THURSDAY, SEPTEMBER 16, 1897.

A SYSTEM OF MEDICINE.

A System of Medicine. Edited by Thos. Clifford Allbutt, M.A., M.D., F.R.S., &c., Regius Professor of Physic in the University of Cambridge. Vol. ii. Pp. xiv + 1176; with 77 illustrations, 6 charts, 1 map, and 1 plate. (London: Macmillan and Co., Ltd., 1897.)

THIS, the second volume of Prof. Allbutt's "System," the first volume of which was reviewed in these columns (NATURE, August 20, 1896), has been delayed somewhat in its appearance owing to a desire on the part of the editor and the corresponding contributors to profit by the results of the Vaccination Commission.

The volume commences with the infective diseases of chronic course, Dr. Sidney Martin contributing the article on tuberculosis, Dr. Phineas Abraham on leprosy, Dr. Acland on actinomycosis and Madura foot. Dr. Martin discusses the ætiology of tuberculosis and the various lesions resulting from tubercular infection; also the varieties of experimental tuberculosis, immunity, and the pathological diagnosis and the prognosis of the disease. Dr. Abraham begins with an historical sketch, and then passes on to the geographical distribution, symptomatology, and pathology of leprosy. The value of Dr. Acland's article on actinomycosis is enhanced by an extensive bibliography which he has added.

The second division of the book is devoted to "Diseases of Uncertain Bacteriology," which are divided into two main classes, "non-endemic" and "endemic or topical." The non-endemic diseases comprise measles, rubella, scarlet fever, varicella, variola, mumps, whooping-cough, and syphilis. The articles on measles and rubella are written by Dr. Dawson Williams, in the latter of which a useful table is given of the differential diagnosis of measles, rubella, and scarlet fever. Dr. Caiger contributes the article on scarlet fever, and under its pathology discusses critically the relation of Klein's scarlatinal streptococcus to this disease. Dr. MacCombie writes the monographs on chickenpox and smallpox. Mumps and whooping-cough are ably treated by Dr. Eustace Smith. Mr. Jonathan Hutchinson writes an admirable medical essay on constitutional syphilis. The author confesses that since 1866, when he wrote the article upon this subject for Reynolds' system, he has changed his views with regard to the power of mercury, when begun early and continued regularly, to prevent the occurrence of secondary symptoms; he says, further, that in his experience patients thus treated usually escape the class of symptoms known as "reminders." With regard to hereditary syphilis, it is of interest that in the author's large experience he has only seen one, and that a doubtful, case of the transmission of syphilis to the third generation. A short article on the coexistence of infectious diseases, by Dr. Caiger, concludes this division of the work.

The "endemic" "Diseases of Uncertain Bacteriology" begin with an essay by Sir Joseph Fayrer, on the climate and some of the fevers of India. The first part of this monograph will be exceedingly valuable to non-professional readers, especially in view of the increased frequency of winter travelling in India, both for health and pleasure. The part devoted to actual disease will be equally useful to practitioners in India, and also to those who practise amongst "old Indians" at home. A valuable bibliography is appended. The articles on dengue, beri-beri, and sleeping sickness are contributed by Dr. Patrick Manson; those on yellow fever and dysentery by Dr. Andrew Davidson. Oriental sore, verruga, and frambœsia are treated by Surgeon-Major Firth.

The third main division of the work is devoted to diseases communicable from animals to man; this, again, is subdivided into those of certain and uncertain bacteriology. The former comprises an article on glanders, by Dr. Sims Woodhead, and one on anthrax, by Dr. J. H. Bell. The second subdivision includes articles on vaccinia, foot and mouth disease, rabies, and glandular fever. The first part of the monograph on vaccinia is contributed by Dr. Acland, and is entitled "Vaccinia in Man—a Clinical Study." The second part treats of the pathology of vaccinia, and is by Dr. Copeman. The third part, "Vaccination as a branch of Preventive Medicine," is by Mr. Ernest Hart. This monograph provides the reader with a complete clinical account of the results of the inoculation of uncontaminated vaccine lymph in man, all that is at present known of the bacteriology, chemistry and morphology of vaccine lymph, and a discussion of the ethics of vaccination.

The article on rabies is by Dr. Sims Woodhead. The author discusses the bacteriology and treatment of the disease at some length. The recent methods of treatment, introduced by Tizzoni and Centanni, and Babes, are discussed, and their advantages over the Pasteur method indicated. The marked difference in the magnitude of the effect produced by antirabic serum according to the seat of inoculation is emphasised by the author. This is of interest from a general point of view as showing that, although the rabic poison itself is in the highest degree selective, *i.e.* wherever introduced, it selects the cells of the central nervous system for the sphere of its action, its antitoxine, although capable of neutralising its effects on these cells, is to a much less degree truly selective, since a much greater effect is produced by it when it is injected into a nerve-sheath on the sub-dural space, *i.e. in situ.*

The next division of the work is devoted to diseases due to protozoa, and includes articles on malarial fever, hæmoglobinuric fever, and amœbic dysentery, by Drs. Osler, Copeman and Lafleur respectively.

The intoxications are next considered. Dr. Sidney Martin contributes an article on poisoning by food—ptomaine poisoning; the author summarises the work of Brieger on the ptomaines. He then describes the Middlesborough epidemic of pleuropneumonia, which was traced to the use of a certain "American bacon." The frequency of *pig's meat* as the offending food stuff in this connection is emphasised; and Dr. Ballard's suggestion that this is connected with the gelatine-producing power of this variety of meat is supported; gelatine being an excellent nutrient medium for many bacteria. The articles on grain poisoning, mushroom poisoning, opium poisoning and other intoxications are from the pen of the editor. In the first article the history, causation, symptoms, diagnosis, prognosis and pathology of ergotism are fully considered. Under diagnosis the author discusses the identity of ergotism and Raynaud's disease. Descriptions of pellagra, the disease due to bad maize, and of lathyrism, that ascribed to certain species of chick-pea, conclude the article. The monograph on snake poison and snake bite is written by Mr. Martin, an appendix being added by Dr. Calmette. Mr. Martin discusses the chemical nature and physiological action of several snake toxines. In his opinion the albumoses, which form the active principle of snake poisons, are produced by the glandular cell from the albumins of the blood by a process of hydration. Dr. Calmette, in his appendix, gives the latest results of his antivenom treatment. He (in opposition to Martin) maintains the efficacy of treatment by hypochlorite of lime, and also by chloride of gold (1 per cent.), which he recommends when antivenom is not to hand. His view is that the antivenom acts by an "insensibilisation" of the cells, and cannot be regarded as *chemically* antidotal. Calmette maintains that animals rendered immune by vaccination against a dose of Cobra or Bothrop's venom many hundred times the ordinary fatal dose, resist likewise inoculations of very powerful doses of the venom of numerous other serpents. Readers interested in this subject are referred by the editor to an article in NATURE (December 10, 1896), by Dr. Kanthack, which gives an account of further researches by Dr. Cunningham and himself upon this subject. Dr. Rolleston contributes an article on alcoholism, in which the approximate composition of the more ordinary alcoholic drinks is considered. On p. 846 of this monograph occurs an amusing misprint—the only one we have noticed—Kirschwasser being written "Kirchwasser." Morphinism, hasheesh poisoning, cocainism, ether drinking, and tobacco poisoning are all fully treated by the editor. Dr. Thomas Oliver contributes a monograph on metallic and some other forms of poisoning, including "poisonous trades."

The final division of the work is devoted to internal parasites. It includes articles on psorospermosis, by Dr. Joseph Griffiths; on worms, by Dr. Patrick Manson; on Bilharzia hæmatobia, by Dr. Guillemard; on hydatid disease, by Dr. Verco and Prof. E. C. Stirling.

The editor has adopted the useful system of placing at the end of vol. ii. addenda containing any important additions to our knowledge of the subjects already written upon, since the completion of the respective monographs. In this instance Dr. Sheridan Delepine writes a description of Widal's typhoid serum reaction. Dr. Payne summarises the ways in which the recent plague epidemic has increased our knowledge of the geographical distribution and therapeutics of that disease. Dr. Davidson discusses Sanarelli's yellow fever bacillus, and protective serum.

It is impossible in a review such as the present one to do justice to the encyclopædic mass of information which is contained in the volume before us. The editor and his collaborators are, however, heartily to be congratulated upon this further result of their labours, which both in matter and manner may be regarded as a model of what such a work ought to be.

F. W. T.

ANTHROPOLOGY versus ETYMOLOGY.

Modern Mythology. By Andrew Lang. Pp. xxiv + 212 (London: Longmans, Green, and Co., 1897.)

READERS of NATURE will remember that it is not many weeks ago since Prof. Max Müller's "Contributions to the Science of Mythology" was reviewed in these columns. It is not many weeks, in fact, since this work appeared, and any serious student of the subject with which it deals will have hardly yet assimilated the mass of new material and varied suggestion which, so short a time ago, it presented to his notice. Such a student taking up "Modern Mythology," and turning to the introduction, will experience a shock of surprise on finding that Mr. Lang's new book poses as "a reply" to the learned Professor's portly volumes. The puzzled student asks himself how any adequate "reply" can have been written, printed and published in so short an interval, and his surprise that such a feat has been attempted changes to regret when he passes from the introduction to the book itself. That Mr. Lang has formulated this hasty indictment is the more to be regretted as he speaks throughout as the champion of the anthropological treatment of mythology; but it must be noted that he is a self-constituted champion, and we may be forgiven for saying that we think he has miscalculated his own importance in that field of science. We willingly accept his assurance that he does know Greek, but we cannot remember that he has anywhere shown that he possesses the masterly knowledge of oriental and other languages possessed by Prof. Max Müller, or that he has a knowledge of scientific anthropology equal to that of Prof. E. B. Tylor and the other great masters of the same school to whom he, in common with ourselves, is really indebted for the main facts and principles of anthropology which he accepts. We admit at once that the greatest linguist is not always the best interpreter of the facts which he has gleaned from the literatures of the various nations with which he is acquainted. But we must at the same time declare that a man who sets himself up to interpret the facts which the linguist has collected, should at least have sufficient knowledge of the language to understand the facts and to discern the reasons which induced the linguist to make his statements.

It cannot be denied that to the older school of mythologists, which counts Prof. Max Müller its most brilliant exponent, was due the first scientific treatment of the subject. They were concerned solely with the mythology of Greece, but they were the first to perceive that the stories of gods and heroes were worthy of classification and systematic study. Their conception of mythology may be briefly described. The Greek gods and goddesses, they postulate, were in their origin merely personifications of the great forces and most striking phenomena in nature. Their names were originally descriptive of their general character as natural forces, and the myths which gathered about them were merely allegories describing, in the form of stories, the working of these forces in the natural world. But in process of time the names of the deities ceased to be understood, and the original meaning of the myths was forgotten.

Popular explanations of the divine names obtained currency and modified the myths. Thus the old name of a deity which had lost its meaning might remind a later generation of the name of some beast; hence might arise those stories of gods taking the forms of beasts and acting like them, which are mixed up with and mar the lofty and poetical character of Greek mythology. To this school mythology is, in a sense, "a disease of language," and can be explained best by means of etymology. Their method consists in extracting the original meaning of Greek divine names by a comparison of Sanskrit roots. Having by this means obtained an inkling of a deity's origin, they proceed to explain the myths connected with him in accordance with his character.

The younger school of mythologists proceed on totally different lines. They do not confine their studies to the mythology of one nation or one family of nations, but examine and classify myths all the world over. They regard the savage stories of Greek gods and heroes not as due to a disease of language, but as survivals from an age of more primitive culture, tracing their origin to certain human peculiarities shared by all races in the early stages of their development. To the mind of the savage, nature is not inanimate; every animal, plant, stone, wind and river he regards as having a life and personality like his own, and attributes to them human powers of thought, speech and action. Moreover, the bounds which mark off the various subdivisions of the natural world are not drawn tight for him, but he regards all things as capable of endless change of form; thus gods may become men, and both gods and men may become beasts or things. When, therefore, stories of gods assuming bestial shapes occur in Greek mythology, the anthropologist regards them not as later developments due to a mistaken etymology of names, but as relics of an earlier state of culture.

Such, broadly stated, are the differences in theory and method between the two rival schools of mythologists, of which the anthropological school will always be pre-eminently associated with the name of Prof. Tylor. In "Modern Mythology" wherever Mr. Lang sings the praises of this method we entirely agree with him; but anthropology is now a sturdy infant, and in no danger of being ignored. That part of the book which deals with Mr. Lang's own utterances and those of Mannhardt, Prof. Tiele and others, though wittily and charmingly written, is not of very great importance, and might well have appeared in the form of two magazine articles; a fate, by the way, which had already befallen the last quarter of Mr. Lang's book. In such a guise Mr. Lang's "reply" would have amused and delighted us, for he has the enviable power of writing attractively on the surface of any subject, however abstruse. When, however, a clever but rambling collection of notes, thrown together in a few days, would pass as a serious reply to the ripe work of many years of scholarly labour, we could wish, in the interests of science, that its author had been a man of less eminence or greater discretion.

OUR BOOK SHELF.

The Vivarium: being a Practical Guide to the Construction, Arrangement, and Management of Vivaria, containing full Information as to all Reptiles suitable as Pets, how and where to obtain them, and how to keep them in health. By Rev. G. C. Bateman. Pp. 424; illustrated. (London: L. U. Gill.)

THE main title of this little work is likely to give the impression that it merely treats of the best way of keeping a few reptiles or other creatures in a fern-case in a window or conservatory. But it is really much more than this, and gives details of the manner to keep in confinement and health, not only small lizards, salamanders, and snakes, but likewise such inconvenient "pets" as alligators, pythons, and boa-constrictors—creatures by no means suited to the *ménage* of every small household. Nor is this all, for it is practically a natural history of reptiles and amphibians, although attention is chiefly directed to those species most easily obtainable in the market, and which thrive best in confinement. The illustrations are, for the most part, of a high class, and the descriptions of the various animals well written, although, perhaps, at times a trifle dull. The instructions for making vivaria appear complete, and the hints on management all that can be desired.

A fair criticism on the book is that it is either a little too scientific, or not quite scientific enough. That is to say, the author is often too scientific for ordinary readers, while naturalists would go elsewhere for the information he seeks to impart. In the general arrangement of reptiles an obsolete classification is adopted, while in the case of genera and species the author is often undecided as to what names to adopt. When both names are given side by side not much harm is done, but when we find the common viper figuring as *Pelias berus* on p. 3, and as *Vipera berus* on p. 170, the beginner is likely to feel a trifle puzzled. Then, again, what is the use of giving abbreviations of authors, such as Dum. and Bibr., after the names? Hieroglyphics or logarithms would be just as comprehensible to the readers who are likely to study the book! It would, perhaps, be severe to suggest that the author's classical knowledge is a little shaky; but it is certainly new to us that *Ichtys* (p. 4) is the Greek for a fish, or *Orphis* (p. 5) for a snake! Probably the long-suffering printer will be blamed.

Many amusing anecdotes are introduced into the book, and even professed naturalists will now and then find something in regard to habits which may be novel to them; the account of the development of axolotls into salamanders being specially good. We observe that the author maintains an undecided neutrality on the subject of vipers swallowing their young, although the anecdote he relates of a live lizard appearing suddenly from a snake's mouth after a sojourn of some four-and-twenty hours, might perhaps have given grounds for thinking that there is a germ of truth in the legend. To those desirous of knowing something about reptiles and amphibians, and, above all, to those venturesome persons who are ambitious to have tame pythons and crocodiles about their houses, the book may be commended.

R. L.

Geological Survey of Canada. Annual Report (New Series), vol. viii., 1895. Pp. 998. (Ottawa: Printed by S. E. Dawson, 1897.)

THIS fine volume of nearly one thousand pages is accompanied by six maps and illustrated by seventeen plates, besides a number of figures in the text. It is a record of work accomplished during 1895, and its pages show that the progress made in that year was both satisfactory and important.

Dr. G. M. Dawson, F.R.S., the Director of the Survey, gives a valuable summary of the explorations and surveys made in 1895, and the museum and other work carried on under his direction. The separate reports contained in the volume are as follows :—

"The Country between Athabasca Lake and Churchill River," by J. Burr Tyrrell and D. B. Dowling.

"The Geology of a Portion of the Laurentian Area lying to the North of the Island of Montreal," by Frank D. Adams.

"Explorations in the Labrador Peninsula, along the East Main, Koksoak, Hamilton, Manicuagan, and portions of other Rivers, in 1892-93-94-95," by A. P. Low.

"Report of the Section of Chemistry and Mineralogy," by G. C. Hoffman.

"Report of the Section of Mineral Statistics and Mines," by E. D. Ingall.

These reports are published separately, and several of them have already been referred to in our columns of "Notes."

A Bibliography of Science. By William Swan Sonnenschein. (London : Swan Sonnenschein and Co., Ltd., 1897.)

THIS classified list of scientific books, extracted from two useful bibliographies prepared by the author a few years ago, will be valuable to readers who are outside the living stream of scientific thought. It is in no sense complete, and it does not pretend to be so ; nevertheless, it will serve a useful purpose. Some of the remarks of the editor may be resented by the authors of the books referred to. Thus, one book is described as "a somewhat slovenly and unscientific performance" (p. 384). If the criticism is a just one, the title of the book might have been omitted.

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.*]

Zeeman's Phenomenon.

IN Section A at the Toronto meeting of the British Association, Dr. Lodge raised the question as to whether we should expect on a simple theory that the spectral lines should be simply widened or be doubled by magnetic force. The simple theory depends on the acceleration or retardation of electrons performing circular orbits under the action of a magnetic force normal to the plane of the orbit. If the plane of the orbit be not normal to the magnetic force, it might appear that the acceleration or retardation would be only that due to the component of the force normal to the plane of the orbit. From this it would follow that the lines would be *widened* and not *doubled*, because every intermediate acceleration or retardation would occur between the extreme cases of orbits perpendicular to the magnetic force. This suggested theory, however, overlooks the effect of the magnetic force in altering plane of the orbit. The complete theory can be very much more simply obtained by another method of attack. The motions being assumed simply periodic in the undisturbed motion, can be resolved for each electron into three linear vibrations, two at right angles to the magnetic force and one parallel to it. This latter is undisturbed and gives no light in the direction of the magnetic force. Each of the other linear vibrations is disturbed, and we can easily see how by considering that a linear vibration may be considered as due to two circularly polarised vibrations. Each of these component circular vibrations will be altered by the magnetic force normal to its plane, one being simply accelerated and the other retarded. We can consequently see that this more complete theory leads to the conclusion that the lines would be *doubled* and not *widened*, though, of course, they may be also widened owing to other disturbances of the motion. There would be no difficulty in writing down the equations of the resulting motion of the electron, but it seems hardly necessary to do so, as this geometrical analysis leads to the kind of vibration emitted, which is all that we can observe. GEO. FRAS. FITZGERALD.

Fort William, Ontario, August 28.

Coccoliths in our Coastal Waters.

ALTHOUGH much has been written about the problematical coccoliths, the presence of these bodies in our coastal waters does not appear to have been recorded. Our observations on the minute marine organisms off this coast (South County Dublin) show that they abound both near the shore and outwards to the limits we have hitherto investigated—some three miles into the Irish Channel.

The following preliminary account of their mode of occurrence, and some features of their structure may be of interest.

Our first finds were effected by means of a cone-shaped, metal, surface dredge ; the wide end guarded with wire gauze—about fifty meshes to the linear inch—and the narrow truncated end closed with fine brass gauze, having about 350 meshes to the linear inch. The dredge is floated horizontally by pine-wood wings, and when in operation is trailed behind a boat, the wide end forwards. At intervals the dredge is lifted, the finer gauze removed and washed in a little sea water.

Examination of the fine particles so gathered reveals many varieties of foraminifera, diatoms, a great abundance of peridineæ, sponge spicules, &c., and an amœboid body resembling

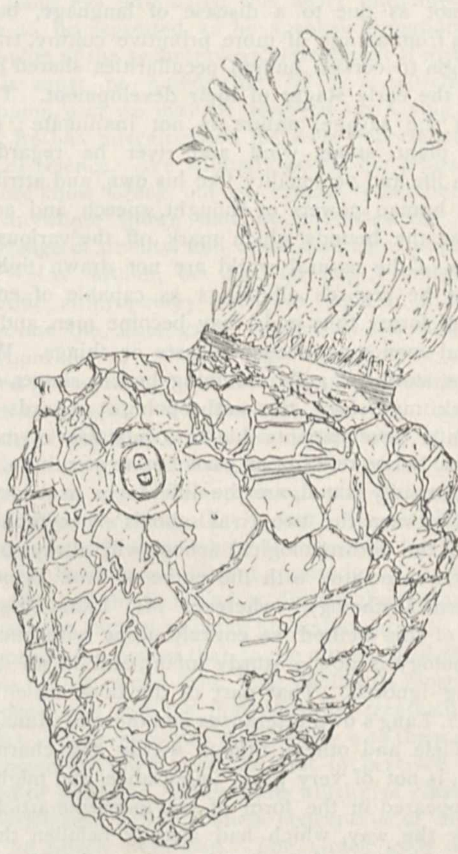

FIG. 1.—*Difflugia*, sp. (?), bearing a Coccolith × 900 diams.

