THURSDAY, OCTOBER 3, 1901.

A SCIENTIFIC ENGINEER.

Papers on Mechanical and Physical Subjects. By Prof. Osborne Reynolds, F.R.S. Vol. ii. 1881–1900. Pp. xii+740. (London: C. J. Clay and Sons, 1901.) Price 21*s.* net.

A FULL account of the first volume of Prof. Osborne Reynolds' collected papers has already appeared in these pages (vol. lxii. p. 243). The second volume, which is no less interesting than its predecessor, brings the author's contributions to mechanical science up to date and enables us to realise the value of the work he has done. The twenty-seven papers here printed vary, no doubt, in importance; but throughout them all Prof. Reynolds has kept one aim clearly in view, the application of physical and mechanical principles to engineering problems; whether he is dealing, as in the first paper, with the question of the fundamental limits of speed or, as in the last, with the reasons why ice is slippery, this aim is always before the author.

It is difficult from a volume of this kind to make a selection of points to notice; there are, however, three papers which stand out conspicuously as dealing in a luminous manner with three fundamental problems. The first is No. 44, an experimental investigation of the circumstances which determine whether the motion of water shall be direct or sinuous, and of the law of resistance in parallel channels. The second, No. 52, on the theory of lubrication and its application to Mr. Beauchamp Tower's experiments, and the third, No. 66, on the method, appliances and limits of error in the direct determination of the work expended in raising the temperature of ice-cold water to that of water boiling under a pressure of 29·899 inches of ice-cold mercury in Manchester. A few lines may be given to each of these in turn.

The fact that for narrow tubes and for small velocities the resistance to the flow of water in a tube is proportional to the velocity follows from the experiments of Poiseuille and others. It was also known that this law did not hold in larger tubes or when the velocity was considerably increased, but the cause of the change and the relation of the velocity to the radius for which it occurred in a given tube were unknown until the date of Prof. Reynolds' experiments. He showed that if D be the diameter of the tube, V the velocity of the stream and P the ratio of the coefficient of viscosity to the density, then the change of resistance takes place at a velocity V given by the equation $V = P/BD$ when B is a constant, and, moreover, that at this critical velocity the motion of the water in the tube changes from direct to sinuous; eddies and vortices are set up which are intimately connected with the change in resistance. Further experiments showed that up to the critical velocity the slope of pressure in the tube varies as the velocity, while for velocities considerably greater than the critical the slope of pressure varies as the velocity raised to the power of 1·72.

The second paper deals with Mr. Tower's experiments on lubrication. Mr. Tower had shown that when the rubbing surfaces, the friction between which was being investigated, were totally immersed in oil, a thin film of oil was formed between them, within which the pressure was enormously greater than in the oil bath; in some cases it was as much as 625 lbs. to the square inch above the pressure in the bath.

Prof. Reynolds gives a very complete account of the existence of this film and of the conditions for complete and incomplete lubrication.

In the last paper mentioned the author gives the theory of a very valuable redetermination of Joule's equivalent.

The laboratory at the Owens College is fitted with a set of triple expansion engines which can be arranged to work on three special hydraulic brake dynamometers, the energy being absorbed by a stream of water which passes through the brake. This water can be taken from a tank holding some 60 tons in a tower 116 feet above the laboratory floor.

The experiment, put briefly, consisted in measuring the work put into the brake, the temperature of the incoming and outflowing water and the quantity of that water. Prof. Reynolds' paper contains a detailed exposition of the theory, with an account of the precautions taken and calculations required to allow for the various sources of error.

The experiments were conducted by Mr. Moorby, and are very closely concordant. It results from them that the mean specific heat of water between freezing and boiling points is 776·94 ft. lbs., or in C.G.S. units 41832000 ergs.

Other papers of great interest and importance might easily be mentioned; for these we must refer the reader to the book itself, at the same time congratulating the author on the conclusion of the task he was asked to undertake and the Cambridge University Press on the service it is rendering to science by its series of reprints of mathematical and physical papers.

NORTH AMERICAN INSECTS.

The Insect Book: a Popular Account of the Bees, Wasps, Ants, Grasshoppers, Flies, and other North American Insects, exclusive of the Butterflies, Moths, and Beetles, with full Life-histories, Tables and Bibliographies. By Leland O. Howard, Ph.D., Chief of the Division of Entomology, U.S. Department of Agriculture. Pp. xxvii+429; 47 plates (plain and coloured), and 264 woodcuts. (New York: Doubleday, Page and Co., 1901.) Price 3 dollars net = 12*s.*

IN the preface to Dr. Holland's admirable "Butterfly Book," the author mentioned that he might subsequently issue a similar work on the moths. The book before us is uniform with Dr. Holland's, who is, as Dr. Howard informs us in his preface, engaged on the promised volume of moths, while another volume on the beetles is in contemplation, we presume by, or under the supervision of, Dr. Howard, though this is not explicitly stated.

Enormous strides have been made in the study of North American entomology during the last forty years, and there must now be a very considerable number of entomologists in the country. No doubt many of these devote themselves to the popular orders of Lepidoptera and Coleoptera, as in Europe; but nevertheless there are numerous active workers, known or unknown, in all the so-called "neglected orders," and a popular manual on these insects, freely illustrated, must greatly conduce to their more extended study, though it is, of course, impossible to treat of five great orders of insects in a single volume in anything like so complete a manner as Dr. Holland was able to achieve for the limited group of butterflies. Dr. Howard has, however, contrived to bring together and condense a large amount of very useful information from various sources, and his book should prove nearly as valuable to European as to North American entomologists; for not only are a large proportion of the various families and genera common to both countries, but a considerable number even of the species here described and figured are common and well-known British species. Here and there we find a slip, as when the number of described species of Hymenoptera is estimated on the first page as nearly 30,000, whereas it almost certainly exceeds 40,000 at the present time; and at p. 345 the exploded superstition originated by Kirby and Spence that earwigs do *not* enter the human ear seems to be insisted on. Perhaps the rarity of earwigs in the States may partly account for this.

We have already said that some of the species included in this work are common British species. Others are large and handsome forms quite unlike any existing in England, or perhaps in Europe. This is especially the case in the orders Orthoptera and Neuroptera; and the pretty plates of dragonflies, especially plates 40 and 43, representing species with coloured wings, will be something like a revelation to the entomologist familiar only with the hundred European species of dragonflies, not more than three or four of which have any considerable amount of colour in the wings, though this is partly atoned for by the bright colours of their bodies.

Most, if not all, of the figures in the plates are probably original; but most of the text illustrations are copied from Riley, Packard, Comstock and other well-known writers.

As is usual with recent American writers, Dr. Howard admits several more families of insects than the seven with which most of our English entomologists are satisfied. Tables of families are given in several of the orders, which will greatly facilitate the work of a beginner. Otherwise, however, there is little technical matter in the book, which mainly consists of descriptions of habits and transformations. There is a good deal of light readable matter; and Mr. Marlatt's account of the way in which boys in Kansas rob humble-bees' nests by enticing the bees into a jar half filled with water will be equally new and amusing to most English readers.

Turning to the end of the volume, we find a good but not too extensive index of thirteen pages, double columns, preceded by a bibliography of twelve pages, very closely printed in double columns, and arranged systematically in a manner that seems a little puzzling till one gets used to it. This will prove a most useful part of the book to serious workers, and it brings out very forcibly the enormous periodical literature to which Dr. Howard alludes in his preface and which is so conspicuous a eature of the American entomological literature of the present day. The bibliography is preceded by a section on "Collecting and Preserving Insects," freely illustrated in the text, like the rest of the book, which, although primarily written for American entomologists, may also furnish useful hints to European collectors.

We cannot do less than strongly recommend Dr. Howard's book to all entomologists who are interested in theorders of insects to which it refers, repeating that the main features of the book are the detailed life-histories and the number of good illustrations of the insects discussed.

OUR BOOK SHELF.

Nature Teaching. By Francis Watts, F.I.C., F.C.S. Pp. 199. (London: Dulau and Co. Barbados: Bowen and Sons.)

THIS is a very useful volume, issued under the authority of the Imperial Commissioner of Agriculture for the West Indies. It is based upon the general principles of agriculture, and has been designed for the use of schools in the islands. Although these colonies depend entirely on the proper cultivation of the soil, there has hitherto been practically no attempt made to impart to the rising generation a knowledge of even the elements of agriculture. Like everything else in the mother country and in Britain across the seas, the rule of thumb, happy-go-lucky system has been preferred to scientific methods, with the result that we are all being left behind in the race. The Imperial Commissioner notes that one of the most hopeful features connected with the West Indies is the general movement which is now taking place in favour of agricultural teaching. Teachers in charge of schools have during the past three years been undergoing training sufficient to enable them to impart a fair knowledge of botanical principles to their scholars, and the volume now prepared by Mr. Watts, with the assistance of Mr. Maxwell-Lefroy, is intended to guide the teachers in the way they should go. The work is divided into nine chapters, dealing respectively with the seed, the root, the stem, the leaf, the soil, plant food and manures, flowers and fruits, weeds, and insects. Simple language is used in describing each subject, and every chapter ends with copious instructions on practical work. Thus the chapter on the seed deals with the parts of a seed; plant food in seeds; and germination; while under "practical work" we find described the conditions for germination; raising seedlings; seed beds; observations on seedlings; and testing vitality of seeds. A glossary and appendices are added. The book is not intended as an ordinary reading-book, but for the use of the older pupils who have already received oral instruction in the various subjects.

Cassell's Eyes and No Eyes Series. Book I. *Wild Life in Woods and Fields.* Pp. 48. Book II. *By Pond and River.* Pp. 48. Book III. *Plant Life in Field and Garden.* Pp. 80. Book IV. *Birds of the Air.* Pp. 79. By Arabella B. Buckley (Mrs. Fisher). (London: Cassell and Co., 1901.) Price, Books I. and II., 4*d.* each; Books III. and IV., 6*d.* each.

THESE attractive little books will promote an intelligent interest in plants and animals among the children who read them. In very simple words Mrs. Fisher describes some insects, birds, flowers, and other living things familiar to observers of outdoor nature, and her descriptions will doubtless direct the attention of many pupils to natural history studies. Each book has several nicely coloured plates in addition to numerous other illustrations. In rural schools the books should be of exceptional value.

LETTER 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.*]

Long-tailed Japanese Fowls.

WITH reference to my previous letter on this subject, I should like to draw the attention of the readers of NATURE to a very interesting paper in the *Transactions* of the Asiatic Society of Japan (vol. xxvii. 1900). The writer, Mr. Basil Hall Chamberlain, who has obtained his information from a Japanese fancier, Mr. Kitagawa Ushimatsu, and has also examined the birds himself, states that "there is absolutely no artificial method of making the feathers grow. All is done by selection. Any failure to obtain good results must proceed from having a bad hen, that is, one not of the true breed, and it is in this point that buyers are liable to be deceived. Also one must know how to treat the birds."

The long tail-feathers, Mr. Chamberlain states, grow during the whole life of the bird, which may extend to eight or nine years. If accidentally pulled out they are reproduced. The rate of growth is about four inches a month in young birds, but as much as seven inches in older specimens. The custom of tying up the tail is stated to be a mistaken one, and not to be followed where the birds are bred. The very best specimens are, not unnaturally, kept at home by the breeders in the Tosa province.

The breed is believed to be about a century old, but its origin is unknown. But it seems obvious from the evidence given that it was bred from birds which "sported" in the direction of continuously-growing feathers, as I suggested. Mr. Chamberlain's paper is illustrated by two excellent photographs of cocks of this breed, one of which at least is evidently far superior to the specimens exhibited at South Kensington, remarkable as these are.

FRANK FINN.

c/o Zoological Society, 3, Hanover-square.

PROF. A. F. W. SCHIMPER.

WILHELM ANDRÉ SCHIMPER, who passed away on September 9 in his forty-sixth year, was the great son of an eminent father. Inheriting from his father, the professor of botany, and from the Abyssinian traveller Schimper, a famous name, he made that name yet more famous.

Schimper studied at the University initially, I believe, with the intention of becoming a mineralogist; and his first paper, on proteid crystals (1879), bears the impress of his special training. But this paper, as well as an early one (issued 1880) on a parasitic flowering plant, *Orobanche*, has been overshadowed by his later achievements.

It was not until the appearance of his paper on the origin of starch (1880) that the botanical world became aware that a young botanist of power and originality had joined it. Before the appearance of this paper the view prevailed that starch-grains were manufactured either by chlorophyll grains or by the general protoplasm. Schimper showed that starch-grains are invariably produced in specialised masses of protoplasm, in chlorophyll grains, or in colourless "starch-builders." Continuing his researches (1880-1885), he, together with Schmitz, proved that chloroplasts, exclusively by division, arise from preexisting ones (or their homologues), but never by a formation *de novo* from the general protoplasm. Schimper further demonstrated the homology of the three classes of chromatophores—leucoplasts (without colouring matter), chloroplasts (with chlorophyll), and chromoplasts (with red or yellow colouring matter). In fact, while other histologists were showing that the plant-cell and animal-cell had two distinct and individualised kinds of protoplasm—cytoplasm and nucleus—Schimper was demonstrating that a third existed, which, like the other two, could produce, and only be produced by, its like. In other words all (or at least nearly all) indubitable animals possess in their cells only two completely distinct kinds of protoplasm, whereas all indubitable plants, with the exception of fungi, and possibly some of the lowest vegetable organisms, have three kinds; and it is to the possession of this third kind of protoplasm—chromatophore-protoplasm—that the plant world largely owes its evolution.

But Schimper's investigations on starch-grains incidentally aided in the inception of another, though minor, revolution in botanical thought. When Schimper commenced his work on the origin of starch, Naegeli's theory of growth of the cell-wall by intussusception was firmly held. Schimper's observations and considerations on the growth of starch grains, and some of Schmitz's observations, were the first blows struck at Naegeli's theory, in favour of growth by apposition, and doubtless they stimulated Strasburger to furnish his masterly case in support of the latter view.

Not to adopt strict chronological order, but to follow Schimper's researches so far as they dealt with pure physiology or histology, the next paper, on the conduction of carbohydrates (1885), was of value, as an exhibition of a strict physiological method, and as an appeal against the alluring and facile method of endeavouring to solve physiological problems solely by histological observations, rather than as a paper containing essentially new physiological views. Schimper's two succeeding physiological papers, on the formation of calcium oxalate in leaves (1887), and the assimilation of mineral salts (1890), were of greater importance. They introduced the method of following by microchemical tests the various inorganic elements in their course from the root to the leaves. Apart from serving as admirable and novel models of physiological research, these papers proved that the leaves are no mere workshops for the manufacture of carbohydrates, but that they are in reality perfectly equipped factories in which the rawest food materials can be, and are, worked up into elaborate proteid compounds, and even into protoplasm. Schimper further showed that chlorophyll, in addition to affecting the decomposition of carbon dioxide and the production of carbohydrates, also in some way influences the reduction of inorganic salts and the production of proteids, apparently in a direct manner.

Despite the value of his contributions to our knowledge of the histology and physiology particularly of green cells, Schimper's fame is possibly wider as the founder of a true method of investigating the "politics," "biology," "bionomics," or œcology of plants.

Though Sprengel, Darwin, H. Müller and others had set so excellent an example in their treatment of questions relating to the pollination of flowers, in other departments of the subject the œcology of plants was mainly a motley array of ill-considered hypotheses, vain phantasies and unfounded conclusions, and by serious botanists the subject was derided as the "romance of botany." Schimper inaugurated a new era. In dealing with problems on the relation between plants and their environments, he insisted that the same thoroughness and precision should be exercised as in investigating morphological and physiological questions.

Schimper's first œcological paper, on epiphytes (1884), was a veritable revelation, magic as a fairy-story in interest, but severely reasoned in substance. In this, and in its final version (1891), it was shown that epiphytes were children of the moist forests, and had arisen as beings that had won a victory in the struggle for light by seizing positions of vantage with very little expenditure of material. Commencing as humble occupants of the soil within the shady forest, epiphytes had in the course of ages laboriously clambered up the trees, striving after the light, and ever struggling against the precarious and fluctuating supplies of moisture and of humus, inventing new absorbing and fixing organs, and contriving fresh devices for resisting threatened death from thirst or starvation, until at length their perilous career was crowned with success and they formed aërial meadows, gardens, shrubberies, and even forests. Schimper showed that the evolution of epiphytes was still reflected in the forest, where the simplest epiphytes lurk low down in moist shaded crevices of the tree trunks, and the more elaborate ones are ranged successively upwards until, even before the tree-tops are reached, perfection is practically attained. Further, he taught how, having emerged into the full blaze of the tropical sun, some epiphytes had sprung across to the savannahs, where they colonised the isolated trees or clothed the nakedness of the bare rocks. And still later he carried the history one step further and revealed some epiphytes flying up to the mountain-tops and others leaping down to the ground near the sea.

The next œcological paper, that on myrmecophilous plants (1888), furnished relatively little that was new, but by the application of a strict method of research it definitely proved views that had been promulgated by that sagacious naturalist, Belt.

The very brief communication on the means of protection against transpiration (1890) was possibly the most suggestive ever issued by Schimper. In it he explained that terrestrial plants living on or near the sea shore, even in saline swamps, or growing inland in the vicinity of salt springs, require to protect themselves against excessive transpiration owing to the difficulty in obtaining a sufficient supply of water with or without salt. Further, he pointed out that Alpine plants in the tropics, at spots where there is no snow, reveal the same xerophilous character as in temperate regions, and it is against desiccation due to exalted transpiration, and not against cold as such, that Alpine plants have to battle. Finally he directed attention to the fact that in temperate regions deciduous trees shed their leaves because they cannot absorb water sufficiently rapidly from the cold soil; whereas evergreen trees can retain their foliage because of the xerophytic structure of the latter. (Though he was not aware of the fact, Schimper was not the actual discoverer of this truth, for I find that Hales appreciated it.) These considerations led to the solution of several geographical problems. They explained how, in temperate and tropical regions alike, Alpine plants may reappear on the sea shore; how, in the tropics, epiphytes reappear as terrestrial plants on Alpine heights, on the sea shore, or near salt-springs. These plants can interchange positions because they are all adapted to resist one danger—excessive transpiration.

In his last œcological paper on a special subject—the Indo-Malayan littoral vegetation (1891)—the principles enunciated in the preceding work were proved and expanded, and other relations between littoral plants and their animate and inanimate surroundings were dealt with. It is impossible to do justice to this paper in a brief note, but it may be mentioned that the important distinction between salt-loving and salt-hating plants was shown to refer, not merely to plants growing on the shores or inland respectively, but to whole orders or cohorts. Littoral plants, then, are salt-enduring representatives that have been driven by competition to the fringe of vegetation, where they have evolved new features in their vegetative and reproductive parts in order that they may exist and spread abroad from shore to shore.

Schimper's last book, a general work on geographical distribution of plants considered from a physiological standpoint, is beyond doubt one of the most illuminating botanical works ever published. No one save a wide traveller, inspired with a deep love for, and close sympathy with, Nature could have written this masterpiece. It was the crowning piece of his life, for Schimper was stricken down in the midst of a new work on island floras.

In conclusion we may say that Schimper revolutionised our ideas as to the fundamental constitution of the unit of plant life, widened and deepened our knowledge of the physiology of green assimilating cells, and, himself in every field in which he worked an earnest advocate, and even inventor, of strict methods of research, he, in particular, took a foremost place in raising up a true science of œcology. Through the passing of Schimper the world of science is darker by the extinction of a light which, if it did not glow with steady incandescence, yet quivered and scintillated with genius.

PERCY GROOM.

NOTES.

