology, the atom in chemistry has long been considered to refer only to the smallest unit of matter that enters into ordinary chemical combination. There is no assumption made that the atom itself is indestructible and eternal, or that methods may not ultimately be found for its subdivision into still more elementary units. The advent of the electron has shown that the atom is not the unit of smallest mass of which we have cognisance, while the study of radio-active bodies has shown that the atoms of a few elements of high atomic weight are not permanently stable, but break up spontaneously with the appearance of new types of matter. These advances in knowledge do not in any way invalidate the position of the chemical atom, but rather indicate its great importance as a subdivision of matter the properties of which should be exhaustively studied.

The proof of the existence of corpuscles or electrons with an apparent mass very small compared with that of the hydrogen atom marks an important stage in the extension of our ideas of atomic constitution. This discovery, which has exercised a profound influence on the development of modern physics, we owe mainly to the genius of the President of this Association. The existence of the electron as a distinct entity is established by similar methods and with almost the same certainty as the existence of individual α particles. While it has not yet been found possible to detect a single electron by its electrical or optical effect, and thus to count the number directly as in the case of the α particles, there seems to be no reason why this should not be accomplished by the electric method. The effect to be anticipated for a single β particle is much smaller than that due to an α particle, but not too small for measurement. In this connection it is of interest to note that Regener has observed evidence of scintillations produced by the β particles of radium falling on a screen of platinocyanide of barium, but the scintillations are too feeble to count with certainty.

Experiment has shown that the apparent mass of the electron varies with its speed, and, by comparison of theory with experiment, it has been concluded that the mass of the electron is entirely electrical in origin, and that there is no necessity to assume a material nucleus on which the electrical charge is distributed. While there can be no doubt that electrons can be released from the atom or molecule by a variety of agencies, and, when in rapid motion, can retain an independent existence, there is still much room for discussion as to the actual constitution of electrons, if such a term may be employed, and of the part they play in atomic structure. There can be little doubt that the atom is a complex system, consisting of a number of positively and negatively charged masses which are held in equilibrium mainly by electrical forces; but it is difficult to assign the relative importance of the *rôle* played by the carriers of positive and negative electricity. While negative electricity can exist as a separate entity in the electron, there is yet no decisive proof of the existence of a corresponding positive electron. It is not known how much of the mass of an atom is due to electrons or other moving charges, or whether a type of mass quite distinct from electrical mass exists. Advance in this direction must be delayed until a clearer knowledge is gained of the character and structure of positive electricity and of its relation to the negative electron.

The general experimental evidence indicates that electrons play two distinct *rôles* in the structure of the atom, one as lightly attached and easily removable satellites or outliers of the atomic system, and the other as integral constituents of the interior structure of the atom. The former, which can be easily detached or set in vibration, probably play an important part in the combination of atoms to form molecules, and in the spectra of the elements; the latter, which are held in place by much stronger forces, can only be released as a result of an atomic explosion involving the disintegration of the atom. For example, the release of an electron with slow velocity by ordinary laboratory agencies does not appear to endanger the stability of the atom, but the expulsion of a high-speed electron from a radio-active substance accompanies the transformation of the atom.

The idea that the atoms of the elements may be complex structures, made up either of lighter atoms or of the atoms of some fundamental substance, has long been familiar to science. So far no direct evidence has been obtained of the possibility of building up an atom of higher atomic weight from one of lower atomic weight, but in the case of the radio-active substances we have decisive and definite evidence that certain elements show the converse process of disintegration. It may be significant that this process has only been observed in the atoms of highest atomic weights, like those of uranium, thorium, and radium. With the exception possibly of potassium, there is no trustworthy evidence that a similar process takes place in other elements. The transformation of the atom of a radio-active substance appears to result from an atomic explosion of great intensity in which a part of the atom is expelled with great speed. In the majority of cases an α particle or atom of helium is ejected, in some cases a high-speed electron, while a few substances are transformed without the appearance of a detectable radiation. The fact that the α particles from a simple substance are all ejected with an identical and very high velocity suggests the probability that the charged helium atom before its expulsion is in rapid orbital movement in the atom. There is at present no definite evidence of the causes operative in these atomic transformations.

Since in a large number of cases the transformations of the atoms are accompanied by the expulsion of one or more charged atoms of helium, it is difficult to avoid the conclusion that the atoms of the radio-active elements are built up, in part at least, of helium atoms. It is certainly very remarkable, and may prove of great significance, that helium, which is regarded from the ordinary chemical standpoint as an inert element, plays such an important part in the constitution of the atoms of uranium, thorium, and radium.

The study of radio-activity has not only thrown great light on the character of atomic transformations, but it has also led to the development of methods for detecting the presence of almost infinitesimal quantities of radio-active matter. It has already been pointed out that two methods—one electrical, the other optical—have been devised for the detection of a single α particle. By the use of the optical or scintillation method, it is possible to count with accuracy the number of α particles when only one is expelled per minute. It is not a difficult matter, consequently, to follow the transformation of any radio-active substance in which only one atom breaks up per minute, provided that an α particle accompanies the transformation. In the case of a rapidly changing substance like the actinium emanation, which has a half period of 3·7 seconds, it is possible to detect with certainty the presence, if not of a single atom, at any rate of a few atoms, while the presence of a hundred atoms would in some cases give an inconveniently large effect. The counting of the scintillations affords an exceedingly powerful and direct quantitative method of studying the properties of radio-active substances which expel α particles. Not only is it a simple matter to count the number of α particles which are expelled in any given interval, but it is possible, for example, by suitably arranged experiments to decide whether one, two, or more α particles are expelled at the disintegration of a single atom.

The possibility of detection of a single atom of matter has opened up a new field of investigation in the study of discontinuous phenomena. For example, the experimental law of transformation of radio-active matter expresses only the average rate of transformation, but by the aid of the scintillation or electric method it is possible to determine directly by experiment the actual interval between the disintegration of successive atoms and the probability law of distribution of the α particles about the average value.

Quite apart from the importance of studying radio-active changes, the radiations from active bodies provide very valuable information as to the effects produced by high-velocity particles in traversing matter. The three types of radiation, the α, β, and γ rays, emitted from active bodies, differ widely in character and their power of penetration of matter. The α particles, for example, are completely stopped by a sheet of notepaper, while the γ rays from radium can be easily detected after traversing twenty centimetres of lead. The differences in the character of the absorption of the radiations are no doubt partly due to the difference in type of the radiation and partly due to the differences of velocity.

The character of the effects produced by the α and β particles is most simply studied in gases. The α particle has such great energy of motion that it plunges through the molecules of the gas in its path, and leaves in its train more than a hundred thousand ionised or dissociated molecules. After traversing a certain distance, the α particle suddenly loses its characteristic properties and vanishes from the ken of our observational methods. It no doubt quickly loses its high velocity, and after its charge has been neutralised becomes a wandering atom of helium. The ionisation produced by the α particle appears to consist of the liberation of one or more slow-velocity electrons from the molecule, but in the case of complex gases there is no doubt that the act of ionisation is accompanied by a chemical dissociation of the molecule itself, although it is difficult to decide whether this dissociation is a primary or secondary effect. The chemical dissociation produced by α particles opens up a wide field of investigation, on which, so far, only a beginning has been made.