Difflugia pyriformis in appearance. This last body, magnified about 900 diameters, is shown in Fig. 1. The drawing shows the organism as freshly dredged and extending finger-shaped pseudopodia from the open collar, which terminates one extremity of its urn-shaped case. Most usually it is observed with the pseudopodia retracted.

The case enclosing the protoplasm is composed of minute grains of quartz sand (resist acids and alkalies), adhering in random fashion to the protoplasmic contents within. Also there will be seen in the figure (which is from a camera-lucida drawing) one small oval body, occurring among the sand grains.

Reference to Dr. Murray's well-known figure of the coccoliths gathered from the surface waters of the North Atlantic, at once shows the close resemblance of both bodies. In a certain focal plane, indeed, the resemblance is even still more striking. Dr. Murray's drawing is reproduced in Mr. G. Murray's and Mr. Blackman's article appearing in NATURE, April 1, 1897, p. 510. It is of interest to note that Bütschli records the appearance of disc-shaped plates of uncertain origin in *Difflugia*.

The number of *Difflugia* present in our slides is very considerable, and of this number perhaps some 25 per cent. show one or two implanted coccoliths. Furthermore, the *Difflugia* are by no means confined to the immediate surface. Sinking our dredge to a depth of eight fathoms in Killiney Bay, we still obtained this organism; and varying states of wind and tide did not appear to affect its numbers.

The first question that arises is as to the relation which the minute adherent organisms bear to the *Difflugia* which carry them. The surmise naturally arrived at was that the relationship is accidental. The protozoan gathers its covering particles from such minute hard bodies as it finds convenient; among them it occasionally picks up an organised particle—the coccolith.

If this surmise as to the relations of the two organisms is correct, it must follow that examination of the most minute solid constituents of the sea water will reveal the presence of free coccoliths in considerable numbers. To test this question, some two litres of sea-water was permitted to stand twenty-four hours in a tall narrow jar; the upper part being then syphoned off, leaving some 200 c.c. of the lower portion. This was then treated in a centrifugal apparatus, readily fitted on a small dynamo, permitting a high rate of rotation. In this manner the water was cleared in a very short time of all turbidity, and a mat composed of its solid contents thrown to the bottom of the tubes of the centrifuge.[1]

Examination of this precipitated material showed at once that coccoliths in a free state abounded in the water, every slide showing not less than a few score of specimens. Fully provided with specimens thus favourably placed for observation, we were enabled to confirm our previous observations as to the structure and probable composition of these bodies.

As full details are hardly in place here, we will refer at once to Fig. 2 for perspective appearances of the organism. The figures are more in outline than our original drawings, to permit of more ready reproduction in these pages. Figs. *a* and *b* are perspective views of opposite faces of the valves. Fig. *c* is an edge view. We explain the appearances presented in these drawings with considerable confidence by the diametral section shown in Fig. *d*. The coccolith consists of two very thin, funnel-shaped, elliptical valves; a small valve attached by a central connection within a wider, and provided with minute radial striations sculptured apparently on the outer or convex surfaces of both valves; between forty and fifty striations going round the valves. The connection attaching the valves is rounded or slightly oval and apparently perforated axially by two D-shaped apertures, but occasionally a single oval opening traverses the collar; or, again, the cross-piece separating the D-openings appears incomplete, and is represented by projections extending into an oval opening. The more minute structure of the connecting neck or attachment is unknown to us. The valves are frequently found chipped and fractured, but, so far as observed, always rigidly connected one with another. Specimens considerably less in dimensions than the normal are occasionally found, but identical in form. The resemblance between our drawings and those given by Bütschli in his *Protozoa* (Plate 1, Figs. 2-5) at once confirms the view that these organisms are identical with those described by this authority as "Coccolithen." The organism is a most difficult and illusive object owing to its minuteness, transparency and complex structure. Our drawings are made with a 1/12 oil immersion of Leitz.

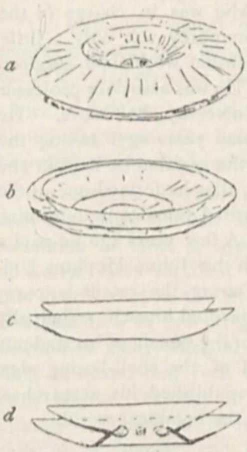

FIG. 2.—Coccolith × 2000 diams. q.p.

The coccoliths dissolve freely in dilute hydrochloric acid, and are partially and much more slowly attacked by strong caustic potash. The latter reagent does not appear to be able to completely dissolve the central parts, more especially of the lesser valve; or at least cannot do so with any celerity. The absence of the appearance of free gas upon attack with the acid hardly negatives the idea—agreeable with the observations of Dr. Murray and others—that these bodies are calcareous. In all these tests we have frequently had well-characterised diatoms present in the same field, and whereas the characteristic silicious covering of the latter held out against the acid, the coccolith immediately dissolved. In the application of the caustic potash test diatom valves were also present, and these showed complete resistance to the caustic alkali.

That there is some living matter present between the valves appears suggested by the granular appearance often presented in the ring embracing the central connection, and also by the fact that upon solution in dilute acid just such a ring of granular particles is thrown down, and alone remains to mark the spot where the coccolith had been. This granular remains assumes a tawny yellow or brownish colour when acted on by iodine. The inference is that a ring of (residual?) protoplasmic matter surrounds the central connection of the valves. Neither nucleus, flagellum, pseudopodia, nor cilia have as yet been observed, neither have we found any evident chromatophores.

In the present stage of our inquiry we can only ask with considerable uncertainty as to the nature and affinities of this interesting organism. Its rigidly attached valves, absence of girdle, and the calcareous nature of the valves, negative, we think, the idea that it is—as sometimes assumed—of diatomaceous nature. Its relationship with the Foraminifera is more probably suggested.

The possibility that they are commensal with, or parisitic on, the protozoan which so often carries them, must not be forgotten; at the same time our abundant free specimens appear so often ringed between the valves with proteid matter, that their independent existence appears highly probable. There is at present hardly data sufficient to render them referable with certainty to either one or the other kingdom of organised beings.

It may be assumed that they are abundant in our coastal waters as well as in the open ocean, where they in certain places bear a part in the formation of the Atlantic ooze. These circumstances, as well as their geological importance, confer great interest on the problem of their life-history—a problem the solution of which we do not think need be despaired of where such abundant materials are at hand. J. JOLY.

Dalkey, August 27. H. H. DIXON.

P.S.—Since the above was written we have found a few coccospheres in the water off this coast. These appear very scarce compared with the abundance of coccoliths. The abundance of the latter is remarkable. A sample of water taken some three miles from the shore on a calm day afforded, according to an estimate made with a divided stage, 200 coccoliths in each cubic centimetre of the sea-water! If this abundance obtains at other points along our coasts (we hope shortly to have results bearing upon this question), they must be one of the most abundant organic constituents of our seas.

We have found many specimens of the free coccoliths with a slimy proteid (?) attachment to the smaller valve.

Between crossed nicols the thin flange of the larger valve appears inactive; the entire inner ellipse, on the other hand, shows a dark-cross, the arms in some cases revealing a certain amount of spiral bending. A concentric and crystalline structure is thus suggested. J. J.

September 9. H. H. D.

A Bright Meteor.

ON Monday evening, the 6th inst., at 7.49 p.m. (Dublin time), I was walking from Blackrock to Dublin on the Blackrock road, and when passing by Booterstown I saw a very fine meteor of a brilliant white (such as the magnesium light) pass across the sky under the Plough at a slow rate, the course being parallel to the two lower stars of the four forming the Plough, and about the distance between the two "pointers" under it. It covered a flight of about 10° to 12°, and disappeared at a point about 15° to 20° above the horizon.

Dublin, September 9. J. P. O'REILLY.

[1] Later we netted them on silk in abundance.

The Centipede-Whale.

BESIDES the passage in Aelian about the *Scolopendra cetus*, quoted in your paper of September 9 by Mr. Minakata, there are epigrams of Theodoridas of Syracuse, and Antipater of Sidon (third and second centuries B.C.), referring to something of the sort. Aristotle's marine *Scolopendra*—a small animal—is, of course, not in point. W. F. SINCLAIR.

102 Cheyne Walk, Chelsea, S.W., September 10.

NOTES.

ON the formation of the British Section of the Pasteur International Memorial, the Secretary, Prof. Percy Frankland, F.R.S., forwarded a circular to India, and invited admirers of Pasteur there to form an Indian Section for the collection of contributions. Surgeon Major-General Cleghorn, who undertook the secretaryship of this section, has now transmitted a list of subscribers together with the substantial sum of 442*l.* 17*s.* 3*d.* to be sent on to Paris. Amongst the centres which have forwarded contributions we find Bengal, Madras, Bombay, the Punjab, Central India, Central Provinces, North-west Provinces and Oudh, Assam, Burma, Rajputana, Berar, and Baluchistan; thus indicating how widely appreciated the services of Pasteur are in our Indian Empire.

REFERRING to the ascent of Mount St. Elias, which was accomplished by the Duke of the Abruzzi (Prince Louis of Savoy) and his companions on July 31, the New York *Nation* remarks:—The two facts of special significance to which the dispatches announcing Prince Louis' success call attention are: the determination of the mountain's altitude, and the demonstration that it is not of volcanic origin, but simply a mass of elevated and partially upturned sedimentary strata, largely fossiliferous in character. The altitude, as computed by the mercurial barometer, is 18,060 feet, a result surprisingly in accord with the determination, by angle measurement, of Prof Russell, who obtained "18,100, plus or minus a probable error of 100 feet." Earlier measurements of the mountain ranged from less than 13,000 feet (La Pérouse, in 1786) to approximately 19,500 feet (Dall, 1874). It is probably safe to accept the present measurement, which places St. Elias—barring a possible excess in favour of the neighbouring Mount Logan—as the second mountain in point of elevation on the North American continent, the place of honour belonging to the Citlaltepetl, the Star Mountain—better known as the Peak of Orizaba—of Mexico, to which the determinations of Heilprin (1890, aneroid), Scovell (1891, triangulation), and Kaska (1897, mercurial barometer) give 18,2(3)00 feet. The non-volcanic nature of Mount St. Elias had already virtually been determined by Prof. Russell, but it will be a satisfaction to geologists to know that Prince Louis' studies of the mountain for the 4000 feet left untouched by Russell confirm this investigator's general conclusions.

MR. J. E. DUERDEN, Curator of the Jamaica Institute Museum, has sent us a short account of the researches in marine biology carried on this year at Port Antonio by students of the Johns Hopkins University, under the direction of Prof. J. E. Humphrey. A number of important investigations were advanced, and the material collected by the party will, no doubt, form the basis of important contributions to natural history. Prof. J. E. Humphrey studied and collected material in connection with the structure and development of plants of various groups.—Dr. F. S. Conant visited Jamaica this year to continue investigations begun by him last summer upon the *Cubomedusæ*, a rare group of jelly-fish of which two species have been found in extraordinary abundance in Jamaican waters.—Dr. H. L. Clark continued the work which he began last summer on the Echinoderms (star-fish, sea-eggs, sand-dollars, sea-cucumbers, &c.) of the island, giving especial attention to the Holothurians or "sea-cucumbers"—forms of life which are very abundant around Jamaica.—Mr. Sudler, who was also a member of last year's party, continued the collection of material exhibiting the metamorphosis, or changes during the life-history, of *Lucifer*, one of the small Crustacea which shows some very important developmental features.—Mr. Grave worked upon the sea-stars or Ophiurians, and collected twelve or more species, only five of which have been previously recorded from Jamaica. The eggs of one of the species were artificially fertilised in the laboratory, and a complete series of the embryos, from the single cell to the fifteen-day Pluteus stage, has been preserved and will be further studied.—Mr. E. N. Berger devoted his time mostly to the Insects, Arachnids (spiders, scorpions, &c.), and Myriapods (centipedes and millipodes), paying special attention to the pseudoscorpions. The pseudoscorpions are small animals, the largest collected not measuring over three-sixteenths of an inch in length. A few specimens of a second species of pseudoscorpion, smaller and more active than the first-mentioned, were collected. One interesting point determined is the building of a small nest from fragments of rotten wood, the nest being evidently lined by the animal with a fine silk when about to shed its skin. The embryo lies as if dead in this little nest, and after a time emerges with its appendages of a very pale green, which later turns to the normal brown. Little is known of the development of the pseudoscorpions, and it is expected that the material collected will aid in throwing some light on the group.—Mr. Duerden devoted himself to the Actiniaria in furtherance of the work already carried out on the south side of this island. A new species of *Bunodeopsis* was discovered, several previously obscure species were recovered, and a supply of embryological material preserved for further research.

WITH the foregoing account of this summer's work in the Johns Hopkins marine laboratory, comes to us the news of the death of Prof. Humphrey, who was in charge of the students at Port Antonio. Prof. Humphrey was only a little over thirty years of age, but his scientific works had stamped him as a botanist of much promise. He was associate professor of botany at the Johns Hopkins University, Baltimore. He graduated at Harvard University some years ago, taking the degree of Sc.D. It is significant of the position he held in the estimation of his American colleagues, that he formed one of the Botanical Commission which lately visited Jamaica to determine the best site for a botanical station. A few years ago he paid a visit to the island in connection with the Johns Hopkins University, to investigate the fauna. During the recent sojourn, which has ended so disastrously, he devoted himself principally to collecting embryological material for the benefit of his students at Baltimore, and especially material of the shell-boring algæ in reference to which he had already published his researches. His death will be deeply regretted in the botanical world.

FROM an obituary notice in the *Lancet* we have obtained the following particulars of the work of Dr. J. Braxton Hicks, F.R.S., whose death we announced last week. Dr. Hicks was born in 1823. He obtained the M.D. of the University of London in 1851, and in the following year was elected a Fellow of the Linnean Society. Ten years later he was elected to the Fellowship of the Royal Society. To medical and scientific journalism Dr. Braxton Hicks was a valued and voluminous contributor; he also published many papers in Italian, American, and Australian medical journals. From his boyhood upward he was a devoted student of natural science, and he published a number of papers on original subjects in the *Proceedings* of the Royal Society. Among these may be noted "Eyes of the Invertebrata" and "Supplementary Forces concerned in the Circulation of the Uterus." To the *Transactions* of the Linnean Society he contributed many papers on zoology and botany, and described many groups of sensory organs on the surface of insects. In the same *Transactions* he also published papers on original researches on the "Lichens, Mosses, and Unicellular Algæ"; and papers on "Volvox Globator, Amœboid Vegetable Bodies," and "Gonidia of Lichens" were contributed by him to the *Microscopical Journal*.

THE meeting of the Australasian Association for the Advancement of Science, to be held at Sydney next January, promises to be an important one. A large number of papers have been promised to the different sections, among them being: "The Classification of Eucalypts," by J. G. Luckmann; "A Statistical Account of Australian Fungi," by D. M'Alpine; "The Algæ of Victoria," by H. T. Tisdell; "Flowers of the Order Proteaceæ," by J. Shirley; "Underground Fungi of Tasmania," by R. Rodway; "Australian Oceanography," by T. W. Fowler; "On the Formation and Structure of Coral Reefs," by J. J. Wild; "The Dialectic Changes of the Indo-Polynesians," by the Rev. S. Ella; "The Oceanic Peoples," by E. Tregair; "The Ancient Geography of the Maoris," and "The Geographical Knowledge of the Polynesians," by S. Percy Smith; "Old Samoa" and "Australian Cave Paintings," by the Rev. J. B. Stair; "Ancient Maori Rites and Customs," by Mr. Elsdon Best; "The Teaching of Mechanical Drawing in State Schools," by J. Plummer; "The Characteristics of Australian and other Diamonds," by E. W. Streeter; "A Series of Microphotographs of Bacteria," by Dr. Frank Tidswell; "The Rationale of Miraculous Cures in Modern Days," by Dr. S. T. Knaggs; "Fact and Idea," by J. C. Brennan; and "Scientific Methods as applied to Modern Education," by Miss E. A. Badham.

THE death is announced of Mr. John Darlington, a well-known mining engineer, and author of a number of works on mining and metallurgy.

THE sixteenth annual congress of the Sanitary Institute opened at Leeds on Tuesday, and the President, Dr. Farquharson, M.P., delivered an inaugural address.

THE eighth annual meeting of the Federated Institution of Mining Engineers was held on Tuesday in Edinburgh, under the presidency of Sir Lindsay Wood.

THE energetic Secretary of the Society for the Protection of Birds has issued another letter of protest against the wanton destruction of birds to supply ladies with wings and feathers and stuffed skins for their bonnets. The Society is unceasing in its efforts to open the eyes of the gentler sex to the cruelty often practised in procuring plumes, and to the gradual extermination of many beautiful and beneficial birds. We regret to think, however, that such trifling matters do not disturb the minds of the majority of women when they choose their millinery. Present effect is to them the sole criterion of the value of a bonnet, and how the effect is produced they complacently leave others to inquire.

ATTENTION has already been called to the fact that the collation of the enormous mass of evidence collected by the Indian Geological Survey with regard to the great earthquake of June 12, is now being carried on under the supervision of Mr. R. D. Oldham. It is as yet too early for any final opinions to be expressed, but some of the preliminary results are of interest as showing the power of the shock. The area affected is stated to be greater than that of the Lisbon earthquake. The earlier reports as to the damage were exaggerated; but it was nevertheless very serious, as can be readily believed, as the cylinder seismometer at Shillong indicates that the shock consisted of an oscillation of 7·4 inches at the rate of 60 times a minute. All the masonry was accordingly simply shattered to pieces, rather than overthrown. Mr. Oldham's conclusions as to any possible connection between the earthquake and a continued uplift of the Himalaya will be awaited with much interest.

THE systematic position of the Dictyotaceæ has been a frequent subject of inquiry among algologists. The occurrence of tetrasporangia and of non-motile male cells has even led some to suggest an affinity with the Florideæ. Crouan was, however, of opinion that the so-called spermatia were motile; but Thuret, after a careful investigation, concluded that they were, like the similar bodies in the Florideæ, devoid of cilia, and incapable of movement. Later Johnson thought he saw evidences of ciliary movement in *Dictyopteris*, another genus of the same family. Mr. J. Lloyd Williams has now clearly established by repeated observations, carried on during this and last summer, that the antherozoids of *Dictyota* and *Taonia* are actively motile like those of Fucaceæ. It is evident that this is an observation of great importance, and botanists will look forward to the publication of details. The work has been conducted in the Botanical Laboratory of University College, Bangor, the situation of which on the shore of the Menai Straits afforded excellent facilities for the investigation.

THE wonderful expansion of mining enterprise in the West Kootanie district of British Columbia during the past few years, and the extent and richness of the deposits carrying silver and gold there, are referred to by Dr. G. M. Dawson in the latest Report (vol. viii., 1895) of the Geological Survey of Canada. One of the most noteworthy points brought out by the field-work of Mr. McConnell is the occurrence, lately ascertained, of ores of exceptional richness in parts of the granite area, which has hitherto been almost disregarded by the miners. In the Rainy Lake and Thunder Bay districts of Western Ontario, surveys have been made by Mr. McInnes in connection with the development and definition of the auriferous quartz veins and iron ores. The rocks characterising the country are divisible, in a general way, into Laurentian and Huronian; and it is in the latter that minerals of value are found to occur. Dr. Dawson states that some assays of quartz from the Manitou and Seine River regions prove the existence of quartz-veins exceptionally rich in gold, of which it only remains to determine the extent and continuance in depth. A survey of the Noddaway River in Northern Quebec, by Dr. Bell, resulted in the important geological discovery that a great area of the Huronian system exists to the north of the main watershed.

