THURSDAY, SEPTEMBER 20, 1900.

A MAGNETIC THEORY OF THE UNIVERSE.

From Matter to Man; a New Theory of the Universe. By A. Redcote Dewar. Pp. 289+viii. (London: Chapman and Hall, Ltd., 1898.)

WE do not recommend this work to the serious attention of our readers, but as a study in word-stringing it is not devoid of interest. It appears to be the production of a writer who has acquired a knowledge of scientific terms by extensive reading, without having any real grasp of the vast range of subjects over which he travels. The result is such as might have been arrived at by a student who had been through a hurried course of cram, and who at his final examination had been set some such question as this:—Given, a vocabulary of scientific terms, construct a theory of the universe.

The author is strong on magnetism. We have never met with such a liberal use of this term as is indulged in by Mr. Dewar. Like the "vapours" which afflicted our ancestors in the last century, and which accounted for all their ailments, the word magnetism accounts for nearly everything in Mr. Dewar's universe. It is in the fifth chapter that the stupendous importance of this form of energy is first sprung upon the reader:—

"The inference from this basis [that every atom is a magnet] is astounding, for not only does it involve the magnetism of the earth as well as the magnetism of all the constituents of the earth, but it establishes beyond a doubt the *magnetism of all the products of the earth—mineral, vegetal and animal.* Every crystal, plant, animal and man is thus a magnet, whose every energy—muscular, nervous, vital, or mental—resolves itself into the familiar operations of magnetism."

"Still further, as all the planets and heavenly bodies are alike in nature, so far as we can judge from analogy, so must they be governed by similar energy to the earth. Hence we reach the final conclusion, that *the bottom energy of the universe is also magnetism*" (pp. 72-73).

Having once become impregnated with this universal magnetic cult, the reader, who may otherwise have been unprepared for the series of mental shocks which is in store for him, will learn with comparative calmness that the difference of gravity at the equator and the poles is because the earth is a magnet (p. 69); he will feel sure that sooner or later "animal magnetism" mesmerism, &c., are bound to appear on the scene, and in this he will not be disappointed (p. 87); and he may even learn with equanimity that he possesses "a virtual magnetic battery" in his "vacuole or stomach" (p. 85). In the chapter on the causes of vegetal evolution we read:—

"These huge internal fires [of the earth] are virtually *the earth's magnetic battery*, through which it is kept in life as a living planet tenanted with vegetal and animal life; hence, when all conditions are suitable, and the soil is properly saturated with water, thereby inducing suitable chemical action, the internal magnetic forces throw up a clotted vegetation on every available spot of ground on the globe. *This vegetation is but a bristling beard of earthly material ejected by the earth's magnetism;* filaments of matter, having the same relation to the earth as a man's beard to his chin, or as the bristling iron filings on a horse-shoe magnet" (p. 162).

It must be admitted that the force of magnetism can no further go, and the attributing to this agency of the vegetable-like accumulation of snow-drift on a projecting obstacle (p. 124), or the turning of a sun-flower towards the sun (p. 137), may be accepted as a mere bagatelle. Truly, as the author says, after having evolved "vegetal molecules" by a "chance flux of suitable atoms," the "magnetic laws are equal to all emergencies" (p. 159). The subtle distinction between a horse-shoe magnet as a *dry magnet*, and a plant as a *wet magnet* (p. 161) is too fine for any but ultra-metaphysical minds to grasp, but since it leads to the practical conclusion that a flower-pot full of moist earth is an artificial plant battery, it may be allowed to pass by virtue of its horticultural merits.

We confess that, in turning over the pages of this astonishing production with the object of endeavouring to learn the author's views, we have been so fascinated by his glib manipulation of the affairs of the universe, that we have allowed ourselves but little time for a critical examination of his scientific data. In fact, the work may be said to consist mainly of generalities, so that there are but few detailed statements to grasp. Here are a few specimens:—

The law of combination in definite proportions is illustrated (p. 58) by the statement that "if 20 parts of oxygen be mixed with 6 of hydrogen, only 16 parts of oxygen and 2 of hydrogen unite, 8 parts remain uncombined." This error is driven home in the following page:—

"Innumerable elements, for instance, may often meet in suitable conditions for combination, but if unsuitable in *proportion*, no selection ensues; consequently there is no production," &c.

Hydrogen is said to be a constituent of saltpetre (p. 79).

"If a lot of chips be thrown into the water they all attract each other and form a mass" (p. 87). This is explained by the statement that sticks and stones require "stick and stone magnets to magnetise them."

"Contrasted with chemical combination, chemical decomposition has been almost ignored by chemists" (p. 101).

"Magnetic induction" is used to explain the crystallisation of a solid from a solution (p. 118).

After describing the movements of a "geometer" caterpillar, the author says: "Other caterpillars and centipedes develop feet on each ring" (p. 198).

"The fire-flies of America, which, Diogenes-like, carry a lamp with them," are classed with the bombardier beetle, both the light of the former and the discharge of the latter being described as "undoubtedly the result of electric action" (p. 201).

It need hardly be said that the propounder of a new philosophy—such as Mr. Dewar claims to be—must clear away the rubbish of previous thinkers before he can lay the foundations of his own system. Many of the current doctrines are accordingly denounced in no measured terms, and the author's emendations launched at the reader. For example, the classification of matter into simple and compound substances by chemists is scoffed at (p. 55), and here is Mr. Dewar's amendment:—

"From unlimited corroborative evidence we believe this [duality or sexuality in elementary substances] to be the case; hence we enunciate as one of the fundamentals of the new Materialism that the normal chemical

division of the elements into metallics and non-metallics is the bottom classification of matter, the only one with confidence to be designated great."

Again (p. 56):

"With this alteration (hydrogen considered as metallic) are we warranted in ascribing to this dual classification of substance that importance, both scientifically and philosophically, which we assign it? The evidence is overwhelmingly affirmative, for no known natural product exists which does not contain both classes of these elements in combination. *Matter itself must thus be sexual.*"

There is a very widely spread mineral substance composed of silicon and oxygen which forms no inconsiderable a proportion of the earth's rocky constituents, and of which the author has no doubt heard. Silica in its various forms is certainly a natural product; and so Mr. Dewar will no doubt insist upon classifying silicon with the metals. There is also a gas composed of carbon and oxygen which is present in the atmosphere, and which is of vital importance for plant life. We should like to know how Mr. Dewar brings carbon dioxide under his "fundamental principle, which embodies one of the most salient truths in the science of the century" (p. 57).

The reader who is anxious to know how the "New Materialism" deals with the problem of life will find it disposed of in a light and airy way that might even be provocative of mirth were it not evident on every page that the author intends us to take him seriously. There is absolutely no mystery about it at all—there is no unknown force, there is no impulse different from the ordinary laws of matter. The animal is "a mere mass of conjoined magnets," containing "a virtual magnetic battery in its stomach" (p. 222). Elsewhere we are told that the plant differs from the animal in having its magnetic battery outside instead of within, and the author seems quite proud of having discovered a distinction between animals and plants that has hitherto eluded the men of science (p. 164). As for the appearance of life on the earth, it is a mere trifle to the "New Materialism":

"Under suitable conditions of heat, light and moisture, a chance flux of suitable atoms combines sexually into vegetal molecules" (p. 159) [magnetism as before].

"Even, as on a frosty night, the surface of the ground is whitened with crystals of rime, so in many a river and ocean bed the water must often coagulate with millions of vegetal and animal cells" (p. 209).

"But as igneous activity subsided to solid quiescence, and water, soil, light and heat interacted, the protoplasmic elements—oxygen, hydrogen, carbon, nitrogen, &c.—would meet in suitable proportion, and [magnetism as before] the spontaneous production of simple organisms—protophyta, protozoa and the lowest kinds of fungi and algæ—would ensue as a matter of course, &c." (p. 246).

The origin of man is described (p. 247) in a manner that can only make the reader exclaim that the New Materialism, like a certain historical character, is *capable de tout*:—

"Man's first progenitors thus probably appeared on the earth as spontaneously produced protoplasmic cells or ovules, hundreds or thousands in number, developed by sexual and magnetic affinities from a flux of the chemical elements in some ambrosial inlet of water."

No further extracts need be given, and no further criticism is necessary to justify the opinions expressed at the beginning of this notice. R. MELDOLA.

OUR BOOK SHELF.

Untersuchungen über Philons und Platons Lehre von der Weltschöpfung. Von Jakob Horovitz. Pp. xiii+124. (Marburg: N. G. Elwart, 1900.)

DR. HOROVITZ' essay is the outcome of his thesis approved for the degree of philosophy in the University of Marburg. Its purpose is to focus the rays of light which close exegesis of the *Timaeus* throws upon the cosmogonic scheme wherein Philo effected the synthesis of Plato and Moses. While recognising the Stoic and Neopythagorean elements in Philo's teaching, Dr. Horovitz has little difficulty in showing that in both style and matter the dominant influence was Plato's. It is to the analysis, then, of Plato's creation-myth that we must turn if we would understand Philo with his enormous influence on the development of the doctrine of the Logos in Christian literature.

The ζῷον νοητόν of the *Timaeus* is no mythical duplicate of the demiurge, but distinguished as *das ewige Urbild* from the latter, whose real causal activity leads to an identification with the creative reason and ideal good of earlier dialogues. The subordinate artificers of physical creation are not the ideas as distinct from the idea of good, but in part a concession to popular theology, in part perhaps due to the place of evil in Plato's system, and the fact that dualism, though overruled, is not extinguished. In his valuable and textually supported discussion of the problems, Dr. Horovitz perhaps tends to overestimate the consistency and continuity of Plato's writings, and to underestimate the *mythus* element in the *Timaeus*.

Now Philo's intelligible world or order, the work of the one day of creation before time was or the serial "days" of the production of the world of sense began, is to be assimilated to the intelligible ζῷον of Plato as modified in conception by a use of the Stoics' metaphor of architect and supra-sensual city. It is not the Logos save in the sense in which his plan is the mind of the architect. Dr. Horovitz moves familiarly among the conceptions of Logos, intelligible world, ideal man and the like, and by adjustment of the emphasis on the various clauses of Philo's commentary produces a construction which might carry conviction. The *mutata* of Philo, and the reasons why they were *mutanda* from the Platonic theory, are well brought out. The ideal man is the work of God, the physical man is the work of God in conjunction with subordinate agents, and these powers find their natural analogue in the angels of the Jewish scheme. Platonic scholars, or those of them who have not despaired of the ζῷον as unintelligible, will find food for reflection in the one side of Dr. Horovitz' study. Theologians, students of Neoplatonism, persons who take an interest in the Hegelian *Religionsphilosophie*, may well take their starting-point from the other. H. W. B.

Fungus Diseases of Citrus Trees in Australia, and their Treatment. By D. McAlpine. Pp. 132; 19 plates. (Melbourne: Brain, Government Printer, 1899.)

THIS is one of the many useful publications dealing with plant diseases issued by the Victoria Department of Agriculture. According to statistics given, the cultivation of orange and lemon trees is extending rapidly, and one successful lemon grower considers that instead of paying 62,498*l.* annually for oranges and lemons, the colony could not only produce sufficient for home consumption, but could also supply the half of Europe. Under these circumstances the appearance of a work of the kind under consideration is most opportune, more especially as it is stated to be written for the benefit of growers. It is therefore somewhat disappointing to find that a considerable portion of the text is devoted to technical descriptions of new species of fungi, a subject of no interest whatever to cultivators, more

especially as many of the species enumerated are simply saprophytic forms, whose presence can do no injury. The enumeration of such species is, from a scientific standpoint, of great value; but they are altogether out of place in a work which should place before practical men the outcome of scientific research in language divested of scientific technicalities. The author considers it essential that each fungus should possess a popular name in addition to its scientific one, and there is some justification for this idea, especially when such names are of local origin, and express a definite idea, as "collar-rot," "wither-top," &c., but it is more than doubtful whether the English rendering of the scientific name, as "West Australian Septoria," or "Glœosporium-like Colletotrichum," will be adopted by the fruit grower. Fifty-one species of fungi found on citrus trees are described as new to science; this is a somewhat daring piece of work in the comparative absence of literature and herbaria. It must be borne in mind that the fact of a fungus not agreeing with any species recorded in Saccardo's "Sylloge Fungorum" by no means justifies an author in describing it as new to science.

In defining parasites and saprophytes respectively, the author states that it is not always easy to decide between the two, and the crucial test, by means of pure cultures, is not alluded to. This, however, may not be due to lack of knowledge or desire on the part of the author, who, as vegetable pathologist, is probably expected to cover too much ground; hence fundamentals, which consume time, are apt to be neglected in favour of less exact methods, which may meet with approval for the time being.

The twelve coloured plates illustrating the most pronounced and destructive forms of disease attacking lemons and oranges are excellent in every respect, and should prove of great service in enabling planters to recognise at an early stage the appearance of a disease which, if neglected, might prove disastrous. The most approved methods of treating the various diseases are given in tabular form.