The β particle differs from the α particle in its much greater power of penetration of matter, and the very small number of molecules it ionises compared with the α particle traversing the same path in the gas. It is very easily deflected from its path by encounters with the gas molecules, and there is strong evidence that, unlike the α particle, the β particle can be stopped or entrapped by a molecule when travelling at a very high speed.

When the great energy of motion of the α particle and the small amount of energy absorbed in ionising a single molecule are taken into consideration, there appears to be no doubt that the α particle, as Bragg pointed out, actually passes through the atom, or rather the sphere of action of the atom which lies in its path. There is, so to speak, no time for the atom to get out of the way of the swiftly moving α particle, but the latter must pass through the atomic system. On this view, the old dictum, no doubt true in most cases, that two bodies cannot occupy the same space, no longer holds for atoms of matter if moving at a sufficiently high speed.

There would appear to be little doubt that a careful study of the effects produced by the α or β particle in passing through matter will ultimately throw much further light on the constitution of the atom itself. Work already done shows that the character of the absorption of the radiations is intimately connected with the atomic weights of the elements and their position in the periodic table. One of the most striking effects of the passage of β rays through matter is the scattering of the β particles, *i.e.* the deflection from their rectilinear path by their encounters with the molecules. It was for some time thought that such a scattering could not be expected to occur in the case of the α particles in consequence of their much greater mass and energy of motion. The recent experiments of Geiger, however, show that the scattering of the α particles is very marked, and is so great that a small fraction of the α particles, which impinge on a screen of metal, have their velocity reversed in direction and emerge again on the same side. This scattering can be most conveniently studied by the method of scintillations. It can be shown that the deflection of the α particle from its path is quite perceptible after passing through very few atoms of matter. The conclusion is unavoidable that the atom is the seat of an intense electric field, for otherwise it would be impossible to change the direction of the particle in passing over such a minute distance as the diameter of a molecule.

In conclusion, I should like to emphasise the simplicity and directness of the methods of attack on atomic problems opened up by recent discoveries. As we have seen, not only is it a simple matter, for example, to count the number of α particles by the scintillations produced on a zinc sulphide screen, but it is possible to examine directly the deflection of an individual particle in passing through a magnetic or electric field, and to determine the deviation of each particle from a rectilinear path due to encounters with molecules of matter. We can determine directly the mass of each α particle, its charge, and its velocity, and can deduce at once the number of atoms present in a given weight of any known kind of matter. In the light of these and similar direct deductions, based on a minimum amount of assumption, the physicists have, I think, some justification for their faith that they are building on the solid rock of fact, and not, as we are often so solemnly warned by some of our scientific brethren, on the shifting sands of imaginative hypothesis.

NOTES.

A MEETING of the permanent commission of the International Association of Seismology will be held at Zermatt on August 30, under the chairmanship of Prof. Arthur Schuster, F.R.S. At this meeting reports will be presented from a number of committees, appointed at the last general meeting, which took place at The Hague in 1907, and questions of organisation will be discussed. Papers will be read by Mr. H. F. Reid, on some lessons of the Californian earthquake and a method of foretelling certain earthquakes; by Mr. Albert Heim, on the objects of earthquake investigations; and by Prof. Palazzo, on a projected seismic triangulation by means of wireless telegraphy. The Central Government of the Confederation has charged the Swiss Naturforschende Gesellschaft with the organisation of the meeting, and arrangements have been made for the accommodation of the delegates taking part in the conference, who will also be able to travel on the railway between Visp and the Gorner Grat at half fares.

ON Tuesday next, August 31, at the ordinary fortnightly meeting of the Royal Horticultural Society, Vincent Square, S.W., there will be exhibited on behalf of Prof. Sargent and the president and fellows of Harvard University, Cambridge, Mass., U.S.A., a selection of photographs illustrating the flora, fauna, and scenery of central and western China. These photographs are from the large collection taken by Mr. E. H. Wilson during his last (third) journey to China. The exhibit will be of importance to all who are interested in the recent new plant introductions from China; it is also hoped that from its varied character the selection made will appeal to a wider circle. The photographs are whole-plate size ($8\frac{1}{2}\times6\frac{1}{2}$ inches), with liberal mounts for herbarium purposes, and all are labelled. The work of developing and printing has been done by the well-known worker in floral photography, Mr. E. J. Wallis, of Kew.

THE preliminary mineralogical and geological survey of Northern Nigeria, carried out under the auspices of the Colonial Office and the Imperial Institute, has just been completed by Dr. J. D. Falconer after five seasons' work. Valuable deposits of tinstone have been located within the Protectorate, as well as less important occurrences of gold, argentiferous galena, monazite, and numerous ores of iron. The economic results of the survey are being issued as colonial reports by Prof. Dunstan, while the scientific results will be published by Dr. Falconer in the course of the coming winter. Important observations have been made as to the age and origin of Lake Chad and the Bauchi plateau, while sufficient data have been secured for the compilation of a geological map of the Protectorate which will largely fill up the existing blank in our knowledge of the structure of this portion of the Central Sudan.

MR. ASQUITH announced in the House of Commons on August 19 that the Government has decided to recommend Parliament to make a grant of 20,000*l.* in aid of the expenses of Mr. Shackleton's expedition in Antarctic regions. Mr. Shackleton has informed a Press representative that this sum will meet all his guarantees. The total cost of the expedition is said to have been nearly 45,000*l.* Of this amount, 6000*l.* was subscribed in Australia and New Zealand, and the rest was provided by Mr. Shackleton's friends. In a letter communicating the decision of the Government to Mr. Shackleton, the Prime Minister said :—" The Government have been induced to take this course as they are much impressed both by the great value of the discoveries made in the course of your voyage and by the efficient and economical manner in which the whole of the enterprise was conducted, as is shown by the fortunate return of your entire party, and by the comparatively small total outlay incurred."

WE learn from *Science* of the death, in his eighty-third year, of Dr. R. E. C. Stearns, known for his work on the geographical distribution and variation of mollusca and for other work in natural science.

THE death is announced, in his sixty-seventh year, of Dr. Otto von Bollinger, rector of the University of Munich and professor of general pathology and pathological anatomy in the University. Prof. von Bollinger was the author of a number of medical works, among them being books on meat poisoning and on the heredity of diseases, and the "Atlas und Grundriss der pathologischen Anatomie," which appeared in 1896.

THE daily papers announce that the Select Committee on the Daylight Saving Bill has adopted a report approving the principle of the proposals made, but adverse to legislation which would make the seasonal change of time obligatory. The committee has arrived at the conclusion that the principle, if applied compulsorily, would tend to cause serious dislocations in certain industries, such as agriculture and railways, where an alteration in the hours of labour would cause great confusion. The hope is expressed, however, that the principle of daylight saving will be adopted voluntarily in cases where it is found to be practicable and desirable.