INTRODUCTORY addresses were delivered on Tuesday at several of the London and provincial medical schools, to open the new session. Dr. P. W. Latham, speaking at St. George's Hospital, pointed out that organic chemistry will in time tell exactly what is the composition and constitution of toxins, albumoses, antitoxins, &c., which have proved of service to medicine, and how they may be artificially synthesised in the laboratory. The vegetable alkaloids quinine, morphine and atropine, have been isolated within the last century; and the syntheses of citric acid and indigo have been effected from their elements. The isolation of the animal alkaloids may be more difficult, but it will be accomplished—some have already been obtained, others will follow; the isolation of the antitoxins will be the next chemical triumph, and then will come the synthetical production of these life-saving substances. At University College, Prof. R. Russell begged his hearers to cultivate the spirit of scientific inquiry. Every scientific investigation, if properly conducted, might be expected to disclose some new fact, and this was the only way in which true progress could be made. It was to men of science that every real fresh advance in medicine was due. The so-called practical man could do little more than apply and utilise the discoveries of the investigator. A belief prevalent among some people, that a man could not be both scientific and practical, and that the cultivation of the one spirit must of necessity be at the expense of the other, he regarded as a great fallacy. Medicine and surgery could only be expected to be advanced by a proper commingling of the scientific and the practical, so that scientific principles might find practical application in the elucidation and treatment of disease. At the London School of Medicine for Women, Dr. F. W. Andrewes also referred to the intimate relation between scientific studies and medical practice. He remarked, for instance, that the methods by which pathology is studied are precisely those used in other pure sciences—observation and experiment—and it is this science which is placing medicine and surgery on a scientific basis. It is obvious that a sound knowledge of disease is an indispensable preliminary to its reasonable treatment. At the Royal Veterinary College, Prof. Crookshank discussed the subject of the relation between human and bovine tuberculosis. Dr. A. P. Luff, at the Pharmaceutical Society, commented upon the too general use of powerful drugs in compressed forms, and of proprietary preparations, in the treatment of disease. Addresses were also given by Dr. W. Hill at St. Mary's Hospital, and Dr. T. H. Kellock at Middlesex Hospital.

THE forty-sixth annual exhibition of the Royal Photographic Society was opened to the public on Monday at the New Gallery, Regent Street, and although the greater part of the available space is occupied by exhibits of the artistic and professional kinds, there is an important section devoted to scientific and technical examples. Among a considerable number of natural history subjects there is a notable series, that has been awarded the Society's medal, by Mr. Douglas English. He shows six frames, each containing three or four different photographs of the brown rat, the common mouse, the wood mouse, the field vole, the bank vole and the water vole respectively. The photographs are not of a haphazard kind, for in spite of the difficulties of the subjects Mr. English has succeeded in giving typical front and side views of each species. A series of waves and ripple marks in water, sand, snow and clouds, by Dr. Vaughan Cornish, and another of typical cloud forms, by Captain D. Wilson-Barker, are good examples of the kind of work that may be done in this direction. M. Henri Becquerel has contributed several interesting examples of the effects of the mysterious rays that emanate from uranium and radium, including their deviation in a magnetic field and the separation of the different kinds of rays. Recent spectrum work of various kinds is also shown. A series of radiographs by Dr. Hall-Edwards is of especial interest as they were made at the Imperial Yeomanry hospitals at Deelfontein and Pretoria a few months ago. They show bullets in different parts of the body, including the chest, and the effects of soft-nosed and expansive bullets. In the Exhibition there will be found a fine collection of examples of various methods of photomechanical work. A panorama of the great working hall of the German Electrical Co. is a remarkable photogravure nearly five feet in length, by Messrs. Meisenbach, Riffarth and Co., but the most notable exhibits in this section are the colour prints. Three-colour prints by the method of superposed films, superposed carbon prints, and the ordinary three-colour typographic work, photogravure in colours and colour collotypes, may be seen at their best. Those who appreciate the curious in this direction may examine gum bichromate prints in three colours, and colour effects produced by exposing gelatino-chloride paper through green leaves. Among the new apparatus the European Blair Camera Co. have contributed their new film cartridge, in which the numbers and dividing marks are simple perforations through white paper, showing the black beneath, and therefore cannot have any effect on the sensitive surface.

THE Cunard steamer *Lucania*, which arrived at Liverpool on Saturday morning, reported that, on September 25, she had been in communication at sea by wireless telegraphy, with the same company's outward bound steamer *Campania*, which left Liverpool on September 21. The ships were 36 miles apart when complimentary messages were exchanged, and were not visible to each other at any time.

THE annual "cryptogamic meeting" of the Essex Field Club will be held on Saturday, October 12, at High Beach, Epping Forest. Dr. M. C. Cooke, Mr. Massee, Prof. Marshall Ward, F.R.S., and other botanists have consented to act as referees. Prof. Marshall Ward will give an address on "The Scientific Study of Fungi." Botanists and others wishing to attend should communicate with the hon. secretary, Mr. W. Cole, Buckhurst Hill, Essex.

WE learn from the *Times* that a statue of Pasteur was unveiled on Sunday at Arbois, where he spent his childhood and where he latterly spent his few holidays. Pasteur's son and his son-in-law, M. Vallery Radot, were present, and almost the whole population of the little town assembled round the statue. M. Decrais, Minister of the Colonies, in a glowing eulogium on Pasteur, stated that in the hope of earning for France the honour of preventing the ravages of yellow fever, Drs. Marchoux and Simon, nominated by the Pasteur Institute, and M. Salimbeni, an eminent Italian, were about to be sent to Brazil to study the malady. M. Liard, of the Institute, also spoke on Pasteur's achievements and character.

PROF. G. SIMS WOODHEAD contributes to the *Monthly Review* an article upon the prevention and cure of tuberculosis, with special reference to the conclusions stated by Prof. Koch in his address to the recent British Congress on Tuberculosis.

THE last two numbers received of Engler's *Botanische Jahrbücher* (vol. xxx. Heft 2 and vol. xxxi. Heft 1 and 2) contain several important systematic papers—a monograph of the Diseæ (a section of Orchideæ), by R. Schlechter, and a monograph of *Mahonia*, by F. Fedde—a report on the botanical results of the Lake Nyassa and Kinga Mountain Expedition, by Prof. Engler; and a very interesting short paper by E. Ule on ant-gardens in the Amazon region. Several species of ants appear to collect the seeds of the "ant-epiphytes" and carefully bury them in humus, covering up and protecting the young plants when they germinate, and thus producing veritable gardens often of considerable size. Quite a number of these epiphytes—three Araceæ, five Bromeliaceæ, five Gesneraceæ, one Moraceæ, two Piperaceæ, one Cactaceæ—were found by Ule in these gardens and nowhere else.

THE Society for the Protection of Birds is this year offering two prizes, of 10*l.* and 5*l.* respectively, for papers on the best means of establishing a "Bird and Arbour Day" in England. In many of the schools of the United States bird days and arbour days have become a very popular institution, and have proved most successful in interesting teachers and children in birds and bird protection; and the Society's offer will, it is hoped, elicit practical hints as to the way in which the scheme may be introduced and worked in English schools. Papers are to be sent in not later than November 30, 1901, and all particulars may be obtained of the Hon. Secretary, Society for the Protection of Birds, 3, Hanover-square, London, W.

DR. T. E. THORPE'S report upon the work of the Government Laboratory has recently become available. From the large amount of work described in the report, we select a few points for mention. It appears that since the Act was passed limiting the amount of moisture in tobacco to 30 per cent., manufacturers have been using an excessive quantity of oil in roll and cake tobacco. An Act was therefore passed last year limiting the proportion of oil to 4 per cent., and a process for the estimation of the amount of oil has been devised. Liquorice, glycerine, and salicylic acid are other substances found in adulterated samples of tobacco. Two samples of British-grown tobacco were received at the Government Laboratory from two small lots of tobacco which had been grown in England by persons who had not received the permission from the Board of Inland Revenue to grow tobacco—such permission is necessary even for experimental cultivation. A sample of pemmican was examined for the Committee of the National Antarctic Expedition. It was supposed to be quite free from moisture and to contain 60 per cent. of ox lard with a highly nutritive base, but on examination it was found to contain 8 per cent. of moisture and 38 per cent. of starch, whilst the total amount of fat present was only 19·6 per cent. Many other instances of adulterated goods and variation of quality are given by Dr. Thorpe. Thus, in ten samples of india-rubber the proportion of vulcanised rubber was found to vary between 5·7 and 44 per cent. Analyses made for the War Office showed that several samples of so-called butter were margarine; baking powders have been found to contain 67 and 75 per cent. of starch; cocoa paste has yielded 41 per cent. of water and only 23 per cent. of real cocoa; a sample of mustard contained 60 per cent. of added flour; strawberry jam 10 per cent. of other fruit, and many other jams and marmalade large proportions of glucose; oatmeal, flour and arrowroot were found of inferior quality, and so on. Among the drugs examined was a sample of effervescing phosphate of soda, which on analysis was found to contain arsenic equal to 4·62 grains of arsenious oxide per pound. The samples examined for the India Office were of the usual wide range. Gold-leaf is required to contain not less than 97 per cent. of pure gold, but in one instance a sample contained 5 per cent. of silver and only 91 per cent. of gold; type-metal is to consist of 65 parts of lead, 30 parts of antimony and 5 parts of tin, and yet in eight samples received together, the lead varied between 65 and 82 per cent., the antimony between 15 and 29 and the tin between 0·6 and 5·5 per cent.; antimony is required to contain less than 3 per cent. of impurities, but of five samples two contained 5·76 and 4·15 per cent. of impurity respectively. The functions of the Government Laboratory are evidently exercised over a wide field, and national interests are promoted by such analytical work as is carried on under Dr. Thorpe's direction.

IN *Symons's Meteorological Magazine* for September, Dr. H. R. Mill, who accompanied the Antarctic exploring vessel *Discovery* as far as Madeira, gives some details of the arrangements for taking observations. During the voyage out meteorological observations will be made every two hours, and these will be kept up subsequently to supplement those made at the land station. For the ordinary routine observations a form of Stevenson's Screen is erected in a position where a current of air will be blowing, when the vessel is under way. Rainfall observations are to be attempted by means of a marine rain-gauge and evaporator on Dr. Black's pattern. The position presented much difficulty; the method finally adopted was to place the gauge on the weather side, shifting it whenever the ship changes her tack, while the evaporator occupies a position on the lee side. The whole of the meteorological work on board is under the charge of the first officer, Lieutenant C. Royds. It is intended to make special observations in the Antarctic regions on the conditions of the upper atmosphere, and for this purpose a captive balloon and kites are provided. A Dines' pressure anemometer will be erected at the land station. The oceanographical observations to be made during the voyage will be under the charge of Lieutenant E. H. Shackleton, while Lieutenant M. Barne will take charge of the deep-sea soundings after leaving Melbourne.

A REMARKABLY simple astatic galvanometer is described by M. G. Lippmann in the *Journal de Physique* for August. It consists essentially of a fixed coil, or in practice two coils, and a needle suspended in such a way as to be capable of displacement parallel to itself. The needle is placed with its axis coinciding with that of the coils, and pointing in the plane of the magnetic meridian. It is suspended by a thread from one arm of a torsion balance. Now the earth's magnetism has no tendency to produce displacements of pure translation in a magnetised needle, and since it is these displacements which alone are observed, it follows that the earth exerts no force in opposition to that produced by the current in the coil; the apparatus is therefore perfectly astatic.

AN interesting phenomenon recently described in connection with the theory of sound forms the subject of a paper by Mr. Bergen Davis in the *Physical Review* for June. The property in question is that if a small cylinder, closed at one end and open at the other, is placed in a stationary sound-wave, it will not only arrange itself perpendicular to the wave, but will also move across it in the direction of its axis. By arranging four such cylinders on a rotating mill, like the cups on an anemometer, and placing this mill with its axis of rotation perpendicular to the wave front, it was found that on sounding the organ pipe producing the waves, the cylinders rotated with a high velocity, except when placed at the nodes. The phenomenon is readily explained as a consequence of Bernouilli's well-known relation between the pressure, density and velocity of a fluid.

MAXWELL'S theory, which attributes electric and magnetic phenomena to tensions and pressures in the medium that forms the seat of electric and magnetic energy, has long been a subject for criticism. In the *Nuovo Cimento*, 5, ii., Signor Luigi Giuganino now advances certain considerations arising from a mathematical investigation of the tensions in the interior of a fluid polarised magnetically or dielectrically. The author finds, among other results, that if the polarised body is compressible and behaves like a fluid body, and only carries induced charges, it is impossible to find a system of elastic stresses equivalent to the given polarisation. If, however, the polarised body is considered to be an imperfect fluid, either there exist an infinite number of systems of tensions and pressures equivalent to the polarisation, or no such system exists. The expression for these tensions and pressures does not, however, reduce to Maxwell's and Helmholtz's formula. Signor Giuganino further advances the view that the elastic constant of the fluid when polarised assumes different values along and perpendicular to the lines of force, and that herein lies the explanation of Kerr's phenomenon.

IN the last *Bollettino* of the Italian Seismological Society, Prof. Grablovitz describes a simple and inexpensive form of recording tide-gauge, the total cost of which he estimates at less than 7*l.* 10*s.* The movements recorded are those of a spiral spring the length of which changes with the varying amount of immersion of a cylinder suspended from it.

IN continuation of his previous reports, Mr. S. Arcidiacono describes the principal eruptive phenomena which occurred in Sicily and the adjacent islands during the year 1900 (*Boll. della Soc. Sismol. Ital.* vol. vii. 1900, pp. 82–91). After the great explosion in the central crater of Etna on July 19, 1899, and the short eruptive period which succeeded it, that volcano remained in a state of almost uninterrupted calm. Stromboli continued in its usual condition of slight activity, varied by a few stronger outbursts, especially in the early part of October. The solfataric phase of Vulcano and the absolute calm of the Salsa di Paterno underwent no change throughout the year.

A CATALOGUE of the marine invertebrata of Eastern Canada, by Dr. J. F. Whiteaves, has also been published by the Geological Survey of Canada (1901). It consists of a systematic list of all the species described from the Bay of Fundy, the Atlantic coast of Nova Scotia, the Gulf and mouth of the River St. Lawrence, as far north as the Strait of Belle Isle. The localities at which some of the species are found fossil in the Pleistocene deposits are also briefly indicated.

Dr. G. A. F. MOLENGRAAFF, who was formerly State Geologist to the South African Republic, has written an excellent account of the geology of the Transvaal Colony, which has been published by the Geological Society of France (*Bulletin*, 4e serie, vol. i. 1901). It is accompanied by a colour-printed map, and many pictorial views and sections.

A SIXTH edition of Mr. Whitaker's useful "Guide to the Geology of London" has just been issued by the Geological Survey. The first edition was published in 1875, and in the present edition the work has grown to the extent of thirty pages, partly owing to an increased number of illustrations, including fossils, flint-implements, and sections of strata. The work has been brought thoroughly up to date, and the price remains one shilling.

WE have received from the Geological Survey of Canada the Annual Report for the year 1898 (Ottawa, 1901). This includes the Summary Report, and also a report on the mineral statistics, previously noticed in NATURE (June 15 and September 20, 1899). There are also reports on the shores of Lake Winnipeg, on those of Hudson Strait, and on Quebec province. In these the fossils of the Cambro-Silurian or Ordovician rocks of Manitoba and of Quebec receive especial attention, and there are full descriptions of the glacial phenomena. There is a good view showing the character of the surface of the Archæan rocks in Keewatin, and many other photographic illustrations of scenery and geological structure.

MR. J. J. WILKINSON has forwarded us a copy of a pamphlet giving an account of the very large and remarkable pharynx of the fly-larvæ commonly known as rat-tailed maggots, which are sometimes seen so abundantly in water. The pamphlet, which is illustrated with two plates, is published by Messrs. R. Clay and Sons, Ltd.

THE *American Naturalist* for September contains only two original communications—the one a continuation of Prof. W. M. Wheeler's account of the compound and mixed nests of American ants, and the other of Prof. H. S. Jennings' synopsis of North American invertebrates. The particular description of social ant-life treated of in Prof. Wheeler's article is that commonly known as slavery, and technically as "dulosis." Instead of slaves, it is suggested that a better title for the subservient ants would be helpmates, or auxiliaries, for the members of the two species found in the same nests behave towards each other as if they were brothers and sisters, and share the task of constructing the habitation. Unlike that which obtains in other kinds of ant-association, the so-called slaves always belong to the same subfamily group as their masters.

IN their Report for 1900 the trustees of the South African Museum remark that "the public events of the past year have, naturally, affected the Museum in more ways than one. Both the number of contributions to the collection and the number of visitors to inspect them have fallen off to a considerable extent. This is the first break in a continuous increase prolonged over a lengthened period." In spite of these discouraging circumstances, it is nevertheless hoped that substantial progress has been made both in regard to the development of the Museum and the extension of our knowledge of the South African fauna. During the year in question were issued Mr. W. L. Sclater's two volumes on the mammals of South Africa and the late Dr. Stark's volume on the birds, all of which have been noticed in our columns. The Director announces that, with the aid of the MS. left by Dr. Stark, he has completed the second volume on the birds, while the third is in hand. The Museum has been enriched by specimens of several mammals from Mr. Rhodes's park at Groote Schuur.

AN interesting and well-illustrated account of the growth and present condition of the Millport Marine Biological Station, or, as it is now called, the Marine Biological Association of the West of Scotland, appears in *Good Words* for September. As many of our readers are aware, this admirable institution, which is so largely indebted for its progress to Sir John Murray and had very small beginnings, was started to commemorate the life-work of David Robertson, the "naturalist of Cumbrae." And it is satisfactory to learn that the "Robertson Museum," occupying the upper part of the main building of the station, attracts during the season a large number of visitors, many of whom display much interest in the living creatures from the Firth of Clyde exhibited in special tanks. From its humble beginnings in the well-remembered "Ark"—a barge given by Sir J. Murray—the author traces the gradual progress of the station, which has been recently enriched by the gift, from an anonymous donor, of a deep-sea dredging steamer, and likewise by a five-year endowment from the same generous hand. As an instance of the manner in which commerce is benefited by undertakings of this nature, Mr. Sinclair tells us how the discovery of large deep-water shrimps in the Scotch lochs led to their detection in the still deeper fjords of Norway, with the result that the Norwegians now do a flourishing trade in these deep-sea crustaceans.

IN a very interesting memoir which has recently appeared in the *Proceedings* of the American Academy of Arts and Sciences (vol. xxxvi. No. 20, March 1901) Messrs. T. W. Richards and E. H. Archibald give a preliminary account of the series of investigations they are carrying on in the chemical laboratory of Harvard College on the growth of crystals. Ever since the discovery of the microscope, the gradual growth of crystals in a solution has proved a fascinating study, but the sudden way in which the embryo crystals flash into existence and the insensible manner in which they enlarge their dimensions appear to defy the acutest observer. Vogelsang introduced the method of retarding the action of the crystallising forces by adding viscous materials to the solvent, and his study of globulites and other forms of embryo crystals has been the starting-point of many important physical investigations by O. Meyer, Ostwald and others. The two American investigators, with the aid of a grant from the Rumford Fund, are now applying the method of instantaneous photomicrography to the study of growing crystals. In their first memoir they discuss the methods of procedure and give illustrations of some of their results, which appear to be full of promise.

ANTHROPOLOGISTS and folklorists would find it worth their while regularly to look over the pages of *Globus*, as in that well-edited journal there are constantly interesting and often illustrated articles and notes which are of permanent value. For example, in No. 23, Bd. lxxix., there is an essay by Julius von Negerlein on souls as birds, and a well-illustrated article on West African masks and the ceremonies with which they are associated, by Dr. Karutz. R. Palleske gives an illustrated account of a find at Ingelstad, in Sweden, of a horse's skull in which is embedded a very fine stone axe head of a form characteristic of the later half of the (Neolithic) Swedish Stone age; as it is highly probable that the horse did not exist in its wild state in Sweden after the Quaternary period, the conclusion is arrived at that in the late Neolithic age the horse was domesticated in Sweden. The original account of this interesting find was published by Gunnar Andersson, in *Ymer*, 1901, heft i. In No. 1, Bd. lxxx., F. von Luschan gives an illustrated description of a new kind of masks from New Britain, Dr. A. Krämer discusses phallic and other sacred stones from the Pacific and Dr. L. Rütimeyer figures two "stone idols" from West Africa. In No. 7 Dr. R. Lasch publishes a learned study on the fate of the souls of women who die in child-bed. All over the world there are beliefs of the disastrous results of this calamity; thus in the Malay Peninsula "the Pontianak" (or Mati-anak, as W. W. Skeat also calls it in his "Malay Magic," which book the author appears to have overlooked) "is supposed to be the ghost of a woman dying in child-bed, and is commonly seen in the form of a huge bird uttering a discordant cry. It haunts forests and burial grounds, appears to men at midnight, and it is said to emasculate them."