Missouri Botanical Garden. Eleventh Annual Report. Pp. 144; 58 plates. (St. Louis, Missouri, 1900.)

THIS volume is almost entirely made up of four scientific papers representing work carried out in connection with the Missouri Botanical Garden. The papers are: a disease of *Tascodium distichum* known as "peckiness," also a similar disease of *Libocedrus decurrens* known as pin-rot, by Dr. H. von Schrenk; Agaves flowering in the Washington Botanic Garden in 1898, by Mr. J. N. Rose; A Revision of the American species of Euphorbia of the section Tithymalus occurring north of Mexico, by Mr. J. B. S. Norton; and a Revision of the species of Lophotocarpus of the United States, and a description of a new species of Sagittaria, by Mr. J. G. Smith. Dr. von Schrenk's paper has already been noticed (vol. lxi. p. 452).

Mr. Trelease, the director of the Garden, shows by these papers and his report that valuable work is being done. A small synoptical collection representative of the principal natural orders of flowering plants has been installed in the central part of the Garden, where it is proposed to continue it as a convenient means of enabling teachers in elementary schools to demonstrate to their pupils the characters of the larger plant groups. The total number of species and varieties now cultivated in the Garden is nearly ten thousand.

Mr. Trelease devoted a couple of months last summer to the study of the botany of the Alaskan coast region and the islands of Bering Sea, as a member of the Harriman Alaska Expedition. The scientific results of his work will, no doubt, be published after the large amount of material collected has been subjected to critical study.

LETTERS TO THE EDITOR.

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

Atmospheric Electricity and Dew-ponds.

IT is not my intention to enter into controversy with such authorities as Mr. Aitken or Mr. Wilson. I wish only to describe certain phenomena which have come under my notice, in the hope that I may help to throw some light on a subject of great importance, theoretical as well as practical.

On the chalk hills in the south-east of England there are a number of ponds known as dew-ponds. One of these was described by Gilbert White ("Natural History of Selborne," Letter 29). There is a pond of considerable size at one of the highest points of the main ridge of the South Downs close to Chanctonbury Ring. From its position it is obvious that this pond can only be fed by water precipitated into it directly from the air. Yet it always contains a considerable volume of water. At the end of the dry weather last year, when most of the ponds in the valleys were empty, this dew-pond still contained several thousand gallons. How does this pond obtain the enormous quantities of water necessary to compensate for the rapid evaporation in such an exposed position, and also to supply large flocks of sheep?

It appeared to me that there was but one possible explanation: a difference of electrical potential must cause an attraction between the particles of moisture and the summit of the hill upon which the pond is situated. It is, of course, well known that drops of rain, &c., usually have an electrical charge, but it was necessary to ascertain whether this was capable of producing such a great effect. In order to test this point I took two porcelain basins of equal size and suspended them by means of silk threads from stakes driven into the ground at a high part of the ridge of the South Downs. In each of these basins was fixed an upright piece of sheet-copper. The two pieces of apparatus were placed in exactly similar positions and were in every respect identical, except that in the one case the copper screen was connected to earth by means of a wire, whereas in the other case it was insulated by the silk threads.

The apparatus was left thus during the night of April 1, 1899. There was a thick mist on the hills, so much so that I was unable to select the most favourable position for the apparatus. In the morning the amount of water in the two basins was measured. In the basin with the insulated screen there were 15·5 c.c. of water; in that with the screen connected to earth there were 18·0 c.c. This clearly confirmed my theory, for the insulated apparatus would tend to acquire an electrical charge from the particles of moisture. Consequently the attraction would be less than in the case of the apparatus which was not insulated. The insulation must have been very imperfect, for the silk became saturated with moisture as soon as the apparatus was erected. The position chosen, also, was not so favourable as it might have been. Nevertheless there was a difference of 16 per cent. in the quantities of moisture collected.

I intended to repeat and extend the experiment, but I have been unable to find an opportunity. I hope that this letter will call attention to a matter of considerable interest.

ARTHUR MARSHALL.

Chemical Department, Woolwich Arsenal, September 10.

Huxley and his Work.

MR. HENKEL'S quotation from "One Hundred and One Great Writers" (NATURE, September 6) reminds one that the taunt of being a populariser was familiar enough to Huxley himself. It recalls also the little side-thrusts with which in return the detractors were sometimes honoured. In the preface to vol. viii. of the "Collected Essays," for instance, Huxley remarks:—

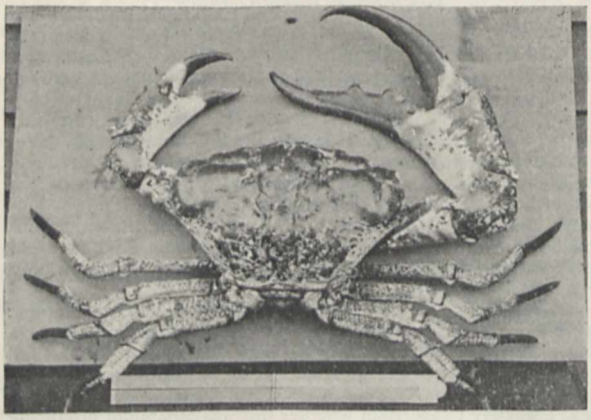
"The popularisation of science has its drawbacks. Success in this department has its perils for those who succeed. 'The people who fail' take their revenge, as we have recently had occasion to observe, by ignoring all the rest of a man's work and glibly labelling him a mere populariser."

The belittling process, though unjustifiable, was understandable enough in those old days of controversy. To-day it seems rather uncharitable. C. SIMMONDS.

Thurlow Hill, West Dulwich, September 17.

A Large Tasmanian Crab.

I AM sending you a photograph of a large crab (*Psilocranium gigas*), caught in the Tasmanian waters during the present month. The crab weighed 30 lbs. It is one of the largest that has been caught in these waters. We have several specimens in the Tasmanian Museum weighing from 16 to 22 lbs. They



are generally caught by the fishermen in very deep water, from fifteen to thirty fathoms, while fishing for the fish known as the Tasmanian Trumpeter (*Latris hecateia*).

I shall be glad to know whether readers of NATURE have ever known of a larger *Psilocranium gigas* having been caught.

ALEX. MORTON.

Tasmanian Museum and Art Gallery, July 30.

Large Puff Balls.

HAVING seen in some papers lately notices of large puff balls, it may probably be of interest to record the measurements of one far exceeding in size any I ever heard of.

It was found by my daughter, Mrs. Pole-Carew, in a small park belonging to me near this place, where she is residing. I took careful measurements of it at the time it was found, of which I send you a copy.

It differed in no respect except size, either inside or out, from the ordinary smooth puff ball.

Measurements of a large Puff Ball found in Chipley Park, near Wellington, Somerset, June 12, 1900.

Horizontal circumference	57	inches
Vertical ditto, greatest	51	,,
,, ,, smallest	46	,,
Height	14	,,
Greatest width	18½	,,
Smallest ,, ...	17	,,
Weight	14 lb. 10 oz.	

W. A. SANFORD.

Nynehead Court, Wellington, Somerset, September 11.

"A Tour through Great Britain in 1727."

Is not the "Tour" queried by your reviewer (p. 417, column 2) that of Defoe, which has frequently been reprinted? and yet the first edition (1724-27) is still the best, in spite of re-editors and its extension from three vols. to four.

Ulverston. S. L. PETTY.

PROF. HENRY SIDGWICK.

THE death of Henry Sidgwick entails the removal of one of the most potent influences that have been felt in Cambridge for the last forty years. Only a brief allusion can be made here to the time and energy which he devoted to University affairs, and to the constant and generous aid given by him to departments handicapped by poverty. As one of the strongest leaders in University policy, his power depended on a practical insight and decision of view for which those who know him only through his writings would be unlikely to credit him.

He was born in 1838. His father, the Rev. William Sidgwick, was headmaster of the Skipton Grammar School. Having been at Rugby under Dr. Goulburn, he entered Trinity College in October 1855. In 1859 he took his degree as Senior Classic and 33rd Wrangler, was elected to a Trinity Fellowship, and soon afterwards appointed Lecturer in Classics and Assistant Tutor. His interest in literary criticism and in problems of practical ethics was indicated, at this early stage, by various minor writings, of which we may specially mention an article on "The Prophet of Culture" (*Macmillan's Magazine*, 1867), in which he made a very characteristic examination of Matthew Arnold's closing lecture at Oxford. In 1868 was founded a Society, called "The Free Christian Union," of which Sidgwick was vice-president. His famous essay on "The Ethics of Conformity and Subscription" (1870) was written at the Society's request. This period of his life culminated in 1869 in the determination to give up his Trinity Fellowship on the ground that he no longer believed in the explicit creed to which the holders of Fellowships were required to subscribe under the old system of "tests." This action of Sidgwick's and the similar acts of some of his friends and contemporaries were undoubtedly important forces in the promotion of the abolition of the tests. Not long after, Sidgwick was made Lecturer and Examiner in the Moral Sciences, and later, Prælector in Moral and Political Philosophy at Trinity. In 1881 he was elected to an Honorary Fellowship there, and in 1883 he succeeded Birks in the Knightbridge Professorship of Moral Philosophy, which he resigned at the beginning of his illness last June.

As a teacher, Sidgwick exerted a profound and enduring influence, largely due to the extraordinary patience and quick perception with which he recognised and criticised the efforts of his pupils at independent thought. He presented to them an ideal of conscientious thoroughness in the pursuit of speculative truth, which has impressed and inspired even those who have developed their thought in directions far removed from his own.

Sidgwick's most important work, "The Methods of Ethics," was published in 1874 (2nd ed., 1877; 3rd, 1884; 4th, 1890; 5th, 1893). Its purpose is unlike that of most other modern works in philosophy. Not aiming directly at the construction of an ethical system, it adopts rather the Socratic method of stimulating the plain man to examine his own principles, and by self-criticism to free them from vagueness, obscurity and inconsistency. By many readers the unimpassioned, elaborately reasoned, judiciously balanced criticism is found unprofitable. But its penetrating subtlety and breadth of view are characteristics which have been recognised by all who have come under its influence, and have won for it a place amongst the philosophical classics. In general spirit it carries on the tradition of English common-sense empiricism; and, while to Sidgwick all forms of transcendentalism were repellent, yet unlike many of his predecessors in English philosophy, his criticism of opposed schools of thought was always keen and thoroughly scholarly. A different side of Sidgwick's intellectual character is shown in his work on "Practical Ethics," a collection of essays and addresses (1898), in which his speculations are applied to the very definite solution of actual problems of conduct in modern life.

In the "Outlines of the History of Ethics for English Readers," Sidgwick has supplied a most useful guide to the study of the subject. In the "Principles of Political Economy" (1st ed., 1883; 2nd, 1887) and in "The Scope and Method of Economic Science" (1885), there is a return to the older English thought, but the subject is treated with an acuteness and originality specially characteristic of Sidgwick's intellect, which have given to these works real value as contributions to economic science. The third book of the principles contains the "Art of Political Economy," which, together with "The Elements of Politics" (1st ed., 1891; 2nd, 1897), shows the keen interest always felt by Sidgwick in political and social questions, and the practical sagacity with which he handles these problems. In politics, Sidgwick combined the freedom from prejudice of the Radical with the caution of the Conservative.

Perhaps the most important practical work with which the name of Sidgwick has been associated is in connection with the higher education of women. He was the virtual founder of Newnham College, through the scheme of lectures for women which he initiated in 1869, and the house of residence which he started and persuaded Miss Clough to take charge of in 1871. In 1880, Mrs. Sidgwick having consented to become vice-principal of the second Hall of the College just opened, they both came to live there for two years; and when, after Miss Clough's death in 1892, Mrs. Sidgwick became principal of the College, they made it their permanent home.

In 1882 Sidgwick accepted the presidency of the newly formed Society for Psychical Research, in the subject-matter of which he had been interested for many years. The spirit which has characterised the proceedings of the Society, and the success which it has achieved, have been largely due to the sobriety and wisdom of Sidgwick's constant counsel and control.

PROF. JAMES EDWARD KEELER.[1]

THE sudden death of Prof. James E. Keeler, director of the Lick Observatory, which occurred at San Francisco on August 12, removes one who stood at the very forefront of astrophysical research.

James Edward Keeler was born at La Salle, Illinois, on September 8, 1857. His qualifications for scientific work clearly showed themselves at the Johns Hopkins University, where he took an undergraduate course, and served as assistant to Prof. Hastings, with whom he observed the total solar eclipse of 1878 in Colorado.