THE Berlin correspondent of the *Times* reports that the fifth International Dental Congress opened its proceedings there on Monday, August 23, under the presidency of Prof. O. Walkhoff, of Munich. In his opening address Prof. Walkhoff referred to the increasing recognition of the public importance of dental surgery, which no longer holds a subordinate place in the field of science. Prof. Waldeyer, director of the anatomical institute of the University of Berlin, referred to the important problems which dental surgery embraces in anatomy, physiology, pathology, and palæontology.

AN "American colony" of a very interesting character has recently been installed near Guildford, in Surrey, where an attempt is being made to acclimatise the American robin (*Merula migratoria*) in England. Seventeen birds—nine cocks and eight hens—were imported last spring, and after being kept for a short time in a large open-air aviary, all, with the exception of two or three pairs, were liberated about the middle of June. They mated immediately, and began nest-building almost at once. The nests—coarse, bulky constructions—were placed in trees, with little attempt at concealment, and clutches of from four to five blue eggs, about the size of those of the thrush, were laid. Old and young, the birds now number between forty and fifty. Fears are entertained that at the approach of winter these robins, impelled by their strong migratory instinct, will leave England and become hopelessly dispersed; but those who know the nature of the birds are confident that by feeding them abundantly as cold weather draws on they can be induced to remain as permanent residents. They are cheery birds, their "Kill 'em, cure 'em, give 'em physic" being the climax of optimism.

IT is matter of just reproach against our statesmen and administrators that, in devising and carrying out measures intended for the amelioration of social conditions, they are very commonly blind to the teachings of science. This point is well brought out in a striking article by Mr. E. B. Iwan-Müller in the August number of the *Fortnightly Review*. In the course of his article, which is entitled "The Cult of the Unfit," the writer argues with great effect that, judged by the standard of biological principles, much recent legislation must be condemned as ill-adapted for its purpose and likely to be harmful in its results. Socialism, he maintains, and any legislation tending in that direction, runs directly counter to all the lessons that can be derived from the contemplation of evolution by struggle and survival. "The new Trades Unionism aims at the establishment and endowment of mediocrity by the elimination of competition." The facts of parasitism and other causes of degeneration are dwelt upon, and stress is laid on the warning they convey against the policy of making the conditions of life too easy—a warning still needed, though not now delivered for the first time. Apposite quotations are given from Sir E. Ray Lankester's Romanes lecture at Oxford. While opinions may differ as to Mr. Iwan-Müller's applications, there can be no doubt that his plea for a recognition of scientific principle on the part of our public men is both reasonable and necessary.

THE Pasteur Institute of Paris will receive in a few days the sum of 1,200,000*l*. which was bequeathed to it by the late M. Osiris. The Paris correspondent of the *Daily News* describes the following interesting circumstances relating to this generous gift. M. Osiris founded in 1903 a triennial prize of 4000*l*. to be bestowed on "the person who had rendered the greatest service to the human race during the three preceding years." The prize was awarded to Dr. Roux, the head of the Pasteur Institute, for the discovery of the anti-diphtheria serum, which has been the means of saving the lives of many thousand children, and the whole of the money was made over by him to the institute. M. Osiris was struck by the unselfish conduct of the man of science, and asked him one day why he had given the money to the institute. "All that I am," replied Dr. Roux, "I owe to the Pasteur Institute, for all my experiments and discoveries have been made there. Besides, the institute is very poor, for we have no income except what we make by the sale of serum, and though that brings in enough to keep the establishment going, some fresh remedy may any day be discovered, in which case I fear the institute would have to close its doors for want of funds." M. Osiris said nothing at the time, adds the *Daily News* correspondent; but at his death, which occurred a year or two afterwards, it was found that he had left the bulk of his wealth to the Pasteur Institute as a token of admiration for the scientific attainments and self-abnegation of Dr. Roux.

No. 4 of vol. i. of the ornithological publications of the Field Museum of Natural History is devoted to a catalogue of birds from British East Africa, by Mr. N. Dearborn.

IN vol. vi., No. 4, of the University of Colorado Studies Prof. T. D. H. Cockerell describes and figures a skull of a ground-sloth from Colorado provisionally referred to the genus Mylodon. It differs from Paramylodon, of the Nebraskan Pliocene, by having the normal five in place of four pairs of upper cheek-teeth.

WE have to acknowledge the receipt of vols. xxx. (1907) and xxxi. (1908) of *Mémoires de la Société des Naturalistes de la Nouvelle-Russie*, Odessa. In the former, Dr. A. Brauner points out that while naturalists regard the green-headed starling of Western Europe as the true *Sturnus vulgaris* of Linnæus, and class the purple-headed bird as distinct, under the name of *S. intermedius*, the latter, as occurring in Sweden, should properly be called *S. vulgaris*. Hence the English starling requires another designation.

THE articles in the July number of the *National Geographic Magazine* are mostly devoted to Alaska and its products, General Greely opening the subject with an account of the economic evolution of Alaska, while Mr. T. Riggs follows with the story of marking the Alaskan boundary, and Messrs. R. H. Sargent and W. H. Osgood respectively discuss the mountains and the big game of the country. In the last of the articles referred to special attention is directed to the uncertainty still existing with regard to the number of forms of Alaskan brown bears.

WE have received the monthly journals of the Meteorological Society of Japan for the first half of this year. These contain notices of recent conspicuous meteorological occurrences, and articles on climatological and other interesting subjects, among which is a discussion of the winds on the east coast of Asia, by Mr. M. Ishida, which runs through several numbers. The practice of summarising the more important articles in a European language has been discontinued; this considerably lessens the usefulness of the journals, so far as western readers are concerned.

IN the July number of the *Museums Journal,* Dr. E. Howarth records his resignation of the editorship, a position he has filled for the last eight years. When that periodical was started in 1901, early failure was predicted; but the prediction has proved altogether untrue, and the *Museums Journal* is now established on a firm, and, it is hoped, lasting base. The issue also contains Mr. Henry Balfour's presidential address, delivered at the Maidstone meeting on July 13th, in which the need for a national museum of British ethnology is strongly advocated. "What is required is a National Folk-Museum, dealing exclusively and exhaustively with the history of culture of the British nation within the historic period, and illustrating the growth of ideas and indigenous characteristics. Until such an institution is founded, there will remain a very serious *lacuna* in the list of our museums, and we shall remain open to the fire of just criticism from other countries, on the score of our almost pathetic anxiety to investigate and illustrate the ethnology of other races and peoples, while we neglect our own."

ZOOLOGICAL students are much indebted to Prof. Spengel for the publication of that very useful and interesting journal, the *Ergebnisse und Fortschritte der Zoologie,* the second part of the second volume of which has just reached us. This part contains two important memoirs of general interest. The first is a very complete and valuable *résumé* of our present knowledge of sponge spicules, by Prof. E. A. Minchin. The spicules of sponges are amongst the most beautiful and at the same time the most incomprehensible objects with which the microscopist has to deal, and a considerable amount of light has lately been thrown upon their nature and origin. Prof. Minchin himself is one of the foremost investigators in this department, which modern methods of research have raised to the level of a branch of cytology. The subject, indeed, is one which of recent years has attracted much attention, and given rise to no little controversy amongst spongologists, and specialists and non-specialists alike will be interested in Prof. Minchin's essay. The second paper in the same journal deals with the excretory organs of invertebrates, our knowledge of which has also progressed by leaps and bounds during the last few years. The author, Prof. Meisenheimer, confines himself for the present to protonephridia and typical segmental organs, drawing largely for his information upon the classical and pioneer work of Mr. Goodrich, especially with regard to solenocytes.