A SIMPLE experiment for determining the source of the rays from a "focus" tube is described by Dean Molloy in the *Scientific Proceedings of the Royal Dublin Society* (vol. viii. part v. 59). Dr. Molloy took a deal board measuring seven inches by five, and into it drove fifteen slender nails in three rows of five; this was attached to the back of a fluorescent screen mounted on a stand so contrived as to allow of the apparatus being revolved in a circle about the focus tube, with the screen always tangential to the circle. By noting the directions of the shadows of the nails, the exact position of the source of radiation could be determined. On adjusting the focus tube so that the central nail pointed towards the platinum plate in all positions of the screen, it was found that this nail gave only a black spot for its shadow, the shadows of the other nails radiating symmetrically from this spot as centre. It followed that the source of radiation was in the line of the central nail produced, and was thus shown to be at or about the centre of the platinum plate. Dr. Molloy then proceeded to determine the size of the area of radiation by means of a pin-hole image, and found it to be an irregularly circular ill-defined patch about a quarter of an inch in diameter, coinciding with the patch which first begins to glow when the current is turned on.

IN the *Atti dei Lincei*, vi. 4, Prof. Domenico Mazzotto gives a continuation of his observations on the electro-magnetic indices of refraction of woods. The object of the new experiments was to ascertain whether the principal indices of refraction were proportional to the square roots of the dielectric constants in the same directions, in accordance with Maxwell's theory. In the case of beech (and presumably other woods) this relation was found to be satisfied. On drying the wood, both the dielectric constants and the indices of refraction diminished correspondingly.

IN the *Rendiconto* of the Naples Academy (iii. 7), Dr. R. V. Matteucci announces the discovery for the first time of the elements iodine and bromine among the products of the fumaroles of Vesuvius. It will be remembered that only quite recently the same author discovered selenium in a similar locality.—Prof. Domenico de Francesco gives an elegant mathematical investigation of the equations of vertical motion of a balloon in free air on the assumption of Newton's law of resistance.—Prof. E. Villari gives a note on the discharging property produced in gases by certain compounds of uranium, first discovered by Becquerel.

SEVERAL partial accounts of Prof. Vicentini's valuable microseismograph have already appeared, but for the first time a complete description is given in a memoir by Dr. G. Pacher (*Atti del R. Ist. Veneto di scienze*, t. viii., 1897, pp. 1–62). The instruments described are the original form of the microseismograph, in which the length of the pendulum is 1·5 m., and its mass 100 kg., and the latest form, in which the length is 10·7 m. and the mass 408 kg. Detailed instructions are given for erecting the apparatus in a suitable place, for putting the different parts together, preparing the smoked paper, &c. There are also brief accounts, with useful bibliographies, of other instruments, such as the horizontal pendulums of von Rebeur-Paschwitz and Milne, the bifilar pendulum of H. Darwin, the vertical pendulums of Agamennone and Cancani, and the geodynamic levels of Grablovitz.

A PHYSICAL theory of the electrical phenomena of the higher atmosphere is briefly described by M. Marcel Brillouin in the *Revue Générale des Sciences* (August 30). It is now well known that any metallic body charged negatively, loses its charge when exposed to ultra-violet light. Experiments carried out in the physical laboratory of the École Normale in Paris have shown that dry ice behaves like a metal, when charged with negative electricity and exposed to ultra-violet radiations. When the ice has a film of water upon it, however, the loss of electricity is extremely small. As cirrus clouds consist of ice needles, and receive ultra-violet radiations from the sun, negative electrification may pass from the needles into the surrounding air, leaving the cloud particles charged positively. This is the basis of the theory, which is summed up by M. Brillouin as follows: (1) atmospheric electricity is produced by the action of ultra-violet solar radiations upon the ice needles in cirrus clouds; (2) the initial electrical field is produced by the movements of the higher regions of the atmosphere relatively to the earth's magnetic field.

THE *Bulletin de la Société de Geographie* contains a suggestive paper by Prof. J. Thoulet on the great need for better maps of the seas and oceans. Maps of those regions are no longer exclusively of interest to the navigator—almost every scientific man is now more or less concerned with oceanography in some of its aspects, and every day raises new practical problems connected with cables, fisheries, submarine mines, &c.—nevertheless the best accessible sea-maps are small of scale and mostly out of date. Oceanographers know that the average current-chart, faithfully copied from one atlas to another, is a disgrace to modern knowledge, but it may be doubted if the time is yet ripe for an elaborate "Sea Atlas" of large-scale maps. The scheme proposed and ably worked out by Prof. Thoulet in the second part of his paper cannot, however, be undertaken too soon. It is proposed, by careful drawing of lines on the large-scale charts, to prepare accurate contour maps of the whole of the sea-bottom within 200 metres of the surface, and then, by enlisting volunteer observers, to collect sufficient material to allow of accurate lithological classification of the deposits on the continental shelf. The distribution of these deposits could be shown by colouring on the contour charts, and we should thus be put in possession of an accurate representation of the relief and geological formation of one of the most interesting and important regions of the globe. Prof. Thoulet suggests that the deposits should be arranged under four headings: "sand," "muddy sand," "sandy mud," and "mud"; the different sorts being determined when necessary by mechanical analyses. The paper contains details referring to the French coasts, but the work is even more needed in this country.

THE publication is announced of a new "Journal of American Science," under the name *Orcutt*. The *Journal of Botany* quotes the following paragraph from the prospectus:—"No complimentary copies; no free samples; no exchanges; no advertisements in the text; no premiums; no discount to agents; the whole income going to make it better and larger. Botany and horticultural science will receive the greatest attention in the first numbers; botanists are invited to publish new species in its pages."

THE Report from the Curator, Lieut.-Colonel King, of the Royal Botanic Garden, Calcutta, for the year 1896–97, is one of considerable disaster; both that garden and the Lloyd Botanic Garden at Darjeeling having suffered much from the drought of that year, following the drought of 1895–96. Notwithstanding this, much useful work has been done in the cultivation of economic plants, the investigation of the flora of British India, and the enrichment of the herbarium. A monograph has been published of the Indian species of bamboo, by Mr. J. Sykes Gamble.

THE following are among the papers and other publications which have come under our notice within the past few days:—"On the Magnetic Properties and Electrical Resistance of Iron as dependent upon Temperature," by Dr. David K. Morris. This paper was read before the Physical Society last May, and is published in the *Philosophical Magazine* for September. The general character of the work and results are described in NATURE of May 20 (p. 70).—Prof. George H. Barton has sent us a report, reprinted from the *Technology Quarterly* (June), upon his "Glacial Observations in the Umanak district, Greenland." Prof. Barton was a member of the Boston party on the sixth Peary Expedition to Greenland, and his report is the second which has been published upon scientific work accomplished during the expedition.—"A Method of determining Magnetic Hysteresis Loss in Straight Iron Strips," by Prof. J. A. Fleming, F.R.S., read before the Physical Society on June 11 (see p. 166), and reprinted from the *Philosophical Magazine* for September.—The seventh and eighth parts of vol. ii. of Prof. G. O. Sars' "Account of the Crustacea of Norway" have just been issued by the Bergen Museum. The Desmosomidæ and part of the family of Munnopsidæ are described and illustrated.

THE additions to the Zoological Society's Gardens during the past week include a Smooth-headed Capuchin (*Cebus monachus*) from South-east Brazil, presented by Mr. W. R. Routledge; a Brown Capuchin (*Cebus fatuellus*) from Guiana, presented by Mr. C. Hardy; a Common Marmoset (*Hapale jacchus*) from South-east Brazil, presented by Mrs. C. J. Anson; an Ivory Gull (*Pagophila eburnea*) from the Arctic Regions, presented by Mr. F. G. Jackson; a Chameleon (*Chamæleon vulgaris*) from North Africa, presented by Mr. H. du Domaine; a King Parrot (*Aprosmictus cyanopygius*) from Australia, presented by

Dr. G. Granville Bantock; a Ring-tailed Coati (*Nasua rufa*), a Kinkajou (*Cercoleptes caudivolvulus*) from South America, deposited; an Indian Civet (*Viverricula malaccensis*) from India, a Chilian Sea Eagle (*Geranoaëtus melanoleucus*) from South America, purchased; a Patagonian Cavy (*Dolichotis patachonica*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE DISINTEGRATION OF COMETS.—If a comet is regarded as a swarm of meteorites, *à priori* considerations point to disintegration as its ultimate fate. Schiaparelli and Bredichin have familiarised astronomers with this fact, and the Great Comet of 1882, as well as Brooks' Comet of 1889, were visible examples of the way in which cometary members of the solar system break up in their old age. M. M. O. Callandreau has a short article in the *Bulletin Astronomique* (September) upon this disintegrating tendency, and also upon the relation of Jupiter to comets of short period. The two subjects are very closely related, for there is evidence that individual orbits in the groups of comets of short period in the neighbourhood of Jupiter have been produced by a process of separation. What M. Callandreau has done is to estimate, in a general manner, the influence the trajectory described by the head of a comet has upon disintegration, and to determine the extent of the sphere of stability at different points of the orbit both when the sun's attraction is considered alone, and when it is considered with the action of Jupiter. The subject is dealt with entirely from a dynamical point of view, no account being taken of the influence of thermal radiation from the sun or of the apparent force of repulsion exercised by the sun upon cometary material. A comet is considered as a spherical swarm of particles, and the density of the swarm is either taken as uniform or varying uniformly with distances from the centre. It appears that the elliptical form of an orbit favours disintegration. The following consequences follow from equations obtained by considering the sun's action alone: (1) When the distance of the nucleus remains constant, the extent of the sphere of stability increases with increase of velocity. (2) The relation of the radii of the spheres of stability at aphelion and perihelion is approximately equal to $\left(\frac{1-e'}{1+e'}\right)^{\frac{4}{3}}$, where e' is the eccentricity of the orbit. As to the combined influence of the sun and Jupiter, it appears that if a comet gets within the Jovian sphere of attraction, the radius of which is 0·3 the radius of the earth's orbit, the disintegrating power upon the comet when near aphelion is equivalent to that of the sun upon a comet when at a perihelion distance of 0·58.

FORECAST OF THE NOVEMBER METEOR SHOWER.—Mr. W. F. Denning continues, in the *Observatory*, an interesting paper upon "The Great Meteoric Shower of November," and predicts the probable character of the showers which will occur during the next six or seven years. His forecast for this year's display is as follows:—"In 1864 (two years before the max. of 1866), a grand display of meteors was witnessed from the deck of a ship off Malta on the morning of November 13, and meteors were conspicuously numerous on the same morning in America. We are therefore entitled to expect a pretty abundant display in 1897, and should it prove a return of the same group which supplied the meteors of 1864, it will probably return in the morning hours of November 14. But the earth will intersect a point of the meteoric orbit rather further in advance of the comet than it did in 1864, and so the exhibition of 1897 is not likely to equal the former, unless, indeed, the richer part of the stream has lengthened out in the interval of thirty-three years, which is quite possible. The really dense part of the system which furnished the brilliant European display of 1866 (max. Nov. 13, 13h. 10m.), and the equally imposing American shower of 1867 (max. Nov. 13, 22½h.), is not likely to be visible in England, as the earth will be centrally involved with it on the 14th at midday. In America something of it may possibly be seen just before sunrise on the 14th. The moon will be full on the morning of the 9th, and will therefore be gibbous on the 14th, rising at 7h. 55m. at Greenwich, and being visible in Gemini during the whole night afterwards. The prospects are therefore by no means good, but a close watch should be maintained on the mornings of the 14th, 15th, and 16th; for if the atmosphere be clear, meteors will sure to be frequent, and fine ones may appear every now and then."

THE RELATIONSHIP OF PHYSIOLOGY, PHARMACOLOGY, PATHOLOGY, AND PRACTICAL MEDICINE.[1]

THE desire for knowledge which is common to the lower animals and man, savage or civilised, and has induced members of this Congress to come from the ends of the earth in order to gain information, must have led primitive man from the earliest times to study the great problems of physiology, the nature of life, of growth, of reproduction, and of death, as well as to notice the connection of the latter with mechanical injuries, such as the wounds inflicted by clubs and spears or by the teeth and claws of wild beasts.

Next to the problems of physiology come those of pharmacology, by which I mean the poisonous or remedial action of various substances, mineral, vegetable, or animal. A knowledge of this subject is found even amongst the lowest savages, and is of the greatest use to them, for it enables them, on the one hand, to avoid eating things which may cause discomfort, pain, or death, and, on the other, to obtain food by poisoning waters and thus catching fish, or by poisoning their arrows to kill game which would otherwise escape. Closely associated with the knowledge of the poisonous is that of the curative powers of herbs, and it is possessed by animals as well as man, for cows avoid noxious plants, and dogs will every now and again eat grass apparently as medicine. Primitive peoples use various substances as remedies in disease, with more or less success, and one of the most extraordinary points in their practice is that they seem to some extent to have forestalled the newest researches on venins, anti-venins, and organotherapy, for in Africa the Bushmen are accustomed to drink the poison of venomous snakes as a prophylactic against their bite, and the Hausas prevent hydrophodia by killing the mad dog and making the man it has bitten eat its liver.

The occurrence of death from wounds or poison is intelligible even to a savage, but when illness and death occur independently of these, men naturally attribute them to invisible powers. Thus the Dyaks of Borneo ascribe sickness to wounds from invisible spears weilded by invisible spirits, and during an epidemic of disease in the Middle Ages the cry often arose that the wells had been poisoned. These crude ideas contain germs of truth, and when we look at Prof. Metschnikoff's drawings of a Daphnia attacked by a Monospora we seem to recognise the invisible darts of the Dyaks, while during an epidemic of typhoid fever we have often to acknowledge that our wells have been poisoned by bacilli.

It is impossible to trace the steps by which the crude ideas of savage peoples regarding physiology, pharmacology, and pathology have grown into definite sciences, nor even to indicate the most important landmarks, though we naturally think of the names of Alkmaon, Galen, and Harvey in physiology; of Nicander, Magendie, and Bernard in pharmacology; and of Morgagni, Virchow, and Pasteur in pathology. During this century these three sciences have developed with almost incredible rapidity, a complete knowledge of them is enough to tax severely the most retentive memory, and it is almost impossible for any individual to keep up with the advance of all three of them.

But just as the whole subject of astronomy became suddenly simplified by a change of standpoint at the very time when cycles and epi-cycles became most bewildering, so at the very time when these three sciences are becoming most complex and diverse they appear to be tending to unification and simplification. Pathology, for example, is now becoming to a great extent a branch of pharmacology, for while a few years ago its chief object was to discover, examine, and classify the microbes which give rise to disease, it is now striving rather to discover the nature and actions of the ferments and poisons which they form, and by which they are able to cause disease and death in the animals they attack. Pharmacological investigation instead of being confined to the alkaloids and other poisons formed by higher plants has now extended to those formed by microscopic plants or microbes, and thus comes to include a great part of pathology.

In the same way, though pharmacology is a branch of physiology, inasmuch as it deals with the phenomena of life as modified by drugs, yet physiology may, to a certain extent, be

[1] An address delivered at the Twelfth International Medical Congress at Moscow, on August 19, by Dr. T. Lauder Brunton, F.R.S.

regarded as a branch of pharmacology, because some of the latest researches regarding the processes of life have been made by pharmacological methods, using the products of animal life instead of vegetable poisons. Amongst the pioneers in this line I may mention my two masters, Kühne and Ludwig; the former of whom by his chemical investigations has enabled us to differentiate the various products of albuminous decomposition, whilst the latter, with his pupils Schmidt-Mühlheim and Wooldridge, discovered the poisonous action of albumoses and peptones, and of the juices of various tissues when injected directly into the blood.

Before the proteid constituents of our food can be absorbed they must be split up during digestion into albumoses and peptones; yet these researches show that the very substances which are necessary to repair waste and are indispensable for the continuance of life, prove fatal when introduced into the body in a wrong way, or too great quantity. But the products of the digestion of albumin do not normally enter the circulation as albumoses and peptones. During absorption they undergo changes of a synthetic nature in the walls of the intestine, and probably to a certain extent also in the liver, so that they again form harmless substances, and their poisonous properties are destroyed before they enter the general blood stream.

But how is it that the ferments which decompose albuminous food and form poisons from it in the intestine do not pass into the blood and kill the animal by digesting the tissues and forming poisons from them? Of course pepsin cannot do so as it only acts in an acid medium, but there is no such hindrance to the action of trypsin, and yet it does not destroy the tissues composing the body itself. In all probability the reason why digestive ferments do not digest the tissues is not that they are destroyed in the digestive canal, nor yet that they are not absorbed, but that they are altered from active enzymes into inert zymogens which can be stored up without risk, and can again liberate active enzymes when these are required to digest a subsequent meal. In this respect they may be compared to the knives used by wandering peoples to cut up their meat, and which are not thrown away after each meal, but are simply put into sheaths which cover their edges and deprive them for a time of their cutting power.

But it is not in the intestine only that enzymes are found, they are also poured into the blood by the pancreas and probably by the thyroid and other glands. As our acquaintance with the processes of cell life increases, it seems more and more likely that the tissue change on which functional activity depends is effected by enzymes, and the truer do the speculations of Van Helmont appear—that life is a process of fermentation.

There can be little doubt that if enzymes in a free state were to circulate through the body they would do much harm, and indeed we may regard this as well-nigh proved in regard to the enzyme of tetanus.

But their action is limited either by their conversion into zymogens or their localisation to the cells or tissues where their action is required. This is more readily seen in plants than in animals, and one of the best examples of it is that in germinating wheat.

In the ordinary state of the grain the diastatic ferment is kept apart from the starch by a small layer of cellulose, through which the diastase cannot pass, but during germination another ferment appears which has the power of dissolving cellulose, and by breaking down this dividing membrane it allows the diastatic ferment to act upon the starch, and renders it available for the needs of the growing plant.

Enzymes appear to differ amongst themselves nearly as much as do albumin, albumoses and peptones. Some are easily separated from the cells in which they exist, whilst others are so closely united to the protoplasm that their separate existence apart from it has been denied. The yeast plant, for example, yields an invert enzyme which can be extracted with comparative ease, but the enzyme which splits up sugar into alcohol and carbonic acid is so firmly attached to the protoplasm of the cell that it is only within the last few months that it has been isolated by Buchner by the application of enormous pressure. It is probable that the enzymes contained in the cells of animal tissues differ in like manner, and that by the use of similar methods we may obtain a number of enzymes with which we are at present unacquainted.

But it is not merely the products formed in the digestive canal, or in the organs of animals during life, nor even the alkaloids that are formed by the higher plants, that act as poisons. The processes of life are much the same in the lowest microbes as in animals, or in the higher plants. and these microbes, by forming ferments and poisons, give rise to disturbance of function or death in animals. When grown in suitable media outside the body they produce enzymes and poisons, albumoses and alkaloids, and many of them continue to do so after their introduction into the body.

One of the most curious points, both in the chemistry of the higher plants and of microbes, is that they tend to form at the same time a poison and its antidote. In Calabar bean, for example, we find there are two poisons—physostigmine and calabarine, the former tending to paralyse the spinal cord and the latter to stimulate it, so that each poison to a certain extent antagonises the other. The same condition is found even more markedly in jaborandi, of which the two alkaloids pilocarpine and jaborine antagonise one another's action so that, although pilocarpine generally greatly predominates, it might be possible to get a specimen of the leaf having no action at all although it contained a quantity of alkaloids.

When injected into animals the toxins formed by microbes and the venins of serpents cause the production of anti-toxins and anti-venins which neutralise their action apparently by chemical combination in somewhat the same way as an acid and alkali, each poisonous by itself, combine to form a comparatively inert salt. But the two components here, like an organic acid and a mineral base, are unequally affected by destructive agencies, and the anti-venin may be destroyed, so that the venin again regains its activity.

The conversion of zymogens into enzymes may be compared to the freeing of venins from their compounds, while the conversion of active venins into inert bodies by combination with anti-venins suggest that a similar process may occur in the case of active enzymes, by which they may be converted into inactive zymogens.

Perhaps the hypothesis I mentioned eight years ago to my pupil and friend, Mr. Hankin, that the germicidal power of organisms is proportional to their power to produce enzymes may not be altogether unfounded, and possibly we may discover also that immunity, natural or acquired, is nothing more than an extension to the cells of the tissues generally of a power which is constantly exercised during digestion by those of the intestine and liver.

This problem is one which pertains to all three sciences, and has a most important bearing on practical medicine.