THE *Transactions* of the American Microscopical Society for 1900 (issued May, 1901), contains papers on a great variety of subjects, ranging from the surface impurities affecting water-supply and "limnology" (the study of lakes), to the classification of desmids and microscopic crustaceans, the parasites of the human ear and of lacustrine fish, and the description of a new cave salamander from Missouri. The latter, it may be observed, is another member of the already large American genus Spelerpes. A special feature of the volume is the first report of the newly constituted Limnological Commission, whose aim is to institute an exhaustive biological and physical investigation of the American lakes, on the plan already carried out with such success in Switzerland.

THE third instalment of Messrs. W. and G. S. West's "Alga-Flora of Yorkshire," reprinted from the *Transactions* of the Yorkshire Naturalists' Union, completes their list of the Conjugatæ (Desmidieæ) of the county, and enumerates the Siphoneæ, Protococcoideæ, and Cyanophyceæ (Myxophyceæ), with the commencement of the diatoms (Bacillariaceæ).

WE have received from Mr. J. H. Maiden, Government Botanist and Director of Botanic Garden, Sydney, copies of about thirty papers contributed by him during the years 1896–1901 to the *Agricultural Gazette* of New South Wales, and reprinted by the Department of Agriculture for the Colony, all relating to some point of interest or importance to farmers, gardeners, or fruit growers in the Colony.

IF sufficient support can be obtained, it is proposed to establish a new monthly journal, under the title *British Botanical Journal*, to afford a ready means of communication and discussion among British botanists. The contents will consist of articles and reviews, short paragraphs on important and striking current botanical matters, correspondence, short notices of books, original papers and notes, &c. Communications should be addressed to Mr. A. G. Tansley, University College, London, W.C., who will be the first editor.

Bulletin No. 28 of the U. S. Department of Agriculture, Division of Vegetable Physiology and Pathology, consists of an elaborate account, occupying more than 150 pages, of the cultural characters of the yellow flagellate bacteria *Pseudomonas Hyacinthi*, *P. campestris*, *P. Phaseoli*, and *P. Stewarti*, parasitic respectively on the hyacinth, on cruciferous plants, on leguminous plants, and on grasses, especially on maize. The favourable and unfavourable conditions for the growth of the parasites are treated of in great detail.

THE first part of a "Handbuch der vergleichenden und experimentellen Entwickelungslehre der Wirbeltiere," edited by Dr. Oscar Hertwig, has been received from the house of Gustav Fischer, Jena. The work promises to contain an exhaustive treatment of comparative and experimental embryology, and will be completed in about twenty parts at four-and-a-half marks each.

MM. GAUTHIER-VILLARS have commenced the publication of a complete "Cours d'Électricité," by Prof. H. Pellat. The work will be issued in three parts, the first of which, dealing with electrostatics, Ohm's law and thermoelectricity, has been received. The second volume will be concerned with electrodynamics, magnetism and induction, and the third with electrolysis, electro-capillarity and related questions. The part already received contains the course of work in electricity at the Sorbonne in 1898–1899; the second part will contain that carried on in 1899–1900, and the third will correspond to the course to be followed next year.

A NEW edition of "The Evolution of Sex," by Profs. Patrick Geddes and J. Arthur Thomson, reviewed in NATURE in 1890 (vol. xli. p. 51), has been published by Mr. Walter Scott. "In this revised edition," say the authors, "though many alterations and additions have been made, the original character of the work has been retained, and that notwithstanding the difficulty that the authors have in the past ten years been diverging biologically—the one towards a Neo-Lamarckian position, the other towards a Neo-Darwinian one. Yet they remain agreed on the main endeavour of the book, which is to set forth the fundamental unity underlying the Protean phenomena of sex and reproduction."

A NEW scientific periodical, the *Allgemeine Naturforscher-Zeitung*, edited by Dr. C. Wenck, commenced its career on October 2, and will appear twice weekly. The aim of the Editor is to publish scientific papers very shortly after they have been presented at meetings or congresses, and to make the journal reflect the chief characteristics of current scientific work. The first number contains two papers—one on anabiosis and the other on electrons—read at the recent Congress of Naturalists and Physicians at Hamburg, and a number of abstracts and reviews. In general character, the new periodical does not differ much from the old-established *Naturwissenschaftliche Wochenschrift*, which has just commenced a new series under the editorship of Prof. Potonié and Dr. F. Körber, and is now published by Mr. Gustav Fischer.

THE additions to the Zoological Society's Gardens during the past week include a Ring-tailed Lemur (*Lemur catta*) from Madagascar, presented by Mr. Chas. Rawsthorne; two Jays (*Garrulus glandarius*), British, presented by Mr. W. Radcliffe Saunders; three Common Snakes (*Tropidonotus natrix*), British; a Viperine Snake (*Tropidonotus viperinus*), European, presented by the Rev. H. A. Soames; a King Crab (*Limulus polyphemus*) from the North Atlantic Ocean, presented by Mr. Walker; two Arabian Baboons (*Cynocephalus hamadryas*, ♂ ♀) from Arabia, a Nilgiri Thar (*Hemitragus hylocrius*, ♂) from Southern India, four Getulian Ground Squirrels (*Xerus getulus*) from Morocco, four Great Wallaroos (*Macropus robustus*) from South Australia, an African Civet Cat (*Viverra civetta*) from South Africa, two Malayan Wrinkled Hornbills (*Rhytidoceros undulatus*) from Malacca, six Gigantic Salamanders (*Megalobatrachus maximus*) from Japan, four American Box Tortoises (*Cistudo carolina*) from North America, six Ceylonese Terrapins (*Nicoria trijuga*), nine Starred Tortoises (*Testudo elegans*) from India, a Lesueur's Water Lizard (*Physignathus lesueuri*) from Queensland, a Bearded Lizard (*Amphibolurus barbatus*) from Australia, deposited; a Rufous-necked Wallaby (*Macropus ruficollis*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

DIAMETER OF VENUS.—In the *Astronomical Journal* (vol. xxii. pp. 13–15), Mr. D. A. Drew gives the results of a series of measures of the diameter of Venus, made with the 24-inch refractor of the Lowell Observatory at Flagstaff, Arizona, in 1898. For the majority of the determinations a power of 165 was employed, together with an ocular diaphragm half a millimetre in diameter and an amber-coloured glass screen.

The tabulation and discussion of the reduced diameters indicates that there appears to be a peculiar variation in the planet's diameter, decidedly periodic, which may be due partly to the variable irradiation with the different phases and brilliancy of the body at different times.

SPECTRUM AND APPEARANCE OF NOVA PERSEI.—Herr E. von Gothard announces in *Astronomische Nachrichten* (Bd. 156, No. 3738) that he has photographed the spectrum of the Nova with a $10\frac{1}{4}$-inch reflector and objective prism, the result showing many of the characteristics of the peculiar structure seen in the spectra of planetary nebulæ. Bright lines are present at $\lambda\lambda$ 5007, 4861 (H_β), 4341 (H_γ), 4101 (H_δ), 3970 (H_ϵ), 3867, and a new line about λ 342. The brightest line in the whole spectrum is that at λ 3867, which is very prominent in planetary nebulæ.

He also alludes to the possibility of the aureole shown surrounding the star on photographs obtained with refracting telescopes being produced by the non-achromatic correction of these glasses for the extreme ultra-violet rays, which are so strongly developed in the Nova spectrum as to produce the chief part of the photographic action. This view of the question is also mentioned by Prof. Max Wolf in No. 3736; in

No. 3737 Skostinsky gives observations made at Pulkowa on the aureole and spectrum. The lines given are as follows:—

	λ		Intensity
1901 August 2	5010	Fairly bright line ..	10
	4960	Weak	2–3
	4861	Hβ	5
	4703	Bright, very broad ..	6

ELEMENTS OF COMET 1901 I.—Mr. C. J. Merfield publishes the computed elements of the orbit of this comet in *Astronomische Nachrichten* (Bd. 156, No. 3738). The reductions are from observations made by Mr. J. Tebbutt on 1901 May 3, 11 and 19.

T = 1901 April 24·22532 G.M.T.

$$\left.\begin{aligned} \omega &= 202^\circ\ 48'\ 46'' \\ \Omega &= 109\ 46\ 23 \\ i &= 131\ \ 2\ 35 \end{aligned}\right\} 1901\cdot 0$$

$$\log q = 9\cdot 3873832$$
$$\log e = 9\cdot 9983750$$

THE GLASGOW MEETING OF THE BRITISH ASSOCIATION.

SECTION K.

BOTANY.

OPENING ADDRESS BY PROF. I. BAYLEY BALFOUR, LL.D. (GLASG.), F.R.S., PRESIDENT OF THE SECTION.

I SHOULD be wanting in my duty, alike to you and to our science, were I at the outset of our proceedings to pass over without notice the circumstances of environment in which we assemble to-day. In this, the first year of the century, our Section meets for the first time in Scotland, and finds itself housed in this magnificent Botanical Institute, which, through the energy and devotion of Prof. Bower, has been added this year to the equipment of Botany in this country. A few months ago the Institute was opened in the happiest auspices and with all the distinction that the presence of our veteran botanist, Sir Joseph Hooker, supported by two other ex-Presidents of the Royal Society—Lord Lister and Lord Kelvin—could give to the ceremony. I am sure we will cordially echo the words of good-will that were spoken on that occasion. It must be to all of us a matter of congratulation that Botany has now provided for it in Glasgow this Institute both for its teaching and for the investigation of its inner secrets, and we may with confidence hope that the output of valuable additions to our knowledge of plant-life which has marked Glasgow during the tenure of office of its present distinguished Professor of Botany, and in which he himself has borne so large a share, will not only continue but will increase in a ratio not incommensurate with the facilities that are now provided.

The subject of my address is the group of Angiosperms. I will speak generally of some points in their construction from the point of view of their position as the dominant vegetation of the earth's surface at the present time, and more particularly of their relationship to water, as it is one which has much to do with their holding the position they now have. I wish, however, in the first place to refer to

The Communal Organisation of Angiosperms.

No fact of the construction of the plant-body that has been established within recent years is of greater importance than that of the continuity of protoplasm in pluricellular plants. As has been the case with so many epoch-making discoveries, we owe our first knowledge of this to the work of a British botanist. The demonstration by Gardiner of the existence of intercellular protoplasmic connections is the foundation of our modern notion of the constitution of the pluricellular plant-body and of the far-reaching conception of the communal organisation of Angiosperms and of all other Metaphyta.[1] It has settled, once and for all, phytomeric hypotheses. We now realise that in an Angiosperm the living plurinucleated protoplasm is spread over a skeletal support furnished by the cell-chambers of shoot and root. The energid of each living cell is connected with the adjacent energids by the protoplasmic threads piercing the separating cell-membrane. The protoplasm thus forms a continuous whole in the plant. According to their position in the organism the energids become devoted to the formation of special tissues for the building up of the various organs. Each one of them, however, whilst its actual destiny is ultimately determined by its relationships to the others, is, so long as its fate as a permanent element is not fixed, a potential protophyte, that is to say, it has within it all the capacities of the plant-organism to which it belongs.

Their construction out of this assemblage of protophytes—this colonial, or perhaps better communal, organisation—gives to Angiosperms their power of discarding effete and old parts of the plant-body without mutilation, of allowing these to pass out of the region of active life yet to remain without damage to the organism as part of the body, of renewing and replacing members as required. The response of the plant to the various horticultural operations of pruning, propagation by cuttings, and so forth is an outcome of this constitution. It is this which gives them the power of developing reproductive organs at any part of the plant-body, to cast them off when their work is done, and to renew them again and again. This dispersion of the reproductive capacity in the Angiosperm is one of the most striking of the properties it possesses, and is perhaps in no way better shown than in the development of stool-shoots. There the energids of the cambium, which normally produce the permanent tissue of wood and bark, and thereby add periodically to the girth of a tree, give origin when the relationships are changed by the cutting over of its bole to a callus from which stool-shoots arise as new growths, which may ultimately produce flower and reproductive organs.

Another outcome of this organisation of the Angiosperm is its power of extension and its longevity. It is potentially immortal. How far this expectation of life of a plant is realised in nature we have no evidence to show. Possibly we may presage the longest life in the case of perennial herbs. Trees and shrubs by their exposure in the air are liable to injury which must militate against long life, and yet cases of trees of great age are well known to you all.

It is this feature of the life of Angiosperms which marks them out sharply in contrast with the higher members of the animal kingdom. There we have individuality, and consequently comparatively short life. Let me emphasise this.

Of the Vegetable Kingdom and the Animal Kingdom.

The root-difference between plants and animals is one of nutrition. Plants are autotrophic, animals heterotrophic.

Whatever has been the origin of the two kingdoms, we must trace the differentiation of plants to their acquisition of chlorophyll as a medium for the absorption of the energy of the sun. The imprint of its operation is borne in the construction of all higher plants and distinguishes them from animals. The vegetative mechanism of the plant has been elaborated upon lines enabling it to obtain the materials of its food from gases and liquids which it absorbs from its environment. For the plant the primary requisite has been a sufficient surface of exposure in the medium whence it could obtain energy along with the gases and liquids of its food. To this end the fixed habit is an obvious advantage, for the question of bulk within the limits of nutrition becomes thereby not a matter of moment; and an upward and a downward extension gives opportunity for the creation of a larger expanse of absorptive surface. Thus it has come about that the plant-organism has developed that polarity which finds expression in the profuse root-system and shoot-system with their localised growing points of the highest forms of to-day. That the communal organisation is well fitted to this mode of life requires no exposition.

The nutritive mechanism of animals, on the other hand, has become one for the ingestion of solids which it obtains by preying upon the bodies of plants and other animals. The exigencies of its feeding have compelled the adoption by the animal of the habit of locomotion, the development of an apparatus for the capture of its prey, and of an alimentary canal for its introduction to the body, for its digestion, and for the final ejection of the unused matter along with the waste of the body. This has

[1] Metaphyta and its antonym Protophyta are well-established names for groups of polyergic and monergic plants respectively. The recent appropriation of Metaphyta as a group name for Vasculares, *i.e.* plants derived from the second antithetic generation, and of Protophyta for Cellulares, *i.e.* plants derived from the first antithetic generation, is unfortunate.

involved the concentration and the specialisation of the individual.

All this is, however, to you botanists but the commonplace of your laboratories and lecture halls. But I have thought that it should be said, because this fundamental difference of organisation between the two kingdoms is apt to be forgotten in discussions of problems of evolution, more particularly those of transmission of characters and the effect of environment. This is especially so when they are approached from the zoological side. Were the point always recognised we should not have zoologists finding similarity between bud-variation in a flowering plant and the change in colour of the hair of a mammal.

Of Origin and Dominance of the Angiospermous Type.

It is now usually admitted that all plants, like all animals, have been derived from aquatic ancestors, and that the trend of evolution has been in the direction of the establishment of a vegetation adapted to a life on land. Of this evolution the Angiosperms as we see them to-day are the highest expression. Can we say anything about the origin of the angiospermous type? As the problem presents itself to me we can only mark time at present.

From the geological record we obtain no help. The earliest traces of Angiosperms in rocks of the middle Mesozoic period enable us to say little regarding them except that the fragments give evidence of an organisation as complete as that possessed by the Angiosperms of the present day. The gap between the angiospermous and other types of vegetation is a wide one, and no links are known. Until further research provides specimens in a better state of preservation and showing structure we can hope for little assistance from the geological record; and when we consider the circumstances in which the angiospermous plants as a whole grow the prospect of such finds does not appear to be very bright.

The appeal to ontogeny likewise gives us little information. Comparative study does not establish connection with, only differentiates more and more, the types of the Pteridophytes and Gymnosperms. The strong likeness of the pro-embryo after the primary segmentation of many Angiosperms to the pro-embryo of many Bryophytes has appeared a sufficient reason to some botanists for ascribing a bryophytous parentage to the Angiosperms. Indeed it has been said that "the monocotylous embryo is the direct homologue of the sporogonium of the moss, the cotyledon being homologous with the spore-producing portion of this out of which it originated." This anaphytic conception of the monocotylous embryo seems to me to have as little real foundation as the hypothesis of its origin. The pro-embryonic resemblance is interesting, but it may as well be homoplastic as genetic.

But if the information available to us does not permit of our building up a pedigree for the Angiosperms, we are on surer ground when we endeavour to fix upon characters which have enabled the group to become established as the dominant vegetation of our epoch. Before the era at which we have first knowledge of Angiosperms the earth's surface was, we know, clad with a dense vegetation composed of members of the various classes of Pteridophytes and Gymnosperms. These appear to have existed in all the growth-forms which we know now amongst the Angiosperms—Herb, Shrub, Tree, Liane. Yet they are now represented amongst living plants by only a few remanent forms. Hordes of distinct forms and whole classes have disappeared, giving place to plants of the angiospermous type. There must then be some feature or features of advantage in this type over those of the groups that previously occupied the ground, and through which it became dominant.

In considering this point we must bear in mind the well-known climatic differences—particularly in the distribution of water—that distinguish our epoch from those in which these extinct plants throve. The factors which determine the success or otherwise of an organism or group of organisms at any period must always be complex, and no exception can be claimed for plants in their struggle for mastery. But looking at the succession of plant life in the world in relation to the known diminution of water-surface and increase of land-area, and the consequent differentiation of climates, we cannot but be convinced that of these factors water is one which has had supreme influence upon the evolution of the facies of the plant-life that we see to-day. I think the statement is warranted that the Angiosperms have become dominant in great measure because in their construction the problem of the plant's relationship to water on a land-area has been solved more satisfactorily than in the case of the groups that preceded them.

The seed character—and the flower which it involves—distinguishes the Angiosperms. What, then, are the relationships to water which the formation of seed implies and through which the Angiosperm has advantage?

Two prominent risks in its relation to water attach to the process of sexual reproduction in a plant of the type of heterosporous Pteridophytes. Firstly, that of failure of moisture on the soil sufficient to promote germination of the spores; secondly, that of failure of moisture on the soil sufficient for the passage of the spermatozoid to the ovum. In addition there is the risk of failure of the fall of microspores and megaspores together upon the soil. In the Angiosperms such risks are practically abolished in the formation of flower. The stigmatic surface of the style itself provides a secretion—the more copious in a dry and sunny atmosphere—to moisten the pollen-grain and stimulate germination, and for the spontaneous movement of the spermatozoid is substituted the passive carriage of the male gamete to the ovum by the agency of the pollen-tube. Possible failure of pollination is, too, provided against by the complex mechanism of the flower in the highest forms in relation to insect-visits. The sexual act, then, might, we conceive, gradually become more and more difficult of consummation to the Pteridophyte as the area of dry land increased. To the seed-plant it was more secure by its independence of the presence of free water. The failure of performance of the function of sexual reproduction may have hastened the disappearance of Pteridophytes before the advance of the Angiosperms.

But if this flower-mechanism relieves the Angiosperm from risks in the performance of the sexual act, it imposes a new duty upon the plant, that of nursing the embryo within the sporangium. This involves a water-supply of a kind not demanded in the Pteridophytes, and we may gain some idea of the importance of this by a comparison of the trivial vascular system required to supply through the stamen the pollen-grain, with the copious system that traverses the gynæceum for the ovules. It is, however, to the ovule—the immediate nursery of the embryo—that we must look for special indications of this water-relationship of which I speak.