THE July number of the Transactions of the Royal Scottish Arboricultural Society contains a large quantity of information useful to forest owners as well as to foresters. Articles from many able pens deal with afforestation, and we need only mention the names of Lord Lovat, Mr. Munro Ferguson, Dr. Nisbet, Profs. Somerville and Schlich. The report of the Royal Commission on Afforestation from a landowner's point of view, by Sir John Stirling Maxwell, contains many useful hints. A report is given of a lecture on trees of California, by Mr. F. R. S. Balfour, delivered to the society, as well as a report of an excursion to Forglen and Hatton, made by the Aberdeen Branch of the society. The volume also contains interesting notes and queries, reviews and notices of books, and altogether it is full of information likely to be of interest to foresters. The price of the volume is 3*s*.

THE first portion of an account dealing with mitosis in higher plants, communicated by Dr. H. A. Haig, is published in the August number of *Knowledge and Scientific News.* A full description is given of methods and materials examined, so that readers, if disposed, may make their own preparations. The first chapters deal with technique and the early stages of division in the cells found near the root-apices of Hyacinthus and Allium.

THE botanists in the Philippine Islands are vigorously prosecuting their identifications of indigenous plants, in pursuance of which Dr. C. B. Robinson publishes in the first part a revision of Philippine Phyllanthineæ and Mr. E. D. Merrill contributes revisions of the families Connaraceæ and Loranthaceæ to the second part of the botanical section of the *Philippine Journal of Science* (vol. iv.). Dr. Robinson accepts the separation from Phyllanthus of Glochidion, which becomes a large genus by reason of several species established by Mr. Elmer and the author. Six genera are recognised by Mr. Merrill for the Loranthaceæ, including the segregation of Phrygilanthus and a new genus, Cleistoloranthus. The number of endemic species is inordinately great, as out of forty-three species of Loranthus—the only large genus—no fewer than thirty-six are endemic.

DR. M. RACIBORSKI contributes to the *Bulletin international de l'Académie des Sciences de Cracovie* (March) a long series of descriptions of parasitic and epiphytic fungi collected and examined in Java. A peculiar formation of the basidium was observed in Cintractia, as it is abstricted directly from the resting spore, and is at once shed; three or more septa are formed in the basidium, and each cell gives rise to a basidiospore. The group of Septobasidieæ furnishes some of the commonest epiphytes. The Javanese species are separated by the author into three genera; Ordonia is characterised by a fibrous mycelium and absence of a special hymenial layer; Mohortia has a sterile layer below the hymenium, while Septobasidium develops three distinct layers. Several of the new species fall into the families Microthyriaceæ and Sphæriaceæ.

THERE are several noteworthy points in the revision of the American group of Thibaudieæ, a section of the family Ericaceæ communicated by Mr. R. Hörold to Engler's *Botanische Jahrbücher* (vol. xlii., part iv.). It provides an independent account of a section which was required to correlate the diverse views of Hooker and Klotzch. In this respect the author follows the latter in splitting the large genus Thibaudia. The classification of the genera based on staminal characters furnishes an interesting study in the variation of this organ, which is a special characteristic of the family; modifications of apical dehiscence are indicated in a text-figure. A list of new plants includes one genus and many additions to the genera Cavendishia, Psammisia, and Thibaudia. In addition, the author sketches the main features in the geographical distribution of the genera.

WE are in receipt of several important bulletins from the Wisconsin Agricultural Experiment Station dealing with subjects of considerable agricultural interest. Messrs. Whitson and Stoddart discuss the importance of phosphates in fertility, and show that the tendency of the local system of farming has been to deplete the stock of phosphates in the soil. Some of the soils are acid, and it is pointed out that acidity and lack of available phosphates usually go hand in hand. In such cases naturally occurring calcium phosphate gives excellent crop returns, and does not require the preliminary treatment with sulphuric acid usually given; fortunately, large deposits of rock phosphate occur in Florida, and can be purchased by farmers at low prices. Two bulletins by Messrs. Russell and Hoffmann deal with bovine tuberculosis. This disease has appeared in Wisconsin, and has spread, especially in the southern parts of the State, where more than 43 per cent. of the herds are infected. The most common mode of herd infection is through the purchase of infected animals, and State regulation is strongly recommended. In another bulletin Mr. Sandsten gives the results of experiments, which are said to have been entirely satisfactory, on the improvement of Wisconsin tobacco through seed selection. The "King" system of ventilating barns and cow-sheds is described in Bulletin No. 164. Its essential feature is that fresh air is introduced by means of flues running in the walls from the bottom to the top of the barn, and thus enters the building from *above*, whilst the foul air is withdrawn by flues running from the bottom to the top of the building, and terminating outside in a ventilator. This inversion of the ordinary system is said to work well, without draught and without great loss of temperature.

MR. E. PHILIPPI, of Jena, justly observes that the stratified structure of rocks is one of the phenomena that remain inadequately explained on account of their very familiarity. In a paper, "Über das Problem der Schichtung und über Schichtbildung am Boden der heutigen Meere" (*Zeitsch. deutsch. geol. Gesell.*, Bd. 60, 1908, p. 346), he summarises what is already known as to the bedding of sediments in waters at some distance from a coast, and urges that the German South Polar Expedition has shown stratification to be the rule and not the exception in such materials. Globigerina ooze, for example, seems regularly to contain more terrigenous matter, and to be poorer in calcium carbonate, 30 cm. or so below its surface, and Philippi attributes this to the former greater extension of the antarctic ice, with consequent production of drift. Climatic changes are probably the normal causes of stratified structure in deep-sea deposits. Deep-sea sands are ascribed to the weathering of submarine slopes and of ridges formed of solid rock, some of which may only recently have been forced towards sea-level. As new earth-ridges rise in submarine areas, new material from them gathers in the concomitant geosynclinals. Regular changes in the character of strata may thus indicate a periodicity in crust-movement in the past.

THE *Philippine Journal of Science* for December last is given up to an elaborate somatological study of the Benguet Igorots, a tribe occupying the Benguet and Lepanto-Bontoc provinces of Luzon, by Mr. R. B. Dean, of the Anatomical Laboratory, Manila. The result is that the writer is able to distinguish four groups:—Tall dolichocephalic types with long arms; small dolichocephalic with short arms; mixed mesocephalic; and brachycephalic with intermediate arm form. One example, of which an illustration is given, is of a type curiously European in appearance. The race, it is clear, has been subjected to repeated modification by the introduction of new varieties. The original type seems to have been small and dolichocephalic, with relatively short arms, conjoined with a brachycephalic element, which became mingled with the former and partially fused. Upon these people intruded a tall, dolichocephalic, long-armed race; and the process of fusion was continued uninterruptedly up to quite recent times. At present the brachycephalic race is more distinct as a type than either the tall or small dolichocephalic people, and they are also present in larger numbers. The memoir, which is fully illustrated and provided with full statistical apparatus, supplies a singularly interesting example of race fusion, and may be expected to throw much light on the ethnological history of the Philippine Islands and the cognate races of that region.