Practical medicine, except when empirical, depends for its advance on physiology, pharmacology, and pathology. A knowledge of the physiology of digestion has led to the satisfactory treatment of dyspepsia by the administration of digestive enzymes, and pharmacological research has enabled us to treat diseases of the circulation with a success previously undreamt of, by teaching us not only how to use aright old remedies, such as digitalis, but also how to apply new ones, such as strophanthus and amyl nitrite, and even to manufacture others, such as nitro-erythrol, which possess the special actions we desire, but are lacking in the drugs we already have. Indeed new remedies, which shall alter tissue change, lower temperature, relieve pain, and procure sleep, are now being made in such numbers that it is hard to keep count of them.

But amongst all the new gains of practical medicine none are so remarkable as those which we owe to pathology. Time would fail me to speak of the prevention and cure of zymotic diseases, but no less astonishing is the discovery that myxœdema depends on inactivity or absence of the thyroid gland, and can be cured by the administration of its extract, which seems to act as an enzyme on living tissues, so that the heavy, shapeless features of the patient resume their natural expression, and the sluggish mental processes become quickened. An exhaustive study of enzymes and their products appears to be the most promising way of advancing our knowledge both of the nature and treatment of disease. Probably more is to be hoped for from an investigation into the nature and properties of those enzymes which are intimately associated with the protoplasm of the cells in the various tissues and organs than even of those which are poured into the blood by glands having an internal secretion, such as the thyroid. For all organs, even those which like muscles and nerves are not glandular, have an action on the blood comparable to that of the yeast plant, which modifies the fluid in which it lives by the substances which it removes from or adds to it. It is to a knowledge of the processes which occur in the protoplasm of the cells in the intestinal wall and liver, and of the enzymes by which these processes are in all probability carried out that we must look for an explanation of the conversion of the poisonous albumoses formed during digestion into innocuous albumins, and of dangerous enzymes into harmless zymogens.

Moreover, it seems to me that it is by researches into the nature and action of the enzymes not only of microbes, but in the various tissues of the body in higher animals, that we shall learn how the microbes, like the enzymes of the intestinal canal, produce poisonous albumoses, and how the tissues, like the cells of the intestinal walls or liver, convert them into harmless or even protective substances. In this way we may hope to obtain an explanation of toxins and anti-toxins, of pathogenesis and immunity, as well as of the nature of diseases unconnected with the presence of microbes, such as diabetes. Twenty-three years ago I attempted to obtain a glycolytic enzyme from muscle, in order to enable diabetic patients to utilise the sugar in their blood. My attempt was unsuccessful, but we may still hope that by other methods we may obtain from animal organs various enzymes, the administration of which may prove as useful in other diseases as the thyroid in myxœdema.

Practical medicine depends on physiology, pharmacology, and pathology, but all three are tending to become more and more subdivisions of the wider and all-embracing science of chemistry. It is to a chemist, Pasteur, that we owe the wonderful development of pathology within the last quarter of a century, and we may fairly regard his fellow-countryman, Lavoisier, as the founder of this science. Men from all countries, and especially from Germany, have aided its development; but it seems fitting that at this Congress, in acknowledging our obligations to this science, we should not omit to mention that at its head now stands a Russian, Mendeleef, whose marvellous prescience enabled him to predict the existence of elements which were then unknown and even to describe their properties more correctly than those who first verified his predictions by obtaining the substances themselves. When we consider that little more than a hundred years have elapsed since the time of Lavoisier, and contemplate the vast benefits which medicine and its allied sciences have derived from chemistry during this time, our hopes cannot be otherwise than great for the centuries to come.

THE BRITISH ASSOCIATION.

TORONTO, *August* 25.

THIS has not been a large, but it has been a very interesting and satisfactory meeting both from the scientific and the social point of view. Out of the 1362 persons present, an unusually large proportion were well-known representative men of science. The more prominent members of each section seem to be with us, and it has been frequently remarked during the meeting that in our sectional officers we have brought over an unusually strong team. We have a fair number of distinguished foreigners, and a considerable number of the members of the American Association: these foreign members include General Billings, Dr. Anton Dohrn of Naples, Profs. Minot, Newcomb, Osborn, Putnam, Ira Remsen, Runge (Hannover), and others. Many Canadians have also taken part in the proceedings, and it may be said that in all the sections the work has been influenced in its nature and direction by our place of meeting. Canadian surveys, geography and climate, the chemistry of the soil, the fisheries and the biology of the lakes, the plants, the timber from the engineering point of view, statistics and trade combinations all received attention; while Sections C (Geology) and H (Anthropology) may fairly be said to have been dominated by the local spirit. The president of C was a distinguished Canadian geologist, Dr. George Dawson, and although the preliminary arrangements had to be made in this case by correspondence, the work of the section was remarkably well organised, and an unusually large number of abstracts were printed. There were papers and demonstrations on the rocks of North America from the Laurentian to the Glacial deposits, and several expeditions of geological interest were organised under local leaders. The Anthropological Section had a succession of interesting papers—notably those of Miss Alice Fletcher—dealing with the folk-lore, customs, religion, &c., of the North American Indians. The work of these two sections appropriately culminated to-day in a joint discussion on "The First Traces of Man in North America," during which Prof. Putnam gave an account of the supposed remains from the Trenton gravels. Prof. Claypole spoke of the human relics in the Drift of Ohio, and Sir John Evans criticised the evidence adversely and showed the probability of error as to the occurrence of the specimens supposed to be from glacial deposits.

Amongst other notable papers which attracted public attention were Profs. Meslans, Moissan and Dewar's demonstration of the preparation and properties of fluorine, and Lord Kelvin's statement as to the fuel supply and air supply of the world.

There seemed to be comparatively few joint meetings of sections—perhaps because each section was so full of its own work. Besides the combined session of C and H, mentioned above, E and F met to hear Mr. F. C. Selous on the economic geography of Rhodesia, and sections C, I, and K joined in discussing the chemistry and structure of the cell *à propos* of Prof. Meldola's paper on the rationale of chemical synthesis, Prof. Green's paper on an alcohol-producing enzyme in yeast, Prof. Macallum's paper on the significance of intracellular structures, and some histo-chemical demonstrations by Profs. Boyce and Herdman on the presence of copper, and by Prof. Macallum on the distribution of iron, in tissue cells.

The custom seems increasing in most of the sections of having a certain number of short addresses, lecturettes, or demonstrations on subjects of novelty or current scientific interest given at fixed times, and usually illustrated by lantern slides. Amongst these at the present meeting may be mentioned:—Sir George Robertson on Kafiristan, Prof. Dixon on explosion flames, Prof. Osborn on American Tertiary mammals, Dr. Munro on the Glastonbury Lake Village, Prof. Herdman on the oyster question, Prof. Poulton on mimicry and natural selection, Prof. Haddon on the evolution of the cart and the Irish car, and Mr. Seward's address on fossil plants. Section K had also some interesting papers and discussions on hybridisation, including an account by Dr. W. Saunders, Director of the Dominion Experimental Farms, of some experiments in cross-fertilisation made with the practical object of producing improved forms of apple and other fruit trees which will stand the severe climate of the North-west Territories. As an outcome of our visits to the experimental farms, and of what we have heard of them, both in the sections and outside, an important resolution, forwarded from Section B (Chemistry), has passed the Committee of Recommendations and the General Committee, to the effect that "the Council be requested to consider the desirability of approaching the Government with the view of the establishment in Britain of experimental agricultural stations similar in character to those which are producing such satisfactory results in Canada."

It may also be stated that, as the result of the consideration given by Section D to the fauna of the lakes, it is expected that a biological station will shortly be established by the Government of Ontario. A deputation of zoologists with this object in view waited upon the Premier and other members of the Cabinet, and the proposition was very favourably received. A fuller account of this matter will be given in the report of the proceedings of Section D.

Several of the sections, recognising that we are meeting in a new country, the natural products of which are more or less unfamiliar to many of the members, organised afternoon and even whole-day excursions in the neighbourhood of Toronto, under the guidance of local leaders. In this way Section B visited the chemical works at Niagara, Section C the glacial deposits, while Sections D and K had several joint expeditions to localities of biological interest. The General Committee at its final meeting to-day passed the report of the Committee of Recommendations recommending grants to committees for scientific purposes amounting to 1350*l.*, a much larger sum than has been voted for some years. One of the reasons of this increase is that the committee are extremely anxious to make some grants for the pursuit of local investigations, to be expended by the various committees which have been appointed for the purpose of study and research in Canada. These Canadian committees are appointed for the following objects: the establishment of a meteorological observatory on Mount Royal, the investigation of the pleistocene fauna and flora, the collection of geological photographs, the biology of the lakes of Ontario, the condition of the North-west tribes, the ethnographic survey of Canada, and the establishment of a biological station in the Gulf of St. Lawrence. The total amounts voted to Committees are shown on the next page.

A—*Mathematics and Physics.*

	£	s.	d.
*Foster, Prof. Carey.—Electrical Standards	75	0	0
*Symons, Mr. G. J.—Seismological Observations	75	0	0
*Atkinson, Dr. E.—Abstracts of Physical Papers	100	0	0
*Harley, Rev. R.—Calculation of Certain Integrals	20	0	0
*Shaw, Mr. W. N.—Electrolysis and Electro-chemistry	35	0	0
Callendar, Prof.—Meteorological Observatory at Montreal	50	0	0
B—*Chemistry.*			
*Roscoe, Sir H. E.—Wave-length Tables of the Spectra of the Elements	20	0	0
*Reynolds, Prof. J. Emerson.—Electrolysis Quantitative Analysis	12	0	0
*Thorpe, Dr. T. E.—Action of Light upon Dyed Colours	8	0	0
Evans, Sir J.—Promotion of Agriculture	5	0	0
C—*Geology.*			
*Hull, Prof. E.—Erratic Blocks	5	0	0
*Bonney, Prof. T. G.—Investigation of a Coral Reef	40	0	0
*Flower, Sir W. H.—Fauna of Singapore Caves (unexpended balance in hand, 40*l.*)	—		
*Geikie, Prof. J.—Photographs of Geological Interest	10	0	0
*Marr, Mr. J. E.—Life-zones in British Carboniferous Rocks (unexpended balance in hand)	—		
Dawkins, Prof. W. Boyd.—Remains of the Irish Elk in the Isle of Man (unexpended balance in hand)	—		
*Jamieson, Mr. T. F.—Age of Rocks near Moreseat	10	0	0
Dawson, Sir J. W.—Pleistocene Fauna and Flora in Canada	20	0	0
D—*Zoology.*			
*Herdman, Prof. W. A.—Table at the Zoological Station, Naples	100	0	0
*Bourne, Mr. G. C.—Table at the Biological Laboratory, Plymouth	20	0	0
*Flower, Sir W. H.—Index Generum et Specierum Animalium	100	0	0
Miall, Prof.—Biology of the Lakes of Ontario	75	0	0
*Herdman, Prof. W. A.—Healthy and Unhealthy Oysters	30	0	0
E—*Geography.*			
*Ravenstein, Mr. E. G.—Climatology of Tropical Africa	10	0	0
F—*Economic Science and Statistics.*			
Sidgwick, Prof. H.—State Monopolies in other Countries	15	0	0
Price, Mr. L. L.—Future Dealings in Raw Produce	10	0	0
G—*Mechanical Science.*			
*Preece, Mr. W. H.—Small Screw Gauge	20	0	0
H—*Anthropology.*			
*Tylor, Prof. E. B.—North-western Tribes of Canada	75	0	0
*Munro, Dr. R.—Lake Village at Glastonbury	37	10	0
*Brabrook, Mr. E. W.—Ethnographical Survey (and unexpended balance in hand)	25	0	0
*Evans, Mr. A. J.—Silchester Excavation	7	10	0
*Dawson, Dr. G. M.—Ethnological Survey of Canada	75	0	0
Turner, Sir W.—Anthropology and Natural History of Torres Strait	125	0	0
I—*Physiology.*			
Gaskell, Dr. W. H.—Investigation of Changes associated with the Functional Activity of Nerve Cells and their Peripheral Extensions	100	0	0
K—*Botany.*			
Farmer, Prof. J. B.—Fertilisation in Phæophyceæ	15	0	0
Corresponding Societies.			
*Meldola, Prof. R.—Preparation of Report	25	0	0
	£1350	0	0

* Reappointed.

The evening lectures given before the Association were much appreciated. The projection of Prof. Roberts-Austen's electrical furnace upon the screen was especially a source of much interest to the inhabitants of Toronto. The evening reception given by the Governor-General and Lady Aberdeen was a brilliant function. At the second conversazione, given by the Local Executive Committee, one missed the usual lantern lectures, demonstrations and exhibits; but it was a pleasant gathering marked by much cordiality between hosts and guests, and utilised by members for comparing notes as to the work of the sections, and as to plans for taking advantage of the numerous expeditions and visits to places of interest provided for their visitors by the Local Committee. Four parties start for the Pacific coast during the next few days, stopping at various points of scientific or industrial interest on the way, under the guidance of men of first-rate local knowledge such as Dr. George Dawson, Dr. W. Saunders, Mr. Walker, one of the Local Secretaries, and others. The end of this article is being written in the train as the first of these parties, including Lord Kelvin and Sir John Evans, is passing along the northern shores of Lake Superior. Other expeditions have been organised to the Muskoka Lakes, to Niagara, to Parry Sound, &c., in addition to visits to Montreal and Ottawa.

The arrangements of the Local Committee have been excellent, and it was felt at the concluding meeting, when cordial votes of thanks were passed to our hosts, to the Local Executive, and especially to Prof. Macallum and his colleagues the Local Secretaries and Treasurers, that much hard work had been done, and that our thanks were thoroughly deserved. The University of Toronto and Trinity University both conferred honorary degrees upon a few of their eminent guests, and a great banquet in honour of Lord Kelvin, Lord Lister and Sir John Evans, the three notable figures of the gathering, formed a fitting and enthusiastic termination to a memorable meeting.

W. A. HERDMAN.

SECTION K.

BOTANY.

OPENING ADDRESS[1] BY PROF. H. MARSHALL WARD, SC.D., F.R.S., F.L.S., PRESIDENT OF THE SECTION.

THERE are many industrial processes which depend more or less for their success on bacterial fermentations. The subject is young, but the little that has been discovered makes it imperative that we should go on, for not only are the results of immense importance to science, but they open up vistas of practical application, which are already being taken advantage of in commerce, and we may be sure that every economic application of such knowledge will give the people employing it an advantage over those who proceed by the old rule-of-thumb methods, where nobody knows or cares where the waste or leakage occurs that spoils a commercial product.

The discovery by Alvarez of the bacillus which converts a sterilised decoction of indigo plant into indigo sugar and indigo white, the latter then oxidising to form the valuable blue dye, whereas the sterile decoction itself, even in presence of oxygen, forms no indigo, may be cited as a case in point. It remains to be decided whether this bacillus alone is concerned, or whether the infusion of indican will ferment under the action of enzymes alone derived from the leaves of the indigo plant. It also remains for future investigation to determine whether the indigo bacillus is the same as the pneumonia bacillus—which resembles it—and will also induce the indigo fermentation, and to explain why the woad-makers of the Fens find a sale for this indigo preparation among indigo makers, as well as to clear up certain mysterious "diseases" in the indigo-vats. Our much more extensive knowledge of the diseases of beer and wine suggests the possibility of profitable bacteriological investigations in several directions here.

That certain stages in the preparation of tobacco-leaves—as also in the preparation of tea—depend on a carefully regulated fermentation, which must be stopped at the right moment, or the product is impaired, or even ruined, has long been known. Regarding the possible *rôle* of bacteria in the preparation of tea, nothing is ascertained, but, if Suchsland's investigations are confirmed, there is among the many and various organisms concerned in the fermentation of West Indian tobacco a bacterium which has been isolated and plays an important part. It is

[1] Concluded from p. 461.

claimed that the flavour of European-grown tobacco can be materially improved by its use. I read that the process is patented, which may or may not affect its value as a scientific announcement; but in view of the increasing number of researches into this subject by Behrens, Dávalos, Schloesing, and others, it is evidently a domain for further bacteriological investigations in a properly equipped laboratory.

Every botanist knows that flax and hemp are the bast fibres of *Linum* and *Cannabis* respectively, separated by steeping in water until the middle lamella is destroyed and the fibres isolated; but it is perhaps not so well known that not every water is suitable for this "retting" or steeping process, and for a long time this was as much a mystery as why some waters are better than others for brewing.

Only quite recently Fribes, working under Winogradsky, has isolated the bacillus which accomplishes this dissolution of the middle lamella, and its behaviour brings to light some very interesting details, and furnishes another of those cases where the reactions of living micro-organisms can be utilised in deciding questions of plant chemistry too subtle for testing with ordinary reagents.

You are aware that recent researches, especially those of Maquin in France and of Walter Gardiner in Cambridge, Cross and Bevan and others, have caused us to discard the view that the middle lamella is composed of cellulose, and to learn that it consists of pectin compounds. Now Fribes' anaërobic bacillus dissolves and destroys pectins and pectinates, but does not touch cellulose or gum, and thus enables us to criticise from a new point of view the bacillus (*B. Amylobacter*) which Van Tieghem asserted to be the cause of cellulose fermentation and the retting of flax. Clearly it cannot be both, otherwise the flax-fibre would be destroyed; and we know from other facts that *B. Amylobacter* is not the cellulose ferment.

Fribes' discovery has yet to be tested with reference to other processes of retting. The Indian Government have lately published a series of notes on jute and other fibres, and the description of the retting of jute suggests this as a very definite problem for investigation.

I am told that a patent exists in the United States for a process whereby the retting organisms may be sown and encouraged in waters otherwise unfitted for the steeping of flax, &c., another indication of the keen interest taken in these matters.

It goes without saying that the steeping of skins in water in preparation for tanning involves bacterial actions, owing to which the hair and epidermal coverings are removed; but it appears from recent investigations that in the process of swelling the limed skins, the gases evolved in the substance of the tissues, and the evolution of which causes the swelling and loosens the fibre so that the tanning solutions may penetrate, are due to a particular fermentation, caused by a bacterium which, according to Wood and Wilcox, is similar to, if not identical with, a lactic ferment. If Haenlein's results may be accepted, it is a bacillus introduced into the tanning solution by the pine bark, which is responsible for the advantageous acidification of the tanning solutions much valued for making certain kinds of leather, and of decisive importance in the quality, so that tanners add the souring liqour of other vats to encourage the souring of the doubtful one.

Hay is made in very different ways in different countries, and in those where a "spontaneous" heating process is resorted to there seems to be no doubt that certain thermogenic bacteria are concerned. The researches of Böhmer, Dietrich, Fry, Lafar, and others show that here and in the preparation of ensilage we have important fermentation processes which affect the end result.

The whole question of fermentation in hay, and the high temperatures produced in the process, as well as what occurs in straw-stacks under similar conditions, have important theoretical bearings, and we know of bacilli which grow at 70° C.

Probably no other subject in this domain has, however, attained so much importance as the bacteriology of the dairy—the study of the bacteria found in milk, butter, and cheese in their various forms. In all cases of this kind, as in brewing, bread-making, and so on, there are three aspects of the bacteriology of the operations: we have to consider first the bacteria concerned in the normal process; secondly, introduced forms which bring about abnormalities, or "diseases" of the normal operation; and, thirdly, the possible pathogenic bacteria, *i.e.* pathogenic to man, which may lurk in the product.

Of milk especially much has been said as a disease-transmitting medium, and with good reason, as is well known; and if we may accept the statement of a continental authority, who calculated that each time we eat a slice of bread and butter we devour a number of bacteria equal to the population of Europe, we have grounds for demanding information as to what these bacteria are, and what they are doing. And similarly with cheese, every kind of which teems with millions of these minute organisms.

Now I cannot, of course, go into the question of pathogenic bacteria, nor is there time to discuss those forms which bring about undesirable or abnormal processes in the dairy; but I want to call your attention to the splendid field for bacteriological investigation which is being opened up by inquiries into the normal changes utilised in making butter and cheese.

We may pass over the old controversies as to the souring of milk, culminating in Pasteur's discovery of the bacteria of lactic fermentation in 1857–58. Lister in 1877 isolated *Bacterium lactis*. Hueppe in 1884 confirmed his results, and added several other lactic bacteria, and we now know a whole series of forms which can turn milk sour by fermenting its sugar, and this in various ways, as Warington and others have shown. The souring of milk and cream by merely leaving it to stand often led to failure, and the study of this preliminary to butter- and cheese-making is itself a bacteriological question of great importance. We shall not be surprised, therefore, that when, in 1890, Wiegmann proposed to use pure cultures of lactic-acid bacteria for the souring of cream, the plan was at once taken up.