Perhaps no organ has given rise to more discussion than this characteristic one of flowering plants. To most of us I believe the controversy over its axial or foliar nature will be, in a measure, historical only. All recent investigations of sporangia—and to no one does Botany owe more in this respect than to Bower—tend to confirm the view that it is, and always has been, an organ *sui generis*. To that category the nucellus of the ovule is now pretty generally admitted. It is the body of a sporangium. But the nature of the tegumentary system and of the funicle which give the ovule so distinctive a character is still the subject of disagreement.[1]

I do not share a view which sees in the integuments or other parts of the ovule anything of an axial or of a foliar nature. To me the funicle is a sporangiophore—a sporangial stalk—and the tegumentary system is an outgrowth of the sporangial primordium of somewhat variable origin and development, whose first function it is to carry and store water for the embryo, and then also to serve as a food-reservoir. The whole construction is adapted to the function claimed for it. The well-developed vascular system from the placenta traverses the funicle, but the subsequent fate of the nucellus forbids its passing through this, and the needs in respect of water (and what it carries) of the embryo and of the other further developments that proceed in the embryo-sac are provided for by the production of the tegumentary outgrowths into which the vascular system may, if necessary, be continued and spread out.

That the tegumentary covering has this function we have direct proof in its penetration by haustoria, derived either from the embryo itself or from the embryo-sac, which absorb from it water and food for the developing embryo. These haustoria appear to be much more elaborate and more widespread than has been supposed, and a definite correlation has been established in many cases between them and the integuments. The thicker the integument the better developed is the haustorium.

[1] Scott's discovery of a bracteal investment to the megasporangium in Lepidocarpon is an interesting one in relation to the question of the enclosure of sporangia. It shows how in the Lepidodendreæ a covering of the sporangium could be developed, much in the same way as a carpellary envelope in Angiosperms. Whether the ovular integument or the ovarian covering in Angiosperms was the earlier development is open to discussion. I am disposed to give precedence to the ovular coat.

In some ovules where no vascular system appears in the integument, the chalazal haustorium is prominent, and it can therefore at once tap the main water-supply of the ovule. We know also of cellular ingrowths proceeding from the vicinity of the vascular system of the raphe to the interior of the embryo-sac, and these, too, may have a conducting function. All these point to a water and nutritive function in the integuments. The protective function of the tegumentary system to which attention has been chiefly directed must be primarily only slight. It only becomes prominent as the seed is formed, and then changes consonant therewith, and with its changed function, proceed within it. Nor can we now, with our increased knowledge of the ways in which the pollen-tube may reach the embryo-sac, consider the function of the integuments in forming the micropylar canal as one of so much importance to the reproductive act as was formerly supposed. We obtain, I think, a better conception of the ovule in the view that the primary function of the tegumentary system is that of a water-jacket and food-store, and that it has been developed in response to the special demands for water involved in the seed-habit.[1]

To the question why there are two integuments in some cases and only one in others we can only reply that our knowledge of ovular structure and changes is yet too slight to permit of a definite opinion being expressed. We find that there is a remarkable concurrence of the unitegminous ovule with a gamopetalous corolla in the flower, for the character apparently holds for the whole of the gamopetalous Dicotyledones excepting Primulales. On the other hand, not all Polypetalæ have bitegminous ovules, whilst bitegmeny is usual in Monocotyledones. Recently the character has been used by Van Tieghem as one of prominence in his new classification of the families of Dicotyledones. But it is not so constant an one as his groups of Unitegmineæ and Bitegmineæ would lead one to suppose. The degree in which it is inconstant we cannot yet fix, because we know details of so few genera. We do know, however, that all genera in one family are not always alike in respect of it. In Ranunculaceæ, for instance, the most of the genera with radial flowers are unitegminous, whilst those with dorsiventral flowers are bitegminous. Again, in Rosaceæ, the Potentillæ are unitegminous, as is Rosa, whilst Pomeæ and Pruneæ are bitegminous; and of the Spiræeæ, Neillia is unitegminous, but the closely allied Spiræa is bitegminous.[2] In other cases the character confirms distinctions; as, for instance, in separating the unitegminous Betuleæ and Coryleæ from the bitegminous Quercineæ. The explanation of all these constructions may, I suggest, be sought for with better prospect of success in the water-relationship and food-relationship of the integuments to the embryo than in protective function and relations to pollination. It is, perhaps, not without significance from this point of view that in, for instance, the Gamopetalæ such protective function as attaches to the tegumentary system in the seed is reduced or extinguished through the development of indehiscent fruits, accompanied in many Aggregatæ and higher Heteromeræ by the sinking of the gynæceum in the torus, and in many Bicarpelletæ by its enclosure in a persistent accrescent calyx.

All the information at our disposal seems to indicate that the tegumentary system of the ovule is extremely adaptive, and that its characters are not of themselves of much phyletic import. An extended examination of its characters as an organ of the nature I have depicted in relation to embryogeny is greatly needed. It is made all the more interesting by the questions of development of endosperm opened by the discovery of "double fertilisation." There is no more promising field of investigation than this, for it must yield results infinitely more interesting than the technicalities of formal morphology which have been for too long the stimulus to ovular research. I am tempted to go further and to say that it might supply an explanation of that most puzzling of subjects, the forms and curvature of the ovule. The common assumption that these have relation to pollination and make the advent of the pollen-tube at the micropyle easier is not altogether satisfactory. For the curvature not infrequently seems to place the micropyle in a position the opposite of favourable, and there is an absence of curvature in cases where it would appear to be desirable.

I will not dwell upon the subject of the seed itself as an advantage to the Angiosperm. Its construction follows upon the successful water-relation previously secured. We all know how its manifold adaptations to dissemination bring about its fortuitous deposition upon various soils, and the embryo is placed well guarded within the seed-coat ready to take advantage of the moment when moisture is sufficient for its germination.

Whilst the seed-habit is the character which has primarily given to Angiosperms their advantage as a land-type,[1] their vegetative organs also show an advance in their relationship to water upon those of the forms they have supplanted. I have already remarked that the growth-forms of the vegetation of the present day are the same as those of old. That means that the early as well as the later groups of vegetation have solved in much the same way, so far as general form is concerned, the problem of the exposure in the atmosphere of a large assimilating area with a sufficient mechanical support and adequate water-supply. That wherever a water-carrying system is found in these growth-forms it dominates the anatomy is witness to the importance of the water-relationships I wish to emphasise.

There are two features in the water-carrying system of Angiosperms in which they are superior to the older types—namely, their general monostely and their vasa.

No one will contest that polystely is a less perfect mechanism for water-carriage in a massive plant than is monostely. The limitation imposed by it to an increment in the area of carriage contrasts unfavourably with the openness in this respect possessed by monostely. In the moister climatic conditions of the age of domination of Pteridophytes polystely may have well sufficed for the water-needs of the plants, especially of the dwarfer forms; but even then, as we know, monostely was the habit in many of the larger tree-forms, and the development of a cambium enabled them to provide for continued additions to their carrying system. Where such monostely and secondary growth occurred in these older types their adaptation in these respects to water-carriage was on lines similar to those of our dominant Dicotyledones and was effective in giving them dominance in their epoch. There is no more interesting page in the history of evolution than that—and we owe it in large measure to the labours of Scott and Seward—upon which is depicted the struggle of some polystelic forms amongst these old plants to achieve the structural facilities more easily attained through monostelic construction. The existence of polystely in a few Angiosperms only confirms the advantage which the whole group has derived from its monostely. Such polystelic forms amongst them as we know have many of them special water-adaptations, and in no case can they be said to be progressive types.

I do not need to remind you that vasa are not the exclusive possession of the angiospermous type, but they are the conspicuous feature of their carrying system, whilst the tracheid is the leading one in the older type of vegetation. All anatomical evidence indicates that vasa give greater facility to rapid transport of water than do other elements, and we may, therefore, conclude that they have been adjuvants in enabling the Angiosperm to meet effectively the demand made upon it by the drier atmospheric conditions.

I now pass on to consider from the same standpoint the classes which make up the group of Angiosperms.

Of the Classes of Angiosperms.

There has been for long a general recognition of two classes amongst the Angiosperms—Dicotyledones and Monocotyledones—separated one from the other by definite characters which I need not specially depict here. Recently, however, we have seen an attempt made by Van Tieghem to establish another class—that of Liorhizal Dicotyledones—for which is claimed a rank equal to that of the Dicotyledones and Monocotyledones. Were this valid it would be a matter of supreme importance, for whatever be the relationship between Dicotyledones and Monocotyledones there can be no doubt of their having developed as

[1] To discuss the morphological interpretations of the funicle and integument that have been advanced would carry me beyond the scope of this address. I do not know that an axial hypothesis for any part of the ovule is now maintained. The foliar interpretation of the funicle and integuments as against their sporangial nature is supported by two distinct schools of botanists. One approaches the subject from the standpoint of the anaphytose of the earlier years of last century, and appeals largely to teratology; the other from that of vascular anatomy. I do not accept the starting-point of either the one or the other.

[2] Spiræa is, however, exalbuminous, whilst Neillia is albuminous.

[1] Gymnosperms, sharing with Angiosperms the seed-habit, have in that had advantage over Pteridophytes. But their flower-mechanism is much less perfect. The reasons for their being bested as a class by Angiosperms must be complex. Gymnosperms, as a whole as we know them, are less adaptive than Angiosperms. The decadence of the cycadean line of descent may have been helped by their conservatism in the methods of water-carriage in the vegetative organs. The coniferous type has held its own in the Northern Hemisphere.

distinct groups within the whole period of which we have knowledge of them, and the existence of a third class intermediate or outside of them might lead to interesting conclusions. It is worth while, therefore, to consider the evidence on which this class is founded. It includes two of our recognised families —the Nymphæaceæ and the Gramineæ.

What is the exact position and the affinities of the Nymphæaceæ amongst Angiosperms is no new theme of discussion. That they have characters resembling those of Monocotyledones[1] has often been insisted on. Van Tieghem lays stress on what he considers the monocotylous differentiation of the root-apex and the derivation of the piliferous layer from the same meristem-initials as the cortex, whilst in the embryo he finds the two cotyledons of Dicotyledones. But the most recent observations of the embryogeny of the family go to show that the embryo is that of the monocotylous plants, the apparent dicotylous character being the result of the splitting of one cotyledon. If this be so the position of Nymphæaceæ will be amongst the Monocotyledones, a position the root-characters in Van Tieghem's view will support. But whether this be confirmed by further research or no—and a complete reinvestigation of their embryogeny and development is much wanted—what we may say at present is that it is not in features such as this one of the root-apex—which is, after all, not so simple and uniform as Van Tieghem would have it—that we are likely to find phyletic diagnostic characters of groups.

The reason for the inclusion of the Gramineæ in this new group is the assumed presence of a second cotyledon. The construction of the embryo of grasses is peculiar, as is well-known, and has for a long time been a main support of the hypothesis that the Monocotyledones are derived from the Dicotyledones; for here alone, since the dicotylous character of forms like the Dioscoreæ was shown to be untenable, was there a structure which could be interpreted as evidence of a reduced second cotyledon. The idea that the epiblast is such a structure was enunciated by Poiteau at the beginning of the last century, and along with hypotheses of the nature of the other parts of the grass-embryo has been a subject of vigorous discussion since that time. The controversy is not yet closed. Whilst we have Van Tieghem now adopting the view of the cotylar nature of the epiblast and using it as a character of fundamental taxonomic importance, we have others who as strongly uphold the interpretation of it, first formulated by Gaertner, as a winged appendage of the scutellum, which is considered to be the cotylar lamella. And, again, there are those who take the view that it is a mere outgrowth of the hypocotylar body of the embryo and without any cotylar homology. Our interpretation of the part must depend primarily upon the standpoint from which we view the embryo of Angiosperms. This I shall discuss presently. All I need say here, *àpropos* of the class of Liorhizal Dicotyledones, is that whatever the epiblast be—and for my part I am disposed to regard this simple cellular structure as merely an outgrowth with a water-function from the embryonal corm—a dispassionate consideration must lead us to hold that it is a bold step to use a character the morphological value of which can be so variously interpreted as one of primary importance for separation of a group of Angiosperms. Moreover, we must remember that the feature of the epiblast is not one of universal occurrence in the Gramineæ. If we take a well-defined tribe like the Hordeæ, as framed by Bentham and Hooker, we find that of eight of its twelve genera which have been examined for this feature five have the epiblast and three want it. And surely the fact of its presence in Triticum and absence in Secale, its presence in Elymus and absence in Hordeum, is strong evidence that the epiblast is not a character of such importance as it would have were it a reduced cotyledon as is asserted.

It appears to me, therefore, that this third class of Angiosperms has no sound foundation, no more, perhaps less, than Dictyogens and Rhizogens which appeared as parallel groups with Endogens and Exogens in Lindley's old classification. Our present knowledge allows the recognition of only two classes of the angiospermous type—the Dicotyledones and the Monocotyledones.

Of Dicotyledones and Monocotyledones.

The relationship of these two groups is involved in the origin of the angiospermous type. They may have had a common origin or they may have arisen separately; and if the former the Dicotyledones may have been a subsequent offshoot from the Monocotyledones, or the reverse may have been the case. Each of these possibilities has its supporters. Were I to maintain an opinion it would be that the two classes have arisen on separate lines of descent. The embryo-characters, as well as those of the epicotyl, can, I think, be shown to be fundamentally different and to afford no basis for an assumed phyletic connection. The differences between Hepaticæ and Musci, to take a parallel case in a lower grade, are not more conspicuous. The parallel sequence in development in the two classes is no more than one would expect, and may be regarded as homoplastic. To the question which group is the older I would answer that the Dicotyledones are by far the most adaptive and progressive if—as is not necessarily the case—this can be taken as evidence of their more recent origin. This, however, is not the matter I intend to discuss here. I wish rather to inquire if there are any features broadly characterising the groups to which, as in the case of Angiosperms as a whole, we may look for help to an explanation of the predominance at this time of the type of Dicotyledones. I think there are, but they are not to be found in the reproductive system. That is constructed on sufficiently similar lines in each class. The features I refer to are to be found in the construction of the vegetative system both in the embryo and in the adult. That of the former gives the dicotylous plant an advantage in its start on life; that of the latter, both in shoot-system and root-system, is better adapted in Dicotyledones in relation to water-supply.

I specially differentiate the embryo-condition from the adult because in our consideration of these higher plants we are apt to overlook the two distinct stages into which their life is divided, and which call for altogether different adaptations. There is, firstly, the life in the seed and in germination; and, secondly, there is the life after germination. The conditions and the manner of life are not alike in the two stages. In the first the plant is heterotrophic, in the second it is autotrophic. The functions of the portion of the plant which lives the life within the seed, and which bears the incipient epicotyl and primary root as small, at times hardly developed, parts, are to absorb food, either before germination, as in exalbuminous seeds, or during germination in albuminous seeds, to rupture the seed-coat, and to place the plumular bud and the primary root in a satisfactory position for their growth and subsequent elongation. The functions of the adult may be summarised as the development and maintenance of a large assimilating and absorbing area preparatory to reproduction.

We ought, I think, to look upon the embryo as a protocorm[1] of embryonic tissue adapted to a seed-life. Under the influence of its heterotrophic nutrition and seed-environment it may develop organs not represented in the adult plant as we see in, for instance, the embryonal intraovular and extraovular haustoria it often possesses. There is no reason to assume that there must be homologies between the protocorm and the adult outside an axial part with its polarity. There may be homologous organs. But neither in ontogeny nor in phylogeny is there sufficient evidence to show that the parts of the embryo are a reduction of those of the adult.[2]

The protocorm has, I believe, developed along different lines in the Dicotyledones and Monocotyledones. This has been to the advantage of the former in the provision that has been made for rapid as opposed to sluggish further development. Confining ourselves to the general case, the axial portion of the protocorm of the Dicotyledon, the hypocotyl, bears a pair of lateral outgrowths, the cotyledons, and terminates in the plumular bud and in the primary root respectively. The cotyledons are its suctorial organs, and the hypocotyl does the work of rupturing the seed and placing the plumular bud and root by a rapid

[1] The anatomical characters upon which this resemblance was chiefly based are now known to be of another nature.

[1] The term has already been used for the embryo of Orchideæ, where the axis is tuberous as is the structure to which the term has been given in Lycopodineæ. But tuberousness is not an essential for the designation corm.

[2] I cannot pursue the subject here, nor discuss the view of the cotyledons as either ancestral leaf-forms or arrested epicotylar leaves. The analogies with existing Pteridophytes that are cited are not pertinent, for there is no evidence that Angiosperms have that ancestry, or indeed that their phylogeny was through forms with free embryos. Nor is the fact of resemblance between cotyledons and epicotylar leaves and the existence of transitions between them convincing. That the cotyledons, primarily suctorial organs, should change their function and become leaf-like under the new conditions after germination is no more peculiar than that the hypocotyl should take the form of an epicotylar internode, from which it is intrinsically different as the frequent development upon it of hypocotylar buds throughout its extent shows.

elongation[1] which commonly brings the plumular bud above ground, protected, it may be, by the cotyledons. These latter may then become the first assimilating organs unlike or like to the epicotylar leaves. In the Monocotyledones the axial portion of the protocorm has usually no suctorial outgrowths. Its apex and usually its base also are of limited growth. The plumular bud is a lateral development, and the primary root often an internal one. The suctorial function is performed by the apex of the protocorm, termed here also the cotyledon.[2] The rupture of the seed and the placing of the plumule along with the primary root—for the axis of the corm does not elongate between them—are the work of the base of the suctorial portion of the corm.

The whole arrangement in Monocotyledones is in marked contrast with that of the Dicotyledones. Instead of the free axial elongation begun in the protocorm and continued upwards and downwards in the epicotyl and primary root, there is limited axial growth of the protocorm with lateral outgrowth of the plumular bud and arrest of the primary root. These differences in the protocorm are, I think, primary, and they point to independent origins of the two groups. The advantage lies, as I have said, with the Dicotyledones, and we find that the features of development of the protocorm are continued in the adult. There is a marked contrast between the free internodal growth of the shoots of Dicotyledones with their copious root-system and the contracted stem-growth and the arrested root-system in Monocotyledones. It is interesting to note further how the monocotylous type has developed so largely upon restricted lines in the way of short rhizomatous, often tuberous, growth, whilst the dicotylous gives us the characteristic growth-form tree.

When we compare the tree-type of the Dicotyledones with that of the Monocotyledones we see at once the feature I refer to in the adult, which has given the advantage to the dicotylous type in respect of its water-supply. In Dicotyledones we have a much-branched stem ending with numerous shoots with long internodes and small apices, and bearing many small leaves which are mainly deciduous. In the monocotylous tree, of which we may take the palm as a type, there is a straight stem with short internodes, a large apex bearing few large leaves not often renewed; if there be branching it takes more or less the form of a fork. The whole of this external configuration bears relationship to the internal structure. In the Dicotyledon the open bundles of the central vascular system provide through their cambium for a continued increase of the water-carrying system and medullary rays, which, although it is to many a heresy, I hold to have profound influence upon the movement of water in trees. The buttressing of the branches is also secured, and thus is rendered possible a large assimilating area made up of a vast number of small individual surfaces, each one of which can be readily thrown off. In the Monocotyledones, on the other hand, the distribution of a large number of closed vascular bundles in a matrix without a cambium involves the provision of a broad terminal cone, gives no support, outside interstitial growth, to lateral branches, which are consequently when developed placed so as to give an equipose, and the assimilating surface has to be concentrated in a few large leaves. The possession of cambium has enabled the Dicotyledones to meet in a much better way the requirements of water-supply and strength in correlation with feeding.