IN the August number of *Man* Mr. W. G. Smith discusses the character of the eoliths said to have been found in association with remains of *Elephas meridionalis* in undisturbed beds at Dewlish in Dorsetshire. This discovery has been assumed by Dr. C. A. Windle and others to prove the existence of man in the Pliocene period. Mr. Smith shows that the evidence of the association of these eoliths with remains of the Pliocene period is more than doubtful. He has examined the remains found at Dewlish by the Rev. Osmund Fisher, and finds that one of them is an undoubted sponge of the Cephalitis order, while none of the others, in his opinion, exhibit the faintest trace of human work. The case of the flints found in the same locality by Dr. Blackmore in 1814 is similar; and an iron stain on one example suggests that it was a surface find. He sums up the question as follows:—"If bulbed flakes of undoubted human origin have been found at Dewlish (none were sent to me) with *Elephas meridionalis*, this cannot prove that the elephant and the stones are Pliocene in age; it only suggests that the elephant had survived into Palæolithic times, for the sufficient reason that Dewlish is an old and well-known locality for Palæolithic implements. It is mentioned in Evans's 'Stone Implements,' ed. i., 1872, p. 559, and ed. ii., 1897, p. 638. I have not written this and former notes on 'eoliths' in an attempt to show that a Pliocene ape-man probably never existed. It is, to me, possible that such an animal did live somewhere in pre-Glacial and Pliocene times. When the evidence—geological, osteological, and archæological—is conclusive, I shall be one of the first to accept it."

IT has been shown experimentally that the incidence of β or γ rays from a radio-active substance on a dielectric increases its conductivity, and Dr. H. Greinacher, of the University of Zürich, describes, in the July number of *Le Radium*, his endeavours to detect a corresponding effect in the case of the α rays. The rays were derived from a layer of polonium, and fell on the dielectric of a condenser placed in series with an electrometer and a battery of storage cells. Although at first a considerable increase of the conductivity of the dielectric appeared to be produced when the radiation fell on it, Dr. Greinacher finally traced the effect to the improved contact between the dielectric and the electrodes of the condenser, and found no effect of the radiation on the conductivity. This he attributes to the closeness of the ions together in a solid, and the rapid re-combination of them which in consequence ensues.

THE best method of determining an electrical resistance in absolute measure has hitherto been that of Lorenz, but in the Bulletin of the Bureau of Standards for May, Mr. E. B. Rosa proposes to substitute for it a method which depends on the revolution of a coil in the magnetic field due to an electric current in another fixed coil. The fixed coil consists of two portions set a little further apart than in the Helmholtz galvanometer. The revolving coil consists also of two parts wound in planes at right angles to each other. The balancing is done by means of a differential galvanometer provided with three coils. Of these, two are each in series with a part of the revolving coil, and the third is connected to the ends of the resistance to be measured, which is in series with the fixed coil. By means of this apparatus Mr. Rosa hopes to obtain an accuracy ten times that which has been obtained with the Lorenz apparatus.

WE note from an article on machine-tool practice in the *Engineering Magazine* for July an interesting example of the standardisation of lathe and planer tools on a large scale. A central tool-dressing plant has been established recently at the Philadelphia Navy Yard, which supplies high-speed lathe and planer tools to all navy yards on the Atlantic coast. These tools are forged, treated, and ground to standards. Each of the various yards is equipped for re-grinding the tools until they require re-dressing, when they are returned to the central tool-dressing plant at Philadelphia for replacement by newly dressed tools. The advantages of this system are that all yards are equipped with tools of standard shapes and of uniformly high quality, and as the forging, dressing, and grinding of tools are done in large lots, substantial reductions in cost result.

The necessity for keeping records of the steam consumption in the various prime-movers in use in large factories and generating stations has given a stimulus to the development of means of measuring and recording automatically the flow of water. In the Lea water-recorder, illustrated in *Engineering* for August 13, advantage is taken of the accuracy of the Thompson V-notch, the magnitude of the angle of the notch being selected to suit the flow. The recording arrangement consists essentially of a float having a vertical rod attached to it; a rack on this rod gears with a pinion fixed to the spindle of a horizontal drum. The angle of rotation of this drum will therefore be proportional to the head of water over the notch. A spiral wire coil or screw thread is wound round the drum, and has a contour similar to the curve of flow for the notch, this curve being plotted with head for abscissæ and gallons or pounds per hour for ordinates. A bar capable of sliding parallel to the axis of the drum is actuated by the spiral on the drum, and has an arm carrying the recording pencil. The movement horizontally of the pencil will therefore be a measure of the quantity of water flowing per hour. The record is made on a chart wrapped round a drum which is clock-driven; hence the total flow in a given time is easily ascertained by means of a planimeter. The makers are the Lea Recorder Company, 28 Deansgate, Manchester.

The tenth edition of Messrs. Townson and Mercer's catalogue of scientific apparatus for physical laboratories should prove of service to science masters and others. The volume runs to 413 large pages, and contains well-illustrated information of a great variety of instruments designed to be of assistance in giving instruction in all branches of physics. Some parts of the catalogue, with their full descriptions and well-executed drawings of important pieces of apparatus, partake of the character of a practical text-book of physics. Teachers in charge of physical laboratories should see that a copy of the catalogue is added to their works of reference.

We have received from the Geographical Model Works, Middlesbrough, a photograph of a hypsometrical model of the district of Ingleborough, near Settle, by Mr. J. Foster Stackhouse. The model is said to be correct within 2 feet of the actual district dimension at every part. The area covered is 42 square miles, and the horizontal scale 6 inches to a mile. Vertically, the measurements are one-sixteenth of an inch to every 25 feet. The model is built up of a series of ninety-four layers of cardboard, and between 500 and 600 pieces were used in its formation. The weight of the model in its complete state is above a hundredweight and a half. Accurate full-size copies of the model are now available, and particulars concerning them may be obtained on application to the offices of the Geographical Model Works at Emerson Chambers, Blackett Street, Newcastle-on-Tyne.

OUR ASTRONOMICAL COLUMN.

Comet 1909*b* (Perrine's, 1896 vii.).—The re-discovery of Perrine's, 1896 vii., comet by Herr Kopff is confirmed by a notice in No. 4347 of the *Astronomische Nachrichten*, where it is stated that perihelion passage should occur about October 31·35 (Berlin M.T.). This comet, according to Herr Ristenpart, passed through perihelion for the first time since its discovery in 1896, in April, 1903, but, owing to its small angular distance from the sun, was not found at that return. According to an ephemeris given by Prof. Kobold in No. 4348 of the *Astronomische Nachrichten* (p. 62, August 18), the position of the comet on August 26 will be α=0h. 49·3m., $\delta=+42° 35'$, and it is travelling in a direction parallel to, and slightly north of, the line joining ν and 51 Andromedæ; since its discovery on August 12 the magnitude has increased 0·5. A photograph of this object was obtained at Greenwich on August 14.