Some years ago Storch found that the peculiar aroma of a good butter was due to a bacterium which he isolated, and Wiegmann has now two forms, or races, one of which develops an exquisite flavour and aroma, but the butter keeps badly, while the other develops less aroma, while the butter keeps better.

According to a recent publication of Conn's, however, this subject has been advanced considerably in America, for they have isolated and distributed to numerous dairies pure cultures of a particular butter-bacillus which develops the famous "June flavour" hitherto only met with in the butter of certain districts during a short season of the year. I am told that this fine-flavoured butter is now prepared constantly in a hundred or more American dairies. Simultaneously with these advances in the manufacture of pure butter with constant flavour, the days of "diseased" butters seem numbered.

Properly considered, the manufacture of cheese is a form of microscopic gardening even more complex and more horticultural in nature than the brewing of beer. From the outset, when the cheesemaker guards and cools his milk till his stock is ready, he is doing all he knows how to do to keep down the growth of the germs introduced into the milk; he then coagulates it, usually with rennet—an enzyme of animals, but also common in plants—and the curd thus prepared is simply treated as a medium on which he grows certain fungi and bacteria, with the needful precautions for favouring their development, protecting them against the inroads of animal and plant pests, and against unsuitable temperature, moisture, access of light, and so on. Having succeeded in growing the right plants on his curd, his art then demands that he shall stop their growth at the critical period, and his cheese is ready for market.

The investigations of Duclaux, Wiegmann, and others on the continent, of Conn in America, and of Lloyd in England, to say nothing of other workers now busy at this subject in various parts of the world, are getting at the particular forms of fungi concerned in so altering the constitution of curd that it becomes the very different article of food we call cheese, and they have even determined to some extent what *rôle* is played by these plants in giving the peculiar odours and flavours to such different cheeses as Camembert, Stilton, and Roquefort. It is known, for instance, that a certain fungus (*Penicillium*) cultivated on bread is purposely added to Roquefort, and that it destroys the lactic and other acids, and so enables certain bacteria in the cheese, hitherto inhibited in their actions by these acids, to set to work and further change the medium, whereas in making Emmenthaler cheese the object is to prevent this fungus thus paving the way for these bacteria. Pammel claims to have discovered a bacillus which gives a peculiar and much-admired clover aroma to certain cheeses, and according to recent statements a definite *Streptococcus* is responsible for the peculiarities of certain Dutch cheeses, and so on. Nevertheless, we are still profoundly ignorant of most of the forms concerned in the ripening of cheese, and every research which throws light on this difficult and complex subject, and so paves the way to rendering uniform and certain this at present most haphazard and risky manufacture will be doing service to the State. Considering that Cohn only discovered that the ripening process is due to bacteria in 1875, and that Duclaux only published his researches on *Tyrothrix* in 1878, we can scarcely be surprised that the interval has not been long enough for the isolation and study of the numerous and curious forms, several hundreds of which are now imperfectly known. Nevertheless, there are signs of advance in various directions, and researches into the mysteries of Roquefort, Gorgonzola, Emmenthaler, and other cheeses are being industriously pursued on the continent. Even as I write this comes the news that Freudenreich has discovered the coccus which causes the ripening of Emmenthaler cheese. It is not impossible that the much more definite results obtained by investigations into the manufacture of the vegetable cheeses of China and Japan will aid bacteriologists in their extremely complex task.

These vegetable cheeses are made by exposing the beans of the leguminous plant *Glycine*—termed soja-beans—to bacterial fermentations in warm cellars, either after preliminary decomposition by certain mould-fungi, or without this. The processes vary considerably, and several different kinds of bean-cheeses are made, and known by special names. They all depend on the peculiar decompositions of the tissues of the cotyledons of the soja-bean, which contain 35 to 40 per cent. of proteids and large quantities of fats. The softened beans are first rendered mouldy, and the interpenetrating hyphæ render the contents accessible to certain bacteria, which peptonise and otherwise alter them.

Here, however, I must bring this subject to a close, and time will not permit of more than the mere mention of the vinegar fermentation, to which Mr. Adrian Brown has lately contributed valuable knowledge, of the preparation of soy, a brine extract of mouldy and fermented soja-beans, of bread-making, and other equally interesting cases.

When the idea of parasitism was once rendered definite, as it was by De Bary's work, and the fundamental distinction between a parasite and a saprophyte had been made clear, it soon became evident that some distinction must be made between *obligate facultative parasites* and *saprophytes* respectively; but when De Bary proposed the adoption of these terms of Van Tieghem's he can hardly have contemplated that they would be abused as they have been, and was clearly alive to the existence of transitions which we now know to be so numerous and so gradual in character that we can no longer define any such physiological groups.

Twenty years ago *Penicillium* and *Mucor* would have been regarded as saprophytes of the most obligate type, but we now know that under certain circumstances these fungi can become parasites; and the border-land between facultative parasites and saprophytes on the one hand, and between the former and true parasites on the other, can no longer be recognised.

In 1866 the germ of an idea was sown which has taken deep root and extended very widely. De Bary pointed out that in the case of lichens we have either a fungus parasite on an alga, or certain organisms hitherto accepted as algæ are merely incomplete forms. In 1868 Schwedendener declared the lichen to be a compound organism.

In 1879, in his celebrated lecture, De Bary definitely launched the new hypothesis, and brought together the facts which warranted his disturbance of the serenity of those unprepared to accept so startling a new notion as *Symbiosis*.

The word itself, in the form "Symbiotismus," is due to Frank, who, in an admirable paper on the biology of the thallus of certain lichens, very clearly set forth the existence of various stages of life in common.

This paper has been too much overlooked; but its existence is the more noteworthy from its being in the same number of the "Beiträge zur Biologie"—which we owe to Cohn, the founder of scientific bacteriology—in which Koch's remarkable paper on Anthrax occurs.

The details of these matters are now principally of historical interest; we now know that lichens are dual organisms, composed of various algæ, symbiotic with ascomycetes and even basidiomycetes, and, as Massee has shown, even gastromycetes. The soil contains also bacterio-lichens. The point for our consideration is rather that botanists were now awakened to a new biological idea—viz. that a fungus may be in such nicely balanced relationships with the host from which it derives its supplies as to afford some advantage in return, whence we must look upon the limited liability company formed by the two symbionts as a better business concern than either of the plants could establish for itself—a case, in fact, where union is strength. Symbiosis, consequently, is now understood to be of advantage to both the symbionts, and not to one only, as is the case in parasitism, or, to use Vuillemin's term, *Antibiosis*.

In 1841 an English botanist, Edwin Lees, discovered the existence of "a hirsuture that appears like a byssoid fungus" on the roots of *Monotropa*, and observed that the hyphæ linked the roots to those of a beech; he regarded the fungus as conveying nutriment from the latter to the former, and as an essential constituent of the *Monotropa*. This discovery was published in the now defunct "Phytologist" for December 1841, and was unearthed by Oliver and by Dr. Dyer, of Kew. This is apparently the first observation of a mycorhiza yet recorded, and, although the naturalists referred to did not understand the full significance of Lees' find, several of them made excellent guesses as to the meaning of the phenomenon. As Dr. Dyer points out, it disposes of Wahrlich's claim that Schleiden (1842) first discovered mycorhiza, as well as of Woronin's contention that the priority is due to Kamienski, though the latter (1881–82) probably was the first to clearly indicate that we have here a case of symbiosis, and thus anticipated Frank's generalisation in 1885.

Kamienski and Frank, followed by numerous other observers, among whom Oliver and Groom are to be mentioned, have now shown that the peculiar type of symbiosis expressed in this intimate union of fungus-hyphæ with the living cells of the roots of trees and other plants in soils which abound in vegetable remains—*e.g.* leaf-mould, moors, &c.—is very common.

In the humus of forests we find the roots of beeches and other *Cupuliferæ*, willows, pines, and so forth, clothed with a dense mantle of hyphæ and swollen into coral-like masses of mycorhiza; in similar soils, and in moorlands which abound in the slowly decomposing root-fibres and other vegetable remains so characteristic of these soils, the roots of orchids, heaths, gentians, &c., are similarly provided with fungi, the hyphæ of which penetrate further into the tissues, and even send haustoria into the living cells, but without injuring them.

As observations multiplied it became clear that the mycorhiza, or fungus-root, was not to be dismissed as a mere case of roots affected by parasites, but that a symbiotic union, comparable to that of the lichens, exists; and that we must assume that both the tree and the fungus derive some benefit from the connection.

Pfeffer, in 1877, suggested that the deficiency of root-hairs observed in orchids might be explained by the fungus-hyphæ playing the part of these organs, and taking up materials from the soil which they then handed on to the roots. He is quite clear on the subject, and recognises the symbiosis definitely, comparing it with other cases of symbiosis indicated by De Bary.

Frank stated that, as the results of experiments, seedling forest-trees cannot be grown in sterilised soil, where their roots are prevented from forming mycorhiza, and concluded that the fungus conveys to the roots organic materials, which it obtains by breaking down the leaf-mould and decaying plant-remains, together with water and minerals from the soil, and plays especially the part of a nitrogen-catching apparatus. In return for this important service the root pays a tax to the fungus by sparing it certain of its tissue contents, and no doubt can well afford to do so.

It appears that the mycorhiza is only formed where humus or vegetable-mould abounds. In sandy soils the roots bear root-hairs, as usual, and it is now clear that, while mycorhiza is a far more general phenomenon than was previously supposed, it is not essential for all the roots, nor even under all circumstances for any of them.

Probably what really happens is this. Trees and other plants with normal roots and root-hairs, when growing in ordinary soil, can adapt their roots to life in a soil heavily charged with humus only by contracting the symbiotic association with the fungus and paying the tax demanded by the latter in return for its supplies and services. If this adaptation is impossible, and no other suitable variation is evolved, such trees cannot grow in such soils.

In certain cases—*e.g.* ground orchids, *Monotropa*, various *Ericaceæ*, &c.—it would seem that the plant is unable to grow in other than humus soils, and always forms mycorhiza.

Much further we cannot at present go, but it is evident that various different grades of symbiosis exist in these mycorhizas.

In the first place, there are several different fungi concerned—those on cupuliferæ and pines, apparently mostly *Tuberaceæ* and *Gasteromycetes*, and allied forms, being different from those in orchids, some at least of which appear to be *Nectrias* or related genera.

The physiological relations of the root to the fungus must be different in details in the case of non-green, purely saprophytic plants, like *Neottia*, *Monotropa*, &c., and in that of the green plants like *Erica*, *Fagus*, *Pinus*, &c.

It is well known that ordinary green plants cannot utilise vegetable débris directly, whereas trees in forests appear to do so: this in appearance only, however, for the fungi, yeasts, and bacteria there abounding are actively decomposing the leaves and other remains.

Now it is possible that the mycorhiza theory is not applicable in all cases, and that, sometimes, what happens is this. The trees, once well established, make so good a fight that in spite of the leaf-decomposing fungi attacking their roots parasitically, or merely ensconcing themselves in the dead primary cortex as it is sloughed, they manage to keep going and to obtain such shares of the nitrates and other products due to the fungus-action as satisfy their needs. But although there may be something to be said for this view as regards a few forest-trees, it is not easy to see how it would apply to the non-assimilating humus-plants like *Neottia*, *Monotropa*, &c., and we may probably regard the two sets of cases as standing or falling together.

No treatment of this subject would be complete without reference to those obscure cases of symbiosis—as we must regard them—between certain algæ which occur in the cavities of the leaves of *Azolla* and in *Gunnera*, and those found in the intercellular spaces of cycad-roots. When we know more of the physiology of these blue-green algæ, it may be possible to explain these puzzles, but at present they are mysterious curiosities.

A class of pseudo-symbiotic organisms is being more and more brought into the foreground where the combined action of two symbionts results in death or injury to a third plant, whereas each symbiont alone is harmless, or comparatively so.

Some time ago Vuillemin showed that a disease in olives results from the invasion of a bacillus (*B. oleæ*), which, however, can only obtain its way in the tissues through the passages driven by the hyphæ of a fungus (*Chætophoma*). The resulting injury is a sort of burr. Vuillemin has this year observed the same bacillus and fungus in the canker burrs of the ash, and so confirms Noack's statement to the same effect

Among many similar cases, well worth further attention, the invasion of potato-tubers by bacteria, which make their way down the decaying hyphæ of pioneer fungi, may be noted. I have also seen tomatoes infected by these means, and have facts showing that many bacteria which quicken the rotting of wood are thus led into the tissues by fungi.

Probably no subject in the whole domain of cryptogamic botany has wider bearings on agricultural science than the study of the flora and changes on and in manure and soil.

As vegetable physiology and agricultural science progressed, it became more and more of primary importance that we should learn what manure is composed of, what changes it undergoes in the soil, and what the roots of plants do with it. Chemistry did much to solve some of the earlier problems, but it soon became evident that it only raised new questions which it could not solve; and it was not till the sequence of changes induced by the successive growths of *Mucor*, *Pilobolus*, *Coprinus*, *Ascobolus*, and other moulds and fungi of various sorts, followed by bacteria and yeasts, began to be understood, that anything approaching a coherent account of the complex phenomena going on in soil or in a manure-heap could be attempted. Not that all the difficulties have been solved even now, but we are at least able to trace some very important chains of occurrences which throw light on many hitherto obscure matters going on in the field.

Since Pasteur in 1862, and Van Tieghem in 1864, showed that certain bacteria are concerned in converting urea to ammonium carbonate, much has been learnt, and we now know from the investigations of Miquel, Jaksch, Leube, and others that numerous urea-bacteria exist; and Miquel, in 1890, isolated an extremely unstable enzyme—urase—which converts sterile urea to ammonium carbonate very rapidly, a discovery of considerable interest, as it was one of the first examples of this class of bodies to be examined; and when we reflect on the enormous quantities of urea which have to be destroyed daily, and that fresh urine is in effect a poison to the roots of higher plants, some idea of the importance of these urea-bacteria is obtained. The necessity for preventing the losses of this volatile ammonia by fixing it in the soil and presenting it to the action of the nitrifying organisms is also obvious.

Winogradsky's classical isolation and cultivation of bacteria which take up these ammonia compounds and oxidise them to nitrous and to nitric acids in the soil, may be quoted as further instances of the bearing of bacteriological work on this department of science, as explaining not only the origin of nitre-beds and deposits, but also the way the ammonia compounds fixed by the soil in the neighbourhood of the root-hairs are nitrified and so rendered directly available to plants.

The theoretical explanation of many questions connected with the washing out of nitrates from fallows, the advantages of autumn and winter sowing, and processes occurring in the upper soil as contrasted with sub-soil, has been rendered much easier by these researches; moreover, as is now well known, they brought to our knowledge a startling instance of the assimilation of carbon-dioxide by these non-green plants—bacteria—which not only take some of the purely inorganic ammonia, but by means of energy set free by its oxidation obtain their carbon also by breaking up the carbonate—a true case of the assimilation of carbon-dioxide by a plant devoid of chlorophyll and without the direct aid of light. Indirectly, it is true, the source of the energy is the light of the sun, because the oxygen employed by these aërobic forms has been liberated by green plants in the last instance; but the case is none the less a startling and important contribution to physiology, and Winogradsky's work, which had been preceded by investigations in England by Warington and others, affords one of the best illustrations I know of the importance of this branch of botanical investigation.

Stutzer and Hartleb's recent publications go to show that the nitrifying organism is a much more highly developed and complex form than has hitherto been suspected; that it can be grown on various media, and exhibits considerable polymorphism—for instance, it can be made to branch, and show the characteristics of a true fungus, statements confirmed to a certain extent and independently by the even more recent work of Rullmann; and it appears that we have much more to learn of the morphology of this widely-spread and interesting plant..

It is impossible to go into the controversy between the observers referred to and Winogradsky, the discoverer of the definite nitrifying organism; but there is one point I must just mention: if Stutzer and Hartleb's details are confirmed we have here the most remarkable case of polymorphism I know of, for they claim characters for their fungus which prevent our putting it into any existing group.

I have for some time insisted on the fact that river-water contains reduced forms of bacteria—*i.e.* forms so starved and so altered by exposure to light, changes of temperature, and the low nutritive value of the river-water, that it is only after prolonged culture in richer food-media under constant conditions that their true nature becomes apparent. Now, Stutzer and Hartleb show that the morphological form of the nitrifying organism can be profoundly altered by just such variations in the conditions as the above, and occurs as a branched mycelial form, as bacilli or bacteria, or as cocci of various dimensions according to conditions.

These observations, and the researches of Zopf, Klebs, and others on variations in form (polymorphism) in other fungi and bacteria, open out a vast field for further work, and must lead to advancements in our knowledge of these puzzling organisms; they also help us to explain many inconsistences in the existing systems of classification of the so-called "species" of bacteria as determined by test-tube cultures.

But the urea bacteria and the nitrifying organisms are by no means the only forms found in manure and soils.

In 1868 Reiset found evidence of a reduction of nitrates in fermenting beet-juices, and in 1873 Schloesing found that free nitrogen escaped in certain soil-fermentations. Further work by Mensel, Deherain, and others led to the suspicion that certain bacteria can undo the work of the nitrifying organisms, and in 1879 Warington showed that both nitrites and nitrates occurred in his soil-fermentations.

In 1886 Gayon and Dupetit put this almost beyond doubt, and in 1891 Giltay and Aberson isolated and cultivated a denitrifying bacterium, capable of completely reducing nitrates with evolution of free nitrogen, provided it is cultivated anaërobically.

Several such forms have now been obtained, the observations of Burri and Stutzer that certain of the commonest bacteria of the alimentary canal— e.g. *B. coli commune*—abounding in fresh manure, are especially active, being particularly suggestive. You will thus notice that we have now a sketch of the whole of the down-grade part of the cycle of organic nitrogen in nature ; it only needs supplementing by the history of the fixation of free nitrogen from the atmosphere by leguminous plants and certain soil-organisms to complete the sketch.

As is well known from investigations in which Eriksson, Woronin, Frank, Prazmowski, and others, including myself, have taken part, the nodules on the roots of leguminous plants contain a fungus—the morphological nature of which is in dispute—living in symbiotic union with the protoplasm of the cells. Hellriegel and Wilfarth showed in 1888–90 that, provided the root-nodules are present, these leguminous plants fix the free nitrogen of the atmosphere ; and Laurent and Schloesing put this beyond all doubt in 1892 by demonstrating that a closed atmosphere in which *Leguminosæ* grow loses nitrogen in proportion as the plants gain it. Meanwhile Schulz Lupitz had shown that agricultural land poor in nitrogen can be made to accumulate it in paying quantities by growing lupines on it, and quite recently pure cultures of the organism of the nodules have been placed on the market under the unfortunate name *Nitragin.* It is claimed that these organisms can be readily used in practice to inoculate the seeds or soil.

Kossowitsch in 1894 showed that certain symbiotic unions of algæ with bacteria are also capable of fixing nitrogen ; and Winogradsky declares that there exists in the soil a bacterium which, provided it is kept protected from oxygen by aërobic soil organisms, can itself do this. We are quite unaware of the mechanisms here concerned ; but in all cases it appears certain that active destruction of carbohydrates is an essential condition, and we can only assume that the nitrogen is forced into synthetic union by means of energy derived from this destruction. Here, then, we have a glimpse of the up-grade part of the cycle of nitrogen in nature, the importance of which to agriculture cannot be overrated. As to the theoretical bearings of the matter, we are still much in the dark, and can only anxiously await the results of further investigations into the nature of the peculiar fermentations and their products going on in these nodules. I now want to draw your attention to a bearing of the above discoveries concerning denitrifying bacteria on some agricultural and horticultural questions.

It is well known that a gardener eschews the use of fresh manure. Why is this ? The most obvious reply might seem to be, because the ammonia compounds and other nitrogenous constituents in such manure are not directly useful, or are even harmful to the roots of the plants. Some recent researches suggest that the matter is more complex than this.

It has not unfrequently happened that a farmer, finding himself short of stable-manure, has made up the deficit by adding some such artificial manure as Chili saltpetre, his argument running somewhat as follows :—Both are good nitrogenous manures, the one acting slowly, the other rapidly, so that a mixture of both should be better than either alone. The results have disappointed him, and numerous experiments in Norfolk, as I am informed by Mr. Wood, and in the North of England, as Dr. Somerville assures me, have shown that most disastrous results ensue if such mixtures are used, whereas if the farmyard manure is employed at first—the "shorter" the better—and the nitrates applied later on as a "top-dressing," excellent crops follow. The explanation seems to come from some recent experiments by Wagner, Maercker, Burri and Stutzer, and others. The farmyard manure, especially if fresh, so abounds in denitrifying bacteria that they destroy the nitrates rapidly and completely, free nitrogen escaping. Curiously enough, a very active denitrifying bacillus was found on straw, and we know that straw abounds in such manures.