The general uniformity and effectiveness of the scheme of cambial growth is a remarkable feature in the dicotylous type; but there is still a wide field of investigation in the relationships of size and distribution of vasa both to the other structural elements of the stem and to the form of the plant in relation to its environment. So far as I know the monocotylous tree-forms, there has been an attempt in two different directions to provide an increased water-carrying system in them. There is the familiar one of the secondary cortical cambium in Dracæna and other genera. In them the cambium merely repeats in its products the construction of the primary stem, and does not provide so copious an increase of carrying area as does the system in dicotylous plants. And then in such plants as Barbacenia, many Bromeliaceæ, perhaps Kingia, we have an arrangement reminiscent of the superficial root-system which is found in many polystelic arborescent Pteridophytes of the present day. There is a copious growth of adventitious roots from the central vascular cylinder, and these pass down within the cortex, and from its cells are no doubt able to draw water for the upper parts of the stem.[1] Ultimately many of these roots reach the soil. At best, however, neither of these systems has been satisfactory. All that can be said for them is that they have enabled the monocotylous trees in which they are found to hold their own in xerophilous conditions.

Of Phyla within Dicotyledones and Monocotyledones.

A brief reference only to the groups within the Dicotyledones and Monocotyledones must conclude these remarks. Whilst there is a wonderful concurrence in the opinion of botanists as to the natural groups—real phyla, whether termed cohorts, alliances, or series—into which many of the families of both Dicotyledones and Monocotyledones fall, there is irreconcilable divergence of view as to their genetic sequence or sequences. And this is not surprising when we remember that we know nothing of the starting point or points of the classes themselves; and have, moreover, no critical mark by which to diagnose a primitive from a reduced feature in many of the flower constructions to which, as characteristic of Angiosperms, importance is attached. The desire to establish a monophyletic sequence of these phyla is natural, and finds expression in pedigrees of Dicotyledones issuing from, it may be, Ranales or Piperales, of Monocotyledones from, say, Apocarpæ or Arales. But all such attempts appear to me, in the present state of our knowledge, to be in vain. We see in the phyla, as we know them, culminating series in our epoch in lines of descent; some, for instance Myrtales or Lamiales, progressive; others, like Primulales or Pandales, apparently not so. We also recognise that these series group themselves in many cases as branches of broader lines of descent; for example, in the Bicarpellatæ of Gamopetalæ, in the Helobieæ of Monocotyledones. To a greater or less degree such relationships are traceable now, and as we obtain more knowledge of the angiospermous plant-life of the world they will be widened. But this is a different thing from the carrying back the pedigree of every phylum of dicotylous and monocotylous plants to one or other of the existing ones, which may possess what are taken to be elementary characters. We have, so far as I know, no evidence to sanction the belief, or even the expectation, that there is extant any family of Dicotyledones or Monocotyledones which represents, even approximately, a primitive type in either class. The stem in each has gone. We have the twigs upon a few broken branches.

Amongst the phyla we cannot discern any one type that can be described as the dominant one. The multifarious adaptability of the angiospermous type has given us diverse forms, suited, as far as we discern, no less well to the varied environments of our epoch. Yet we are able to differentiate certain of them which take precedence alike in point of number of species and in area of distribution. If we seek for some general character that marks these advanced groups we find it in the tendency to greater investiture of the ovule, both in Dicotyledones and Monocotyledones. This is brought about in different ways; for instance, by the sinking of the gynæceum in the torus as in Compositæ, by inclusion within a persistent calyx as in Labiatæ, or within bracts as in Gramineæ. This feature, it will be observed, emphasises that which I have put in the forefront, as leading to the establishment of the angiospermous type. That it must give greater security to the embryo in relation to its water supply is obvious, although it has evidently also direct

[1] In relation to this function it is noteworthy that the hypocotyl relatively seldom in the exalbuminous seed of Dicotyledones becomes the reservoir of food-material, whereas in Monocotyledones the axis of the embryo is the usual seat of deposition.

[2] I use the term purely as an objective designation, and in the original meaning of the suctorial organ in the embryo. This terminal cotyledon in the Monocotyledones is not a leaf nor the homologue of the lateral cotyledones in the Dicotyledones. The "traceable and direct developmental history in the formation" of the two organs is clear, and they are not alike. To those who hold the contrary view a terminal leaf is no obstacle. I think, however, the question of lateral or terminal is of importance in organography. The "sympodial leaf-from-leaf evolution," described in the first epicotylar stages of Júncus, Pistia, and other plants, demands examination with the aid of modern methods. All cases of vegetative organs in which the distinctions between organs are said to break down are worthy of being looked at in the light of their relation to their nutritive environment. How nutrition affects plant-form we do not yet understand. Its effects are familiar, both in vegetative and reproductive organs. The grosser cases, in parasites, show in the extremes an abolition of most of the landmarks of morphology—"the whole scheme of formation of organs is jumbled." Heterotrophic "jumbles" do not, however, deny the ordinary morphological categories. Pseudo-terminal reproductive organs are to be expected under the cessation of growth with which their development is concurrent.

[1] I leave it to Palæophytologists to say whether this construction may sometimes account for the profusion of roots alongside of stem-structure in fossil-sections.

connection with seed-dispersal. Another general character observed in these higher groups is the greater security for economical pollination afforded by the adaptations in relation to insect-visits. At the same time the case of the Gramineæ shows us that other adaptations in this respect are not incompatible with prominence.

I will not dwell upon the influence of water upon the vegetative organs in Dicotyledones and Monocotyledones. Of all the factors of environment its effects are best known because most easily seen. The examination of plants from the standpoint of their relation to water—bearing in mind that this is physiological, and not merely physical—has already thrown a flood of light upon their forms and upon their distribution, and offers a fertile field of investigation for the future.

Water has been, then, a dominating influence at all periods in the evolution of our vegetation. The picture of its claim in this respect which I have presented to you is drawn in the broadest outline, and with the intention more of recalling points of view from which familiar facts in the life of plants may be looked at. It is just occasions like this which give the opportunity of telling to a competent audience of the impressions received by one's most recent glimpse in the kaleidoscope of plant-life. It is in this spirit I offer my imperfect sketch.

SECTION L.

EDUCATION.

OPENING ADDRESS BY THE RIGHT HON. SIR JOHN E. GORST, F.R.S., PRESIDENT OF THE SECTION.

THE invitation of the British Association to preside over the Section of Education, established this year for the first time, has been given to me as a representative of that Government Department which controls the larger, but perhaps not the most efficient, part of the education of the United Kingdom. The most suitable subject for my opening Address would therefore seem to be the proper function of National Authority, whether central or local, in the education of the people; what is the limit of its obligations; what is the part of Education in which it can lead the way; what is the region in which more powerful influences are at work, and in which it must take care not to hinder their operation; and what are the dangers to real education inseparable from a general national system. I shall avoid questions of the division of functions between Central and Local Authorities, beset with so many bitter controversies, which are political rather than educational.

In the first place, so far as the mass of the youth of a country is concerned, the Public Instructor can only play a secondary part in the most important part of the education of the young—the development of character. The character of a people is by far its most important attribute. It has a great deal more moment in the affairs of the world, and is a much more vital factor in the promotion of national power and influence, and in the spread of Empire, than either physical or mental endowments. The character of each generation depends in the main upon the character of the generation which precedes it; of other causes in operation the effect is comparatively small. A generation may be a little better or a little worse than its forefathers, but it cannot materially differ from them. Improvement and degeneracy are alike slow. The chief causes which produce formation of character are met with in the homes of the people. They are of great variety and mostly too subtle to be controlled. Religious belief, ideas, ineradicable often in maturer life, imbibed from the early instruction of parents, the principles of morality current amongst brothers and sisters and playmates, popular superstitions, national and local prejudices, have a far deeper and more permanent effect upon character than the instruction given in schools or colleges. The teacher, it is true, exercises his influence among the rest. Men and women of all sorts, from university professors to village dames, have stamped some part of their own character upon a large proportion of their disciples. But this is a power that must grow feebler as the number of scholars is increased. In the enormous schools and classes in which the public instruction of the greater part of the children of the people is given the influence on character of the individual teacher is reduced to a minimum. The old village dame might teach her half-dozen children to be kind and brave and to speak the truth, even if she failed to teach them to read and write. The head master of a school of 2000, or the teacher of a class of eighty, may be an incomparably better intellectual instructor, but it is impossible for him to exercise much individual influence over the great mass of his scholars.

There are, however, certain children for the formation of whose characters the nation is directly responsible—deserted children, destitute orphans, and children whose parents are criminals or paupers. It is the duty and interest of the nation to provide for the moral education of such children and to supply artificially the influences of individual care and love. The neglect of this obligation is as injurious to the public as to the children. Homes and schools are cheaper than prisons and workhouses. Such a practice as that of permitting dissolute pauper parents to remove their children from public control to spend the summer in vice and beggary at races and fairs, to be returned in the autumn, corrupt in body and mind, to spread disease and vice amongst other children of the State, would not be tolerated in a community intelligently alive to its own interest.

A profound, though indirect and untraceable, influence upon the moral education of a people is exercised by all national administration and legislation. Everything which tends to make the existing generation wiser, happier, or better has an indirect influence on the children. Better dwellings, unadulterated food, recreation grounds, temperance, sanitation, will all affect the character of the rising generation. Regulations for public instruction also influence character. A military spirit may be evoked by the kind of physical instruction given. Brutality may be developed by the sort of punishments enjoined or permitted. But all such causes have a comparatively slight effect upon national character, which is in the main the product for good or evil of more powerful causes which operate, not in the school, but in the home.

For the physical and mental development of children it is now admitted to be the interest and duty of a nation in its collective capacity to see that proper schools are provided in which a certain minimum of primary instruction should be free and compulsory for all, and, further, secondary instruction should be available for those fitted to profit by it. But there are differences of opinion as to the age at which primary instruction should begin and end; as to the subjects it should embrace; as to the qualifications which should entitle to further secondary instruction; and as to how far this should be free or how far paid for by the scholar or his parents.

The age at which school attendance should begin and end is in most countries determined by economic, rather than educational, considerations. Somebody must take charge of infants in order that mothers may be at leisure to work; the demand for child labour empties schools for older children. In the United Kingdom minding babies of three years old and upwards has become a national function. But the infant "school," as it is called, should be conducted as a nursery, not as a place of learning. The chief employment of the children should be play. No strain should be put on either muscle or brain. They should be treated with patient kindness, not beaten with canes. It is in the school for older children, to which admission should not be until seven years of age, that the work of serious instruction should begin, and that at first for not more than two or three hours a day. There is no worse mistake than to attempt by too early pressure to cure the evil of too early emancipation from school. Beyond the mechanical accomplishments of reading, writing, and ciphering, essential to any intellectual progress in after life, and dry facts of history and grammar, by which alone they are too often supplemented, it is for the interest of the community that other subjects should be taught. Some effort should be made to develop such faculties of mind and body as are latent in the scholars. The same system is not applicable to all; the school teaching should fit in with the life and surroundings of the child. Variety, not uniformity, should be the rule. Unfortunately, the various methods by which children's minds and bodies can be encouraged to grow and expand are still imperfectly understood by many of those who direct or impart public instruction. Examinations are still too often regarded as the best instrument for promoting mental progress; and a large proportion of the children in schools, both elementary and secondary, are not really educated at all—they are only prepared for examinations. The delicately expanding intellect is crammed with ill-understood and ill-digested facts, because it is the best way of preparing the scholar to undergo an Examination-test.

Learning to be used for gaining marks is stored in the mind by a mechanical effort of memory, and is forgotten as soon as the Class-list is published. Intellectual faculties of much greater importance than knowledge, however extensive—as useful to the child whose schooling will cease at fourteen as to the child for whom elementary instruction is but the first step in the ladder of learning—are almost wholly neglected.

The power of research—the art of acquiring information for oneself—on which the most advanced science depends, may by a proper system be cultivated in the youngest scholar of the most elementary school. Curiosity and the desire to find out the reason of things is a natural, and to the ignorant an inconvenient, propensity of almost every child; and there lies before the instructor the whole realm of Nature knowledge in which this propensity can be cultivated. If children in village schools spent less of their early youth in learning mechanically to read, write, and cipher, and more in searching hedgerows and ditch-bottoms for flowers, insects, or other natural objects, their intelligence would be developed by active research, and they would better learn to read, write, and cipher in the end. The faculty of finding out things for oneself is one of the most valuable with which a child can be endowed. There is hardly a calling or business in life in which it is not better to know how to search out information than to possess it already stored. Everything, moreover, which is discovered sticks in the memory and becomes a more secure possession for life than facts lazily imbibed from books and lectures. The faculty of turning to practical uses knowledge possessed might be more cultivated in Primary Schools. It can to a limited extent, but to a limited extent only, be tested by examination. Essays, compositions, problems in mathematics and science, call forth the power of using acquired knowledge. Mere acquisition of knowledge does not necessarily confer the power to make use of it. In actual life a very scanty store of knowledge, coupled with the capacity to apply it adroitly, is of more value than boundless information which the possessor cannot turn to practical use. Some measures should be taken to cultivate taste in Primary Schools. Children are keen admirers. They can be early taught to look for and appreciate what is beautiful in drawing and painting, in poetry and music, in Nature, and in life and character. The effect of such learning on manners has been observed from remote antiquity.

Physical exercises are a proper subject for Primary Schools, especially in the artificial life led by children in great cities: both those which develop chests and limbs, atrophied by impure air and the want of healthy games, and those which discipline the hand and the eye—the latter to perceive and appreciate more of what is seen, the former to obey more readily and exactly the impulses of the will. Advantage should be taken of the fact that the children come daily under the observation of a quasi-public officer—the school teacher—to secure them protection, to which they are already entitled by law, against hunger, nakedness, dirt, over-work, and other kinds of cruelty and neglect. Children's ailments and diseases should by periodic inspection be detected: the milder ones, such as sores and chilblains, treated on the spot, the more serious removed to the care of parents or hospitals. Diseases of the eye and all maladies that would impair the capacity of a child to earn its living should in the interest of the community receive prompt attention and the most skilful treatment available. Special schools for children who are crippled, blind, deaf, feeble-minded, or otherwise afflicted should be provided at the public cost, from motives, not of mere philanthropy, but of enlightened self-interest. So far as they improve the capacity of such children they lighten the burden on the community.

I make no apology for having dwelt thus long upon the necessity of a sound system of primary instruction: that is the only foundation upon which a national system of advanced education can be built. Without it our efforts and our money will be thrown away. But while primary instruction should be provided for, and even enforced upon, all, advanced instruction is for the few. It is the interest of the commonwealth at large that every boy and girl showing capacities above the average should be caught and given the best opportunities for developing those capacities. It is not its interest to scatter broadcast a huge system of higher instruction for anyone who chooses to take advantage of it, however unfit to receive it. Such a course is a waste of public resources. The broadcast education is necessarily of an inferior character, as the expenditure which public opinion will at present sanction is only sufficient to provide education of a really high calibre for those whose ultimate attainments will repay the nation for its outlay on their instruction. It is essential that these few should not belong to one class or caste, but should be selected from the mass of the people, and be really the intellectual *élite* of the rising generation. It must, however, be confessed that the arrangements for selecting these choice scholars to whom it is remunerative for the community to give advanced instruction are most imperfect. No "capacity-catching machine" has been invented which does not perform its function most imperfectly: it lets go some it ought to keep, and it keeps some it ought to let go. Competitive examination, besides spoiling more or less the education of all the competitors, fails to pick out those capable of the greatest development. It is the smartest, who are also sometimes the shallowest, who succeed. "Whoever thinks in an examination," an eminent Cambridge tutor used to say, "is lost." Nor is position in class obtained by early progress in learning an infallible guide. The dunce of the school sometimes becomes the profound thinker of later life. Some of the most brilliant geniuses in art and science have only developed in manhood. They would never in their boyhood have gained a county scholarship in a competitive examination.

In Primary Schools, while minor varieties are admissible, those, for instance, between town and country, the public instruction provided is mainly of one type; but any useful scheme of higher education must embrace a great variety of methods and courses of instruction. There are roughly at the outset two main divisions of higher education—the one directed to the pursuit of knowledge for its own sake, of which the practical result cannot yet be foreseen, whereby the "scholar" and the votary of pure science is evolved; the other directed to the acquisition and application of special knowledge by which the craftsman, the designer, and the teacher are produced. The former of these is called Secondary, the latter Technical, Education. Both have numerous subdivisions which trend in special directions.

The varieties of secondary education in the former of these main divisions would have to be determined generally by considerations of age. There must be different courses of study for those whose education is to terminate at sixteen, at eighteen, and at twenty-two or twenty-three. Within each of these divisions, also, there would be at least two types of instruction, mainly according as the student devoted himself chiefly to literature and language, or to mathematics and science. But a general characteristic of all Secondary Schools is that their express aim is much more individual than that of the Primary School: it is to develop the potential capacity of each individual scholar to the highest point, rather than to give, as does the Elementary School, much the same modicum to all. For these reasons it it essential to have small classes, a highly educated staff, and methods of instruction very different from those of the Primary School. In the formation of character the old Secondary Schools of Great Britain have held their own with any in the world. In the rapid development of new Secondary Schools in our cities it is most desirable that this great tradition of British Public School life should be introduced and maintained. It is not unscientific to conclude that the special gift of colonising and administering dependencies, so characteristic of the people of the United Kingdom, is the result of that system of self-government to which every boy in our higher Public Schools is early initiated. But while we boast of the excellence of our higher schools on the character-forming side of their work, we must frankly admit that there is room for improvement on their intellectual side. Classics and mathematics have engrossed too large a share of attention; science, as part of a general liberal education, has been but recently admitted, and is still imperfectly estimated. Too little time is devoted to it as a school subject: its investigations and its results are misunderstood and undervalued. Tradition in most schools, nearly always literary, alters slowly, and the revolutionary methods of science find all the prejudices of antiquity arrayed against them. Even in scientific studies, lack of time and the obligation to prepare scholars to pass examinations cause too much attention to be paid to theory, and too little to practice, though it is by the latter that the power of original research and of original application of acquired knowledge is best brought out. The acquisition of modern languages was in bygone generations almost entirely neglected. In many schools the time given to this subject is still inadequate, the method of teaching antiquated, the results unsatisfactory. But the absolute necessity of such knowledge in literature, in science, and in commerce is already producing a most salutary reform.

The variety of types of secondary instruction demanded by the various needs and prospects of scholars requires a corresponding variety in the provision of schools. This cannot be settled by a rule-of-three method, as is done in the case of primary instruction. We cannot say that such and such an area being of such a size and of such a population requires so many secondary schools of such a capacity. Account must be taken in every place of the respective demands for respective types and grades of secondary education ; and existing provision must be considered.

It must not, however, be forgotten that a national system of education has its drawbacks as well as its advantages. The most fatal danger is the tendency of public instruction to suppress or absorb all other agencies, however long established, however excellent their work, and to substitute one uniform mechanical system, destructive alike to present life and future progress. In our country, where there are public schools of the highest repute carried on for the most part under ancient endowments, private schools of individuals and associations, and Universities entirely independent of the Government, there is reasonable hope that with proper care this peril may be escaped. But its existence should never be forgotten. Universal efficiency in all establishments that profess to educate any section of the people may properly be required ; but the variety, the individuality, and the independence of schools of every sort, primary and secondary, higher and lower, should be jealously guarded. Such attributes once lost can never be restored.

There still remains for our consideration the second division of Higher Education, viz., the applied or technological side. It is in this branch of Education that Great Britain is most behind the rest of the world ; and the nation in its efforts to make up the lost ground fails to recognise the fact that real technical instruction (of whatever type) cannot possibly be assimilated by a student unless a proper foundation has been laid previously by a thorough grounding of elementary and secondary instruction. Our efforts at reform are abrupt and disconnected. A panic from time to time sets in as to our backwardness in some particular branch of commerce or industry. There is a sudden rush to supply the need. Classes and schools spring up like mushrooms, which profess to give instruction in the lacking branch of applied science to scholars who have no elementary knowledge of the particular science, and whose general capacities have never been sufficiently developed. Students are invited to climb the higher rungs of the ladder of learning who have never trod the lower. But science cannot be taught to those who cannot read, nor commerce to those who cannot write. A few elementary lessons in shorthand and book-keeping will not fit the British people to compete with the commercial enterprise of Germany. Such sudden and random attempts to reform our system of technical education are time and money wasted. There are grades and types in technological instruction, and progress can only be slow. It is useless to accept in the higher branches a student who does not come with a solid foundation on which to build. In such institutions as the Polytechnics at Zurich and Charlottenburg we find the students exclusively drawn from those who have already completed the highest branches of general education ; in this country there is hardly a single institution where this could be said of more than a mere fraction of its students. The middle grades of technological instruction suffer from a similar defect. Boys are entered at technical institutions whose only previous instruction has been at elementary schools and evening classes ; whose intellectual faculties have not been developed to the requisite point ; and who have to be retaught the elements to fit them for the higher instruction. In fact there is no scientific conception of what this kind of instruction is to accomplish, and of its proper and necessary basis of general education.