The Recent Perseid Shower.—Further observations of the recent display of Perseids are published in the *Yorkshire Weekly Post* for August 21 by Mr. J. H. Elgie, of Leeds. A number of bright meteors was seen by him, between 11 p.m. and midnight, on August 11, and he gives the positions of the limits of their tracks. The brightest object seen appeared at 11.30, and, increasing in brightness, travelled from 210°, +35° to 222·5°, +10°. A number of the meteors observed appeared to radiate from a small group of stars which includes β and ξ Draconis. A party of four observers at Sandfield, Moor Allerton, saw 105 meteors between 11h. and 11h. 45m. p.m. on August 11, and one of the party, Mr. J. C. Jefferson, considers it the finest display he has seen since 1866. Another observer, Mr. E. Hawks, of Leeds, recorded 175 meteors between 9 p.m. on August 11 and dawn on August 12.

The Spectroscopic Binary β Orionis.—The radial velocity of Rigel was first determined at Potsdam in the years 1888–91, and variability was suspected, but the measures were not sufficiently definite to confirm the suspicion. Similarly, Frost and Adams obtained a range of about 8·5 km., and Campbell and Curtis suspected one of 10 km., but in neither case were the results considered sufficiently definite to affirm the variability of the velocity. Results now published, by Mr. J. Plaskett, in No. 1, vol. xxx., of the *Astrophysical Journal* (July, p. 26), show, however, from 275 plates taken on fifty-five nights in 1908–9, that the star is probably a binary, with a period of velocity-variation of about 21·90 days. There is, further, a variation of amplitude which suggests the interference of a third body, and may account for the difficulties encountered by the previous observers, but more evidence must be obtained before this can be considered certain.

The elements now published give the eccentricity as $0{\cdot}296 \pm 0{\cdot}059$, the range of velocity as $+26{\cdot}09$ km. to $+18{\cdot}55$ km., the velocity of the system as $+22{\cdot}616 \pm 0{\cdot}158$ km., and the length of the semi-major axis of the orbit as 1,108,900 km. These results are based on the measures of the three lines Mg λ 4481, He λ 4472, and Hγ λ 4341.

Ephemeris for Comet 1909*a* (Borrelly-Daniel).—An ephemeris for comet 1909*a* is published by Dr. M. Ebell in No. 4347 of the *Astronomische Nachrichten* (p. 42, August 13). As the present brightness is given as 0·07, that at discovery being taken as 1·0, it is unlikely that this object will be observed again except with the largest telescopes or by photography.

Maximum of Mira, 1908.—Mr. Naozo Ichinohe, having observed the magnitude of Mira Ceti during the period which included the last three maxima, publishes the results of his observations in No. 4346 of the *Astronomische Nachrichten*, the measures made during the period October, 1907, to February, 1909, being given in detail. The following table shows the observed dates of, and magnitudes at, the maxima, and compares the dates with those calculated by Guthnick:—

Guthnick	Observed date	Magnitude
1906, Dec. 19·6	Dec. 12	2·00
1907, Nov. 15·5	Nov. 1	3·60
1908, Oct. 11·3	Oct. 11	3·33

THE ASSUMED PLANET, O, BEYOND NEPTUNE.—Replying to a criticism which appeared in the previous number, Prof. W. H. Pickering has a letter in the current number of the *Observatory* (No. 412, August, p. 326) in which he recounts some of his reasons for assuming the existence of a planet beyond Neptune, which is exercising a perturbative force on Uranus. After pointing out essential differences between the present problem and that which presented itself to Leverrier and Adams, Prof. Pickering states that in the observations of Uranus he finds six distinct deviations from the computed course of the planet which occur where they should if produced by such a perturbing body as his assumed planet O; without the assumption three must remain unexplained. He then points out that the Greenwich observations of the last ten years show a steadily increasing deviation from those of the previous sixty years, a deviation which he considers is, of itself, a strong argument in favour of the existence of a hitherto unrecognised disturbing force.

With regard to the suggestion, made in NATURE for June 17, that the time is ripe for the discussion of the observations of Neptune, for the determination of any perturbing influence, Prof. Pickering suggests that such a discussion would probably be more hopeful in twenty years' time, when the deviations of Neptune should amount to two or three seconds. Another maximum of Uranus will occur about then, and a graphical solution would be likely to furnish trustworthy data concerning the perturbing force, or forces, very quickly.

AGRICULTURE IN THE TRANSVAAL.

THE issue of the annual report of the Transvaal Department of Agriculture is an important event in the agricultural world, and each year's report furnishes fresh proof of what science can do for agriculture. The work has outgrown the accommodation, and Mr. Smith puts in a strong plea for buildings which, in the Transvaal, is not likely to be disregarded.

An account is given by the heads of the separate departments of the work that has been going on. Dr. Theiler reports further experiments with *Piroplasma mutans* and *P. bigeminum*, two organisms causing serious animal diseases, and is making considerable progress with inoculation methods of coping with them. The botanical division, under Mr. Burtt-Davy, has occupied itself with the improvement of the seed maize. Already the Transvaal farmer exports maize, and could export more; he would secure higher prices and greater profits if supplies of trustworthy seed were available. New and promising plants have also been investigated, and one or two appear as if they will be useful, especially the Florida beggar weed, a leguminous plant suitable for the bushveld, and much liked by stock.

The plant pathologist, Mr. Pole Evans, finds that the potato-rot fungus, *Nectria solani*, Pers., hitherto regarded as a saprophyte, is, in the Transvaal at any rate, an active parasite, attacking the tubers at all stages of growth, and causing a putrid rot in them while still in the soil. Infected potatoes are not admitted into the Transvaal, and steps are being taken to eradicate the disease, but the other South African colonies are doing nothing to prevent the disease from establishing itself within their borders. A uniform system of dealing with plant diseases will be not the least among the advantages of unification.

Locust destruction has received much attention from the Entomological Division. There was a serious invasion of brown locusts, doing damage estimated at about 1,000,000*l.*, but the swarms were marked down, and the voetgangers destroyed by spraying with sodium arsenite solution. Unfortunately, some of the farmers and many of the natives are still indifferent about the work, and look upon locusts as a scourge against which it would be impious to contend; thus places where eggs are laid are not always notified.

There is also a general rise in the standard of agriculture in the colonies, in which the experimental farms of the department have played a conspicuous part. An increased area of land has come under the plough. Thrashing machines are being used more commonly; wheat is being taken up. The quality of the live stock is improving; there is a large demand for well-bred animals, and competition for the pedigree stock raised on the Government farms is very keen. Some farmers are interesting themselves in ostrich farming, which is likely to be a valuable industry in some parts of the colony, where the wild birds are fairly numerous.

Altogether the record is a highly satisfactory one, and the director, Mr. F. B. Smith, and the staff, are to be congratulated on what they have accomplished.

SPONTANEOUS COMBUSTION.