Shortly after this he was appointed assistant at the Allegheny Observatory, where he had an important part in the long series of bolometric investigations carried on by Prof. Langley, then director of the Observatory. In July 1881 he was a member of Prof. Langley's well-known expedition to Mount Whitney, in Southern California, where an extensive region in the extreme infra-red of the solar spectrum was discovered with the bolometer. Later he studied for two years in Berlin and Heidelberg under Helmholtz and Quincke, and returned to the Allegheny Observatory, where he remained until appointed a member of the staff of the Lick Observatory. His work on Mount Hamilton commenced in 1885, and for some time he was the only astronomer at the Observatory, which was still in process of construction. In May 1891 he was elected professor of astrophysics in the Western University of Pennsylvania and director of the Allegheny Observatory.

Keeler's work at the Lick Observatory was continued in a most effective manner with the modest instrumental resources at Allegheny. With a full understanding of the art of making the most of his means, he took up photography for the first time, made himself thoroughly familiar with photographic processes, and then, with the aid of a spectrograph whose general design has been followed in the construction of the great modern spectrographs at Mt. Hamilton, Potsdam, Pulkowa and Williams Bay, he obtained the photographs of the spectra of red stars which excited so much interest at the dedication of the Yerkes Observatory. He also made an admirable series of drawings of Mars, which was published in the *Memoirs* of the Royal Astronomical Society.

In the spring of 1898 Keeler had practically decided to accept a position on the staff of the Yerkes Observatory, and would have done so had he not just then been appointed director of the Lick Observatory. His recent work on Mt. Hamilton has not been confined to the direction of the affairs of a great observatory. The remarkable success of his experiments with the Crossley reflector, of which a full account is fortunately preserved in the June number of the *Astrophysical Journal*, has impressed every one who has seen the wonderful photographs of nebulæ and star clusters made with this instrument.

Of Keeler's other contributions to science two in particular deserve present mention: his determination with the Lick telescope of the motion in the line of sight of the planetary nebulæ, and his demonstration of the meteoric constitution of Saturn's rings. The memoir which describes the first of these investigations already ranks as a classic of astrophysical literature; while the spectroscopic demonstration of the meteoric constitution of Saturn's rings is perhaps the most striking of the many effective applications which have been made of Doppler's fruitful principle.

Much more might be said of Keeler's work, but this should suffice to indicate its lasting value. It is a satisfaction to add that its merit has been widely appreciated, as has recently been evidenced by the award of the Draper and Rumford medals. He was president of the Astronomical Society of the Pacific and a councillor of the Astronomical and Astrophysical Society of America. He was elected an Associate of the Royal Astronomical Society in 1898 and a member of the National Academy of Sciences at its last meeting. His kindly and genial manner, combined with unusual tact and rare judgment, drew to him many friends, who will long mourn his loss.

[1] Abridged from an obituary notice contributed to *Science* of September 7 by Prof. George E. Hale.

NOTES.

THE annual meeting of the Iron and Steel Institute was opened at Paris on Tuesday with an address by the president, Sir W. Roberts-Austen, K.C.B., F.R.S. It was announced that Mr. Andrew Carnegie has offered to the Institute the sum of 6500*l.* for the purpose of founding a medal and scholarship to be awarded for any piece of work that may be done in any works or University, and to be open to either sex.

IT is stated by the Paris correspondent of the *Times* that M. Yersin, to whom the Academy of Moral Sciences recently awarded a prize of 15,000 francs for philanthropic acts, has devoted the sum to his anti-plague serum establishment at Nha-trang.

THE *British Medical Journal* announces that the prize of 4000 marks voted by the Berlin Congress of Tuberculosis for the best popular work on tuberculosis as a social scourge, and the means of preventing its ravages, has been awarded to Dr. S. A. Knopf, of New York. The work will be published by the German Central Committee.

A TABLE of standard sizes of conductors for electric supply mains has been drawn up by the Cable Makers' Association and sent to electrical engineers. The table shows the nominal

size of conductors, in square inches, number and diameter of strands, resistance in standard ohms per 1000 yards, and weight in lbs. per 1000 yards. It is proposed to adopt the sizes and combinations of conductors shown in the table as the basis for tenders, beginning on October 1.

THE list is now completed of the subjects to be discussed at the International Botanical Congress to be held in Paris from the first to the tenth of October, in connection with the Exposition, and promises a time of varied interest from both a structural and an economical point of view. Those who wish to become members, and thus to obtain the results of the Congress, should send their subscriptions (20 fr.) to M. H. Hua, Treasurer to the Congress, 2 Rue de Villersexel, Paris.

FIVE additional cases of plague, of a mild type, were reported in Glasgow on Monday. This raises the total to twenty-two plague cases, one suspected case, and 115 persons under observation. The attacked persons had been in contact with plague cases. Prof. Muir states in his report on the new cases that his experiments show without doubt that the bacillus was that of bubonic plague. He examined nine cases, both microscopically and by means of cultures, and found the same results.

AT the Geographical Congress at Berlin in October 1899 it was decided to form an International Seismological Society. The first meeting of the delegates from different countries will be held at Strassburg on April 11, 1901. The principal subjects chosen for discussion are: The organisation and extension of macroseismic investigations in all countries, the organisation of international microseismic observations, the selection of apparatus for international and local seismic observations, the annual publication of international seismic reports, and the statutes of the new society.

THE Liverpool Marine Biology Committee's station at Port Erin has been very fully occupied during the greater part of the summer, and there are at present half-a-dozen workers doing original research in the laboratory. On Saturday last a party of the Isle of Man Natural History and Antiquarian Society proceeded to Port Erin on a visit to the laboratory, and were heartily welcomed by Prof. Herdman, F.R.S. Mr. Isaac C. Thompson gave a lecture, "On the Place of the Copepoda in Nature." It was pointed out that the copepoda are of the utmost value as scavengers, as they live on the products of decomposition, putrefaction, drainage matter, &c., and by their internal laboratories convert refuse matter into most valuable food material, some copepoda constituting one of the chief sources of food for fishes, and therefore of man. Mr. Thompson said that no less than 200 species have been found in Liverpool Bay. Their beautiful organisation illustrates the truth that the wonderful structure of some animals, which can only be studied with the microscope, shows them to be as full of interest as those familiar to our ordinary vision. Besides the many free swimming copepods, there are many species found as fish parasites, living on the gills and on other external parts of our common fishes; some of these are nourished by the fish and do harm, while others do not, their presence being rather an advantage than otherwise.

THE importance of an organised and continuous system of rainfall observations is obvious to every one possessing sufficient knowledge of physical geography to know the relation of rainfall to agriculture, water supply, and all questions in which the development of natural resources is concerned. It is as essential that such observations should be systematically carried on in a thickly populated country like our own as it is that they should be made in all parts of the British Empire in which observers can be found. And when stations have been established, it is again essential that there should be a central bureau in which the observations can be collected, and their relation to one another, and to the natural features of the district determined. A report, by Mr. F. R. Johnson, upon irrigation and water supply, rainfall, and water rights in Cape Colony, published in the *Cape Agricultural Journal* (August 2), issued by the Department of Agriculture, reminds us of the value of continuous rainfall records in connection with works for irrigation and water supply. It is unusual for stream flow measurements, owing to their cost, to be available, even in the most favourable circumstances, to anything like the same extent, and it is therefore very necessary that the rainfall records should be carefully discussed, and full advantage taken of all they are capable of teaching, so that when considered and compared with shorter periods of stream flow measurement (possibly only available for an adjoining catchment) the significance of the whole may be appreciated and understood. So far this has not been done in Cape Colony, from an engineering point of view, and the need of the information is felt now that the hydrographic conditions of the Colony are being investigated. From the rainfall observations so far examined, it appears that sufficient water should be available to irrigate about five million acres of arable land; and when it is considered that this means an enhanced land value in the Colony of upwards of a hundred million pounds, the advantage of setting to work at once to digest and apply the data available to specific proposals for irrigation is apparent.

IN an article on "The Amount the Circulation of the Carbonate of Lime and the Age of the Earth," by Prof. Eug. Dubois (*K. Akad. van Wetenschappen te Amsterdam*, 1900), it is conceded that the ocean, which derives all of its carbonate of lime from rivers or the waste of sea-cliffs, holds as much of it as it can, and that rivers are incessantly bringing a surplus. A considerable amount of carbonate of lime is often to be found in the matter carried in suspension by large rivers to the ocean, and it is obvious that in these river-waters the solution must be saturated. The quantity of carbonate of lime in river-waters is naturally determined by the rocks in the drainage areas. The author gives reasons which lead him to conclude that not more than one-thirtieth part of the carbonate of lime which rivers now discharge into the ocean is newly formed from silicates, although originally all was so derived. His calculations, based on the amount of carbonate of lime annually carried to sea by rivers, show that the formation of the whole estimated minimum amount of carbonate of lime on the earth would require about 45,000,000 of years, and that of the real amount a much larger lapse of time. He estimates that 1/2,770,000th of the total quantity of carbonate of lime of the earth participates annually in the present circulation. The final result of his investigation, though admittedly only suggestive, is that the real lapse of time since the formation of a solid crust and the appearance of life upon the globe may be more than a thousand million of years.

MR. A. GIBB MAITLAND, Government geologist of Western Australia, has issued, as *Bulletin* No. 4 of the survey reports, a general account of "The Mineral Wealth of Western Australia." This work is intended to replace the useful mining handbook which was prepared by Mr. Harry P. Woodward, and has long been out of print. The author gives a sketch of the geological features of the Colony, and then deals specially with gold, lead and copper, tin, iron, miscellaneous minerals (such as antimony, zinc, &c.), coal and graphite, guano and artesian water (with records of borings). A full list of minerals is appended, and there is a map showing the distribution of useful minerals in Western Australia, and five geological maps of particular mineral districts. The guano, which is obtained from the Abrolhos Islands and elsewhere in the north, is an important product. In 1899 upwards of two thousand tons were obtained, the total value being over 5000*l*. The amount raised last year was, however, small compared with some previous records.

A REPORT on the mineral statistics and mines of Canada for 1898 (1900), drawn up by Mr. E. D. Ingall, contains records of a great variety of mineral products. It is interesting to note that the output of coal, supplied mainly from Nova Scotia (nearly two-thirds), and from British Columbia (nearly one-third), shows an increase: the total production being nearly four million tons. Natural gas is obtained from wells in southern Ontaria. Gold shows a large increase, due to the output from the Yukon; but silver, which is almost wholly derived from British Columbia, shows a decrease. On the whole, however, the growth of Canada's mineral industries is stated to be very encouraging.

IN the memoirs of the Society "Antonio Alzate" (vol. xiv.), Señor M. Moreno publishes a discussion of the sunshine values at the Observatory of Leon (Mexico), situated in latitude 21° ·07′ N., showing the daily amounts recorded by a Campbell-Stokes instrument from June 1892 to December 1898. These values are all the more acceptable from the fact that out of some thirty observatories in the Mexican Republic, Leon appears to be the only station which furnishes a complete record of sunshine. The following figures, giving the average percentages of the possible amounts, show that the locality enjoys a large amount of bright sunshine:—winter, 71; spring, 72; summer, 59; autumn, 69; and for the year, 68. In Dr. Scott's discussion of ten years' sunshine in the British Isles, the annual average for London (City) is 24; for Greenwich, 25; and for Jersey, the sunniest part of the British Isles, 40.

THE U.S. *Monthly Weather Review* for May last contains an interesting article, by Prof. C. Abbe, on the history of modern weather prediction. He considers that the first effort towards this end was the publication of the "Mannheim Ephemerides," a series of thirteen volumes, for the years 1780–92, containing detailed meteorological observations for thirty-six stations in Europe and for three stations in America. After many years, Prof. H. W. Brandes first compiled from those observations daily weather maps for 1783 ("Beiträge zur Witterungskunde," Leipzig, 1820). In 1826 Prof. J. P. Espy organised a joint committee for the purpose of studying storms; numerous maps were constructed and many published in four successive reports (1845–60). The labours of Espy and Redfield established the fact that individual features of the weather, as well as storms, move in such a manner that their approach can be predicted by means of maps. Prof. J. Henry constructed daily weather maps from telegraphic reports, for personal study, for several years from 1848, and from 1856 onwards they were exhibited at the Smithsonian Institution. These maps were made the basis of frequent special predictions of the weather for the benefit of members of Congress and others. This date brings us down to the time of the establishment of the meteorological offices in this country and abroad.