Yet this is just the division of higher education in which public authority finds a field for its operations practically unoccupied. There are no ancient institutions which there is risk of supplanting. The variety of the subject itself is such that there is little danger of sinking into a uniform and mechanical system. What is required is first a scientific, well-thought-out plan and then its prompt and effective execution. A proper provision of the various grades and types of technological instruction should be organised in every place. The aim of each institution should be clear ; and the intellectual equipment essential for admission to each should be laid down and enforced. The principles of true economy, from the national point of view, must not be lost sight of. Provision can only be made (since it must be of the highest type to be of the slightest use) for those really qualified to profit by it to the point of benefiting the community. Evening classes with no standard for admission and no test of efficiency may be valuable from a social point of view as providing innocent occupation and amusement, but they are doing little to raise the technical capacity of the nation. So far from "developing a popular demand for higher instruction" they may be preventing its proper growth by perpetuating the popular misconception of what real technical instruction is, and of the sacrifices we must make if our people are to compete on equal terms with other nations in the commerce of the world. The progress made under such a system would at first be slow ; the number of students would be few until improvements in our systems of primary and secondary instruction afforded more abundant material on which to work ; but our foundation would be on a rock, and every addition we were able to make would be permanent, and contribute to the final completion of the edifice.

It is the special function of the British Association to inculcate "a scientific view of things" in every department of life. There is nothing in which scientific conception is at the present moment more urgently required than in National Education ; and there is this peculiar difficulty in the problem, that any attempt to construct a national system inevitably arouses burning controversies, economical, religious, and political. It is only a society like this, with an established philosophical character, that can afford to reduce popular cries about education (which ignore what education really is, and perpetuate the absurdity that it consists in attending classes, passing examinations, and obtaining certificates) to their true proportions. If this Association could succeed in establishing in the minds of the people a scientific conception of a National Education System, such as has already been evolved by most of the nations of Europe, the States of America, and our own Colonies, it would have rendered a service of inestimable value to the British nation.

GEOLOGY AT THE BRITISH ASSOCIATION.

AN arduous week's work was carried out in the Section of Geology at Glasgow. There was a full list of papers—in fact, too full for adequate discussion of all—ranging widely over the whole group of sciences combined under the name of geology. While stratigraphical papers were, as usual, in the ascendancy, petrology and palæontology were both strongly represented, mineralogy (with crystallography), of late years somewhat neglected in this Section, counted several contributions, and matters of physical and economic geology received attention in others. Many of the papers were admirably adapted for initiating discussion, and in some instances fulfilled this purpose, though, as generally happens with a heavy list, the discussions were somewhat unequally distributed. It might, perhaps, be said of many of the papers that they were instructive summaries of what was already known rather than new additions to our knowledge. The general arrangement was that the papers dealing with Scottish geology were taken as far as possible on Thursday and Friday, Saturday was given up to excursions, palæontological subjects occupied most of the Monday sitting, mineralogical papers were given precedence on Tuesday, and the concluding session on Wednesday served for the postponed or unclassified contributions. In the following outline of the proceedings of the Section we shall not have space to mention all the papers which were read, and must content ourselves with brief mention of those which seemed to us to be of chief interest.

After the president's address on Thursday, already printed in our columns, a paper on recent discoveries in Arran geology, by Mr. W. Gunn, of H.M. Geological Survey, read by Mr. Peach, gave a general summary of recent important advances in our knowledge of the island. Among its older rocks a series of dark schists and chert, unfossiliferous but probably of Arenig age, have been discovered ; the Old Red Sandstone has been found to comprise two subdivisions, of which the upper is unconformable on the lower ; the Carboniferous, including beds probably of Coal Measure age, are overlapped unconformably by the New Red rocks, the latter consisting of sandstones, conglomerates and marls which seem to be of Triassic age.

Fragments of Rhætic, Liassic and Cretaceous rocks which must once have covered the area have been recognised by their fossils in a large volcanic vent; this volcano was probably of Tertiary age, to which period are also assigned most of the igneous rocks, though six earlier periods of volcanic activity have been now recognised in this most interesting island.

Mr. G. Barrow followed with a suggestive paper on lateral variations of composition in zones of the Eastern Highland schists, which he ascribed to original variation in the sediments deposited in a delta. Mr. P. Macnair then gave his interpretation of the structure and probable succession of the schists of the Southern Highlands, which he considers to form an ascending sequence in the following order: Lower Argillaceous zone, Lower Arenaceous zone, Loch Tay Limestone, Garnetiferous schist, Upper Argillaceous zone and Upper Arenaceous zone.

The differentation of a rock-magma was well illustrated by Prof. J. Geikie and Dr. J. S. Flett in their description of the granite of Tulloch Burn, Ayrshire, which passes at its margins into intermediate and basic rocks.

The occurrence of a phosphatic layer at the base of the Inferior Oolite in Skye, lining a hollow of local erosion in the Upper Lias shales, was briefly described in a paper by Mr. H. B. Woodward.

On Friday the first paper was a lucid account by Sir Arch. Geikie of the re-discovery of a tree-trunk embedded in volcanic ash in Mull. This tree was described long ago by Macculloch, but occurs in a sea-cliff very difficult of access, and received no further notice until visited recently by Sir Arch. Geikie. The stump is about 5 feet in diameter and 5 feet high, and must have belonged to a tree originally at least 80 feet high. It is of peculiar interest in showing that time-intervals of quiescence of considerable length occurred between separate volcanic outbursts.

Another notable contribution to Scottish volcanic geology was made by Mr. A. Harker in a paper on the sequence of the Tertiary igneous eruptions in Skye, read by Dr. Flett in the absence of the author. As the result of his detailed mapping of the volcanic rocks of Skye for the Geological Survey, Mr. Harker finds that he can recognise three successive phases of igneous activity—the *volcanic*, the *plutonic*, and the phase of *minor intrusions*. He further distinguishes two parallel series of events—the *regional* and the *local*, the former of very wide extension, the latter connected with certain definite foci, one of which was situated in Central Skye.

The *regional* eruptive rocks are all of basic composition, but the *local* groups exhibit much greater diversity. During the plutonic phase the successive groups of intrusions at the Skye centre followed an order of increasing acidity; but for the local groups of the succeeding phase of minor intrusions this order was reversed. Mr. Harker suggests that this sequence of Tertiary igneous eruptions may probably be taken as a type of the whole British area; and we may be sure that all students of these difficult rocks will await with impatience the publication of the detailed observations on which Mr. Harker's far-reaching generalisations are based.

Two papers by Messrs. A. McHenry and J. R. Kilroe, of the Irish branch of the Geological Survey, dealing with the older rocks of the north-west of Ireland and their bearing on Scottish geology, were next read. In the first the authors called attention to the close resemblance of the Old Red Sandstone of north-west Ireland to the Torridon rocks of Sutherland both in composition and structural relationships, and suggested that the Torridon rocks were therefore really of Old Red age. This paper gave rise to an animated discussion, in which Profs. Sollas, Lapworth and Hull, Messrs. Peach, Barrow, Greenly, Goodchild, Caddell, Hinxman, Craig and the President took part. The consensus of opinion was that the suggested new reading of the Torridon succession could not be sustained; and one of the speakers aptly proposed that as the question had been well-threshed out, an abstract of the discussion should be printed as a permanent record of the evidence for the age of the Scottish Torridonian.

Messrs. Kilroe and McHenry's second paper dealt with the relation of the Silurian and Ordovician rocks of north-west Ireland to the Great Metamorphic Series, their contention being that the latter consisted of metamorphosed Lower Silurian sediments and associated intrusions, over which the unmetamorphosed rocks were carried by overfolding and great dislocations in Llandovery times. In the next paper on the list, by Mr. G. H. Kinahan, this view was controverted, and the earlier age of the metamorphic series upheld, these being compared with the Algonkian of North America.

Dr. Traquair then gave interesting lantern demonstrations on the geological distribution of the fishes of the Carboniferous rocks and of the Old Red Sandstone of Scotland. The study of the Carboniferous fish-faunas led to the conclusion that the rocks were divisible into two parts—Upper and Lower Carboniferous, with a great break at the base of the Millstone Grit, the Upper Carboniferous fauna being like that of England, and that of the Lower Carboniferous differing only where fresh-water or estuarine conditions displaced the marine forms. At a later session similar results were presented by Mr. R. Kidston in his description of fossil plants from Berwickshire.

In the concluding papers on Friday the Section was carried far afield by Miss C. A. Raisin in her account of the volcanic rocks of Perim Island, and by Dr. R. Logan Jack in his description of the conditions under which enormous supplies of artesian water are obtained in Queensland, where borings of the aggregate length of 185 miles have been made with incalculable advantage to the country, as the result of geological investigations in which Dr. Jack was a pioneer. The deepest of these borings attained the exceptional depth of 5045 feet.

On Monday, when precedence was given to palæontological papers, Mr. B. N. Peach came first with an admirable *résumé* of our knowledge of the Cambrian fossils of the North-West Highlands, in which stress was laid on the close agreement between the Scottish and North American fossil zones of this ancient period, betokening a shore-line connection between the continents, with a deep-water barrier to the southward, separating the north of Scotland from the mid-European and Welsh areas.

Prof. Sollas then exhibited and explained his machine for investigating fossil-remains. By Prof. Sollas's method the fossil is ground down slowly, and a series of parallel sections obtained from which it is easy to construct a model of the whole fossil. The great value of this machine as an instrument of research was demonstrated by a series of lantern slides and by wax models.

Mr. A. M. Bell gave an account of the plants and coleoptera from a Pleistocene deposit at Wolvercote, Oxfordshire; the plants indicated a more continental climate of the Thames valley during the period than at present, and a later date for the deposit than the Hoxne beds.

Papers on glacial geology were fewer than of late years, and indeed, with the exception of the Report of the Erratic Blocks Committee, the only strictly glacial paper was that of Prof. P. F. Kendall and H. B. Muff on overflow channels and other phenomena indicating glacier-dammed lakes in the Cheviots, in which region these observers have recently recognised similar phenomena to those which they had previously investigated in Yorkshire.

The application of geology to agriculture by the preparation of soil maps was the subject of a communication by Mr. J. R. Kilroe, who exhibited a specimen-map, on which the general character of the soil was indicated by a few colours selected from those of our usual geological maps, but intended to show the soil-characters only, without particular reference to the geological structure.

Tuesday was primarily the mineralogists' day, and the session was opened by Mr. J. G. Goodchild with a paper on the Scottish ores of copper in their geological relations, in which these ores were classed into two primary categories, those of the first being assigned to the uprise of thermal waters, and of the second to solutions passing downwards from higher to lower levels. The same author, in another communication, dealt with a revised list of Scottish minerals, and indicated its more salient points. Dr. W. Mackie followed with a series of three papers on the Trias of Elgin and Nairn, one describing the occurrence of barium sulphate and calcium fluoride as cementing substances in the Elgin area, believed by the author to have been directly deposited during the concentration of the waters of an inland lake; another recording covellite and malachite in a vein in the sandstone of Kingsteps, Nairn; and the third, on which there was an excellent discussion, on the pebble-band of the Elgin Trias, which was shown to be of wider extent than hitherto supposed and to mark a definite horizon at the base of the Trias, the overlying Cutties Hillock sandstones being really made up of Triassic sand-dunes, while in the pebble-bed many of the stones present characters showing them to have been wind-worn. At this point we may also mention a mineralogical paper by Dr. J. S. Flett, read at an earlier session, on crystals dredged from the Clyde near Helensburgh, which are believed to be pseudomorphs after celestine.

In a paper on the source of the alluvial gold of the Kildonan field, Sutherland, Mr. J. Malcolm Maclaren, as the result of a recent investigation, concludes that the gold has been derived from the white quartz veins of the local schists, whence it has been distributed into the glacial drift and finally concentrated mechanically in the present stream-courses. In a second paper Mr. Maclaren dealt with the influence of organic matter on the deposition of gold in veins, from personal observation on the reefs of the Sympic and Croydon goldfields of Queensland and of the Ballarat field of Victoria, giving illustrations of the enrichment of the veins at the contact with carbonaceous or graphitic rocks, and suggesting the possibility of precipitation by carbonaceous matter, in accordance with the opinion once generally held, but latterly much discredited.

Mr. E. H. Cunningham Craig described the mode of occurrence of cairngorms, the search for which was formerly a profitable Scottish industry, but has now been practically abandoned. These idiomorphic quartz-crystals occur in the drusy central zones of veins of fine-grained granite traversing the normal coarser and less acid granites.

Prof. Joly's computations of the age of the earth from the amount of salt in the sea were incidentally criticised by Mr. W. Ackroyd in a paper on the circulation of salt and its geological bearings. It was shown by Mr. Ackroyd that for the Millstone Grit and limestone districts of Yorkshire, as well as for a belt of the American coast some 200 miles broad, fully 99 per cent. of the salt carried by the rivers was cyclic sea-salt which had been atmospherically transported and carried down by rain, while Prof. Joly allows only 10 per cent. as the proportion thus derived in our rivers. Reference was made to estimates by the author that during 1900–1901 the deposition of salt derived from the sea amounted to 172·3 lbs. per acre per year on the Pennine Hills at over 1000 feet above sea-level.

At the same session Mr. W. H. Wheeler discussed the sources of the warp in the Humber, urging that the material was brought down by the rivers flowing into the Humber, and not by the inflowing tide from the waste of the Holderness coast as has been authoritatively stated. Two papers by Mr. J. Rhodes were also read, describing the discovery of phosphatic nodules and phosphate-bearing rock in the Upper Carboniferous Limestone series on the Yorkshire and Westmorland border, and of a silicified plant seam in the same locality.

There still remained a list of ten papers and reports to be taken at the final meeting on Wednesday, the majority being papers dealing with foreign geology. Dr. A. Smith Woodward sent an account of his recent investigations of the famous bone-beds of Pikermi, Attica, where in re-working the old locality he obtained fragmentary evidence of a gigantic tortoise at least as large as the largest hitherto found in Europe, and in a new locality, at Achmet Aga in North Eubœa, sixty miles distant from the former, he found a similar bone-bed, probably formed in like manner by torrential floods carrying down their débris into lakes.

Mr. H. J. L. Beadnell, of the Geological Survey of Egypt, also sent an account of the discovery of bone-beds of early Tertiary age in the Fayum depression, which have yielded many new mammalian and reptilian remains now being worked out by Dr. C. W. Andrews, of the British Museum, who visited the locality with Mr. Beadnell.

Prof. E. Hull, in continuance of his researches on submarine physiography, discussed the physical history of the Norwegian fjords. These he believes to be essentially river-valleys, of which the lower portions, probably once deep gorges traversing what is now the open sea-floor, are entirely filled with drift, and thus obliterated.

The origin of the gravel flats of Surrey and Berkshire was discussed by Mr. H. W. Monckton, who concludes that these deposits were river-gravels formed since the country last rose above the sea, during periods of repose in the process of elevation, which was differential in its effects.

As usual, much of the best work brought before the Section was embodied in the Reports of Committees of Research, for which, unfortunately, we have barely space for mention. The report of the Geological Photographs Committee, by Prof. W. W. Watts, and that on Erratic Blocks, by Prof. P. F. Kendall, showed the same substantial progress which these vigorous committees customarily present. The report on Carboniferous Life-zones, by Dr. Wheelton Hind, and that on the Underground Waters of N.W. Yorkshire, by Captain A. R. Dwerryhouse, though hampered by unforeseen local difficulties in the latter case, also showed solid progress; while that on the Exploration of Irish Caves gave a preliminary account of the good results attained by the first year's working at Keish, co. Sligo; and that on the Structure of Crystals (drawn up by Mr. W. Barlow and Prof. H. A. Miers, assisted by Mr. G. F. Herbert Smith) forms an invaluable contribution to the history of crystallographic research.

As usual there were afternoon excursions during the meeting to places of geological interest within easy reach of Glasgow, besides the whole-day excursions to Girvan, Arran, Loch Lomond and The Trossachs on Saturday. The attendance at the sectional meetings throughout was quite up to the average of recent years, and general satisfaction was expressed with the character of the proceedings of Section C at Glasgow.

ZOOLOGY OF THE TWENTIETH CENTURY.[1]

WE have stood in retrospect at the close of the nineteenth century and marvelled at what it brought forth. Here at the threshold of the twentieth century it is natural that we should wonder what it will unfold. Will the changes be as great and in what direction will advance chiefly be made? I am the more content to consider such questions for three reasons: first, because we can use history to formulate predictions; second, because the attempt may possibly influence to some slight degree the future development of zoology; and third, because the attempt is tolerably safe since we shall none of us know all that the century will bring forth.

Comparing the beginning of the twentieth century with that of the nineteenth we find the most striking advances to have taken place in our morphological knowledge. The nineteenth may, indeed, be designated the morphological century. The demands of systematic zoology first made anatomical studies necessary. Later, comparison came to be accepted as the fundamental zoological method, and comparative anatomy, emancipated from its servitude to systematic zoology, became an independent science. Still later embryology arose, at first as a descriptive science and then as a comparative one. Out of embryology arose modern cytology, which in turn is creating a comparative histology. Partly as a result of studying embryology as a process has arisen the modern tendency toward comparative physiology. As a result of the general acceptance of the evolution doctrine the study of the geographical distribution of organisms and of adaptations has gained a new meaning. From the great matrix of "general biology" there have begun to crystallise out a number of well-defined subsciences.

Looking broadly at the progress made during the past century we see that zoology has become immensely more complex due to its developing in many lines, and that the new lines are largely interpolated between the old and serve to connect them. The descriptive method has developed into a higher type—the comparative; and of late years still a new method has been introduced for the study of processes—the experimental. The search for mechanisms and causes has been added to the search for the more evident phenomena. The zoologist is no longer content to collect data; he must interpret them.

In view of the past history of our science what can we say of its probable future? We may be sure that zoology will develop in all these three directions: (1) The continued study of old subjects by old methods; (2) the introduction of new methods of studying old subjects; and (3) the development of new subjects.

I am not of those who would belittle the old subjects, even when pursued in the old way. There is only one class of zoologist that I would wish to blot out, and that is the class whose reckless naming of new "species" and "varieties" serves only to extend the work and the tables of the conscientious synonymy hunter. Other than this all classes will contribute to the advancement of the science. No doubt there are unlabled species and no doubt they must, as things are, be named. And no doubt genera and families must be "revised" and some groups split up and others lumped. So welcome to the old-fashioned systematist, though his day be short, and may

[1] Address delivered before the Section of Zoology of the American Association for the Advancement of Science, at Denver, by Prof. C. B. Davenport, president of the Section

he treat established genera gently. No doubt there are types of animals of whose structure we are woefully ignorant; no doubt we need to know their internal anatomy in great detail. So welcome to the zootomist in this new century, and may he invent fewer long names for new organs. No doubt there are groups of whose relationships we know little, and which have been buffeted about from one class to another in a bewildering way. We need to have their places fixed. So welcome to the comparative anatomist and the embryologist, and may their judgment as to the relative value of the criteria of homology grow clearer. No doubt our knowledge of inheritance and development will be immensely advanced by the further study of centrosomes, asters and chromosomes. Welcome, therefore, to the cytologist, and may he learn to distinguish coagulation products and plasmolytic changes from natural structures. All these subjects have victories in store for them in the new century. To neglect them is to neglect the foundations of zoology.