DR. JOHN KNOTT has published in the *New York Medical Journal* (April 17 and 24) an article on spontaneous combustion, with the object of showing that the cases of death reported as occurring from that cause are mere fancy legends which were partly the result of ignorance and mainly of imagination. Many years ago Liebig, and later Casper, wrote treatises with the same object; but Dr. Knott's contribution is not devoid of interest, if only for the exhibition of gentle sarcasm with which he attacks the writings and statements of past Fellows of the Royal Society and others of equal standing who lent the sanction of their names to these idle fables. He does not include among his cases the one which is probably best known to English readers, namely, the celebrated case of Mr. Krook recorded by Dickens in "Bleak House." The evidence in favour of spontaneous combustion as the cause of Mr. Krook's death is just about as convincing (or the reverse) as in the majority of the others.

We fancy, however, that Dr. Knott is preaching to the converted, for we can hardly believe him when he states that "spontaneous combustion is still accepted as an article of pathological faith by our recognised leaders in the domain of medico-legal opinion and teaching."

The belief in spontaneous combustion in the human body doubtless originated in the observation of electrical phenomena long before electricity was understood or even discovered. The "will-of-the-wisp" was endowed, as its name suggests, with a personality. The saintly halo and the fiery tongues of painters and poets familiarised the onlooker with imaginary exhalations; the easy combustibility of certain organic substances, the occurrence of phosphorescence in the sea and in decaying organisms, were then mysteries which combined to lend credence in an unusual combustibility of the human frame in those inclined to believe in the miraculous on the slenderest of evidence.

This point of view was accentuated and stimulated by the discovery of a new element, phosphorus, especially as it was first isolated from human urine and bones. The discovery of phosphorus in its day excited just the same kind of interest and imaginative thought as the discovery of radium is doing at the present time.

ETHNOLOGY IN AMERICA.

THE American Ethnological Society has reprinted in facsimile the first part of their Proceedings, originally published in 1853. The most interesting article is that contributed by W. Bartram, which was written in 1789, entitled "Observations on the Creek and Cherokee Indians," being replies to a series of ethnological questions prepared by Dr. B. S. Barton, vice-president of the Philosophical Society of Philadelphia. The connection of this tribe with the Iroquois, of whom they formed the southern branch, has now been established by Horatio Hale and Gatschet. This paper gives a singularly interesting account of the ethnography of a tribe now practically extinct, describing their probable origin, relations with other tribes, their picture records, religious beliefs, forms of tribal government, physical characteristics, social relations, their "Chunkey-yards" or earthworks, tenures of land and conditions of property, diseases and their remedies, food and means of subsistence. In connection with the divine kings of Prof. J. G. Frazer, it is interesting to find that the King of the Seminoles threatened a certain Mr. McLatche that "if he did not comply with his requisitions, he would command the thunder and lightning to descend upon his head, and reduce his stores to ashes." They had also a remarkable cult of the sacred fire. "The Spiral Fire, on the hearth and floor of the Rotunda, is very curious; it seems to light up in a flame of itself at the appointed time, but how this is done I know not."

Another important article in the same reprint is that by E. G. Squier on "The Archæology and Ethnology of Nicaragua." He describes a curious kind of spindle, resembling a gigantic top, which revolved in a calabash, and an equally primitive hand-loom. Mr. Squier was the first traveller who collected a vocabulary and prepared a grammar of the speech of these tribes. They used, he says, the vigentesimal system of counting by twenties instead of the decimal, while the Eskimos, Algonkins, and Choctaws counted by fives. They were emigrants from Mexico, "and presented the extraordinary phenomenon of a fragment of a great aboriginal nation, widely separated from the parent stock, and intruded among other and hostile nations; yet from the comparative lateness of the separation, or some other cause, still retaining its original, distinguishing features, so as to be easily recognised." Their arms were identical with those of the Mexicans—lances and arrows pointed with flint, copper, and fish-bones, with blades of obsidian set on the edges. These papers are specially interesting, because they were written before the age of scientific ethnography, and were prepared without reliance on any particular theory of the origins, social organisation, or beliefs of the tribes which were studied by their authors. The re-publication of this valuable material is a laudable enterprise on the part of the Ethnological Society.

PURIFICATION OF WATER BY STORAGE.

THE third annual report, compiled by Dr. Houston, of the Metropolitan Water Board, on the results of the chemical and bacteriological examination of the London waters for the twelve months ended March 31 has just been issued, and contains a mass of valuable information. The chief conclusions formulated by Dr. Houston may be summarised as follows. The raw waters from which the supplies are derived are usually unsatisfactory, particularly during the winter months, and a judicious selection for waterworks purposes is important. The storage is unequal, and in some cases inadequate in the different works; filtration is also unequal, and in some instances too rapid. The quality of the filtered water is likewise variable, and in some cases not altogether satisfactory, though a remarkable percentage improvement in the quality of the raw water is effected by storage and filtration; on the whole, however, the water supplied to the consumer is of satisfactory quality. Storage has been clearly proved to be advantageous in all respects. The recent investigations of the Board point to the fact that the present sources of the water supply of the metropolis may be regarded with less disfavour than previously.

Dr. Houston, in a fourth report on research work, also details the results of an investigation on the vitality of the cholera microbe in artificially infected samples of raw Thames, Lee, and New River water, which may be considered to be supplementary to his previous report on the vitality of the typhoid bacillus in similar circumstances (see NATURE, vols. lxxviii., p. 377, lxxix., p. 259, and lxxx., p. 286). A number of different strains of the cholera vibrio was dealt with, and only those which, after investigation, might be regarded as undoubted cholera vibrios were employed in the research, and their bacteriological characteristics are detailed. The conclusions are that cholera vibrios rapidly die in the raw waters as a result of storage in the laboratory. At least 99·9 per cent. of the organisms perish within one week, and none could be isolated even from 100 c.c. of the water three weeks after infection. These results are of considerable interest now that cholera is prevalent in Russia and other parts of Europe, and emphasise the importance of storage of the raw water as a safeguard against water-borne disease.

R. T. HEWLETT.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. R. K. McCLUNG has been appointed lecturer in physics in the University of Manitoba, Winnipeg.

DR. FRITZ COHN, extraordinary professor of mathematics and astronomy at the University of Königsberg, has been appointed professor of theoretical and mathematical astronomy, and director of the Königliche Astronomischen Recheninstitut, at Berlin; he enters upon his new duties on October 1.

THE Central News Agency reports from New York that, by the will of the late Mr. Cornelius C. Cuyler, the sum of 100,000 dollars is bequeathed for the immediate benefit of the Princeton University, and on the death of Mr. Cuyler's widow several million dollars will pass into the hands of the University authorities.