MANY interesting points referring to the work of the Government Laboratory are mentioned by the director, Dr. T. E. Thorpe, F.R.S., in the report recently issued. A number of tinned meats were examined for the Admiralty for food preservatives, but no antiseptic other than common salt was detected. Numerous butters contained boric preservative and were artificially coloured. As usual, the use of boric acid is most prevalent in butters from France, Belgium and Australia, and is very common also in Holland. The most frequent colouring-matter is annatto, but the use of coal-tar yellows appears to be on the increase, and is especially prevalent in Holland, the United States and Australia. In the course of the year it was decided by the Board of Trade that all passenger ships should be required to carry a filter capable of delivering water free from micro-organisms. With Dr. Thorpe's assistance, a filter which satisfactorily fulfils this condition has been decided upon. As a supplement to the work of the Steel Rails Committee (see p. 437), an investigation was undertaken with the object of elucidating the mode in which the phosphorus in steel is chemically combined. The inquiry clearly showed, as has already been surmised, that the phosphorus present is, like the carbon, not infrequently in more than one form of combination. The greater part of the work done in connection with the Home Office arose out of the inquiries instituted by the Home Secretary, relative to the prevalence of lead-poisoning arising from the use of lead compounds in pottery manufacture. A considerable number of "fritts" and "glazes" have been examined, and the conditions determining the ease with which lèad compounds may be extracted from them by dilute acids, comparable as regards their action with that of the gastric juice and other animal solvents, have been ascertained. As the result of the inquiry made last year, the Home Secretary has required the manufacturers of pottery to abandon the use of raw lead, and in view of the facts brought to light by the examination of the fritts and glazes, he has expressed his intention of prescribing that in future such glazes shall conform to a standard of insolubility as regards lead.

THE evidence for presence of totemism in various parts of the world is now being carefully examined, as it is beginning to be realised that a cult of animals is not necessarily the same as totemism. This is the attitude taken by Dr. C. Hose and Mr. W. MacDougall in their paper read before the recent meeting of the British Association, and to which reference will be made elsewhere in our columns. Dr. E. Westermarck, the author of the well-known work on "Human Marriage," has published some of the results of his investiga tions in Morocco in a paper in the *Journal* of the Anthropological Institute (vol. xxix. p. 252), entitled "The nature of the Arab *Ginn*, illustrated by the present beliefs of the people of Morocco," in which he adopts the same conclusion. The *Gnun*, as they are called in Morocco, form a special race of beings, created before Adam. They have no fixed forms, but may assume almost any shape they like. Usually they are hurtful to man. The bad *Gnun* being always ready to attack human beings, various means are used for keeping them at a distance. The *Gnun* are afraid of salt and steel, which are consequently employed as prophylactics; the best and, from a religious point of view, the correct preventive against their attacks is the recital of passages of the Koran. Dr. Westermarck adversely criticises Robertson Smith's explanation that the *Ginn* are modernised representatives of totem animals, and states that they are beings invented to explain the wonderful and mysterious in nature. They are, in fact, survivals of the early indigenous animistic beliefs of a saltless and ironless antiquity, which, at a later date, were absorbed and developed under the influence of Islâm.

THE Society for the Protection of Birds has just issued, in pamphlet form, a communication from Sir C. Lawson, which appeared in the *Madras Mail* of March 27 and April 11, pleading for the adequate protection of insectivorous birds in India. It appears that for more than a decade a law has been in force in Madras for the protection of birds, but that when, some time ago, steps were taken to extend this enactment to the other presidencies, the responsible advisers to the Indian Government did not consider that the time was ripe for such legislation. Sir C. Lawson now urges that, in great part owing to the famine, the need of bird protection by law demands immediate recognition. At present he pleads only for those insectivorous species whose wholesale slaughter for the sake of their plumage leaves grain and cotton-fields at the mercy of insect pests, thus causing "a deplorable sacrifice of human food and the materials of human raiment, besides inflicting penury on individuals and great loss to the State." The society is endeavouring to form an Indian

branch, and applies for support to all interested in India. Of the excellency of the object in view we are fully assured, but it must be borne in mind that legislation of the nature proposed entails many difficulties in India, and should not be introduced without very mature consideration.

WE have received a *Bulletin* (vol. iii. No. 2) of the Madras Government Museum containing an illustrated account by the superintendent, Dr. E. Thurston, of the sea fisheries of Malabar and South Canara. A considerable portion of the pamphlet is taken up with an account of the instructions which have been recently drawn up by the author for the guidance of the officials at the various fish-curing establishments in attaining statistics of the life-history and migrations of the more abundant species of fish. As an instance of the difficulties encountered in India in obtaining statistics of this nature, it may be mentioned that "at the fish-census, 1889, the officer who was told off to make the record of fishes brought ashore, was at first driven away by the fishermen, who refused to give him the requisite information, from fear that the census was being taken with a view to increased taxation." The remainder of this valuable report is taken up by a diary made by the author during a tour of inspection of the fish-curing yards of the districts in question during the autumn of last year. Some of the most striking modes of fishing are illustrated in the plates, and details given of the amount and value of the catches at the different stations. Dr. Thurston is of opinion that a much greater variety of fish might be introduced with advantage at the dinner tables of Europeans residing in Madras than is at present the case.

AS nest-building fishes are comparatively few, naturalists will read with interest an account given in the August issue of the *American Naturalist*, by Messrs. Young and Cole, of the manner in which the brook-lamprey (*Lampetra wilderi*) makes a structure of this nature. It is believed that the males precede the females at spawning time and commence nest-building before the arrival of the latter. The nest is made among pebbles, but it does not seem that the lampreys follow any definite plan in its construction. They affix themselves to such pebbles as require removing from the nest, and then endeavour to swim straight away with them. In the case of a heavy stone two lampreys may join forces. The number of fish in a nest may vary from one to thirty or forty; but there are generally between three and twenty-five.

A PAIR of fenestræ covered with membrane have for some time been known to occur in the head of the common cockroach, and represent functional ocelli in other species of the same group. In the *American Naturalist* for August, Mr. C. Kochi records the existence of a pair of spots in the former insect, just below the aforesaid fenestræ. These spots he believes also represent the sites of another pair of ocelli which in other insects have shifted their position and coalesced to form the unpaired median ocellus.

THE *Sunday Magazine*, like many other popular journals, publishes occasional articles on scientific subjects, the one in its September issue being devoted to swimming crabs. Excellent illustrations are given of several of the species to be met with on the British coasts, while the letterpress describes their distinctive features and the leading peculiarities in their habits.

A PAPER on the life-histories of the mosquitoes of the United States, by Dr. L. O. Howard, recently published in one of its *Bulletins* by the U.S. Department of Agriculture, appears opportunely. The writer gives concise but clear descriptions, accompanied by enlarged illustrations, of all the members of the group met with in the States, devoting special attention to those of the malaria-producing genus, Anopheles. Dr. Howard calls attention to the circumstance that he advocated the employment of kerosene for the destruction of the larvæ as far back as 1894, and claims that this mode has proved more effectual, when used on a sufficiently large scale, than any other yet suggested. In certain cases, however, as in the instance of tanks containing water intended for drinking purposes, the employment of kerosene may be undesirable, and the introduction of fish, where none previously existed, is then advocated. The value of most small fishes as destroyers of mosquito larvæ is well illustrated by a natural experiment which recently took place in Connecticut. "In this case a very high tide broke away a dyke and flooded the salt meadows of Stratford, a small town a few miles away from Bridgeport. The receding tide left two small lakes, nearly side by side and of the same size. In one lake the tide left a dozen or more small fishes, while the other was fishless. An examination in the summer of 1891 showed that while the fishless lake contained tens of thousands of mosquito larvæ, that containing the fish had no larvæ."

WE have received from the publishers two numbers of the *Zeitschrift für wissenschaftliche Zoologie*—the last of vol. lxvii. and the first of lxviii. The former contains an article, by Herr E. Wasmann, describing a new genus (Termitoxenia) of wingless Dipterous insects parasitic in the nest of white ants or termites. Four species of these remarkable insects are recognised, of which one is Indian, while the other three are from Africa. Another article in the same issue, which should be of considerable interest to stock-beeders, treats of the histology of certain infusians found in the stomachs of cattle and in the cœcum of the horse. The three articles forming the first part of vol. lxviii. are all devoted to invertebrate anatomy and morphology.

THE August issue of the *Journal* of the Royal Horticultural Society contains, in addition to numerous articles dealing with fruits, vegetables and flowers, a paper treating of the scale and mealy-bug, and a second discussing the black currant-mite and its ravages. In the latter, which should be especially valuable to horticulturists, it is stated that the origin of the pest in question is unknown, but that its first recorded occurrence in the British Isles is about fifty years ago, when it was found in Scotland.

THE Natural History and Ethnographical Museum of Para, Brazil, has commenced to issue a series of memoirs; the first of these is an account by Dr. Emilio A. Goeldi, the director of the museum, of some archæological excavations which he made in 1895 of some artificial burial caves of an extinct tribe of Indians on the Rio Cunany (Goanany). Each cave consists of a circular shaft, 8 feet 2½ inches deep and 3 feet 4½ inches in diameter, the opening of which was closed by a large disc of granite. A crescentic chamber had been cut in the soil at the base of the shaft, in which were deposited a number of remarkable earthen vessels of very varied form, most of which were painted in red with peculiar designs and patterns. Some of the funeral vases were conventionally modelled to represent the human form, and others had on them various animals moulded in high relief. The memoir is illustrated by capital plates.

MESSRS. G. W. WILSON, of Aberdeen, have just issued a catalogue of more than seven hundred new lantern slides representing scenes and objects in Spain. The list should be of particular interest to teachers of geography.

WE have received the Annual Reports of the Royal Botanic Garden, Calcutta, from the superintendent, Major Prain, for the years 1898-1899, 1899-1900. Close attention has been given by the garden staff throughout the past year to the propagation and distribution of plants of economic importance.

AFTER an interval of about two years, Sir George King, late superintendent of the Royal Botanic Garden, Calcutta, continues, in the *Journal* of the Asiatic Society, Bengal, his materials for a flora of the Malayan Peninsula. The present part consists of a monograph of the Malayan species of Melastomaceæ, prepared with the assistance of Dr. O. Stapf, of the Kew Herbarium.

IN an article on the fertilisation of *Peronospora parasitica* in the *Annals of Botany* for June, Mr. Harold Wager points out that there are at present known three distinct types of fertilisation in the Peronosporeæ. In the first, represented by *Peronospora parasitica*, the oosphere and oospore are uninucleate, and fusion takes place between two nuclei only. In the second type the oosphere is uninucleate and the oospore multinucleate, and fusion is effected between two nuclei only. In the third type the oosphere and oospore are both multinucleate, and fusion takes place between a number of nuclei in pairs.

IN a paper recently read before the Linnean Society, on the origin of the Basidiomycetes, Mr. G. Massee points out the connection between the Hyphomycetes and the Protobasidiomycetes. The conidial forms of many Hyphomycetes are true Protobasidiomycetes. There is no evidence that the Autobasidiomycetes are in any way descended from the Protobasidiomycetes; while, on the other hand, there are indications that the Autobasidiomycetes may probably have been derived by gradual modifications of the spore-bearing organs or oasids of conidial forms of certain ascigerous fungi.

PROF. J. J. THOMSON'S inspiring work on "The Discharge of Electricity through Gases" (Constable and Co.) has been translated into French by Dr. L. Barbillion, and published by MM. Gauthier-Villars under the title "Les Décharges électriques dans les Gaz." Dr. Barbillion adds a few notes, and Dr. C. E. Guillaume contributes a preface. The original volume was reviewed in NATURE of January 12, 1899 (vol. lix. p. 241), and the translation will doubtless be received by French physicists with the same appreciation as the work has commanded in Great Britain.

SEVERAL articles of real interest to students of science and philosophy have appeared in recent numbers of *The Open Court*. The August number contained an account of Galileo in which his work is presented in new aspects, and the opposition to his conclusions as to the movements of the earth and the character of the visible universe is in some part explained. The current number contains an instructive contribution on Greek religion and mythology, by the editor, Dr. Paul Carus, and one on animism in popular thought and in science, by Prof. E. Mach. Many of the articles in the magazine are excellently illustrated.

AN atlas for druggists and students of pharmacy, by Prof. Ludwig Koch, is in course of publication by the firm of Gebrüder Borntraeger, Leipzig, under the title of "Die mikroskopische Analyse der Drogenpulver." The first volume is to be devoted to barks and woods, and the second part of it, containing six plates, has just appeared.

THE third and fourth parts of Dr. Chun's elaborate account of the German *Valdivia* expedition have just been published by the firm of Gustav Fischer, Jena. The parts are illustrated with numerous half-tone figures and some very fine plates, and the work promises to be a very attractive narrative of an extensive voyage.

THE additions to the Zoological Society's Gardens during the past week include a Sooty Mangabey (*Cercocebus fuliginosus*) from West Africa, presented by Mr. B. Stewart; a Squacco Heron (*Ardea ralloides*), South European, presented by Mr. A. F. Putz; a Black-headed Terrapin (*Damonia reevesi unicolor*) from China, an Algerian Skink (*Eumeces algeriensis*) from North-west Africa, a Common Chameleon (*Chamaeleon vulgaris*) from North Africa, presented by Mr. F. J. Bridgman; an European Pond Tortoise (*Emys orbicularis*), European, presented by Miss F. M. Weippert; a Wall Lizard (*Lacerta muralis*), a Tessellated Snake (*Tropidonotus tessellatus*), European, presented by Mr. Walter Hunter; two Badgers (*Meles taxus*), British; two Indian Fruit Bats (*Pteropus medius*) from India, three Black-spotted Teguexins (*Tupinambis nigropunctatus*) from South America, two Antillean Boas (*Boa diviniloqua*) from the West Indies, five Undulated Lizards (*Sceloporus undulatus*) from South-east United States, deposited.