I did not intend to go so far into agricultural details as this, but it was impossible to resist these illustrations of the splendid field of mycological research which here lies before us.

Nor can I avoid instancing at least one more example of the organisms at work in manure. We all know what enormous quantities of cellulose are manufactured daily, and even hourly, by the activity of green leaves ; and when we reflect on the millions of tons of dead-wood, straw, fallen leaves, roots, &c., which would accumulate every year if not destroyed, we see at once how important is the scavenging action of the moulds and bacteria which gradually reduce these to carbon-dioxide and water, setting these gases free to enter once more into the cycle of carbon, oxygen, and hydrogen in nature.

In 1890 Van Senus obtained two bacteria, one an aërobic and the other an anaërobic form, which in symbiotic union were found to excrete an enzyme which dissolved cellulose. Such a cellulose-dissolving enzyme I had myself isolated from the *Botrytis* of the lily disease in 1888. In 1895 Omeliansky, working with river mud, found an anaërobic bacillus which dissolves paper with remarkable rapidity. I can only hint at the importance of these forms in connection with the production of marsh gas in swamps, the question of the digestion of cellulose in herbivorous animals, the manufacture of ensilage, and the processes of "shortening" of manure ; and it is clear they have much to do with the destruction of paper, &c., in sewers and refuse-pits. Moreover, their further investigation promises a rich harvest of results in explanation of the rotting of stored tubers, certain diseases of plants, and several theoretical questions concerning anaërobism, butyric fermentation, and, possibly, that extremely difficult question on which Mr. Gardiner has done such excellent work, the nature of the various celluloses and constituents of the cell-wall.

I now turn to the subject of fungus epidemics, of world-wide interest, if only because the annual losses to agriculture due to epidemic diseases of plants amount to millions of pounds sterling.

The history of wheat-rust can be traced to Genesis, and at least five references to it exist in the Old Testament. The Greeks were familiar with it, and the Romans had a special deity and special ceremonies devoted to it. References can be given to it in old Norman times, and Shakespeare can be quoted as acquainted with it.

According to Loverdo, a law existed in Rouen in 1660, authorising the pulling up of barberry bushes as in some mysterious way connected with rust, and in 1755 the celebrated Massachusetts law was promulgated. Eriksson refers to an English farmer destroying his neighbour's barberry in 1720.

The words *Robigo*, *Rubigo*, *Rouille*, *Ruggine*, *Rufus*, and *Rust* comprise a history in themselves, into which, however, we have not time to go, and there are many fascinating points in the history of wheat-rust which must be passed over.

Felice Fontana in 1767 probably made the first scientific investigation of rust ; he distinguished the uredo- and puccinia-stages under other names, and even thought of them as rootless plants exhausting the wheat ; in this, and his conviction that no remedy was possible until a careful study of all phases of the disease had been made, he was far ahead of his times.

Jethro Tull, Marshall, and Withering are the most conspicuous English names in connection with this question and period, and Marshall in 1781–84 experimented intelligently with barberry and wheat inter-planted.

Persoon in 1797 gave the name *Puccinia graminis* to the fungus. In 1805 Sir Joseph Banks described it, and suggested that the germs entered the stomata : he also warned farmers against the use of rusted litter, and made important experiments on the sowing of rusted wheat-grains.

A great discussion on the barberry question followed, in which Banks, De Candolle, Windt, Fries, and others took part, Fries particularly insisting on the difference between *Æcidium berberidis*—a name conferred by Gmelin in 1791—and *Puccinia graminis.*

De Candolle had also distinguished *Uredo rubigo-vera* in 1815, and Schmidt soon after described a third wheat-rust—*Uredo glumarum.*

Matters were at about this stage when Tulasne confirmed the statement of Henslow—one of my predecessors in Cambridge—that the uredo- and puccinia-stages really belong to the same fungus, and are not, as Unger asserted, mixed species.

Then came De Bary and his classical investigation of the whole question in 1860–64. He proved that the *sporidia* of some Uredineæ (e.g. *Coleosporium*) will not infect the plant which bears the spores, and that the æcidia of certain other forms are only stages in the life-history of species of *Uromyces* and *Puccinia.*

In 1864 De Bary attacked the question of wheat-rust, and by means of numerous sowings of the teleutospores on barberry proved beyond doubt that they bring about its infection.

But De Bary did more. For the first time in history he saw the entrance of the infecting tube and the beginning of its growth in the tissues. In 1865 he demonstrated in the same faultless way the infection of the cereal by means of the æcidiospores, and showed that *P. rubigo-vera* alternates on Boragineæ as *Æc. asperifolii*, while *P. coronata*, separated by Corda in 1837, does the same as *Æc. Rhamni* on *Rhamnus*.

Thus was discovered the astounding phenomenon of *Heterœcism*, introducing a new idea into science and clearing up mysteries right and left.

During the next twenty-five years the number of heterœcious forms has risen to about seventy, including Woronin's recent discovery of this phenomenon in an ascomycete—*Sclerotinia heterœcia*.

About 1890 the rust question entered on a new phase. In Australia, India, Sweden, Germany, and America especially, active commissions, inquiries, and experiments were set on foot, and amid some confusion of meaning among some of those concerned much knowledge has resulted from the investigations of Plowright and Soppitt in England; Barclay in India; Cobb, Anderson, and McAlpine in Australia; Arthur, Bolley, Smith Ellis, Galloway, Farlow, Harper, and others in the United States; Dietel, Klebahn, Sorauer, and others in Germany; Rostrup in Denmark; and especially from the continued and indefatigable researches of Eriksson and Henning in Sweden. This renewed work has resulted in the complete confirmation of De Bary's results, but with the further discovery that our four common cereals are attacked by no less than ten different forms of rust belonging to five separate species or "form-species," and with several physiological varieties, and capable of infecting the barberry. Some of these are strictly confined to one or other of the four common cereals, others can infect two or more of them, and yet others can infect various of our common wild grasses as well.

The fact that what has usually gone by the name of *Puccinia graminis* is an aggregate of several species is in itself startling enough, but this was not unexpected; the demonstration that varietal forms exist so specially adapted to their host that, although no morphological differences can be detected between them, they cannot be transferred from one cereal to another, points, however, to physiological variation of a kind met with among bacteria and yeasts, but hitherto unsuspected in these higher parasitic fungi. It now appears that we must be prepared for similar specialisation of varietal forms among *Ustilagineæ* as well as among other *Uredinæ*, as follows from the results obtained by Kellermann and Swingle in America, by Klebahn, Tubeuf, and others in Germany, and by Plowright and Soppitt in England.

Not less remarkable is the conviction that among the many different pedigree varieties of wheat, some are more susceptible to attacks of rust than others. This had often been asserted in general terms, but the extensive observations of Cobb in Australia, and the even more extensive and exact experiments of Eriksson in Sweden, seem to put the matter beyond doubt.

Of course attempts have been made to account for these differences in predisposition to the attacks of wheat-rust.

N. A. Cobb, who has done much for the investigation of Australian wheat-rusts, regards the different susceptibility to rust as due to mechanical causes, and seeks to explain it by the difference in thickness of the cell-walls on the upper and lower leaf-surfaces offering different resistance to the outbreak of the spore-clusters; the average number of stomata per square millimetre differing in the different sorts of grain, influencing the predisposition to infection; the presence of waxy bloom affording a protection, and so on.

Eriksson and Henning have made a critical examination of Cobb's mechanical theory, and show that, for Sweden at any rate, the conclusions of the Australian investigator cannot be confirmed.

Nevertheless, the problem remains. As matter of fact, different sorts of wheat, of oats, of barley, and of rye are susceptible to their particular rusts in different degrees, and the question is, Why? Some complex physiological causes must be at the bottom of it.

Sorauer pointed out in 1880 that every change of vegetative factors induces differences in composition and form of a plant, and therefore alters the predisposition of each individual and variety; and this applies to the fungus as well as to the host.

De Bary's proof, in 1886, that a Peziza succeeds in being a parasite only after saprophytic culture to a strong mycelium, that its form is altered thereby, and that probably a poison is excreted, throws side-lights on the same question; while I myself showed that similar events occur in the case of the lily disease.

Reinhardt, in 1892, showed that the apical growth of a Peziza is disturbed and interrupted if the culture solution is concentrated by evaporation or diluted; and Büsgen, in 1893, showed that *Botrytis cinerea* excretes poison at the tips of the hyphæ, confirming my results with the lily disease in 1888, and that a similar excretion occurs in rust-fungi.

De Bary had also shown, in 1886, that the water-contents of the infected plant influence the matter; and I may remark that we have here also to consider the case of *Botrytis* attacking chrysanthemums, &c., in autumn, with respect to the chilling of the plant, which lowers the vitality of the cells and causes plasmolysis, as well as the fact that cold increases the germinating capacity of spores, as Eriksson showed.

I discussed these points at some length a few years ago in the Croonian Lecture to the Royal Society, and it now remains to see if any further gleams of light can be found in the progress of discoveries during recent years.

You are all no doubt familiar with Pfeffer's beautiful work on chemotaxis, and with the even more fascinating experiments of Engelmann, which prove that bacteria will congregate in the neighbourhood of an algal cell evolving oxygen.

When Pfeffer took the matter up in 1883, he was interested in the question as to the stimulating action of various bodies on mobile organisms, for he found that many motile antherozoids, zoospores, bacteria, &c., when free to move in a liquid, are vigorously attracted towards a point whence a given chemical substance is diffusing.

Pfeffer's problems had nothing to do with those of Engelmann; he was concerned, not with the proof of oxygen evolution or the movements of bacteria as evidence of the presence of that element, but with a fundamental question of stimulation to movement in general.

Pfeffer found that the attractive power of different chemical substances varies according to the organism, and according to the substance and its concentration. He also showed that various other bodies besides oxygen thus attract bacteria—*e.g.* peptone, dextrose, potassium salts, &c. These experiments are by no means difficult to repeat, and are now employed in our laboratories.

During the course of several years not only were these facts confirmed, but it was also shown that this remarkable attraction—chemical attraction, or "*chemotaxis*"—is a very general phenomenon.

Pfeffer had already shown that swarmspores of the fungus *Saprolegnia* are powerfully attracted towards the muscles of a fly's leg placed in the water in which they are swimming about, and pointed out that in many cases where the hyphæ of fungi suddenly and sharply bend out of their original course to enter the body of a plant or animal, the cause of the bending lies in a powerful "*chemotropic*" action due to the attraction of some substance escaping from the body.

This idea of an attractive action between the living substance of two organisms growing in close proximity was not entirely new—it was, so to speak, in the air—*e.g.* the fusions of mycelial cross-connections and clamp-organs, and of the spores of *Tilletia*, *Entyloma*, &c. One of the most striking examples is afforded by Kihlmann's demonstration of the parasitism of *Melanospora* on *Isaria*, where he states that some attractive action exists. In 1882 I had myself seen zoospores of *Pythium* suddenly dart on to the cut surface of a bean-stem, and there fix themselves. But it is due to Pfeffer and his pupil Miyoshi to state that they were the first to demonstrate these matters clearly.

To understand the important consequences which followed, I must now refer to another series of discoveries.

When a spore of a parasitic fungus settles on a plant, it frequently behaves as follows. The spore germinates and forms a slender tube of delicate consistence, blunt at the end and containing colourless protoplasm. De Bary long ago showed that such a tube—the germinal hypha—only grows for a short time along the surface of the organ, and its tip soon bends down and enters the plant, either through one of the stomata or by boring its way directly through the cell-walls. Several observers, and among others myself, remarked how the phenomena suggested that the end of the tube is attracted in some way and by some force which brings its tip out of the previous direction, and De Bary even threw out the hint that this attraction might be due to some chemical substance excreted by the host-plant. I myself showed that the condition of the attacked plant affected the ease with which the tube penetrates the cell-walls, and that the actual boring of the cell-walls is due to a solvent enzyme secreted by the tip of the fungus, and in clearly demonstrating this excretion of an enzyme capable of dissolving cellulose carried a step further what was so far known, principally from De Bary's researches, as to this process. In 1892, Reinhardt showed that the tips of hyphæ curve over towards spores they are about to attack, and found that sugar-gelatine of greater strength attracts them from the same medium with a smaller proportion of sugar.

Miyoshi then showed, in 1894, that if a leaf is injected with a substance such as ammonium-chloride, dextrine, or cane-sugar, all substances capable of exerting chemotropic attraction on fungus-hyphæ, and spores of a fungus then sown on it which is *not parasitic*, the hyphæ of the fungus penetrate the stomata and behave exactly as if the fungus were a true parasite.

This astounding result throws a clear light on many known cases of fungi which are, as a rule, *not* parasitic, becoming so when the host-plant is in an abnormal condition—*e.g.* the entry of species of *Botrytis* into living tissues when the weather is cold and damp and the light dull; the entry of *Mucor* into various fruits, such as tomatoes, apples, pears, &c., when the hyphæ meet with a slight crack or wound, through which the juices are exposed. Nay, I venture to suggest that it is even exceedingly probable that the rapid infection of potato-leaves in damp weather in July is not merely traceable to the favouring effect of the moisture on the fungus, but that the state of super-saturation of the cell-walls of the potato leaf, the tissues of which are now unduly filled with water and dissolved sugars, &c., owing to the dull light and diminished transpiration, is the primary factor which determines the easy victory of the parasite, and I suggested some time ago that the suppressed life of *Ustilagineæ*, in the stems of grasses, is due to the want of particular carbo-hydrates in the vegetative tissues there, but which are present in the grain.

Miyoshi, in 1895, carried to proof the demonstration that a fungus-hypha is really so attracted by substances on the other side of a membrane, and that its tip pierces the latter; for the hyphæ were made to grow through films of artificial cellulose, of collodion, of cellulose impregnated with paraffin, of parchment-paper, cork, wood, and even the chitinous coat of an insect, simply by placing the intact films on gelatine impregnated with the attracting substance, and laying the spores on the opposite side of the membrane.

Hyphæ so separated by similar membranes from gelatine to which the attracting substance was not added, did not pierce the membranes, whence we may conclude that it is really the substance referred to which incites the hyphæ to penetration.

Now, obviously, this is a point of the highest importance in the theory of parasitism and parasitic diseases, because it suggests at once that in the varying conditions of the cells, the contents of which are separated only by membranous walls from the fungus-hyphæ, whose entrance means ruin and destruction, there may be found circumstances which sometimes favour and sometimes disfavour the entrance of the hyphæ; and it is at least a remarkable fact that some of the substances which experiments prove to be highly attractive to such hyphæ—*e.g.* sugars, the sap of plums, phosphates, nitrates, &c.—are just the substances found in plants, and the discovery that the action depends on the nature of the substance as well as on the kind of fungus, and is affected by its concentration, the temperature, and other circumstances, only confirms us in this idea.

Moreover, there are substances which repel, instead of attracting the hyphæ.

Is it not, then, natural to conclude that the differences in behaviour of different parasites towards different host-plants, and towards the same host-plant under different conditions, probably depend on the chemotropic irritability of the hyphæ towards the substances formed in the cells on the other side of the membranous cell-walls? And when, as often happens, the effusion of substances such as the cells contain to the exterior is facilitated by over-distension and super-saturation, or by actual wounds, we cannot be surprised at the consequences when a fungus, hitherto unable to enter the plant, suddenly does so.

In spite of all the progress made towards an explanation of the origin and course of an epidemic of rust, however, one serious inconsistency has always puzzled men who have worked with it in the open and on a large scale. This inconsistency concerns the outbreaks of epidemics over large areas, at periods, and within intervals, which do not agree with the weather records and the described biological facts. We know, speaking generally, the conditions of germination of the spores, we know how long infection requires, and the latent period is known: we know much as to the conditions which favour or disfavour the fungus mycelium in the tissues, and, nevertheless, an outbreak of disease over large areas sometimes occurs under conditions which appear quite inconsistent with this knowledge.

During his six years' study of the wheat rusts Eriksson was so impressed with these difficulties that he has lately committed himself to an hypothesis which may perhaps crystallise the ideas which have floated in the minds of several who have been puzzled by these matters.

The facts which seem to have finally impelled Eriksson to his hypothesis were those of the distribution of the wild rusts and grasses. Having learnt which grasses could infect the wheat, oat, barley, and rye respectively, he found cases of epidemics occurring where it was impossible to fit in the facts with the view that spores had been transferred from these grasses within the period required for infection and development of the disease spots. Again, seasons occurred when all the conditions pointed to the probability of a serious outbreak of rust, and no such epidemic occurred. Further, experiments were made in which cereals of varieties known to be susceptible to given rusts were planted in close vicinity to grasses infected with such rusts, and, nevertheless, in seasons eminently suitable for the outbreak of this particular rust on these particular cereals none appeared, or so little that it was impossible to explain the outbreaks of this same rust on this cereal elsewhere, during that season, as due to direct infection from the surrounding grasses.

More and more it became evident that the infective capacity of the rusted grasses is small, and confined to restricted areas, and that the outbreaks in certain seasons—rust-years—must be due to something other than wind-borne spores distributed by gales over the district.

Three hypotheses can be suggested to account for the non-spreading of the disease on to susceptible cereals—(1) Indisposition to germinate on the part of the spores; (2) unfavourable weather for germination; (3) some structural peculiarities of the leaves on which the spores fell, of such a nature that infection was prevented.

The results of many experiments showed that, as matter of fact, the spores are often very obstinate, and refuse to germinate even when the weather is apparently favourable, and Eriksson discovered during these experiments that cooling the ripe spores on ice increased their germinating power. Neither of the other two hypotheses mentioned could be brought into agreement with the results, however.

The conclusion was thus arrived at that an outbreak of rust cannot always be referred directly to the normal germination and infection of wind-borne spores from neighbouring centres of infection.

In some patches of extremely susceptible cereals, the disease appeared simultaneously on plants isolated from all perceptible sources of infection, and on plants not thus protected; the date of outbreak in these cases—reckoned from the sowing of the grain—was far too late to be explained by direct infection from spores on the soil, or on the grain sown. Experiments demonstrated that if such spores had been there, and germinal tubes formed as usual, the disease would have shown itself much earlier.

These and numerous other inconsistencies drove Eriksson to look for an "internal source of infection," in spite of the improbability of any such existing, and of its apparent incompatibility with scientific theory since De Bary's time.

Two methods were pursued. In one each plant of the cereal was enclosed from the beginning in a long glass tube, stuffed with cotton-wool above and below, and so carefully protected against infection from wind-blown spores that we may accept forthwith the improbability of such infection.

Notwithstanding these precautions, the cereal was rusted at the same time as its unprotected neighbours, and equally badly.

Granting the accuracy of the experiments, only two explanations seem to suggest themselves. Either (1) winter-spores attached to the grain had germinated and infected the young seedling—a not impossible event, since several observers have found spore-bearing mycelia in the pericarp of the ripe grains, and we know these spores can conserve their germinating power for months; or (2) the infective material had been handed down to the embryo from the parent plant—an almost inconceivable hypothesis.

To answer this question Eriksson protected his seed-plants from external infection, and sowed the grains in sterilised soil in specially constructed greenhouses, through which the air can only pass *viâ* cotton-wool filters. Between the double-glass windows water was allowed to stream, and the plants thus kept cool. Some of these protected plants became rusted.

Before we draw any conclusions from such difficult experiments as the above, let us see the results of microscopic examination.

Reference has already been made to the mycelium and spores in the tissues of the pericarp of the grain; no trace could be, or ever has been, detected in the endosperm or embryo. In some cases the seedlings, four to eight weeks old, showed the first uredo-pustules on their leaves, and the mycelium but no spores could be detected in the seed-coats.

The tissues of the leaf, in the neighbourhood of young uredo-pustules, frequently showed curious clumps of protoplasm in the cells, either free in the cell-cavity, or attached to the primordial utricle, and looking like haustoria. Eriksson assumes that we have here the key to the puzzle; he regards these "plasmatic corpuscles" as the protoplasm of the fungus which, after leading a dormant life commingled symbiotically with the living protoplasm of the cell, is now gaining the upper hand and beginning to form a dominant mycelium.