But the coming century will, I predict, see a change in the methods of studying many of these subjects. In systematic zoology fine distinctions will no longer be expressed by the rough language of adjectives, but quantitatively, as a result of measurement. There is every reason to expect, indeed, that the future systematic work will look less like a dictionary and more like a table of logarithms. Our system of nomenclature, meanwhile, will probably break down from its own weight. Now that the binomial system of nomenclature has been replaced by a trinomial, there is no reason why we should not have a quadrinomial nomenclature or even worse. It seems as if the Linnæan system of nomenclature is doomed. What will take its place can hardly be predicted. The new system should recognise the facts of place-modes and colour-varieties. We might establish certain categories of variation such as those of geographical regions, of habitat, of colour. A decimal system of numbers might be applied to the parts of the country or the kinds of habitat and the proper number might take the place of the varietal or subvarietal name. Thus the north-eastern skunk might be designated *Mephitis mephitica* 74, and the south-eastern skunk *Mephitis mephitica* 75 (adopting the Dewey system of numerals). The Maine skunk would then be 741, that of New York 747, and so on. This much for a suggestion.

So likewise for the morphologist the coming century will bring new aims and new methods. No longer will the construction of phylogenetic trees be the chief end of his studies, but a broad understanding of the form producing and the form maintaining processes. The morphologist will more and more consider experiment a legitimate method for him. The experimental method will, I take it, be extended especially to the details of cytology, and here cytology will make some of its greatest advances.

Not only will the old subjects be studied by new methods, but we have every reason to believe that new subsciences will arise during the twentieth century as they arose during the nineteenth. Of course we cannot forecast all of these unborn sciences, as cytology and neurology could hardly have been forecast at the beginning of the nineteenth century. But we can see the beginnings of what are doubtless to be distinct sciences. Thus comparative physiology is still in its infancy, and is as yet hardly worthy of the name of a science; there is no question that this will develop in the coming decades. Animal behaviour has long been treated in a desultory way, and many treatises on the subject are rather contributions to folk-lore than to science. But we are beginning to see a new era—an era of precise, critical and objective observation and record of the instincts and reactions of animals. One day we shall reach the stage of comparative studies and shall have a science of the ontogeny of animal instincts. This will have the same importance for an interpretation of human behaviour that comparative anatomy and embryology have for human structure.

Prominent among the advances of the century will be the ability to control biological processes. We shall know the factors that determine the rate of growth and the size of an animal, the direction and sequence of cell-divisions, the colour, sex and details of form of a species. The direction of ontogeny and of phylogeny will be to a greater or less extent under our control.

The study of animals in relation to their environment, long the pastime of country gentlemen of leisure, will become a science. Some day we shall be able to say just what determines an animal's presence at any place; and, more than that, we shall be able to account for the fauna, the sum total of animal life of any locality, and to trace the history of that fauna. This is at least one of the aims of animal ecology. It is a reproach to zoology that the subject of animal ecology should lag so far behind that of plant ecology. When zoologists fully awaken to a realisation of what a fallow field lies here this reproach will quickly be wiped out. As it is we have a notion that the factors determining the occurrence of an animal or of a fauna are too complicated to be unravelled. As a matter of fact the factors are often quite simple. Let me illustrate this by some studies I have made this summer on the Cold Spring Beach. This beach is a spit of sand 2000 feet long and 50 to 75 feet broad, running from the western mainland into the harbour and ending in a point that is being made several feet a year through the cooperation of wave, tide, and a silt-transporting creek of fresh water. On the outer harbour side is a broad, gradually sloping sandy and gravelly beach, covered by high tide, and devoid of living vegetation. Above that is a narrow zone—the middle beach—covered with the débris of storms, supporting a few annual plants, and bounded above by a storm-cut bluff. Above is the upper beach, covered with a perennial, sand-loving vegetation. On the lower beach the zonal distribution of animals is striking. Just above the water are found the scavenger mud-snails, and, further up, a crowd of Thysanura—small insects that rise to the surface of the water when the tide comes in. These find a living on the finer débris or silt that settles on the pebbles during the high tides. In this zone also Limulus lays its eggs in the sand, and its nests are crowded with nematodes that feed on the eggs. During the breeding season scores of the female Limulus die here, and their carcasses determine a complex fauna. First, carrion beetles (Necrophorus) and the flesh fly live on the dead bodies; then the robber flies and tiger-beetles are here to feed on this fauna, and, finally, numerous swallows course back and forth, gleaning from this rich field. At the upper edge of the lower beach is a band of débris dropped at slack water and consisting especially of shreds of Ulva and many drowned insects, especially beetles. At this zone or just above, under the drier but more abundant wreckage of the last storm, occur numerous Amphipoda of the genera Orchestia and Talorchestia. Associated with these marine creatures are numerous red ants, sand-coloured spiders and rove-beetles. The amphipods feed on the decaying sea-weed. The ants are here looking chiefly for the drowned insects. Their nests are further up on the middle beach, but the workers travel to the edge of the high tide to bring away their booty. The rove-beetles are general scavengers. The spiders, which are mostly of the jumping sort (of the family Attidæ), feed on the active insects and amphipods. At a higher zone and above all but the storm-driven tides one finds the nests of the ants, especially under logs, certain predaceous beetles and the xerophilous grasshoppers and crickets. Finally, on the plant-covered upper beach one finds characteristic leaf-eating beetles, grasshoppers and carnivorous insects. Now all this seems commonplace enough and not especially instructive, and yet if you go to the shore of Lake Michigan you will find on a similar beach closely similar, if not identical, forms (excepting the beach fleas and the horse-shoe crabs); you will find similar ants, spiders, rove-beetles, tiger-beetles and sand grasshoppers. This fact alone shows the greater importance of habitat over geographical region in determining the assemblage of animals that occurs in any one place. It may be predicted that studies on the relation of animals to their habitat will multiply, that they will become comparative and that the science of animal ecology will become recognised as no less worthy and no less scientific than the science of morphology.

Studies on the origin of species were far from being unknown in the nineteenth century, but they were for the most part fragmentary or speculative or narrow in view. The opinion that there was one method of evolution seemed to hold sway. It seems to me that the signs of the times indicate that we are about to enter upon a thorough, many-sided, inductive study of this great problem, and that there is a willingness to admit that evolution has advanced in many ways. The attempt, therefore, to explain all specific peculiarities on the ground of natural selection, or on the ground of self-adjustment, or on the ground of sport-preservation through isolation we may expect equally to prove futile. All these causes are no doubt real in some cases, but to exclude any one or to deny that new causes may be found in the future is equally dangerous and unscientific.

It is often said that the factors of evolution are inheritance and variation. In the new century careful and quantitative studies will be made on these factors. We shall get at quantitative expressions of the more complicated forms of heritage in the same way as Galton has given us an expression of a simple form of inheritance. We shall hope to understand why some qualities blend and others refuse to do so. We shall learn the laws of mingling of qualities in hybrids and get an explanation of the monstrosities and the sterility which accompany hybridisation. What we call reversion and prepotency will acquire a cytological explanation, and it may be that the theory of fertilisation will be seriously modified thereby. When we can predict the outcome of any new combination of germplasms, then, indeed, we shall have got at the laws of inheritance.

As for the other factor, that of variation, I anticipate interesting developments in our knowledge of its laws and of its causes. The methods by which this knowledge is to be acquired are doubtless comparative observation, experimentation and a quantitative study of results. Within the last decade a profouud student of variation (Bateson) has declined to discuss its causes, holding that we had no certain knowledge of them. Even the categories of variation are still unenumerated. The science of variation is therefore one of those that we may hope to see established in this century. I feel convinced that statistical studies are first of all necessary to lay the foundations of the science.

As an illustration o. an application of statistics to evolution studies I will give some account of my work during the past two years on the scallop of our east coast, *Pecten irradians*.

Pecten irradians is a bivalve mollusc of flattened lenticular form that inhabits our coast from Cape Cod southward. The Cape Cod limit is a rather sharp one, but southward our scallop passes gradually into the closely related forms of the South American coast. This fact would seem to indicate its southerly origin. To get light on the evolution of the group, I have studied and measured more than 3000 shells, chiefly from four localities :—(1) Cold Spring Harbour, Long Island ; (2) Morehead, North Carolina; (3) Tampa, Florida; and (4) the late Miocene or early Pliocene fossils of the Nansemond River. The fossil shells, to which I shall frequently refer, were found embedded in the sand of Jack's Bank, one mile below Suffolk, Virginia. The bank rises to a height of twenty-five to thirty feet. Shells were obtained from three layers, respectively one foot, six feet and fifteen feet above the base of the bluff. Of course, the upper shells lived later than the lower ones and may fairly enough be assumed to be their direct descendants. The time interval between the upper and lower levels cannot be stated. As I have measured sufficient shells from the bottom and top layers only I shall consider them chiefly. I wished to get recent Pectens from this locality, but the nearest place where they occur in quantity is Morehead, North Carolina. These Pectens may therefore stand as the nearest recent descendants of the Pectens of the Nansemond River.

The Pecten shells have a characteristic appearance in each of the localities studied. After you have handled them for some time you can state in 95 per cent. of the cases the locality from which any random shell has come. First of all the shells differ in colour, especially of the lower valve. In the specimens from Cold Spring Harbour this is a dirty yellow, from Morehead, yellow to salmon, from Tampa, white through clear yellow to bright salmon. Second, the anterio-posterior diameter of the shell becomes relatively greater than the vertical diameter as you go north. Thus the anterio-posterior diameter exceeds, on the average, the dorso-ventral diameter: at Tampa, by about 1·5 m.m. ; at Morehead, 2·5 mm. ; and at Cold Spring Harbour, 6 mm. The fossil Pectens have an excess of about 4 mm.

Comparing the fossils with the Pectens of Morehead we find, as shown above, that the fossils are more elongated. Comparing the depth of the right valves having a height of 59 mm. we get :—

From the lowest level, Jack's Bank	8·8 mm.
,, ,, highest ,, ,, ,,	9·1 mm.
,, Morehead	19·7 mm.

Hence the recent shells are much more nearly spherical than the fossils—there is a phylogenetic tendency toward increased globosity.

The average number of rays in the different localities is as follows :—

Lower level, Jack's Bank	22·6
Middle ,, ,, ,,	22·1
Upper ,, ,, ,,	21·7
Morehead and Cold Spring Harbour	17·3
Tampa	20·5

Here it appears that there is a phylogenetic tendency toward a decrease in the number of rays of *Pecten irradians*. To summarise : the scallop is becoming, on the average, more globose, and the number of its rays is decreasing, and its valves are probably becoming more exactly circular in outline. The foregoing examples illustrate the way in which quantitative studies of the individuals of a species can show the change in its average condition, both at successive times and in different places.

But the quantitative method yields more than this. It is well known that if the condition of an organ is expressed quantitatively in a large number of individuals of a species the measurements or counts made will vary, *i.e.* they will fall into a number of classes. The proportion of individuals falling into a class gives what is known as the "frequency" of the class. Now it appears that in many cases the middle class has the greatest frequency (and is consequently called the mode), and as we depart from it the frequency gradually diminishes, and diminishes equally at equal distances above and below the mode. One can plot the distribution of frequencies by laying off the successive classes at equal intervals along a base line and drawing perpendiculars at these points proportional in length to the frequency. If the tops of these perpendiculars be connected by a line there is produced a "frequency polygon." The shape of the frequency polygon gives much biological information. When the polygon is symmetrical about the modal ordinate we may conclude that no evolution is going on ; that the species is at rest. But very often the polygon is more or less unsymmetrical or "skew." A skew polygon is characterised by this, that the curve runs from the mode further on one side than on the other. This result may clearly be brought about by the addition of individuals to one side or their subtraction from the other side oi the normal frequency curve. The direction of skewness is toward the excess side. The skew frequency polygon indicates that the species is undergoing an evolutionary change. Moreover, the direction and degree of skewness may tell us something of the direction and rate of that change. There is one difficulty in interpretation, however, for a polygon that is skew may be so either from innate or from external causes. In the case of skewness by addition we may think that there is an innate tendency to produce variants of a particular sort, representing, let us say, the *atavistic* individuals. In this case skewness points to the past. The species is evolving *from* the direction of skewness. In the case of skewness by subtraction, there are external causes annihilating some of the individuals lying at one side of the mode. Evolution is clearly occurring away from that side and *in* the direction of skewness.

Now so far as we know at the present time there is no way oi distinguishing skew polygons due to atavism from such as are due to selective annihilation. But in many cases at least the skewness, especially when slight, can be shown to be due to atavism ; and this is apparently the commoner cause. This conclusion is based first upon a study of races produced experimentally and whose ancestry is known, and secondly upon certain cases of compound curves. Take the case of the ray flowers of the common white daisy. A collection of such daisies gathered in the field and studied by De Vries gave a mode of 13 ray flowers with a positive skewness of 1·2. The 12- or 13-rayed wild plants were selected to breed from, and their descendants, while maintaining a mode at 13, had the increased positive skewness of 1·9. The descendants of the 12-rayed parents had a stronger leaning towards the high ancestral number of ray flowers than the original plants had. The 21-rayed plants were also used to breed from. Their descendants were above the ancestral condition as the descendants of the 12-rayed plants were below. The skewness −0·13 is comparatively slight. In this case we have experimental evidence that curves may be skew *toward* the original ancestral condition.

Of the compound polygons it is especially the bimodal polygon that frequently gives hint of two races arising out of one ancestral, intermediate condition. Consequently we should expect the two constituent polygons to be skew in opposite directions ; and so we usually find them to be. For example, Bateson has measured the horns of the heads of 343 rhinoceros beetles and has got a bimodal polygon. The polygon with the lower mode has a skewness of +0·48; that with the higher mode a skewness of −0·03. One might infer that the right-hand form, the long-horned beetles, had diverged less than the short-horned from the ancestral condition. Again, as is well-known, the chinch bug occurs in two forms—the long-winged and the short-winged. Now, in a forthcoming paper my pupil, Mr. Garber, will show that the frequency polygon of the short-winged form has a skewness of +0·44, while that of the long-winged form has a skewness of −0·43. On our fundamental hypothesis the ancestral condition must have been midway between the modes.

Still a third class of cases that gives evidence as to the significance of skewness is that where two place modes have moved in the same direction but in different degrees. Thus the index (breadth ÷ length) of the shell of *Littorina littorea*, the shore snail, as measured by Bumpus has, at Newport, a mode of 90; at Casco Bay, of 93. The skewness is positive in both places and greater (+·24) at the more southern point than at Casco Bay (+·13). This indicates that the ancestral races had a higher index even than those of Casco Bay, probably not far from 96, and also that the *Littorina littorea* of our coast came from the northward, since the northern shells are the rounder. We have historical evidence that they did come from the northward. Likewise the Littorinas from South Kincardineshire, Scotland, have a modal index of 88 and a skewness of +0·065, while those of the Humber, with a mode of 91 have a skewness of +0·048. These figures suggest that if the mode were 97 the skewness would be 0, and this would give practically the same value to the ancestral index as arrived at for the Littorinas of our coast. It will be seen from these illustrations that the form of the frequency polygon may be of use in determining phylogeny.

While skewness is thus often reminiscent, we must not forget the possibility that it may be, in certain cases, prophetic. This has come out rather strongly in a piece of work I have been engaged on during the past year. I have been counting the number of rays in recent *Pecten irradians* from various localities, and have obtained in some cases evident skewness in the frequency polygons. To see what phylogenetic meaning, if any, this skewness has I sought to get a series of late fossils. After careful consideration I was led to go to the Nansemond River for the late Tertiary fossils found there and already referred to; these served my purpose admirably. We may now compare the average number of rays from the two extreme layers at Jack's Bank and at Morehead with the indices of skewness of the frequency polygons from the same localities.

Place.	Av. No. of rays.	Index of skewness	σ
Morehead, N.C.	17·3 ...	−0·09 ...	0·81
Upper layer, Jack's Bank ...	21·7 ...	−0·16 ...	1·10
Lower ,, ,, ,, ...	22·6 ...	−0·22 ...	1·24

This series is instructive in that it tells us that the gradual reduction in number of rays has been accompanied at each preceding stage by a negative skewness. This skewness was thus prophetic of what was to be. The skew condition of the frequency polygon we may attribute to a selection taking place at every stage, and the interesting result appears that the selection diminishes in intensity from the earliest stage onward. It is as though perfect adjustment were being acquired. If adjustment were being perfected we might expect a decrease in the variability in the rays at successive periods. And we do find such a decrease. This is indicated in the last column, where σ stands for the index of variability. From this column it appears that the variation in the number of rays has diminished from 1·24 rays in the Miocene to 0·81 ray in recent times. This fact again points to an approach to perfection and stability on the part of the rays. Exactly why or wherein the reduced number of rays is advantageous I shall not pretend to say. It is quite possible that it is not more advantageous, but that there is in the phylogeny of *Pecten irradians* an inherent tendency towards a reduction in the number of multiple parts. As a matter of fact there are other Pectens in which the number of rays is less even than in irradians.

The reduction in the variability of the rays with successive geological periods has another interest in view of the theory of Williams and of Rosa, according to which evolution and differentiation have of necessity been accompanied by a reduction in variability. Evolution consists, indeed, of a splitting off of the extremes of the range of variation, so that in place of species with a wide range of variability we have two or three species each with a slight range of variability. In the particular case in hand, however, it is not certain that the lower Jack's Bank form-unit (named *Pecten eboreus* by someone) has given rise to any other form than something of which *Pecten* "*irradians*" of Morehead is a near representative. The evidence indicates that the reduced variability is solely the effect of the skewing factors.

The upshot of this whole investigation into the biological significance of skew variation is, then, this: Skewness is sometimes reminiscent and sometimes prophetic. In our present state of knowledge it is not possible by inspecting a single skew curve to say which of the two interpretations is correct in the given case. But by a comparison of the frequency curves of allied form-units the state of affairs can usually, as in the examples given, be inferred. A method of interpreting the single skew curve is a discovery for the future.

I realise that I have been bold, not to say rash, in this attempt to forecast the zoology of the twentieth century. I suppose, after all, I have merely expressed my personal ideals. Let those comfort themselves, therefore, who like my picture not and let them draw one more to their taste. These matters of detail are after all less important, but the general trend of the science I believe to be determined by the great general laws that will hold, whatever the detailed lines of development. First, students of the science will cling closer to inductive methods without abandoning deduction. Speculative web-spinning will be less common, will be less attractive, and will be more avoided by naturalists of repute. Great generalisations will be made, of course, but made with caution and founded at every step on facts. Second, the science will deal more with processes and less with static phenomena; more with causes and less with the accumulation of data. The time is coming when the naturalist who merely describes what he sees in his sections will have neither more nor less claim for consideration than he who describes a new variety of animal. It is relations, not facts, that count. Third, the science will become experimental, at least in so far as it deals with processes. Nothing will be taken for granted that can be experimentally tested. Better experimental laboratories will be founded and larger experimental stations, such as Bacon foresaw in the new world, will be established. Fourth, the science will become more quantitative. This is the inexorable law of scientific progress, at least where processes are concerned. I repeat that there is no reason to expect or desire the abandoning of the lines of work already recognised and followed for a half century or more. Rather, holding fast to and extending the old lines of investigation, zoology will be enriched by new fields of study lying between and uniting the old. As chemistry and physics are uniting and occupying the intervening field, as geology and botany are coming close together in plant ecology, so will zoology and mathematics, zoology and geology, zoology and botany find untouched fields between them and common to them. Working in these new fields and by the aid of new methods the naturalist of the future will penetrate further into the nature of processes and unravel their causes.

The zoology of the twentieth century will be what the zoologist of the twentieth century makes it. One hundred years ago the prerequisites of the naturalists were few, and the opportunities of getting them were small. He must have studied with some master or have worked as an assistant under a naturalist in some museum. The places were few, the masters often difficult of approach. Now, while on the one hand the training required is vastly more exacting, on the other hand the opportunities are generous. Just because of the fact that zoology is spreading to and overlapping the adjacent sciences, the zoologist must have his training broadened and lengthened. A zoologist may well be expected to know the modern languages (let us hope this requirement may not be further extended), mathematics through analytics, laboratory methods in organic as well as inorganic chemistry, the use of the ordinary physical instruments, advanced geology and physiography, botany, especially in its ecological, physiological and cytological aspects, and animal palæontology. The list of prerequisites is appallingly long; zoologists of the future will be forced to an earlier and narrower specialisation, while at the same time they must lay a broader foundation for it.