OUR ASTRONOMICAL COLUMN

EPHEMERIS FOR OBSERVATIONS OF EROS:—

1900.	R.A. h. m. s.	Decl. ° ′
Sept. 20 ...	2 39 43 ...	+40 47·1
21 ...	40 20 ...	41 9·9
22 ...	40 55 ...	41 32·8
23 ...	41 27 ...	41 55·7
24 ...	41 56 ...	42 18·6
25 ...	42 23 ...	42 41·4
26 ...	42 46 ...	43 4·2
27 ...	43 7 ...	43 27·0
28 ...	43 25 ...	43 49·7
29 ...	43 40 ...	44 12·3
30 ...	2 43 51 ...	+44 34·8

SWIFT'S COMET (1892 I.).—In the *Annals of Harvard College Observatory* (vol. xxxii. Part ii. pp. 267–295), Prof. W. Pickering describes the photographs obtained of this comet at Arequipa during March and April 1892, illustrating his remarks by reproductions from nine of the negatives.

The plates were taken with four instruments—the 13-inch Boyden telescope, 8-inch and 2·5-inch doublets, and a 20-inch reflector; two photographs were also obtained with the 8-inch refractor provided with an objective prism of 13° refracting angle. The exposures varied from 5 to 133 minutes.

While the comet was easily visible to the naked eye, it was carefully examined with a double image prism, but no traces of polarisation could be detected in either the head or tail. The nucleus was yellowish-green in colour, giving out a triangular jet towards the sun.

The head was distinctly divisible into three parts—nucleus, bright primary envelope and an outer fainter one. The tail was composed of two sets of rays having distinctly different origins. The brighter of these sets, forming what may be called the "inner" tail, took its origin from the rear side of the inner envelope, and in some of the photographs this attains the great length of over 20° of arc. The rays were absolutely straight so far as could be determined from the photographs, and were inclined to each other about 10°. The outer tail sprung from the external faint envelope, and, in contrast to the other, was marked by conspicuous deep and wide rifts between the rays composing it.

Prof. Pickering thinks that certain periodic differences in appearance are caused by a rotation of the comet about an axis passing longitudinally through the tail. Comparisons of the Arequipa photographs with others obtained by Dr. Wolf and Prof. Barnard show that it is quite possible to detect changes from one hour to another, and from a detailed examination of the angular deviation of the rays it is probable that the rotation period is about 94·97 hours.

The photograph taken April 14 shows a strong deflection of the inner tail, but the absence of other photographs near that date render it impossible to trace the cause, and the phenomenon was not subsequently repeated.

In general, it was impossible to identify any particular feature on two successive days, but on April 6, 7, 8, a bright condensation was noticed each day, and its distance from the nucleus of the comet was found to increase day by day. These displacements were carefully measured, converted into kilometres by reference to the comet's elements, and an estimate made of the amount of the repulsive force exerted upon the comet's tail by the sun. This indicated the total repulsive force to be about 39·5 times the gravitational force. The spectrum photographs have been difficult to reduce, but the brightest region of the spectrum appears as an intense and very narrow line about λ 3890. No indications of the hydrogen lines were seen.

THE BRADFORD MEETING OF THE BRITISH ASSOCIATION.

SECTION D.

ZOOLOGY.

OPENING ADDRESS BY RAMSAY H. TRAQUAIR, M.D., LL.D., F.R.S.

IN opening to-day the sittings of the Zoological Section, I must first express my sense of the honour which has been conferred on me, in having been chosen as your President on this occasion, and I may add that I feel it not only as an honour to myself personally but also as a compliment to the field of investigation in which the greater part of my own original work has been done. It is a welcome recognition of the doctrine, which I, and much more important men indeed than I, have always maintained, namely, that Palæontology, however valuable, nay, indispensable, its bearings on Geology may be, is in its own essence a part of Biology, and that its facts and its teachings must not be overlooked by those who would pursue the study of Organic Morphology on a truly comprehensive and scientific basis. As I have asked on a previous occasion, "Does an animal cease to be an animal because it is preserved in stone instead of spirits? Is a skeleton any the less a skeleton because it has been excavated from the rock, instead of prepared in a macerating trough?" And I may now add—Do animals, because they have been extinct for it may be millions of years, thereby give up their place in the great chain of organic being, or do they cease to be of any importance to the evolutionist because their soft tissues, now no longer existing, cannot be imbedded in paraffin and cut with a Cambridge microtome?

These are theses which I think no one denies theoretically; but what of the practical application of the rule? For though cordially thanking my biological brethren for the honour they have done me in placing me in this chair to-day, I must ask them not to be offended if I say that in times past I have a few things against some of them at least. I refer first to the apathy concerning palæontological work, more especially where fishes are concerned, which one frequently meets with in the writings of biologists, as seen in the setting up of classifications and theories and the erection of genealogical trees without any, or with at least inadequate, inquiry as to whether such theories or trees are corroborated by the record of the rocks. But more vexatious still are the offhand proceedings of some biologists who, when they wish to complete their generalisations on the structure of a living organism, or group of organisms, by allusion to those which in geological time have gone before, do not take the trouble to consult the original palæontological memoirs or papers, or to make themselves in any way practically acquainted with the subject, but derive their knowledge at second or third hand from some text-book or similar work, which may not in every case be exactly up to date on the matters in question. Nay, more than this, I think I have seen the authors of such text-books or treatises credited with facts and illustrations which were due to the labours of hard-working palæontologists years before.

But a better time, I am convinced, is not far off, when the unity of all biological science will be recognised, not merely theoretically, but also practically by workers in every one of its branches.

Of one thing I must, however, warn those who have hitherto devoted their time exclusively to the investigation of things recent, namely, that a special training is necessary for the correct interpretation of fossil remains, especially those of the lower Vertebrata and many groups of Invertebrata. So it comes that what looks to the uninitiated eye a mere confused mass of broken bones or plates may to the trained observer afford a flood of valuable light on questions of structure previously undetermined. We must take into account the condition of the fossil as regards mineralisation and crushing; we must learn to recognise how the various bones may be dislocated, scattered, or shoved over each other, and to distinguish true sutures from mere fractures. We must carefully correlate the positive results obtained from one specimen with those afforded by others, and in this way it happens that to make a successful restoration of the exo- or endo-skeleton of a fossil fish or reptile may require years of patient research. But the thought sometimes does come up in my mind, that some people imagine that fossils, such as fishes, occur in the rocks all restored and ready, so that the author of such a restoration has no more scientific credit in his work than if he were an ordinary draughtsman drawing a perch or a trout for an illustrated book! But the student of fossil remains must not only learn to see what does exist in the specimen he examines, but also to refrain from seeing things which are not there—to know what he does not see as well as what he does see. For many grave errors have arisen from want of this necessary training, as, for instance, where the under surface of a fish's head has been described as the upper, or where markings of a purely petrological character have been supposed to indicate actual structures of the greatest morphological importance. Or we may find the most wonderful details described, which *may* indeed have existed, but for which the actual evidence is only the fertile imagination of the writer.

From this it will be apparent that though Palæontology is Biology and Biology includes Palæontology, yet as regards original research a division of labour is in most cases necessary. For though palæontological investigations are absolutely impossible without an adequate knowledge of recent zoology, yet the nature of the remains with which the palæontologist has to deal renders their interpretation a task of so different a character from that allotted to the investigation of the structure and development of recent forms that he will scarcely have time for the successful carrying out of a second line of research. Conversely, the same holds regarding the sphere of work of the recent biologist.

Now those last remarks of mine may perhaps tend to confirm an idea which I have at least been told is prevalent in the minds of recent biologists, namely, that the results of Palæontology are so uncertain, so doubtful, and so imperfect, that they are scarcely worthy of serious attention being paid to them. And the best answer I can make to such an opinion, if it really does exist, is to try to place before you some evidence that Palæontology is not mere fossil shell hunting, or the making up of long lists of names to help the geologists to settle their stratigraphical horizons, but may present us with abundance of matter of genuine biological interest.

Since the days of Darwin, there is one subject which more than all others engrosses the attention of scientific biologists. I mean the question of Evolution, or the Doctrine of Descent. Time was when controversies raged round the very idea of Evolution, and when men of science were divided among themselves as to whether the doctrine to which Darwin's theory of Natural Selection gave so mighty an impetus was or was not to be accepted. Times have, however, changed, and I hardly think that we should now find a single true scientific worker who continues to hold on by the old special creation idea. Philosophic zoologists now busy themselves either with amassing morphological evidences of Descent or with the discussion of various theories as to the factors by which organic evolution has been brought about—whether Natural Selection has been the all-sufficient cause or not, whether acquired peculiarities are transmissible, and so on.

From the nature of things it is clear that the voice of the palæontologist can only be heard on the morphological aspect of the question, but to many of us, including myself, the morphological argument is so convincing that we believe that even if the Darwinian theory were proved to-morrow to be utterly baseless, the Doctrine of Descent would not be in the slightest degree affected, but would continue to have as firm a hold on our minds as before.

Now as Palæontology takes us back, far back, into the life of the past, it might be reasonably expected that it would throw great light on the descent of animals, but the amount of its evidence is necessarily much diminished by two unfortunate circumstances. First, the terrible imperfection of the geological record, a fact so obvious to any one having any acquaintance with Geology that it need not be discussed here; and secondly, the circumstance that save in very exceptional cases only the hard parts of animals are preserved, and those too often in an extremely fragmentary and disjointed condition. But though we cannot expect that the palæontological record will ever be anything more than fragmentary, yet the constant occurrence of new and important discoveries leads us to entertain the hope that, in course of time, more and more of its pages will become disclosed to us.

Incomplete, however, as our knowledge of Evolution as derived from Palæontology must be, that is no reason why we should not appraise it at its proper value, and now and again stop for a moment to take stock of the material which has accumulated.

You are all already acquainted with the telling evidence in favour of Evolution furnished by the well-known Mammalian limbs, as well as of teeth, in which the progress, in the course of time, from the more general to the more special is so obvious that I cannot conceive of any unprejudiced person shutting his eyes to the inference that Descent with modification is the reason of these things being so. Suppose, then, that on this occasion we take up the palæontological evidence of Descent in the case of fishes. This I do the more readily because what original work I have been able to do has lain principally in the direction of fossil ichthyology; and again, because it does seem to me that it is in this department that one has most reason to complain of want of interest on the part of recent biologists, even, I may say, of some professed palæontologists themselves.

But the subject is really of so great an extent that to exhaust it in the course of an address like the present would be simply impossible, so I shall in the main limit myself to the consideration of Palæozoic forms, and this more especially seeing that we may hope for a large addition to our light on the fishes of the more recent geological formations from the fourth volume of the "Catalogue of Fossil Fishes" in the British Museum, which will soon appear from the pen of my friend, Dr. A. Smith Woodward. I need scarcely say how much his previous volume has conduced to a better knowledge of the Mesozoic forms.

Here I may begin by boldly affirming that I include the Marsipobranchii as fishes, in spite of the dictum of Cope that no animal can be a fish which does not possess a lower jaw and a shoulder-girdle. Why not? The position seems to me to be a merely arbitrary one; and it is, to say the least, not impossible that the modern Lampreys and Haggs may be, as many believe, the degenerate descendants of originally gnathostomatous forms.

To the origin of the Vertebrata, Palæontology gives us no clue, as the forerunners of the fishes must have been creatures which, like the lowest Chordata of the present day (Urochorda, Hemichorda, Cephalochorda), had no hard parts capable of preservation. And though I shall presently refer again to the subject, I may here affirm that, so far as I can read the record at least, it is impossible to derive from Palæontology any support to the view, recently revived, that the ancient fishes are in any way related to Crustacean or merostomatous ancestors.

What have we then to say concerning the most ancient fishes with which we are acquainted?

The idea that the minute bodies, known as Conodonts, which occur from the Cambrian to the Carboniferous, are the teeth of fishes and possibly even of ancient Marsipobranchs may now be said to be given up. They are now accepted by the most trustworthy authorities as appertaining to Invertebrata such as Annelides and Gephyrea.

More recently, however, Rohon[1] has described from the Lower Silurian of the neighbourhood of St. Petersburg small teeth (*Palaeodus* and *Archodus*) associated with Conodonts, and which seem to be real fish teeth, but not of Selachians, as is shown by the presence of a pulp cavity surrounded by non-vascular dentine. It is impossible to say anything more of their affinities.

Obscure and fragmentary fish remains have been obtained by Walcot, and described by Jaekel, from rocks in Colorado supposed to be of Lower Silurian or Ordovician age.[2] But doubts have been thrown on their age, and the fossils themselves, which have, it must be owned, a very Devonian look about them, are so extremely fragmentary that they do not help us much in our present purpose.