We are therefore to suppose that when the spores of rust, even if of the right variety, alight on the tissues of a wheat-plant, it is a matter decided by external and internal conditions whether the germ-tubes forthwith infect the plant and grow out into a dominant, parasitic, sporiferous mycelium, as we know they usually do, or simply manage to infect the cells with enough protoplasm to live a latent symbiotic life for weeks—or even months—as a *Mycoplasma*, which may, under favourable circumstances, gain the upper hand, and grow out in the form of a mycelium.

This is a startling hypothesis, and brings us to the most advanced point along this line of biological speculation. We must distinguish sharply and clearly between such a view, which is by no means inconsistent with all we know of parasites, so far as the dormant mycelium goes, and all the hazy, mystical suggestions as to "infective substance" and so forth, which were so freely flung about at the beginning of this epoch, and which De Bary's strictly scientific methods put down so firmly.

The idea of symbiosis is now comparatively old, and there are many cases of dormant life now well established. Even the astounding notion of blended protoplasms can no longer be regarded as new. I need only remind you of Cornu's *Rozella*, which invades the thallus of *Saprolegnia* and *Woronina* in *Vaucheria*, the protoplasm of the two organisms apparently blending and living a common life for some time before the true nature of the parasite manifests itself. Eriksson has avowedly been influenced by these and other cases among the *Chrytridiaceæ*. That the remarkable intra-cellular fusions of *Plasmodiophora* and the now well-established symbiosis of the organism of the leguminous root-nodules have also had their influence on his work may well be assumed, and I think we may trace also the effects of our knowledge of the latent life of *Ustilago* during the vegetative period of the attacked cereal.

But there are other cases which prevent our casting aside as impossible the view that Eriksson has put forward.

I showed some years ago that the mycelium of the *Botrytis* of the lily disease can lie dormant for some time in the cell-walls, and I have observations showing that other forms of *Botrytis* which attack roses and chrysanthemums only gain the upper hand when the cold autumn nights so chill the attacked cells that they succumb; the mycelium was there long before, but so long as the cells were active no progress could be made, and only when the plasmolysed chilled cells exude their sap can the mycelium advance.

Many cases of similarly dormant mycelia appear to exist in those cortex and cambium diseases which result in the production of cankers—e.g. *Nectria ditissima* and *Peziza Willkommii*, and Tubeuf's experiments with *Gymnosporangium* are even more suggestive. Tubeuf found that if *G. clavariæforme* is sown on hawthorn seedlings the fungus forms yellow spots and induces marked hypertrophy, and normal spermogonia and æcidia—*Roestelia lacerata*—are developed; but if *Pyrus Acuparia* is used as the host, no yellow spots or hypertrophy result, though a mycelium is formed and will even produce a few starved spermogonia. On allied species of *Pyrus* the fungus may even succeed in forming a few poorly developed æcidia. But on the quince the fungus only just succeeds in establishing an infecting mycelium, and soon dies; and Wagner describes similar events with fungi on *Stellaria*.

These cases point to a struggle between the protoplasm of the cells of the different hosts, and of the fungus respectively: sometimes one wins, sometimes the other. The following cases are also suggestive. De Bary found that the germinal hyphæ of *Peronospora pygmæa*, which is parasitic on *Anemone*, will penetrate the tissues of *Ranunculus Ficaria*, but cannot maintain its hold, and the mycelium soon succumbs and dies.

Still more remarkable and to the point is the following case. Soppitt and Plowright in England, and Klebahn and others on the continent, have gradually unravelled a curious case of heterœcism and specialised parasitism among certain *Puccinias* found on *Smilax*, *Convallaria*, *Paris*, and *Digraphis*. The story is too long to recount in detail, but the *Puccinia-spores* from *Phalaris* were found by Klebahn to refuse to infect *Polygonatum* leaves successfully, though they readily infect the allied *Convallaria*. Close investigation showed, however, that, although the sporidia failed to develop a mycelium in the *Polygonatum* leaves, they really penetrate the cells, and the delicate germ-tube is killed off by the protoplasm, a red spot marking the place of entrance.

The perennial mycelia of Witches' Brooms, æcidia in Euphorbia, *Taphrina*, and many other perennial mycelia are also cases in point.

It is not my purpose to hold a brief for Eriksson's hypothesis, but I may point out that it is in no way contradictory to the facts already known since De Bary's time. Its most serious aspect is with regard to possible treatment, and it is obviously essential that we should have it tested to the utmost, for it must be remembered that no method of spraying or dusting has been, or apparently can be, devised for cereals; hence the questions as to the existence of really resistent forms, and whether dormant mycelia lurking in their tissues have deceived us in these cases also, require sifting to the bottom. Experience, so far, points to the selection of pedigree wheats and careful cultivation as the first necessities; how far the question of spring *versus* winter wheat aids us is still matter for further experiment; early and late ripening are also concerned. Climate we cannot hope to control, but it remains to be seen—when the facts are known—how far it can be "dodged."

Clearly what is needed, then, is experiments with varieties or wheat under all conditions, and we may congratulate the Australian, Swedish, and United States experimental stations on their preliminary efforts in this direction.

I have only been able to give a mere sketch of this rapidly growing subject, but I think you will agree that we are justified in saying that an epidemic of parasitic fungi depends on the interaction of many factors, congenital variations of the host-plant and topical variations of its cell-contents being probably among the most important; and since we cannot hope to control the variations of the parasite, or the meteorological conditions, it behoves agriculturists to pay more systematic attention to the selection of those varieties of the cereal which are least predisposed to rust.

When we find the annual losses from wheat-rust alone put down at sums varying from 1,000,000*l*. to 20,000,000*l*. in each of the great wheat-growing countries of Europe, India, Australia, the United States, and elsewhere, it strikes one as very remarkable that so little should be done to encourage the scientific investigation of these practical questions. I need hardly say that the establishment and maintenance of a fully equipped laboratory and experimental station does not cost the interest on the smallest of these sums.

It should be also clear that in the further development of our knowledge of the treatment of parasitic diseases of plants the farmer, gardener, and forester can alone supply the experimental evidence which will enable us to put theory to the test in the field, garden, and forest. The botanist, by means of his pure cultures of the fungus, can now show clearly what stage in the life-history of a parasite is vulnerable. In his "microscopic gardens" he can show what antiseptics may be employed, how strong they should be, and when and how they should be employed.

But we must not forget that it is one thing to kill a fungus when grown pure, and another to kill it when growing on or in, or even associated with, other plants, without harming the latter. We may compare the first case to the destruction of weeds on a gravel path, where the antiseptic dressing may be employed lavishly and at any time, because there are no other plants to injure; but it is another matter to kill the same weeds growing in a lawn or a flower-bed, where we have to pay attention to the neighbouring plants.

Experiments in the open, simple in themselves, but conducted intelligently and with due regard to the rigorous demands of science, can alone determine these questions.

Brewers have long known that burning sulphur in the barrels will rid these barrels of the moulds and yeasts growing on their damp beer-soaked sides; and Berkeley saw clearly that sulphur could be applied to the outside of plants on which such fungi as the hop- or grape-mildew, &c., are growing, the critical period being when the spores are germinating, so that the slowly oxidising sulphur should evolve sulphurous acid in just sufficient quantities to destroy the delicate germs without injuring the leaves. And even better results have been attained with Bordeaux mixture.

But it is clear that this can only be done with an intelligent appreciation of the life-history of the fungus, and a knowledge of when the germinating stage is at hand. The successes obtained in France and America with Bordeaux mixture attest this.

It would obviously be absurd to powder sulphur or spray liquids over plants attacked by bunt- or smut-fungi, for we know that the germ-tubes only infect the germinating grain as its first root emerges. Here, as was shown long ago, and especially by the experiments of Hoffmann, Kühn, and De Bary, the practice known as "dressing the grain" must be followed. Knowing that the spores of the fungus are attached to the grain, or to particles of soil around, the efforts must be directed to covering the outside of the grain with an antiseptic which is strong enough to kill the germs but not the grain. If the land is known to be clean, the grain may be immersed in hot water, the temperature being experimentally determined, and high enough to kill the spores but not the wheat, and so on. In these matters also the American stations have done good work.

Neither of these classes of treatment can be adopted, on the other hand, for diseases such as "Finger and Toes," where we have a delicate slime-fungus making its way into the roots already in the soil; but, here again, intelligently devised experiments, such as those of Somerville and Massee, have shown that liming the soil renders it so unfavourable to this disease that it can be coped with.

And similarly with other diseases; the particular methods of dealing with the "damping-off" of seedlings, "dry-rot" in timber, the various diseases of trees, and so on, do and must differ in each case, and the guiding principle must be always the same—having learnt all that can be learnt of the habits of the fungus and of the host, and of the relationships of each to the other and the environment, to see how it is possible to step in at the critical moment and interfere with these relationships in the direction desired by human interests.

The whole matter thus resolves itself into a study of variation—a purely experimental inquiry into complex biological relationships, and it is encouraging to see that this is being understood in the large American and other stations, which are distinguishing themselves by their efforts.

GEOLOGY AT THE BRITISH ASSOCIATION.

THE attendance of British geologists at this meeting of the Association was not large, owing, no doubt, to the counter-attractions of the International Geological Congress in Russia, which drew away also some American geologists who might otherwise have attended. But in spite of this, the section was, on the whole, well attended, and its work was exceptionally arduous and interesting. Though with the exception of the reports of Committees, there were only three papers exclusively British in their scope, the large number of contributions on North American subjects more than made up the deficiency, and gave to this meeting a distinctive character. It is significant of the vitality of earth study on the American side of the Atlantic that the papers should have been, upon the whole, well above the average of other meetings.

Contributions of merely local interest were almost absent, and again and again one was struck by the breadth of view and vigour of generalisation which marked the work submitted to the section. The presence of numerous distinguished Canadian and American geologists, many of the latter coming from the Detroit meeting of the sister Association, furnished an audience ready to grasp and to criticise the views brought forward, and in some instances discussions commenced in Detroit were continued in Toronto. It was, indeed, only the amount of work to be got through which limited the debates. The Glacial papers were exceptionally numerous and full of instruction for the European geologist, while that of Prof. Penck must have had a high interest for American glacialists. It was possible, on the day set apart for these papers, to arrange a series which should span the continent from the Atlantic to the Pacific, and thus to bring before the listener a comprehensive view of the whole bearings of the subject in North America. It is noteworthy that neither in the papers nor in the discussion was there a single dissentient from the view that ice-sheets covering the northern portions of the continent had formed the drifts. This seems to be taken as established beyond all doubt in North America.

Next after the Glacial papers in numbers and importance were those dealing with the Archæan and Palæozoic rocks, these again reflecting the locale of the meeting.

Petrological studies were also fully represented, but Palæontology was comparatively neglected, though a feature of the meeting was the special exhibition of several collections of North American fossils. Those to excite the greatest attention were the beautifully preserved trilobites showing the antennæ and pedal appendages, collected from the Utica Shales of Rome, N.Y., by Dr. C. E. Beecher, and exhibited by Dr. Ami.

The excursions arranged for the geologists were highly successful and most enjoyable. Niagara was visited under the leadership of Mr. G. K. Gilbert, of the U.S. Geological Survey; the inter-glacial deposits of the Don Valley and Scarborough Heights, under the guidance of Prof. A. P. Coleman; while Dr. J. W. Spencer pointed out the main features of the Iroquois Beach, a deformed post-glacial shore-line. Of the long excursion to the Pacific Coast, to which the Canadian Pacific Railway Co. has munificently invited a large party of members, it is at the time of writing too early to speak, but this is being anticipated by all invited as the fitting close of a most enjoyable and memorable meeting. The geologists on this excursion will be under the guidance of their President, Dr. G. M. Dawson, and their Secretary, Prof. A. P. Coleman.

The sectional work of the meeting commenced on Thursday, August 19, with the President's address, an able exposition of the present state of our knowledge respecting the most ancient rocks of Canada, of which, as it has already been given in full in our columns, it is necessary now only to record the favourable reception by the meeting.

Next followed a group of papers treating of the pre-Palæozoic and Palæozoic rocks of North America. Dr. L. W. Bailey described some typical sections in south-western Nova Scotia, in which he showed the succession of the Cambrian rocks of that region and their relation to the granite axis. Dr. R. W. Ells discussed problems in Quebec geology, dealing with the origin of the fundamental gneiss and the Grenville series, and their relations to the Hastings series and the oldest fossiliferous rocks. Mr. J. C. Branner traced the former extension of the Appalachians across Mississippi, Louisana, and Texas beneath the newer rocks.

A most interesting paper at this session was that of Dr. F. D. Adams and Mr. J. T. Nicholson, entitled "Preliminary notice of some experiments on the flow of rocks," in which the authors related how they had placed, accurately-fitting columns of Carrara marble about 4 cm. long by 2 cm. diameter, within specially prepared tubes of Swedish iron, and had subjected them to extreme pressure gradually applied. The rock yielded like a plastic substance, and bulged the enclosing tube. In one experiment the column was reduced from 40 mm. to 21 mm. in height, the deformed marble remaining quite firm and compact, though not so hard as the original rock. When sliced and examined microscopically, polysynthetic twinning of the calcite crystals and other indications of strain were observable. These very suggestive experiments are to be continued, and it is certain that all students of dynamic geology will follow the results with keen attention. At a later session Dr. Adams dealt with the structure and origin of certain rocks of the Laurentian system, his conclusions corresponding with those of European workers on rocks of similar type, since he showed by chemical analysis and microscopic examination that the foliated rocks included two distinct and separable types—the one almost certainly highly altered sediments, and the other of igneous origin.

At Friday's session most of the Glacial papers were read.

The wealth of material brought forward left but little time for the final discussion, but the whole sitting was practically a debate on the subject by the authors of the numerous papers. Prof. F. C. Chamberlin led the way with a professedly highly speculative thesis—a group of hypotheses bearing on climatic changes—which turned mainly on the question of the origin and persistence of the various constituents of the atmosphere, more especially of the carbonic acid. The author made a complete departure from the common view, by supposing the atmosphere to have begun as a tenuous envelope which has been subjected to depletion and enrichment during all subsequent time. The author has been led to a rejection of the nebular hypothesis, in favour of the theory of the growth of the earth by the ingathering of solid and gaseous particles. An application of these principles resulted in the conclusion that a glacial climate might be brought about by the impoverishment of the carbonic acid of the air; and a whole cycle of recurrent climatal changes was postulated on this basis.

In his next paper Prof. Chamberlin was content to confine himself to more mundane methods, and gave an able dissertation on the distribution and succession of the Pleistocene ice-sheets of the northern United States, illustrating, by means of a large map, the looped moraines which encircled the terminations of the various lobes. Prof. C. H. Hitchcock described the southern lobe of the Laurentian ice-sheet in New England, laying especial stress on the great uplift of the Laurentian boulders in their southward course, and the divergence of the striæ towards the termination of the lobe "like the barbs of a feather from the central shaft." Prof. H. LeRoy Fairchild discussed the general phenomena of the glacial geology of Western New York, bringing out forcibly the effect of the south-moving ice-sheet from the Ontario-Erie basin in damming the north-flowing drainage south of these lakes, so as to form temporary bodies of fresh-water which emptied southward across the water-shed at every col, cutting characteristic rock-channels now dry. Mr. F. B. Taylor gave an account of the Champlain submergence and uplift, and their relations to the Great Lakes and Niagara Falls, in which the point of chief importance was the description of an old channel by which all the great lakes, except Erie, formerly drained through the Nipissing outlet into the Ottawa river, thus enormously reducing the volume of Niagara, and consequently affecting very seriously any calculation as to the time occupied in the wearing back of the Niagara Gorge. This Nipissing outlet Mr. Taylor believes to have been finally closed by differential uplift, a factor which all the American geologists seem to recognise and allow in relation to glacial and post-glacial geology.

Prof. A. P. Coleman gave a lucid description of the glacial and inter-glacial deposits at Toronto. The recognised importance of these deposits to the vexed question of inter-glacial periods led to the formation of a Committee with a grant of 20*l.* to further investigate their flora and fauna. Dr. J. W. Spencer brought forward fresh evidence from the West Indies and elsewhere in favour of the continental elevation during the Glacial Epoch. At a later session Mr. J. B. Tyrrell, of the Canadian Survey, in a paper of wide scope, under the title of "The glaciation of North Central Canada," gave the result of his prolonged researches in the barren lands west of Hudson's Bay. He concluded that the glaciation of these great plains has been effected by ice radiating at different times from three centres of glaciation: the Cordilleran in the west, the Keewatin in the middle region, and the Laurentide or Labradorian in the east, and that there has been throughout the Glacial Period a progressive shifting westward of the centres of maximum glaciation. He found no evidence to denote any extensive pre-glacial elevation of the region. Mr. Tyrrell's observations cannot fail to modify considerably some existing views as to the cause and growth of ice-sheets. Mr. Bailey Willis, in his paper on the drift-phenomena of Puget Sound, and their interpretation, held that the hollows now occupied by the sea in that region were the casts of glaciers, and not, as has been supposed, the effects of submergence. Mr. R. Chalmers sent a contribution on the pre-glacial decay of rocks in Eastern Canada, in which were described the thick sheets of decomposed rock, of Tertiary age, which occur in sheltered positions where they have not been removed by glaciation.

Three papers dealing with European glacial geology, which were also read on Friday, afforded a clear indication of the similarity of the phenomena on the opposite sides of the Atlantic. Prof. A. Penck, in a general description of the glacial deposits of the Alps, compared their glaciation with that of British Columbia and Alaska, the glaciers pouring down the valleys to form Piedmont ice-lobes terminated by moraines. He thought that two inter-glacial epochs were indicated, each of much longer duration than post-glacial time, the proportions being stated as 1 : 4 : 6. Assuming the post-glacial period to have extended over 20,000 years, he conjectured that the two inter-glacial periods together occupied 200,000 years, and, from the evidence of the Poe Plain, that the entire glacial and inter-glacial periods lasted 500,000 years. While favouring Richthofen's eolian theory for the loess, he considered that the material had been originally derived from fluvio-glacial deposits. He recognised a slight folding of the older glacial strata, and held that the lakes, which all lay within the limits of the last glaciation, were deformed valleys deepened and widened by the ice-sheet and dammed by its moraines. He noted that there were abundant evidences for the existence of man during the last inter-glacial and glacial epoch; man's antiquity in Europe, therefore, being about 150,000 years.

Prince Kropotkin prefaced his paper on the Åsar of Finland by explaining that his observations were made in 1871, and that the reason for his long delay was that in running away from his fortress-prison at St. Petersburg, he had to leave his MSS. behind, and had only lately recovered them through the good offices of the Russian Geographical Society. He demurred from the prevalent view that the Åsar have been formed in fluvio-glacial rivers, as he had in several instances found that they enclosed a hidden core of true morainic material.

Mr. H. B. Woodward's paper, on the chalky boulder clay and the glacial phenomena of the west-midland Counties of England, brought clearly forward the similarity of these English glacial deposits in their origin with those of North America.

Among the Petrological papers, which were chiefly taken at Monday's session, was that of Messrs. Barlow and Ferrier, on the relation and structures of certain granites and associated arkoses in Lake Temiscaming, Canada, in which they showed that in this region there was a gradual passage from granite to a stratified arkose, as the result of the decomposition and dynamic alteration of the former rock. They concluded that there has been "a pre-existing basement or floor essentially granitic in composition at the base of the Huronian." Prof. W. G. Miller gave a description of some nickeliferous magnetites from Eastern Ontario.

A valuable contribution by Mr. J. J. H. Teall, on differentiation in igneous magmas as a result of progressive crystallisation, was read in the absence of the author. Mr. Teall referred to certain rocks recently collected by the Jackson-Harmsworth expedition in Franz-Josef Land, as proving that magnetite may belong to a very late stage of consolidation, and that progressive crystallisation may lead to a concentration of iron-oxides in the mother-liquor.

The Palæontological papers were not numerous, perhaps partly because some which might be classed under this head were carried to other sections. A note was read from Sir W. Dawson, on certain pre-Cambrian and Cambrian fossils supposed to be related to Eozoon. Mr. J. F. Whiteaves described a Dendrodont tooth from the Upper Arisaig rocks of Nova Scotia, which he thinks may add a second vertebrate species to the Silurian in Canada. Dr. H. M. Ami had an interesting account of some new or hitherto little-known Palæozoic formations in North America, in which the author discussed the successive faunas of Ordovician age in New Brunswick and Nova Scotia. An important contribution from Dr. G. F. Matthew was also read by Dr. Ami, on some characteristic genera of the Cambrian, in which the horizon of *Olenellns* was especially discussed, the conclusion being that its place was above rather than below the *Paradoxides* beds, and therefore not at the base of the Cambrian system.