But if the prerequisites of the zoologists are to be numerous, their acquisition will be easy. Even now scores of universities put the services of the best naturalists at the disposal of students, and offer free tuition and living to come and study with them. Libraries, great museums, great teachers are made available to him who would work and had the requisite capacity.

All these advantages will, however, count for nothing if zoological research do not attract the best men and if the best men be not accorded time and means for research. Our best students slip from our grasp to go into other professions or into commerce, because we can offer them no outlook but teaching, administration, and a salary regulated by the law of supply and demand. We must urge without ceasing upon college trustees and corporations the necessity of freedom for research and liberal salaries if America is to contribute her share to the advance of zoology in the twentieth century.

THE CARNEGIE TECHNICAL SCHOOL AT PITTSBURG.

TWO of the addresses delivered by presidents of sections of the American Association for the Advancement of Science at the recent Denver meeting were concerned with scientific and technical education. Mr. J. A. Brashear, Chancellor of the Western University of Pennsylvania, described the plans, drawn up at Mr. A. Carnegie's request, for a great technical college at Pittsburg, and Prof. C. M. Woodward, Dean of the School of Engineering and Architecture, Washington University, St. Louis, took as his text the differences between the educational ideals of to-day and of the time when education was considered merely as needful to the "embellishments of life." The movement towards a study of the materials and forces of Nature and the problem of modern life—sociological, commercial and industrial—has produced a change of front as remarkable as it is gratifying. Out of the vast extension of the horizon of human activities which the movement has promoted, and a corresponding multiplication of occupations, has come an imperative demand for better education and for technically educated men. The scheme for the Carnegie Technical School has been drawn up with the intention of suggesting how to train students to supply this want.

Reference has already been made (July 25, p. 319) to the report of the committee appointed to determine the best plan and most suitable scope of the new institution which Mr. Carnegie is prepared to build, equip and endow in the city of Pittsburg. Further details are given by Mr. Brashear in his address, and are here summarised. After a careful discussion of the plan of procedure, the committee on the plan and scope of the proposed school decided to call to their assistance, as an advisory board, Dr. Robert H. Thurston, Prof. J. B. Johnson, Dr. Thomas Gray and Dr. Victor Alderson, acting president of the Armour Institute of Chicago.

Each member of the advisory board formulated his plans without consultation with other members of the committee, yet it is a matter of interest to know that the expressed views of the advisory board as individual members were so nearly in accord on the general principles formulated for the great school of technology. The following is an outline of the scheme for the new technical school:—

First, as to site. The advisory board suggested that not less than fifty acres be secured, and as a tract of sixty-five acres is available not far distant from the Carnegie Institute, the board strongly recommended its purchase, or a similar piece of land as near by as it is possible to obtain it. A potent reason for placing the technical school near the Carnegie Institute is the fact that its library is rich in technical and other valuable works which need not be duplicated in the technical school library; indeed the association of the school with the great and increasingly valuable library, museum, art gallery and Academy of Science and Art is certainly to be desired.

As to the buildings for the technical school, but little has been suggested. Dr. Thurston in his report has given an interesting *résumé* of the space occupied by the student in the various German technical schools, remarking that the German motto "viel Platz, viel Licht, viel Luft," would be an excellent guide in determining this question. He says: "Ample space, good light and plenty of fresh air are essential, although the architect, who should be the most earnest and intelligent of them all, is often woefully deficient in appreciation of their importance when brain work is going on." Dr. Thurston further states that taking figures from the best German technical schools, which are based on the largest experience, the school of architecture at Berlin has 150 feet floor space per student, the engineering school 35 feet; but this latter department is so much overcrowded that arrangements are being made to give the student in this department at least 75 feet of floor space. In marine engineering 111 feet, and in metallurgy and the chemical departments each have 426 square feet of space. Prof. Thurston advises not less than 30 square feet per student in class rooms, in drawing rooms about 100, and in laboratories from 150 to 500 feet, according to character of the work to be done and magnitude of the space required for machinery and apparatus.

The Brunswick school has 410 feet floor space per student in all departments. At Karlsruhe 450 square feet is provided in the department of electrotechnics. The cost of the Berlin building is placed at 1000 dollars per student, of the Brunswick buildings 2000 dollars per student. From these data it may be seen that an institution which may be called upon to provide for a thousand students at once, and perhaps three or four times that number in the near future, must be planned upon a most liberal scale to meet the demands which shall be made upon it.

As to the scope of the work of the new school, Prof. Johnson's proposed scheme is as follows:—

A. Colleges. Courses of four years with a high school preparation: (1) College of Science; (2) College of Engineering; (3) College of Commerce. All these to be of university grade, with degrees conferred at graduation. B. Schools. Courses of three years with a grammar school preparation: (1) Manual Train School; (2) Domestic Science School; (3) School of Industrial Design; (4) School of Commerce. All these to be of high-school grade. Diplomas to be given at graduation. C. Artisan Day School. Courses of three years, with a preparation in reading, writing and arithmetic. To include courses of instruction in subjects of essential importance in the practice of the various trades. D. Night School for day workers. Preparation same as C. Regular courses, and also special instructions of practical value to day workers of all sorts and all employments.

Prof. Johnson, Dr. Alderson and Dr. Gray studied a number of the industries of Pittsburg, and in all their reports they emphasised the value of the secondary schools. The question of monotechnic or trade schools, *i.e.* where a young man or woman can learn at least the rudiments of a trade by which they propose to make their living, was also discussed; and it is the opinion of both committee and advisory board that in due time this part of the problem should be given earnest consideration.

Dr. Alderson recommended that the six following departments should be established, each with several branches:—(1) Engineering, (2) Secondary Education, (3) Library Economy, (4) Domestic Arts and Sciences, (5) Art, (6) Evening Instruction.

Dr. Gray recommends that the institute should offer a course of instruction covering the whole nine years of study; that it be divided into two distinct schools, a secondary and upper secondary, and a higher college or professional school. He advises that the secondary school commence first above the grade schools with a minimum age limit of fourteen years, and that the course of this instruction should include all the subjects commonly given in the best high schools with the possible exception of Latin and Greek, and in addition the subjects more commonly given in business schools or colleges, along with this course of class-room instruction, provision should be made for practical instruction, either manual or otherwise, bearing upon the particular branch of industry which the scholar intends to enter.

Dr. Gray recommends a good sound course in English for students of the secondary school, but not a study of foreign languages. He also recommends that the technical college or professional school be open only to a selected small number of students who have shown special fitness for the work, and that the entrance requirements should be considerably higher than is usual in existing technical colleges. For this department extensive laboratory practice is recommended and thorough drill in the methods of testing properties of matter and in investigational work.

The general scheme laid out for the great technical university by Dr. Thurston comprises the following colleges:—(1) Mechanical Engineering and the Mechanic Arts, with eight different departments of Mechanical Engineering; (2) Civil Engineering, with six departments; (3) Architecture, with three departments; (4) Mines and Metallurgy, with two departments;

(5) Agriculture, with six departments; (6) Applied Chemistry, with four departments; (7) Physics, with two departments; (8) Fine Arts, with three departments; (9) Business, with four departments; (10) Navigation and Marine Transportation, with two departments; (11) Mathematics, with two departments; (12) Politics and Ecomomics, with four departments; (13) Languages and Literature, with four departments; (14) Philosophical Science and Ethics; (15) Biology; (16) The Preparatory College (standard curriculum).

In his presidental address to the section of social and economical science, Prof. C. M. Woodward referred to the report of the advisory committee on the Carnegie Technical School in the following terms:—"For a variety of excellent reasons the committee reaches the conclusion that some new kind of preparation for the work of life must be introduced into the school training of both boys and girls. It then proceeds to outline a technical college, a technical high school and an artisan day and evening school, which are to meet this demand.

"The artisan day and evening school is somewhat of the order of German and English low-grade technical schools. I earnestly hope that the suggestion of this school may be adopted that the experiment may be fairly tried in America. The plan for a technical college is in complete harmony with the best engineering schools.

"The scheme for a technical high school, however, seems to me faulty. This school would be of high-school grade, taking pupils from the grammar schools and covering presumably four years. The normal ages of entrance and graduation would accordingly be fourteen and eighteen. Three things in the committee's outline of this technical high school deserve attention: (1) The elective principle is to be recognised, the student selecting the required number of courses under the direction of the director of the school. Here the pupil at a tender age (only fourteen or fifteen) is asked to surrender his birthright to the privilege of choice when he is eighteen.

"(2) The course in mathematics—which begins with elementary algebra—is to include the elements of calculus! Of course, it must include solid geometry, higher algebra, trigonometry and analytical geometry! One rarely meets with such an astounding proposition from engineers who are supposed to have studied mathematics and to know what they are talking about. They might as well propose that the pupils shall take thermodynamics in a short course of lectures. To be sure, similar ambitious schemes have been proposed elsewhere for boys just out of the grammar school, but they came from people who could have known very little mathematics, and nothing of the uses of the calculus. This criticism may seem trivial, but in more than one place the scheme attempts too much.

"(3) The technical studies suggested take the form of trade work or special employments, with well equipped shops and experimental laboratories under the direction of expert artisans.

"What Mr. Carnegie will do with this last suggestion remains to be seen, but any attempt to embody it in a real technical high school of secondary grade will be full of interest to the educational world. If any man was well prepared to give the scheme a fair trial, that man is Andrew Carnegie; but it will cost a vast amount of money and its experience will teach us how not to do many things.

"I have high respect for the members of the advisory committee, but I think a less ambitious scheme would be more successful. You cannot teach the higher mathematics in a high school, and I have no great faith in the value of attempts to teach employments, commercial or industrial, within the limits of any secondary school. Such attempts are certain to mislead and ultimately hinder those they aim to help. Any trade or special employment must be dwarfed and narrowed before it can be brought down to the grasp of an untrained boy, and its very narrowness unfits it for the best educational uses.

"The school is the place where one should learn the fundamental unchanging laws and manifestations of force and materials. Special occupations, like special constructions, should be analysed in their elements, and pupils should become expert in such analyses, in so far as they involve universal elements that pupils can comprehend. But there are many things essential to a business employment, which cannot even be apprehended in school."

From the foregoing it will be seen that much difference of opinion exists as to the nature and extent of the subjects which should be included in the curriculum of a large technical school. Three different and distinct forms of school, which may be combined as parts of one complete technical university, have been proposed. If the whole scheme is accepted by Mr. Carnegie, there will be, in the first place, a first-class technical college. "This college," says the committee, "should be made attractive to the greatest scholars in the fields of physical and chemical science. To obtain and hold such men they must be given ample opportunities for research. This college must be supplied, therefore, not only with great experimental shops and laboratories for students' use, but in all departments there should be splendidly equipped laboratories of investigation and research, under the direction of the head of such department, and with a full corps of assistants for the carrying on of all lines of investigation which are now partly or wholly unprovided for in America." There will also be a Technical High School to carry on work above that of the public grammar school, and day and evening classes for the benefit of those who are unable to take advantage of the more complete courses in this school. Mr. Carnegie has now to decide whether he will found a school for artisans, a technical high school or a technical college, or, if his ambition mounts so high, a true technical university including them all.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE building fund of 150,000*l.*, which it is proposed to raise for the Glasgow and West of Scotland Technical College, has reached about 100,000*l.*, and Mr. Carnegie has promised to subscribe one-half the deficiency upon the condition that the other half is promptly obtained.

THE position of science and technical instruction in schools inspected by officers of the Secondary Branch of the Board of Education can be seen in vol. ii. of the Report just issued by the Board, containing extracts from the inspectors' reports for the year 1900. Improvement is manifest in the larger technical schools in the teaching of advanced science. General improvement is also reported in the mode of teaching experimental science. "Moreover," remarks Mr. A. E. Tutton, F.R.S., "the influence of the advocates of the heuristic method of teaching has proved to be so far effective that the general attention of teachers has been directed to the educative value of calling forth the highest thinking and experimenting powers of their pupils." Dr. H. H. Hoffert also reports that "there is amongst the teachers a widely spread spirit of enthusiastic eagerness to ascertain the best methods of instruction and to apply them in their own schools." The movement for reform is being felt in the teaching of mathematics, and Mr. J. Brill contributes a short special report upon the subject to the volume just issued. The work being done in the Schools of Science is favourably reported upon by all the inspectors. In these schools five or six hours a week are given to experimental science, two or three to drawing and geometry, about five to mathematics, and eight or ten to literary subjects. Beyond this minimum requirement the extra time at the disposal of the school is given to languages, to science, to commercial subjects, or to manual occupations according to the particular type of the school. In fact, these schools possess a curriculum which is adapted to modern requirements, and in most of them excellent work is being done, not only in science and art, but also in literary subjects.

A FULL report of the opening of the Harper-Adams Agricultural College at Edgmond, Newport, by Mr. Hanbury, the President of the Board of Agriculture, appears in the *Newport and Market Drayton Advertiser* of September 28. The College owes its establishment to the late Mr. Thomas Harper-Adams, who left a large sum of money and an estate in order to found it. It is provided with lecture rooms and laboratories in which work can be carried on in physics, chemistry, biology, and other sciences connected with agriculture. The farm attached to the College is about 180 acres in extent and is intended for experimental purposes; and all the work will be arranged with the object of instructing students in the practical management of a farm on modern business lines. The Salop County Council make a grant of 1000*l.* a year towards the College funds, and together with the Stafford County Council offer a certain number of scholarships tenable at the College. The Principal is Mr. P. Hedworth Foulkes. In opening the College, Mr. Hanbury referred to the small sum available for agricultural education. At present the Board of Agriculture had to spend, in grants, the small sum of 8000*l.* for the whole of the United Kingdom. In France, for the same purpose, 153,000*l.*

is granted by the State. In Denmark, 108,000*l.* is granted; in Canada, 156,000*l.*; and in the United States, 26,000*l.* Moreover, a comparison of the assistance given to agriculture with that given to the towns shows that out of the Science and Art grants given by the Board of Education, no less than 505*l.* out of 506*l.* goes to the towns, and only 1*l.* to the rural population. Referring to the value of agricultural colleges and scientific work to the practical farmer, Mr. Hanbury remarked that it was sometimes asked, What is the good of science? He took science to mean this, however practical a man might be, it was impossible for him, in his own experience, to have learned everything. What science meant was, that other people had been experimenting, and had found that those experiments had been a success, and that it made money to work in that way. He therefore asked them not to be afraid of the word "science"; and, above all, not to think, because they were practical men, that they knew everything, for there was no trade in the world in which there was any man who had occupied the whole region of science, or the whole region of knowledge. He thought they made a mistake in making experiments over and over again. He was a little afraid the County Councils, in too many instances, were going over the same ground over and over again. What was to be of some use to farmers was that those experiments had been made, and the results proved to be true. He should like to see more demonstrations made all over the country—not mere pocket handkerchief demonstrations over a small field, but, if they were to be any good, over several fields of a farm.

SCIENTIFIC SERIAL.

American Journal of Mathematics, vol. xxiii. No. 4.—Memoir on the algebra of symbolic logic is the second part of a paper by Mr. A. N. Whitehead, which treats of the theory of substitutions under the heads, types of transformation, relations between the coefficients of a substitution, the reverse substitution, the group of substitutions, substitutions satisfying special conditions, congruence of functions, the identical group of a function, and common subgroups of identical groups.—Secular perturbations of the planets, by G. W. Hill, follows up Halphen's presentation of Gauss' procedure (*Werke*, vol. iii. pp. 331–355). The author thinks that, though a remarkable degree of elegance is attained by Halphen's changes, additional statements are needed to show the connection with the astronomical problem which originally suggested the investigation; for Halphen, like Gauss, treats only the attraction of a certain form of ring. This ignores the second integration which the problem demands. The present memoir attempts to supply the lacuna.—Representation of linear groups as transitive substitution groups, by L. E. Dickson, is a piece of work on the well-known lines of this mathematician.—A class of number-systems in six units, by G. P. Starkweather, is a further contribution to the same subject which was treated of by the author in vol. xxi. No. 4.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 16.—M. Bouquet de la Grye in the chair.—Demonstration and use of the formulæ relating to the refractometer, by M. A. Cornu.—On the elastic arch, by M. G. Poisson.—On the simultaneous employment of multiplex and ordinary telegraphy in the same circuit, by M. E. Mercadier.—On the molecular weight of chloral hydrate at the temperature of its boiling point, by M. de Forcrand. By a discussion of thermochemical data the author arrives at the conclusion that at the boiling point chloral hydrate is not totally dissociated, from 4 to 5 per cent. remaining undissociated.—On dunite from Koswinsky-Kamen, in the Ural, by MM. K. Duparc and F. Pearce. The results of a microscopical and chemical study of the dunites from this district.—A new cave with drawings on its walls of the Palæolithic period, by MM. L. Capitan and H. Breuil. An account of the discovery of a cave situated at Combarelles, in Tayac (Dordogne), about two kilometres from the Mouthe cave. The cave is about 225 metres long, and about 119 metres from the entrance drawings can be seen on the walls, which continue to the end of the cave. They are engraved upon a cretaceous rock, but the greater number are covered with a stalagmitic deposit, which is sometimes so thick that the lines cannot be seen through it. No less than 109 figures can be clearly made out, including drawings of the horse, cow, bison, reindeer, mammoth, and wild goat. It would appear that these drawings, the antiquity of which cannot be doubted, could only have been executed by artists reproducing animals that they saw. Hence they are clearly Palæolithic, and go back to the epoch when the mammoth and the reindeer lived in France.—Luminous rays diverging at 180° from the sun, by M. Jean Mascart.

September 23.—Binary systems and couples of kinematic elements, by M. G. Kœnigs.—Lecithin in tuberculosis, by MM. H. Claude and A. Zaky. Experiments on animals and on man showed that lecithin, owing to its specific action on the elimination of phosphates by the urine, has a remarkable action on the nutritive exchanges, and it must be considered as a valuable adjunct to the various modes of treatment of tuberculosis.—On the ravages of the pyralis in the Beaujolais, and on the destruction of the night moths by means of luminous traps fed with acetylene, by MM. G. Gastine and V. Vermorel. The traps consisted of basins containing water covered with a layer of oil, above the centre of which was placed a small acetylene lamp to attract the insects. By this method between August 13 and 31 no less than 170,000 pyrales were destroyed.—The distribution of acidity in the stem, leaf, and flower, by M. A. Astruc. The acidity of the stem diminishes with the distance from the top. In the case of the leaves the acidity is greatest in the youngest leaves, and in general it is always the youngest parts of the plant which present the maximum acidity.—A new cave with figures on its walls of the Palæolithic period, by MM. L. Capitan and H. Breuil. A description of the drawings on walls of a cave at Font-de-Gaume, situated in the valley of the Beune, about two kilometres from the cave of Combarelles. The drawings consist largely of animals, of species resembling those represented in the cave of Combarelles. These drawings are noteworthy for the fact that different colours have been used, black, red, and brown. They are probably not so ancient as the drawings on the walls of the cave at Combarelles.

NEW SOUTH WALES.

Royal Society, August 7.—Prof. T. W. Edgeworth David, F.R.S., vice-president, in the chair.—Notes on some analyses of air from coal mines, by A. A. Atkinson and F. B. Guthrie. The authors gave the analyses of several samples of air from the return air-ways at Wallsend and Burwood collieries, and of gases produced by fires in the Gunnedah and Greta collieries, the latter was an old gob. fire. The analyses were compared with published analyses of air in the return-ways of English collieries made by Dr. Haldane, and the question of the effects of diminution of oxygen, presence of carbonic acid, black-damp and other injurious gases found in the air of coal-mines, discussed in relation to their action on men and lights.—Symmetrically distorted crystals of Cassiterite from Western Australia, by W. G. Woolnough.

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