WE have received a copy of the Directory for higher education, 1909–10, issued by the Education Committee of the Staffordshire County Council. The directory contains the regulations of the committee and the details of schemes in operation throughout Staffordshire. We notice that a very complete scheme of technological instruction is provided throughout the county by the committee. In the case of mining, instruction is given by two lecturers, whose whole time is devoted to the work, and their assistants. For this purpose the county is divided into two portions, comprising the North Staffordshire Coalfields and the South Staffordshire Coalfields respectively. Theoretical and practical classes in metallurgy and iron and steel manufacture are conducted in accordance with the regulations of the Board of Education and the City and Guilds of London Institute. Lectures and laboratory work in pottery and porcelain manufacture will be given during the coming session at Burslem, Longton, Stoke, and Tunstall. The services of an instructor in boot and shoe manufacture are engaged jointly by the committee and the Education Committee of the Borough of Stafford. Silk manufacture is taught at Leek, glass manufacture at Stourbridge, and art metal-work at Bilston. To enable teachers in elementary and secondary schools to impart instruction in various branches of technical and manual training, special classes are provided at convenient centres by the committee. Courses of lectures on health and the care of children are delivered at suitable localities in both rural and urban districts, and demonstrations and lectures are also provided on gardening, bee-keeping, and poultry-keeping. An elaborate system of scholarships is in vogue, including training scholarships for teachers and midwives, extensive aid is given to secondary schools, university extension lectures are provided, useful work has been arranged in rural districts, and numerous evening classes are available. Altogether the Staffordshire committee is making adequate provision for the education of young men and women anxious to equip themselves properly for their work in life.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, August 17.—M. Bouquet de la Grye in the chair.—The synthesis of unsaturated fatty ketones: F. **Boudroux** and F. **Taboury**. Calcium carbide attacks the ketones of the fatty series. Acetone gives mesityl oxide and other condensation products; butanone is dehydrated in a simpler manner, the unsaturated ketone $C_2H_5.C(CH_3)=CH—CO.C_2H_5$ being formed.—The influence of the reaction of the medium on the development and proteolytic activity of Davaine's bacteridium: Mlle. Eleonore **Lazarus**. The limits of acidity or alkalinity between which it is possible for the organism to develop, as well as the reaction corresponding to the maximum proteolysis, depends, not only on the strain, but also on the nature of the food material.—The mitochondria of the muscular fibres of the heart: Cl. **Regaud**.—The geological history of the Tellian Atlas of eastern Numidia (Algeria): J. Dareste **de la Chavanne**.

GÖTTINGEN.

Royal Society of Sciences.—The *Nachrichten* (physico-mathematical section), part ii. for 1909, contains the following memoirs communicated to the society:—

March 6.—Seismic records at Göttingen in 1907, with an introduction on the working out of seismic diagrams: L. **Geiger.**—Contributions to the theory of tensions in plastic and sand-like media: A. **Haar** and T. **von Karmán.**

May 8.—Procedure for the determination of magnetic inclination by means of the induction-inclinometer: O. **Venske.**—New developments in linear differential equations: E. **Hilb.**—New members of the systems β, γ, δ, ϵ, ζ Ursæ Majoris: E. **Hertzsprung.**—The notion of the work of deformation in the theory of the elasticity of solid bodies: J. J. **Weyrauch.**

The "Business Communications," part i., 1909, include the report of the Samoa Observatory for 1908, a communication on certain notes of Riemann's lectures, and a memorial address on Hermann Minkowski, by D. **Hilbert.**

CAPE TOWN.

Royal Society of South Africa, July 21.—Prof. L. Crawford in the chair.—Notes on the absorption of water by aërial organs of plants: Dr. **Marloth.** Numerous experiments were made with various Karroo plants in order to ascertain whether they are able to absorb water by means of their leaves, and thus to utilise the dew, which is of common occurrence in the Karroo every night during the winter. The results showed that some plants possess specially constructed hairs, like *Mesembrianthemum barbatum* and *Crassula tomentosa*; others, peculiar stipules like *Anacampseros Telephiastrum* and *Afilamentosa*; others, an unusually modified epidermis like *Crassula decipiens*; and others, again, aërial rootlets like *Cotyledon cristata.* These organs absorb sufficient moisture to supply the requirements of the plants during a part of the year, thus enabling them to exist in arid regions like some parts of the Karroo or the desert coast-belt of Namaqualand.—Evaporation in a current of air (part i.): J. R. **Sutton.** The results of previous observations upon the rate of evaporation made under natural conditions at Kenilworth (Kimberley) with gauges of various patterns suggest that the relative humidity of the air is of more importance than the absolute humidity in determining the loss of water from a given surface, and that there is no simple correspondence between the wind and the evaporation. In this paper the author describes some experiments made to determine the rate of evaporation under different conditions of moisture and temperature in the forced draught generated by an electrically driven fan.—The genesis of the chemical elements: James **Moir.** The author has found a relationship between the atomic weights, whereby the accepted values can be calculated with remarkable accuracy. The scheme brings out closer relationship between such groups as the alkali metals and the halogens, and although it follows the periodic law, it would require the latter to be modified in important particulars.—Some flowering plants from the neighbourhood of Port Elizabeth: S. **Schönland.**—Statement of Silayi, a Tembu of the Zemba tribe, with reference to his life among the Bushmen: W. E. **Stanford.** This communication contains interesting information about a clan of Bushmen whose haunts were in the Drakensberg Mountains, and could muster forty-three men. It is a narrative of cattle lifting in various ways and devices, as well as of their domestic habits and mode of life, and also of the ultimate destruction of the clan by the Tembu chief.

CALCUTTA.

Asiatic Society of Bengal, August 4.—The constitution of the roots of *Arisaema concinnum*, Schott, and *A. speciosum*, Mart.: B. B. **Dutta.** These roots contain an abundance of carbohydrates, and are used as food by the Lepchas of Sikkim in case of need, after taking precautions in the cooking to get rid of the irritant needle crystals.—The ova of a Distoma found in the skeletal muscles of *Saccobranchus fossilis*: G. C. **Chatterjee** and T. C. **Ghosh.** Last year, during the small-pox epidemic, a peculiar eruption was noticed on fish offered for sale in the Calcutta markets, and popularly connected with small-pox. This fish disease, on examination, was found to be due to a flat worm of the parasitic genus Distoma. The authors have found the ova in various parts of the body of the fish, but particularly near the dorsal fins in the skeletal muscles towards the posterior third of the body. Two actual moving worms were found in water where diseased fish were which are described as presumably the adult form of the worm.—Chemical examination of aurvedic metallic preparations, part i., "Shata-puta lauha and Shahasra-puta lauha" (iron roasted hundred times and thousand times): Panchanan **Neogi** and Birendra Bhusan **Adhicary.** The method of preparing "Shata-puta" and "Shahasra-puta" lauha, as given in Rasendra-Shara-Shangraha, as well as that followed by modern aurvedic physicians, are given in this paper. Samples of iron heated once, ten times, seventy-eight times, 100 times, and 1000 times have been collected and analysed. Samples which have undergone a fewer number of "putas" are magnetic, and contain ferroso-ferric oxide. As the number of roastings (puta) increases the amount of ferrous oxide diminishes, and "Shata-puta" and "Shahasra-puta" lauhas contain ferric oxide only, and are not magnetic. "Shata-puta" and "Shahasra-puta" lauhas are almost identical in composition, the amount of ferric oxide varying from 78·1 per cent. to 84·6 per cent. Siliceous matter is present in considerable quantities, varying from 10·1 per cent. to 34·1 per cent. These "lauhas" are very light and porous, and "swim on water like a duck," but precipitated ferric oxide does not "swim." It is on account of their fineness and lightness that these "lauhas" are efficacious. Ordinary ferric oxide is not incorporated in the British Pharmacopœia. Incidentally, a method of estimating metallic iron in presence of ferrous iron is given.

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