It is not till we come to the Upper Silurian rocks that we begin to feel the ground securely under our feet, though we may be certain, from the degree of specialisation of the forms which we there find, that fishes lived in the waters of the globe for long ages previously.

Characteristic of the "Ludlow bone-bed" are certain minute scales on which Pander founded the family Cœlolepidæ, having a flat or sculptured crown, below which is a constricted "neck," and then a base usually perforated by an aperture leading into a central pulp cavity. As these little bodies, looked upon by Agassiz as teeth, were shown by McCoy to be scales, and as they occurred at Ludlow in England and Oesel in Russia along with small Selachian spines (*Onchus*), they were usually considered as appertaining, with the latter, to small Cestraciont sharks. The genera *Thelodus*, *Coelolepis* and others were founded on these dermal bodies, but it is doubtful if any but the first of these names will stand.

But the aspect of affairs was altogether changed by the discovery three years ago, by the officers of the Geological Survey, of entire specimens of *Thelodus* in the Upper Silurian rocks of the South of Scotland, from which it was evident that the fish, though somewhat shark-like, could hardly be reckoned as a true Selachian.[1] *Thelodus Scoticus*, Traq., has a broad flattened anterior part corresponding to the head and forepart of the body, very bluntly rounded in front, and passing behind into right and left angular flap-like projections, which are sharply marked off from the narrow tail, which is furnished with a deeply cleft heterocercal caudal fin. Unless the flap-like lateral projections are representatives of pectorals, no other fins are present, neither do we find any teeth or jaws, nor any trace of internal skeleton; and it is only a few days since Mr. Tait, collector to the Geological Survey of Scotland, pointed out to me in a recently acquired specimen a right and left dark spot at the outer margins of the head near the front, which spots may indicate the position of the eyes.[2] A previously unknown genus, *Lanarkia*, Traq., also occurred, in which the creature had the very same form, but instead of having the skin clothed with small shagreen-like scales, possessed, in their place, minute sharp conical hollow spines, without base and open below. What we are to think of those two ancient forms, apparently so primitive, and yet undoubtedly also to a great extent specialised, we shall presently discuss.

Let us now for a moment look at the genus *Drepanaspis*, Schlüter, from the Lower Devonian of Gmünden in Western Germany.[3] We have here a strange creature whose shape entirely reminds us of that of *Thelodus*, having the same flat broad anterior part, bluntly rounded in front, and angulated behind, to which is appended a narrow tail ending in a heterocercal caudal fin, which is, however, scarcely bilobate. But here the dermal covering, instead of consisting of separate scales or spinelets, shows a close carapace of hard bony plates, of which two are especially large and prominent—the median dorsal and the median ventral—other large ones being placed around the margins, while the intervening space is occupied by a mosaic of small polygonal pieces. The position of the mouth, a transverse slit, is seen just at the anterior margin; it is bounded behind by a median mental or chin-plate, but no jaws properly so called are visible, nor are there any teeth. Then on each margin near the front of the head is a small round pit, exactly in the position of the dark spot seen in some examples of *Thelodus*, which, if not an orbit, must indicate the position of some organ of sense. Again, the tail is covered with scales after the manner of a "ganoid" fish, being rhombic on the sides, but assuming the form of long deeply imbricating fulcra on the dorsal and ventral margins. The position of the branchial opening, or openings, has not yet been definitely ascertained.

All these plates are closely covered with stellate tubercles, and we cannot escape from the conclusion that they are formed by the fusion of small shagreen bodies like those of *Thelodus*, and united to bony matter developed in a deeper layer of the skin.

If the angular lateral flaps of *Thelodus* represent pectoral fins, then we would have the exceedingly strange phenomena of such structures becoming functionally useless by enclosure in hard unyielding plates, though still influencing the general outline of the fish. Be that as it may, can we doubt that in *Drepanaspis* we have a form derived by specialisation from a Cœlolepid ancestor?

This *Drepanaspis* throws likewise a much desired light on the fragmentary Devonian remains known since Agassiz's time as *Psammosteus*. These consist of large plates and fragments of plates, composed of vaso-dentine, and sculptured externally by minute closely-set stellate tubercles, exactly resembling the scales of some species of *Thelodus*. These tubercles are also frequently arranged in small polygonal areas, reminding us exactly of the small polygonal plates of *Drepanaspis*, and, like them, often having a specially large tubercle in the centre.

[1] "Ueber untersilurische Fische," *Mélanges Géol. et Paléont.* vol. i. (St. Petersburg, 1899), pp. 9–14.

[2] *Bulletin Geol. Soc. America*, vol. iii. 1892, pp. 153–171.

[1] R. H. Traquair, "Report on Fossil Fishes collected by the Geological Survey in the Silurian Rocks of the South of Scotland," *Trans. Roy. Soc. Edin.*, vol. xxxix. 1899, pp. 827–864.

[2] I am indebted to Sir A. Geikie, F.R.S., Director-General of the Geological Survey, for permission to make use of this and other facts disclosed by Mr. Tait's work in the Lesmahagow Silurians during the present summer.

[3] R. H. Traquair, *Geol. Mag.*, April 1900.

That *Psammosteus* had an ancestry similar to that of *Drepanaspis* can also hardly be doubted.

Finally, in the well-known *Pteraspis* of the Upper Silurian and Lower Devonian formations we have a creature which also has the head and anterior part of the body enveloped in a carapace, to which a tail covered with rhombic scales is appended behind, and, though the caudal fin has never been properly seen, such remains of it as have occurred distinctly indicate that it was heterocercal in its contour. The plates of the carapace have a striking resemblance in general arrangement to those of *Drepanaspis*, though the small polygonal pieces have disappeared, and there is a prominent pointed rostrum in front of the mouth; and it is to be noted that the small round apertures usually supposed to be orbits are in a position quite analogous to that of the sensory pits in *Drepanaspis*. The plates of the carapace of *Pteraspis* are not, however, tuberculated, but ornamented by fine close parallel ridges, the microscopic structure of which, along with their frequent lateral crenulation, leaves no doubt in our minds that they have been formed by the running together in lines of *Thelodus*-like shagreen grains. An aperture supposed to be branchial is seen on the plate forming the posterior angle of the carapace on each side.

Until these recent discoveries concerning the Cœlolepidæ and Drepanaspidæ, *Pteraspis* and its allies, *Cyathaspis* and *Palaeaspis*, constituted the only family included in the order Heterostraci of the sub-class Ostracodermi, distinguished, as shown by Lankester, by the absence of bone lacunæ in the microscopic structure of their plates. It is now, however, clear that we can trace them back to an ancestral family in which the external dermal armature was still in the generalised form of separate shagreen grains or spinelets.

But the Ostracodermi are usually made to include two other groups or orders, namely the Osteostraci and the Asterolepida.[1]

The Osteostraci are distinguished from the Heterostraci by the possession of lacunæ in their bone structure, and by having the eyes in the middle of the head-shield instead of at the sides. *Cephalaspis*, which occurs from the Upper Silurian to the top of the Devonian, is the best known representative of this division. Instead of a carapace, we find a large head-shield of one piece, though its structure shows evidence of its having been originally composed of a mosaic of small polygonal plates, and it is also to be noted that the surface is ornamented by small tubercles, there frequently being one larger in size in the centre of each polygonal area. The posterior-external angles of the shield project backward in a right and left pointed process or *cornu*, scarcely developed in *C. Murchisoni*, internal to which, and also organically connected with the head-shield, is a rounded flap-like structure, which strongly reminds us of the lateral flaps of the Cœlolepidæ. The body is covered with scales, which on the sides are high and narrow; there is a small dorsal fin, and the caudal, though heterocercal, is not bilobate. It is scarcely necessary for me to add that we find just a little evidence of jaws or of teeth as in the case of the Heterostraci.

The association of the Heterostraci and Osteostraci in one sub-class of Ostracodermi has been strongly protested against by Prof. Lankester and Dr. O. M. Reis, but here the Scottish Silurian strata come to the rescue with a form which I described last year under the name of *Ateleaspis tessellata*, and of which some more perfect examples than those at my disposal at that time have recently come to light through the labours of Mr. Tait, of the Geological Survey of Scotland.

Here we have a creature whose general form reminds us strongly of *Thelodus*, but whose close affinity to *Cephalaspis* is absolutely plain, were it only on account of the indications of orbits on the top of the head.

The expanded anterior part which here represents the head-shield of *Cephalaspis* shows not the slightest trace of cornua, but forms posteriorly a gently rounded lobe on each side, clearly suggesting that the cornual flaps of *Cephalaspis* are homologous with and derivable from the lateral expanses in the Cœlolepidæ. This cephalic covering is composed of numerous small polygonal plates like those of which the head-shield in *Cephalaspis* no doubt originally consisted, and the minute tubercles which cover their outer surfaces also suggest that the superficial layer was formed by the fusion of Cœlolepid scales. The body is covered with rhombic scales, sculptured externally with tubercles and wavy transverse ridges, and arranged in lines having the same general direction as the scutes of *Cephalaspis*, from which we may infer that the latter originated from the fusion of scales of similar form. The fins are as in *Cephalaspis*, there being one small dorsal situated far back, and a heterocercal caudal, which is triangular in shape, and not deeply cleft into upper and lower lobes as in the Cœlolepidæ. Finally, the scales, on microscopic examination, show well-developed bone lacunæ in their internal structure.

That *Ateleaspis* belongs to the Osteostraci there is thus not the smallest doubt, but its general resemblance to the Cœlolepidæ in its contour anteriorly led me to regard it as an annectent form, and consequently to believe that there is after all a genuine genetic connection between the Heterostraci and the Osteostraci. And I have not seen reason to depart from that opinion even though *Ateleaspis* turns out to be still closer to *Cephalaspis* than was apparent in the original specimens.

If this be so, then *Cephalaspis*, as well as *Pteraspis* and its allies, is traceable to the Cœlolepidæ, shark-like creatures in which, as we have already seen, the dermal covering consists of small shagreen-like scales, or of minute hollow spines, and consequently all theories as to the arthropod origin of the Ostracodermi, so far as they are founded on the external configuration of the carapace in the more specialised forms, must fall to the ground. And from the close resemblance of these scales of *Thelodus* to Elasmobranch shagreen bodies—for forty-five years they had been, by most authors, actually referred to the Selachii—I concluded that the Cœlolepidæ owed their origin to some form of primitive Elasmobranchs. That is, however, not in accordance with the view of the late Prof. Cope, that the Ostracodermi are more related to the Marsipobranchii, and that, from the apparent absence of lower jaw, they should be placed along with the last-named group in a class of Agnatha, altogether apart from the fishes proper. And Dr. Smith Woodward, who is inclined to favour Cope's theory, has expressed his view that the similarity of the Cœlolepid scales to Elasmobranch shagreen is no proof of an Elasmobranch derivation, but that such structures, representing the simplest form of dermal hard parts, may have originated independently in far distant groups.[1] Knowing what we do of the occurrence of strange parallelisms in evolution, it would not be safe to deny such a possibility. But as to a Marsipobranch affinity, I would point out that the apparent want of lower jaw among the hard parts which nature has preserved for us is no proof of the absence of a Meckelian cartilage among the soft parts which are lost to us for ever; and also, as Prof. Lankester has remarked, that there is no evidence whatever that any of the creatures classed together as Ostracodermi were monorhinal like the Lampreys. The only fossil vertebrate having a single median opening, presumably nasal, in the front of the head is *Palaeospondylus*, but, whatever be the true affinities of this little creature, at present the subject of so much dispute, I think we may be very sure that it is not an Ostracoderm.

The Devonian "Antiarcha" or Asterolepida, of which *Pterichthys* is the best known genus, are also usually placed in the Ostracodermi, with which they agree in the possession of a carapace of bony plates, in the absence of distinct lower jaw or teeth, in the non-preservation of internal skeleton, and in having a scaly tail furnished with a heterocercal caudal fin, and, as in the Cephalaspidæ, also with a small dorsal. But they have in addition a pair of singular jointed thoracic limbs, evidently organs of progression, which are totally unlike anything in the Osteostraci or in the Heterostraci, or indeed in any other group of fishes. These limbs are covered with bony plates and hollow inside, but though I once fancifully compared them in that respect with the limbs of insects, I must protest strongly against this expression of mine being quoted in favour of the arthropod theory of the derivation of the Vertebrata!

Nor do I think that there is any probability in the view published by Simroth nine years ago,[2] namely, that *Pterichthys* may have been a land animal which used its limbs for progression on dry ground, and that the origin of the heterocercal tail was the bending up of the extremity of the vertebral axis caused by its being dragged behind the creature in the act of walking. That view was promulgated before the discovery of the membranous expanse of the caudal fin in this genus.

But though the Asterolepida are apparently related to and inclusible in the Ostracodermi, the geological record is silent as

[1] To these I myself recently added a fourth, the Anaspida, for the remarkable Upper Silurian family of Birkeniidæ, but as these throw no light as yet on the problem of Descent they may at present be only mentioned.