Mr. A. C. Seward's paper, on the possible identity of *Bennettites*, *Williamsonia* and *Zamites gigas*, explained with the aid of lantern illustrations, completes the Palæontological list.

On Tuesday, among other papers, Dr. E. W. Claypole gave a comprehensive account of the Palæozoic geography of the Eastern States, illustrating by lantern slides the chief geographical and hydrographical changes of the mid-Palæozoic era in that region.

Space forbids notice of the various Committees of Research, though several of these were of considerable interest, notably that on the secondary fossils of Moreseat, Aberdeenshire, by J. Milne and A. J. Jukes-Browne; that on erratic blocks, by

P. F. Kendall; that on the Irish elk in the Isle of Man, by P. M. C. Kermode; and on geological photographs, by Prof. W. W. Watts.

The final meeting of the section on Wednesday was devoted to a joint discussion with Section H, on the first traces of man in North America, in which the President of the Association, Profs. Putnam, McGee and Claypole, and Drs. Dawson and Spencer took part. Though no definite conclusion was reached, the general feeling of the meeting seemed to be against the high antiquity of the reputed finds in the Trenton gravels.

This completed the work of the section, and brought an extremely busy week to a successful termination. The Toronto meeting of the British Association, so far as Section C is concerned, must be regarded as well above the average of recent meetings, both in the quantity and quality of its work, and as one which all the geologists present will remember both with profit and pleasure.

ANTHROPOLOGY AT THE BRITISH ASSOCIATION.

NATURALLY most of the papers read before Section H related to American anthropology; the following abstracts give some idea of the more important of the communications.

Miss A. C. Fletcher, who has a long and intimate acquaintance with the Omaha, gave a couple of papers on the Scalp-lock and the import of the totem among that tribe. Her sympathetic studies have thrown considerable light upon the religious conceptions of these people, and she has demonstrated that they can compose highly dramatic songs and music. In the legend of the Sacred Pole of the Omahas, we are told, "The people felt themselves weak and poor. Then the old men gathered together and said, 'Let us make our children cry to Wakonda.' So all the parents took their children, covered their faces with soft clay, and sent them forth to lonely places. The old man said, 'You shall go forth to cry to Wakonda. When on the hills you shall not ask for any particular thing; whatever is good, that may Wakonda give.'" Thenceforth on arriving at puberty the youth went fasting among the hills till he fell into a trance; whatever he then beheld in his sleep would be the special medium through which he could receive supernatural aid. This was his personal totem. He then banded himself with those who had received similar visions, and who formed a brotherhood or religious society. These were probably the most primitive social organisations. A further integration resulted in the grouping of brotherhoods into gentes, who practised exogamy and traced descent through the father. Each gens had its totem, which was probably that of the original founder of the gens.

The gentile totem gave no immediate hold upon the supernatural, as did the individual totem to its possessor; it served solely as a mark that the individual belonged to a definite kinship group from which he could never sever himself without incurring supernatural pnnishment.

The child entered into the gens by means of the ceremony of hair-cutting. As recently practised this rite consisted of two parts, of which the first was confined to boys. A child was presented by his mother to Thunder priest with the words, "I desire my child to walk long upon the earth, I desire him to be satisfied with much food, we seek your protection, we hold to you for strength." While singing a song the priest cut a tuft of hair from the crown of the head, and laid it away in the sacred case. The hair typified the life of the boy, which was thus symbolically entrusted to the safe-keeping of the Thunder god. The child thenceforth passes out of the simple relation he bears to his parents, and by this act is re-born into the tribe and becomes a recognised member of the tribe. The sign of this consecration is the small lock of braided hair, which is isolated from the rest, and to which is fastened the talisman and the war honours worn by the warrior. It was this lock that was cut from the head of a slain enemy and formed the central object in the triumph ceremonies, since it pre-eminently represented the life of the vanquished enemy. The second part was common to all children. In a symbolic ceremony the child was turned in the four quarters in order to place it in relation with the elements, and thus to ensure long life and prosperity.

Probably the turning ceremony was the more primitive portion, so that the sequence may have been much as follows: A child was put into harmonious relation with its environment by the rite of the "turning of the child." Then a boy was placed in the safe-keeping of the Thunder god, by means of the "hair-cutting" rite, that he might become a brave defender of his people. The need of the assistance of supernatural forces led to the "vision rite," with its consequent totem. Those having the same totem naturally formed brotherhoods, and which acknowledged spiritual affinities, and lastly kinship was recognised and relatives were bound together by a common totem, and the restrictions of a common tabu. This important paper will shortly be printed in full by the Anthropological Institute.

Mr. C. Hill-Tout presented a long folk-tale, entitled "Sqaktktquacht, or the Benign-Faced"—an interesting hero-tale of a clever younger brother who went about doing good. He was the youngest of three brothers, who were the children of the red-headed woodpecker and his wife, the black bear. This saga will be published by the Folk-lore Society.

A legend concerning Scar-face, which is believed by the Algonquian Blackfeet to explain the origin of their principal sacred ceremonies, was sent by Mr. R. N. Wilson. So much ritual has reference to this myth, and so many observances are founded upon it, that the student of Indian religious thought may accept it as one of the most significant and instructive of their legends. A beautiful Indian girl refused many suitors, but promised to marry one young man if the scar that disfigured his face could be removed. After a long journey he came to where the Sun lived with his wife, the Moon; their son, the Morning Star, befriended Scar-face. The Sun healed him and retained him until he had been taught many religious ceremonies. Eventually he returned home, married the girl, and taught the ceremonies to his tribe, and the Sun, as he had promised, was kind to the people and heard their prayers. Mr. Wilson's other paper gave a detailed account of Blackfoot Sun-offerings. The tribal religious ceremonies are performed by "prayerful" men; they are not members of any society, but simply individuals of an extremely religious temperament gifted with a good memory. There is no medical priesthood, as has been inaccurately stated. The Sun is pre-eminently the Blackfoot divinity; they may have had more ancient deities, but the "Creator" was never heard of by them until the advent of the missionaries. An account of the life of the Blackfoot women was given by the Rev. J. Maclean. According to Mr. Stansbury Hagar, who presented a paper on the star-lore of the Micmacs of Nova Scotia, the Micmacs believe the stars to be the camp fires of the inhabitants of the sky. The larger fires are before the dwellings of the chiefs, and around them are grouped the lesser lights of the people who bear the same totem name. The Milky Way is the road between heaven and earth. The four stars of the body of the Plough are known as the Bear. He is pursued by seven birds (the three stars of the Plough-handle, Arcturus and γ, ϵ, and υ of Böotes). Near the second of these hunters is a faint star representing the kettle in which the bear is to be cooked. Behind them the Northern Crown with μ and ν of Böotes form a typical den. In the spring the bear is seen climbing out of his den; in summer he runs across the sky; in the fall, overtaken by his pursuers, he is wounded with an arrow and totters to the ground; in winter he lies dead upon his back, but with the following spring returns to life, and so the cycle continues eternally.

Dr. W. J. McGee gave a graphic account of the Seri Indians of the Gulf of California. This very ancient tribe has been so isolated that it had never before been studied. These cannibals are extremely active and warlike; they use poisoned arrows, and owing to their bellicose disposition they are now nearly extinct. They are more distinctly matriarchal than any other tribe, and were originally monogamous, though now they are polygamous. They live entirely by fishing and the chase, and have no agriculture. Their implements are natural stones, which by use may become pounded into more serviceable shapes; for these the term "protolithic" was suggested. A cultural art has been but recently acquired, as there is no name in general use for the chipped arrow-points that they now employ.

The Kootenays and Salishans of British Columbia were described by Dr. A. F. Chamberlain; though allied in many respects, they belong to two distinct linguistic stocks. The former are intensely democratic and without complicated secret societies or totemistic clans. Sun-worship is strongly developed among them. A large series of interesting Kootenay drawings was exhibited by the author.

A summary of the twelfth report of the Committee appointed to investigate the North-western tribes of Canada, by

Dr. Franz Boas, was read. This closes a very valuable piece of work which was instigated at the first meeting of the Association in Canada.

Mr. E. Sidney Hartland gave a comparative account of hut-burial among the American aborigines and other peoples, and its probable significance. The origin of the custom must be sought for in the savage idea of kinship, and in the desire to retain within the kin the deceased and all his power and virtues.

The papers on physical anthropology, or somatology, as our American colleagues call it, were four in number, the most important being two papers by Prof. A. Macalister. In dealing with the causes of brachycephaly, he pointed out that those brain areas are the first to increase which will be earliest called upon to work; thus the area which presides over the skilled movements of the arm develops before that which is connected with similar movements of the leg. The central parietal and temporal lobes grow quickest, and thus in the majority of cases we find an infantile brachycephaly. By the end of the first dentition the frontal length and parietal height increase. About the end of the first year the brain ceases to be free and untrammelled by its envelope, and a contest begins between brain and bone. The hitherto broad open sulci become narrowed and linear. In the English child the change from brachycephalism to mesaticephalism takes place shortly after completing the first dentition. Two types of brachycephaly may be distinguished: (1) Primary, due to the retention of fœtal proportions of the components of the brain, and hence short-headedness accompanied by microcephaly. (2) The secondary brachycephaly is due to increased frontal growth, and is usually associated with megacephaly. The second paper gave a *résumé* of a study of the brains of several Australian aborigines, and exhibited a number of photographs and drawings. He demonstrated that these brains were not deficient in those areas that were implicated in regulating the movements of the limbs, or in the sensory centres; but that there was a disproportionate lack of development of those regions which are known as the association centres.

In a paper detailing an experimental analysis of certain correlations of mental and physical reactions, Prof. Lightner Witmer gave the following statistics relative to rate of movements.

Rate of movements in	American males.		American females.		Indians.	
	Right arm.	Left arm.	Right.	Left.	Right.	Left.
Flexion ...	77	78	163	154	132	124
Extension	107	110	197	194	150	153
Minimum	77		154		124	
Maximum	110		197		153	
Reaction time to						
Sound ...	123		154		121	
Light ..	136		146		137	
Electric shock	117		131		117	

He stated as the results of his experiments, that women were deficient in will power, and do not know how to move so rapidly as men. They also felt more responsibility, while making these experiments, that is, they were more self-conscious. When experiments on sensation for pain were made, there was a tendency for the females to anticipate the sensation, and for the men to deny they felt it at all.

A prominent feature of the session were two discussions, in which the American anthropologists present took a prominent part. The first was on the evidences of American-Asiatic contact, and the second was a joint discussion with Section C (Geology) on the first traces of man in the New World. The former was led off by Prof. Putnam giving an account of the origin, aims and organisation of the Jesup expedition to the North Pacific. The object of this extremely important and well-planned expedition is to minutely study the natives of the North-west coast of Canada, those of Alaska and of the corresponding coasts of Siberia, and thus to endeavour to gain accurate data towards the solution of the problem of the origin of the American aborigines. The funds for the expedition, which will be six years in the field, have been supplied through the munificence of Mr. Jesup of New York. The discussion was very animated, and was joined in by the President of the Section, Messrs. Morse, Cushing, McGee and Chamberlain. Prof. Morse argued strongly against any cultural influence between Asia and America, appealing to the distinctness in the pottery, roofing tiles, method of arrow release, &c., and to the absence in America of the thumb-ring in archery, of the chop-sticks, plough, potter's-wheel, and tea. Cushing argued on the same side, though he believes in a primitive Asiatic origin of the Indians. He said if there is a science of anthropology it must be demonstrable that the development of man is according to certain fixed laws, and hence there must be some similarity between different peoples in an analogous stage of culture. In his reply Putnam referred to the distribution of jadite and nephrite implements, and still maintained that there had been more Asiatic influence than most of the speakers admitted.

Not less interesting was the discussion of the antiquity of man in America. This was opened by Prof. F. W. Putnam, who gave an account of the excavations in the Trenton gravels, and of the argillite implements that were found in the lower beds. Prof. E. W. Claypole narrated the discovery of a polished stone implement in the Drift of Ohio (*cf.* NATURE, vol. lv. p. 350). Sir John Evans argued that the Trenton finds were all neolithic, and that palæolithic forms were absent from America, though widely spread over the Old World. The true test of a Palæolithic age was the occurrence of animals now extinct. Dr. J. W. Spencer stated that the Lafayette beds followed the Glacial Period, as they contain some re-arranged glacial deposits; then came a period of elevation and denudation, in which the Columbian beds were deposited. Later there were several oscillations of level, during some of which the Trenton gravels were formed. The Trenton gravels may be older than the Falls of Niagara (to which he gave 32,000 years), and he believed they were deposited between 5000 and 50,000 years ago. Dr. McGee believed that the gravels were a wind-blown formation, and stated that Prof. Holmes had failed to find a single artificial object in the undisturbed Trenton gravels, but such objects were found in the talus. Few geologists think implements occur in the gravels. He did not lay much stress on the argument based on the argellite implements. Argellite quarries have long been worked by the Algonquins, and plenty of their rejects have been considered as palæoliths. Prof. Putnam, in his reply, said Sir John Evans was wrong in supposing that neoliths were found in the gravels. The various forms of European palæoliths could be easily matched in numbers in America; but it must be remembered that the European examples are made of flint, but as there is no true flint in America we must not expect a very close correspondence. He again emphasised the preponderance of argellite implements in the lower beds, and alluded to the presence of 99 per cent. of argellite implements in the oldest parts of the shell-heaps of New Jersey.

The genesis of implement-making was the subject of a thoughtful and suggestive essay by F. H. Cushing. He believed that anthropoidal man, who arose somewhere about the Indian Ocean, was coaxed down from the trees by the abundance of food along the shores of the sea, and there, by his own domestication, sowed seeds for variation. Manual dexterity set at naught all the effects of previous evolution, and henceforth evolution became more psychical than physical. As a psychic effect of the upright position, the nascent human beings now looked, for the first time, into the face and eyes of their mates, and conscious love was begotten, then volitional selection began to replace mere sexual selection, and language became possible. For a long period man was "prelithic," and supplemented his teeth and nails with the fangs and claws of wild animals. Stones were picked up and used as occasion required without any preliminary dressing. At first, judging from the actions of monkeys and children, the bones and nuts were broken upon the stones; later, stones were used as crushing or breaking implements. Some of the bruised stones were found to be more effective than others, and these would be treasured, and soon it would occur to people to intentionally fracture stones so as to resemble these. It is possible that some of the earliest implements to be manufactured were made in imitation of the sharks' teeth that they picked up on the shore and used as implements. In employing flint implements on bone or horn it would be discovered that the bone actually worked the flint, and so the removal of flakes by pressure would be found to be more effectual than by hammering, and thus the neolithic technique was arrived at and perfected. Certainly some chipped tools would be worn smooth by use; and if these proved more useful, the actual process would be definitely repeated. In early Palæolithic times man made an important conquest and captured fire, which he kept and fed to protect himself from wild animals and from cold. The domestication of fire was the beginning of the conquest of nature. Later a tacit understanding arose between primitive man and the dog. Mr. Cushing gave a demonstration on some of the early stages of stone implement-making in illustration of his paper.

Several lantern demonstrations were given in the afternoons, among which may be noted the following:—"The Lake-Village of Glastonbury and its Place among the Lake-Dwellings of Europe," by Dr. R. Munro; "Some Old-World Harvest Customs," by F. T. Elworthy; "The Evolution of the Cart and Irish Car," by Prof. A. C. Haddon; "The Kafirs of Kafiristan," by Sir George Robertson; and "The Mangyans and Tagbanuas of the Philippine Islands," by Prof. Dean C. Worcester.

The sectional meeting was very successful, and it was a great pleasure to the British anthropologists to meet those of their Canadian and American colleagues who attended the meeting. It was a memorable occasion for the interchange of cordial friendship and valuable information.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE current number of the *Chemical News* (September 10) is devoted to descriptions of courses in chemistry at British Universities and Colleges. In a brief introduction to this information, reference is made to "the recognised superiority of German chemists in the quantity of research yearly executed," and attention is called to a pamphlet in which Prof. Dr. F. Fischer recommends that the position in technical chemistry which Germany occupies in comparison with other countries be further extended and secured. It appears that there are in Germany four thousand technical chemists, exclusive of about two hundred others, who study chemistry from a purely scientific point of view.

THE 1897-98 Programme of Technological Examinations conducted by the City and Guilds of London Institute, including regulations for the registration and inspection of classes in technology and manual training, has just come to hand. Year by year, we are glad to remark, this publication increases in size and value. Syllabuses are given of the sixty-seven technological subjects in which the Institute holds annual examinations, and helpful lists of works of reference are appended to them. The questions set in this year's examinations are all printed in the Programme, and they show that the Institute is working wisely and well for the advancement of technical education.

SCIENTIFIC SERIALS.

Bulletin of the American Mathematical Society, July.—Newton's theory of kinetics, by W. H. Macaulay, is a discussion of Newton's Scholium to the "definitiones" in the "Principia." Galileo, in his study of the motions of falling bodies and projectiles relative to the earth, though he eliminated the effects of friction and of the resistance of the air, did not introduce any correction involving the earth's rotation. Mr. Macaulay, after referring to Newton's letter to Hooke (Ball, "Essay on Newton's Principia," p. 142), summarises the chief points laid down in Newton's first and second chapters, and notices how difficult Newton's task was, and attempts to clear away some of the difficulties.—The decomposition of modular systems of rank n in n variables is a paper presented by Prof. E. H. Moore to the Chicago section of the American Mathematical Society.—An interesting note upon the biquadratic, entitled "On a solution of the biquadratic which combines the methods of Descartes and Euler," by Dr. McClintock, read at the May meeting of the Society, employs a resolution which is new to us.—Dr. L. E. Dickson contributes a paper on higher irreducible congruences, which in part runs on parallel lines with the "beautiful" developments of Serret ("Algèbre Supérieure"), and in part is quite independent and so is worked out in some detail.—Prof. Van Vleck gives an extended review of Dr. Max Stegemann's editions of Kiepert's "Grundriss der Differential- und Integral-Rechnung" (the former in its seventh and the latter in its sixth edition). The work, with some slight blemishes, appears to be a most valuable work of reference, and it is to be hoped that its good points may be made available to English students.—A short notice, by Dr. Stabler, follows of A. Arnaudeau's "Projet de Table de Triangulaires de 1 à 100,000." E. de Joncourt's tables (published at the Hague in 1762) go from $n = 1$ to $n = 20,000$ in the formula $\frac{1}{2}n(n+1)$. The present tables "are a valuable and interesting addition to the tables now in existence for facilitating multiplication," and are "a great advance over any previously published table of triangular numbers."—Notes, a long list of new publications, list of papers read before the Society (giving places of publication of the same), and index to the volume close the number.

IN the *Journal of Botany* for August, Messrs. W. and G. S. West complete their revision of Welwitsch's "African Freshwater Algæ," a collection which has proved remarkably rich in new forms, including a very large number of new species and not a few new genera. The collection comprises 300 species distributed over 77 genera.—In the number for September, Mr. F. Townsend commends a monograph of the British species of *Euphrasia*, founded on Wettstein's classical monograph of the genus.—Mr. J. Lloyd Williams records the interesting discovery that the antherozoids or pollinoids of *Dictyota* and *Taonia* are not, as has hitherto been supposed, immotile, but are provided with cilia and endowed with motion.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 6.—M. A. Chatin in the chair.—On the number and symmetry of the fibro-vascular bundles as a measure of the organic perfection of vegetable species, by M. Ad. Chatin. This paper treats of the perigynous *Gamopetalæ*, the hypogynous *Gamopetalæ* or *Corolliflora* having being considered in a previous communication.—On Bessel's functions $O^n(x)$ and $S^n(x)$, by M. L. Crelier.—On the hypocycloid with three cusps, by M. Paul Serret.—The magnetic deviation of the kathode rays and X-rays, by M. G. de Metz. The author continues his study of the magnetic deviation of these rays and, under different experimental conditions, obtains results similar to those described in a preceding note.—Influence of the X-rays on the luminosity of gases, by M. A. de Hemptinne. The action of electric vibrations causes gases to become luminous at a low pressure, but if the gas is, at the same time, submitted to the influence of the X-rays the luminosity appears at considerably higher pressures. Numbers are given for hydrogen and oxygen gases, and for a few organic compounds.—The composition of potatoes, by M. Ballard. Analyses of a number of varieties are given. The amount of water is found to be closely connected with the nature of the soil, and to be independent of the variety and the size of the tuber.

CONTENTS.