[1] *Geol. Mag.*, March 1900.

[2] "Die Entstehung der Landthiere," Leipzig, 1891.

to their immediate origin, no intermediate forms having been found connecting them more closely with either the Heterostraci or the Osteostraci. In the possession of bone lacunæ and of a dorsal fin they have a greater resemblance to the latter, but it may be looked upon as certain that they could have had no direct origin from that group.

As regards the Ostracodermi as a sub-class, they become extinct at the end of the Devonian epoch, and cannot be credited with any share in the evolution of the fishes of more recent periods, not even if we restore the Coccosteans or Arthrodira to their fellowship. To the latter most enigmatical group, which I shall still continue to look upon as fishes, I shall make some reference further on.

Coming now to say a word regarding the Elasmobranchii, it is plain from the fin-spines found in Upper Silurian rocks that they are of very ancient origin, and that if we only knew them properly they would have a wonderful tale of evolution to tell. But their internal skeleton is from its nature not calculated for preservation, and for the most part we only know those creatures from scattered teeth, fin-spines and shagreen, specimens showing either external configuration or internal structure being rare, especially in Palæozoic strata. But from what we do know, there is no doubt that the ancient sharks were less specialised than those of the present day, and that the recent Notidanids still preserve peculiarities which were common in the Selachii of past ages.

If we ask whether the fossil sharks throw any light on the disputed origin of the paired limbs, whether from the specialisation of right and left lateral folds, or whether that type of limb called "archipterygium" by Gegenbaur, consisting of a central jointed axis with pre- and post-axial radial cartilage attached, was the original form, I fear we get no very definite answer from Elasmobranch palæontology. The paired fins of the Upper Devonian shark, *Cladoselache*, as described by Bashford Dean, Smith Woodward and others, seem to favour the lateral fold theory, and Cope pointed to the right and left series of small intermediate spines which in some Lower Devonian Acanthodei (*Parexus* and *Climatius*) extend between the pectorals and ventrals as evidence of a former continuous lateral fin. So also, if I am right in looking on the lateral flaps of the Cœlolepidæ as fins, the evidence of these ancient Ostracodermi would be in the same direction.

But, on the other hand, we have the remarkable group of Pleuracanthidæ, extending from the Lower Permian back to the Upper Devonian, in which the paired fins are represented by an "archipterygium" which in the pectoral at least is biserial.

From this biserial "archipterygium" in the Pleuracanthidæ, Prof. A. Fritsch, ten years ago,[1] derived the tribasal arrangement of modern sharks, much according to the Gegenbaurian method, effecting, however, a compromise with the lateral fold theory by assuming that the Pleuracanth form originated from one, consisting of simple parallel rods, like that described in *Cladoselache*.

In my description of the pectoral fin of the Carboniferous *Cladodus Neilsoni*[2] I have shown that the cartilaginous structures apparently present an uniserial archipterygium intermediate between the arrangement in *Pleuracanthus* and that in the modern sharks, but I felt compelled to acknowledge that the specimen might also be interpreted in exactly the opposite way, namely, as an example of a transition from the "ptychopterygium" of *Cladoselache* to the Pleuracanth and Dipnoan limb. And so in fact this fin of *Cladodus* is claimed in support of their views by both parties in the dispute.

When we add that Semon emphatically denies that there is any proof for considering that the pectoral fin of *Cladoselache* is primitive in its type,[3] and that Campbell Brown, in his recent paper on the Mesozoic genus *Hybodus*,[4] supports Gegenbaur's theory, it will be seen that Elasmobranch palæontology has not as yet uttered any very clear or decided voice on the question as to whether the so-called archipterygium is the primary form of paired fin in the fish, or only a secondary modification. We shall now inquire if we can obtain any more light on the subject from the Crossopterygii and Dipnoi.

[1] "Fauna der Gaskohle und der Kalksteine der Permformation Böhmens," vol. iii. Pt. i. (Prague, 1890), pp. 44–45.
[2] *Trans. Geol. Soc.* (Glasgow), vol. xi. Pt. i. 1897, pp. 41–50.
[3] "Die Entwickelung der paarigen Flossen des Ceratodus Forsteri." (Jena, 1898.)
[4] "Ueber das Genus *Hybodus* und seine systematische Stellung," *Palæontographica*, vol. xlvi. 1900.

The Crossopterygii are a group of Teleostomous fishes, characterised externally by their jugular plates and lobate paired fins, and represented in the present day only by the African genera *Polypterus* and *Calamoichthys*, which together form the peculiar family Polypteridæ. The Crossopterygii appear suddenly in the middle of the Devonian period, their previous ancestry being unknown to us.

Four families[1] are known to us in Palæozoic times—the Osteolepidæ, Rhizodontidæ, Holoptychiidæ and Cœlacanthidæ, but it is only with the first three that we have at present to deal. The Osteolepidæ and Rhizodontidæ, which appear together in Middle, and die out together in Upper Palæozoic times, resemble each other very closely. In both we have the paired fins, more especially the pectoral, obtusely or subacutely lobate; there are two separate dorsal fins, one anal, and the caudal, which is usually heterocercal, though in some genera it is more or less diphycercal. In both the teeth are conical and have the same complex structure, the dentine being towards the base thrown into vertical labyrinthic folds, exactly as in the Stegocephalian Labyrinthodonts, and this along with the lung-like development of the double air-bladder in the recent Polypteridæ has given rise to the view that from these forms the Stegocephalia have originated. The nasal openings must have been on the under surface of the snout, as in the Dipnoi.

Of these two so closely allied families we must conclude that the Osteolepidæ are the more primitive, as in them the scales are acutely rhombic and usually covered with a thick layer of ganoine, while in the Rhizodontidæ they are rounded, deeply imbricating, and normally devoid of the ganoine layer, which, however, occasionally recurs on the scales of *Rhizodopsis* and the fin-rays of *Gyroptychius*.

What then of the structure of the paired fins? Fortunately in the Rhizodont genera *Tristichopterus* and *Eusthenopteron* the internal skeleton of the lobe was ossified, and what we see clearly exhibited in the pectoral of some specimens is striking enough. We have a basal piece attached to the shoulder-girdle and followed by a median axis of four ossicles placed end to end. The first of these shows on its postaxial margin a strong projecting process, while to its preaxial side, close to its distal extremity, a small radial piece is obliquely articulated, and a similar one is joined also to the second and third segments of the axis. The arrangement in the ventral fin is essentially similar.

In fact, we have in the Rhizodontidæ a short uniserial "archipterygium," and the question is, Has this been formed by the shortening up and degeneration of an originally elongated and biserial one, or on the other hand do we find here a condition in which the stage last referred to has not yet been attained? This question is inseparable from the next, whether the Rhizodonts or the Holoptychians form the most advanced type?

The Holoptychiidæ resemble the Rhizodontidæ extremely closely in their external head-bones, in their rounded, deeply imbricating scales, and in the form and arrangement of their median fins. But the teeth show a more complex and specialised structure than those of the Rhizodontidæ; the simple vertical vascular tubes formed by the repeated folding of the dentine in that family being connected by lateral branches around which the dentine tubules are grouped in such a way as to give rise in transverse sections to a radiating arborescent appearance; hence the term "dendrodont." In this respect, then, the Holoptychiidæ show an advance on the Rhizodontidæ—what then of the paired fins? While the ventral remains subacutely lobate, as in the previous family, the pectoral has now assumed an elongated *acutely lobate* shape, with the fin-rays arranged along the two sides of a central scaly axis exactly as in the Dipnoi; and though the internal skeleton has not yet been seen, yet, judging by analogy, we cannot escape the belief that it was in the form of a complete biserial "archipterygium."

What, then, is the condition of affairs in the oldest known Dipnoan?

The oldest member of this group with whose configuration we are acquainted is *Dipterus*, which likewise appears in the middle of the Devonian period simultaneously with the Osteolepidæ, Rhizodontidæ and Holoptychiidæ. In external form it closely resembles a Holoptychian, having a heterocercal caudal fin, two similarly placed dorsals, one anal, and circular imbricating scales, which, however, have the exposed part covered

[1] *Five*, if we include the singular and still imperfectly known Tarrasiidæ of the Lower Carboniferous.

with smooth ganoine. But now we have the ventrals as well as the pectorals acutely lobate in shape, and presumably archipterygial in structure; the top of the head is covered with many small plates, there is no longer a dentigerous maxilla, the skull is autostylic, and the palatopterygoids and the mandibular splenial are like those of *Ceratodus* and bear each a tooth-plate with radiating ridges.

Now, comparing *Dipterus* with the recent *Ceratodus* and *Protopterus*, the first conclusion we are likely to draw is, that the older Dipnoan is a very specialised form, that its heterocercal tail and separate dorsals and anal are due to specialisation from the continuous diphycercal dorso-ano-caudal arrangement in the recent forms, that the Holoptychiidæ were developed from it by shortening up of the ventral archipterygium, as well as by the changes in cranial structure, and that the Rhizodontidæ and Osteolepidæ are a still more specialised series in which the pectoral archipterygium has also shared the fate of the ventral in becoming shortened up and uniserial.

Five years ago, however, M. Dollo, of the Natural History Museum at Brussels, the well-known describer of the fossil reptiles of Bernissart, proposed a new view to the effect that the process of evolution had gone exactly in the opposite direction;[1] and after long consideration of the subject I find it difficult to escape from the conclusion that this view is more in accordance with the facts of the case, though, as we shall see, it also has its own difficulties.

I have already indicated above that we are, on account of the more specialised structure of the teeth, justified in considering the Holoptychians, with their acutely lobate pectorals, a newer type than the Rhizodonts, even though they did not survive so long in geological time. What, then, of the question of autostyly?

We do not know the suspensorium of *Holoptychius*, but that of the Rhizodontidæ was certainly hyostylic, as in the recent *Polypterus*. Now as there can be no doubt that the autostylic condition of skull is a specialisation on the hyostylic form, as seen also in the Chimæroids and in the Amphibia, to suppose that the hyostylic Crossopterygii were evolved from the autostylic Dipnoi is, to say the least, highly improbable; in my own opinion, as well as in that of M. Dollo, it will not stand. And if we assume a genetic connection between the two groups it is in accordance with all analogy to look on the Dipnoi as the children and not as the parents of the Crossopterygii.

M. Dollo adopts the opinion of Messrs. Balfour and Parker that the apparently primitive diphycercal form of tail of the recent Dipnoi is secondary, and caused by the abortion of the termination of the vertebral axis as in various "Teleostei," so that no argument can be based on the supposition that it represents the original "protocercal" or preheterocercal stage. Very likely that is so, but it is not of so much importance for the present inquiry, as both in the Osteolepidæ and Rhizodontidæ we find among otherwise closely allied genera some which are heterocercal, others more or less diphycercal. *Diplopterus*, for example, differs from *Thursius* only by its diphycercal tail, and in like manner among the Rhizodontidæ *Tristichopterus* is heterocercal, *Eusthenopteron* is nearly diphycercal, and there can be no doubt that, in spite of this, their caudal fins are perfectly homologous structures.

But of special interest is the question of the primitive or non-primitive nature of the continuity of the median fins in the recent Dipnoi. Like others I was inclined to believe it primitive, and that the broken-up condition of these fins in *Dipterus* was a subsequent specialisation, and in fact gave the series *Phaneropleuron*, *Scaumenacia*, *Dipterus macropterus* and *D. Valenciennesii* as illustrating this process of differentiation. This view of course draws on the imperfection of the geological record in assuming the existence of ancient pre-Dipterian Dipnoi with continuous median fins, which have never yet been discovered. But Dollo, using the very same series of forms, showed good reason for reading it in exactly the opposite direction.

The series is as follows:—

(1) *Dipterus Valenciennesii*, Sedgw. and Murch., from the Orcadian Old Red, and the oldest Dipnoan with whose shape we are acquainted, has two dorsal fins with *short* bases, a heterocercal caudal, and one short-based anal.

(2) *Dipterus macropterus*, Traq., from a somewhat higher horizon in the Orcadian series, has the base of the second dorsal much *extended*, the other fins remaining as before.

(3) In *Scaumenacia curta* (Whiteaves), from the Upper Devonian of Canada, the first dorsal has advanced considerably towards the head, and its base has now become elongated, while the second has become still larger and more extended, though still distinct from the caudal posteriorly.

(4) In *Phaneropleuron Andersoni*, Huxley, from the Upper Old Red of Fifeshire, the two dorsal fins are now fused with each other and with the caudal, forming a long continuous fin along the dorsal margin, while the tail has become nearly diphycercal, with elongation of the base of the lower division of the fin. But the anal still remains separate, narrow, and short-based.

(5) In the Carboniferous *Uronemus lobatus*, Ag., the anal is now also absorbed in the lower division of the caudal, forming now, likewise on the hæmal aspect, a continuous median fin behind the ventrals. There is also a last and feeble remnant of a tendency to an upward direction of the extremity of the vertebral axis.

(6) In the recent *Ceratodus Forsteri*, Krefft, the tail is diphycercal (secondary diphycercy), the median fins are continuous, the pectorals and ventrals retain the biserial archipterygium, but the cranial roof-bones have become few.

(7) In *Protopterus annectens*, Owen, the body is more eel-like, and the paired fins have lost the lanceolate leaf-like appearance which they show in *Ceratodus* and the older Dipnoi They are like slender filaments in shape, with a fringe on one side of minute dermal rays; internally they retain the central jointed axis of the "archipterygium," but according to Wiedersheim the radials are gone, except it may be one pair at the very base of the filament.

(8) Finally, in *Lepidosiren paradoxa*, Fitz., the paired fins are still more reduced, having become very small and short, with only the axis remaining.

From this point of view, then, *Dipterus*, instead of being the most specialised Dipnoan, is the most archaic, and the modern *Ceratodus*, *Protopterus* and *Lepidosiren* are degenerate forms, and instead of the Crossopterygii being the offspring of *Dipterus*-like forms, it is exactly the other way, the Dipnoi owing their origin to Holoptychiidæ, which again are a specialisation on the Rhizodontidæ, though they did not survive so long as these in geological time. Consequently the *Ceratodus* limb, with its long median segmented axis and biserial arrangement of radials, is not an archipterygium in the literal sense of the word, but a derivative form traceable to the short uniserial type in the Rhizodonts. But from what form of fin *that* was derived is a question to which palæontology gives us no answer, for the progenitors of the Crossopterygii are as yet unknown to us.

Plausible and attractive as this theory undoubtedly is, and though it relieves the palæontologist from many difficulties which force themselves upon his mind if he tries to abide by the belief that the Dipnoan form of limb had a selachian origin, and was in turn handed on by them to the Crossopterygii, yet it is not without its own stumbling-blocks.

First, as to the dentition, on which, however, M. Dollo does not seem to put much stress, it is impossible to derive *Dipterus directly* from the Holoptychiidæ, unless it suddenly acquired, as so many of us have to do as we grow older, a new set of teeth. The dendrodont dentition of *Holoptychius* could not in any way be transformed into the ctenodont or ceratodont one of *Dipterus*: both are highly specialised conditions, but in different directions. Semon has recently shown that the tooth-plates of the recent *Ceratodus* arise from the concrescence of numerous small simple conical teeth, at first separate from each other.[1] Now this stage in the embryo of the recent form represents to some extent the condition in the Uronemidæ of the Carboniferous and Lower Permian, which stand quite in the middle of Dollo's series.

Again, the idea of the origin of the Dipnoi from the Crossopterygii in the manner sketched above cuts off every thought of a genetic connection between the biserial archipterygium in them and in the Pleuracanthidæ, so that we should have to believe that this very peculiar type of limb arose independently in the Selachii as a parallel development. It may be asked, Why not? We may feel perfectly assured that the autostylic condition of the skull in the Holocephali arose independently of that in the Dipnoi, as did likewise a certain amount of resemblance in their dentition. But those who from embryological grounds oppose any notion of the origin of the Dipnoi from "Ganoids" might here say, if they chose, If so, why should not also the same form of limb have been independently evolved in Crossopterygii?

Accordingly, while philosophic palæontology is much indebted

[1] "Sur la Phylogénie des Dipneustes," *Bulletin Soc. belge géol. paléont. hydr.*, vol. ix. 1895.

[1] "Die Zahnentwickelung des *Ceratodus Forsteri*." (Jena, 1899.)

to M. Dollo for his brilliant essay, and though we must agree with him in many things, such as that the Crossopterygii were not derived *from* the Dipnoi, and that the modern representatives of the latter group are degenerate forms, yet as to the *immediate* ancestry of the Dipnoi themselves, and the diphyletic origin of the so-called archipterygium, we had best for the present keep an open mind.

In his "Catalogue of the Fossil Fishes" in the British Museum (vol. ii. 1891), Dr. Smith Woodward, following the suggestion of Newberry in 1875, classified the Coccosteans or "Arthrodira" as an extremely specialised group of Dipnoi. At first I was much taken with that idea, but after looking more closely into the subject I began to doubt it extremely. My own opinion at present is that the Coccosteans are Teleostomi belonging to the next order, Actinopterygii; but Prof. Bashford Dean, of New York, will not have them to be even "fishes," but places them in a distinct class of "Arthrognatha," which he places next to the Ostracophori (=Ostracodermi), even hinting at a possible union with them, whereby the old "Placodermata" of McCoy would be restored. It will, therefore, be better to leave them out of consideration for the present, pending a thorough re-examination of their structure and affinities.

We come then to the great order of Actinopterygii, to which a large number of the fishes of later Palæozoic age belong, as well as the great mass of those of Mesozoic, Tertiary and Modern times. Of these we first take into consideration the oldest sub-order, namely, the Acipenseroidei or Sturgeon tribe, in which the dermal rays of the median fins are more numerous than their supporting ossicles, while the tail is, in most, completely heterocercal. And the oldest family of Acipenseroids with which we are acquainted is that of the Palæoniscidæ, which, in addition to well-developed cranial and facial bones, has the body normally covered with rhombic ganoid scales furnished with peg-and-socket articulations. Of this family one genus, *Cheirolepis*, appears in the same Devonian strata (Orcadian series) with the earliest known Crossopeterygii, and of its immediate ancestry we know no more than we do of theirs. *Cheirolepis* is a fully evolved palæoniscid, as shown by its oblique suspensorium, wide gape, and other points of its structure. In the Lower Carboniferous rocks of Scotland, where the family attains an enormous development, we find one or two genera, *e.g.* *Canobius*, which appear less specialised, as the suspensorium is nearly vertical, and the mouth consequently smaller.

This family endures up to the Purbeck division of the Jurassic formation, and in the Carboniferous *Cryphiolepis*, the Lower Permian *Trissolepis* and the Jurassic *Coccolepis* we find the same degeneration of the rhombic scales into those of a circular form and imbricating arrangement, which we find repeated in other groups of "Ganoids." In fact, in one Carboniferous genus, *Phanerosteon*, the scales disappear altogether with the exception of those on the body prolongation in the upper lobe of the caudal fin, and a few just behind the shoulder-girdle.

And in these Palæozoic times we notice also a side branch of the Palæoniscidæ, constituting the family Platysomidæ, in which, while the median fins acquire elongated bases, the body becomes shortened up and deep in contour. The scales become high and narrow, their internal rib and articular spine coincident with the anterior margin; the suspensorium, too, instead of swinging back as in the typical Palæoniscidæ, tends to be directed obliquely forward, while the snout becomes simultaneously elongated in front of the nares.

A most interesting series of forms can be set up, beginning with *Eurynotus*, which, though it has the platysomid head contour and a long-based dorsal, has only a slight deepening of the body, and still retains the palæoniscid squamation and a short-based anal fin. In *Mesolepis*, which resembles *Eurynotus* in shape, being only slightly deeper, we have now the characteristic platysomid squamation, and the base of the anal fin is considerably elongated. *Platysomus* has a still more elongated anal fin, and the body is rhombic; while in *Cheirodus* the body is still deeper in contour, with peculiar dorsal and ventral peaks, long fringing dorsal and anal fins, while the ventrals seem to have disappeared altogether. Here also, as in the allied genus *Cheirodopsis*, the separate cylindro-conical teeth characteristic of the family are, on the palatal and splenial bones, replaced by dental plates, reminding us of those of the Dipnoi. Certainly the Platysomidæ seem to me to form a morphological series telling as strongly in favour of Descent as any other in the domain of palæontology.[1]

[1] R. H. Traquair, "Structure and Affinities of the Platysomidæ," *Trans. Roy. Soc. Edin.*, xxix. 1879, pp. 343–391.

If we now return to the Palæoniscidæ we find that they dwindled away in numbers in the Jurassic rocks, and finally became extinct at the close of that epoch. But already in the Lias (leaving the Triassic Catopteridæ out of consideration for the present) we find that they have sent off another offshoot sufficiently distinct to be reckoned as a new and separate family, namely, the Chondrosteidæ, in which the path of degeneration, in all but the matter of size, seems to have been entered on.

In the genus *Chondrosteus*, though the palæoniscid type is clearly traceable in the cranial structure, there is marked degeneration as regards the amount of ossification, and though the suspensorium is still obliquely directed backward the toothless jaws are comparatively short, and the mouth seems now to have become tucked in under the snout as in the recent sturgeon. Then the scales have entirely disappeared from the skin except on the upper lobe of the heterocercal caudal fin, where they are still found arranged exactly as in the Palæoniscidæ.

Chondrosteus in fact conducts us to the recent Acipenseroids—the Polyodontidæ (Paddle-fishes) and Acipenseridæ (Sturgeons).

The first of these resembles *Chondrosteus* in the nakedness of the skin, except on the upper lobe of the caudal fin,[1] the more palæoniscid aspect of the external cranial plates, such of them as remain, for they are now still further reduced. But in front of the mouth and eyes there is an addition in the form of an enormous vertically flattened paddle-shaped snout covered above and below with a large number of small ossifications.

The sturgeons have, however, nearly altogether lost the palæoniscid arrangement of the cranial roof-bones, which, strange to say, now exhibit an arrangement reminding us of that in *Dipterus*, and the external facial plates are still more reduced than even in *Polyodon*; but we may note a very strong resemblance to *Chondrosteus* in the position of the mouth, the edentulous jaws, and the jugal bone, indeed also in the palatal apparatus.

So the sturgeons and paddle-fishes of the present day would seem to be the degenerate, though bulky, descendants of the once extensively-developed group of Palæoniscidæ, even as the modern Dipnoi are degenerated from those of Palæozoic times.

We now notice another *apparent* offshoot of the Palæoniscidæ, namely, the family of Catopteridæ (*Catopterus* and *Dictyopyge*), which is limited to rocks of Triassic age. Unfortunately the osteology of the head is not well known, but Dr. Smith Woodward's observations are to the effect that both the head and shoulder-girdle are of palæoniscoid type. The relationship of these small fishes to the Palæoniscidæ is shown by the general shape, the number and position of the fins, the rhombic ganoid scales, and the close arrangement of the rays of the median fins. But the rays of the dorsal and anal fins are now almost equal in number to their supporting ossicles, and the tail has become only abbreviate heterocercal. That is to say, the caudal body prolongation no longer proceeds to the termination of the upper lobe, which is reduced in size and in the number of its rays. The Catopteridæ are obviously an annectent group, as although from their abbreviate heterocercal tail they have usually been placed in the next sub-order, Dr. Smith Woodward prefers to look upon them as Chrondrostei (*i.e.* Acipenseroidei).[2] Wherever we place them they express the beginning of a set of changes towards a more modern type of fish, which are emphasised in the great series of Lepidosteoid fishes (Protospondyli + Ætheospondyli of Smith Woodward), being the fishes more or less allied to the recent Bony Pike of North America.

But these changes must have been well advanced before the Triassic era, for already in the Upper Permian occurs the genus *Acentrophorus*, whose fellowship with *Semionotus*, *Lepidotus*, and all the rest of the series of Mesozoic semi-heterocercal "Ganoids" is at once obvious.

If we look at the configuration of a typical Jurassic member of this series, such as *Lepidotus* or *Eugnathus*, we shall at once see that we are a stage nearer the modern osseous fish. Though the scales are bony, rhombic, and ganoid we are struck by the "Teleostean"-like aspect of the external bones and plates of

[1] Collinge has, however, found rudimentary scales in the skin of the recent *Polydon folium* (*Journ. Anat. and Phys.*, ix. pp. 458–487), and Cope has described an allied Eocene genus, *Crossopholis*, in which minute scales are seen (*Mem. Nat. Acad. Sciences*, iii. 1886, pp. 161–163).

[2] Dr. Smith Woodward also refers the singular Belonorhynchidæ of the Trias to the same sub-order on account of the excess of the number of the dermal rays of the dorsal and anal over that of their supporting ossicles, even although the tail is here abbreviate diphycercal.

the head, the rays of the dorsal and anal fins are fewer and correspond in their number to that of the internal supports or "interspinous" bones, while in the caudal we see again the semi-heterocercal or abbreviate-heterocercal condition we noticed above in *Catopterus*.

Then if we refer to the tail of *Lepidosteus* itself we shall observe how few are its rays and how evident it is that we have here to do only with the lower lobe of the original palæoniscoid caudal fin. For a convincing corroboration of this we have only to look at the tail of the embryo *Lepidosteus* as described and figured by Prof. A. Agassiz to see that it in reality passed through an Acipenseroid stage, and the last we see of the upper lobe of this tail is in the form of a filament which projects from the top of the original lower lobe and then disappears.

Again, in these Lepidosteid forms we have a repetition of the same tendency for the thick rhombic, peg-and-socket articulating scales to become rounded and imbricating as we saw in the Crossopterygii and again in the Palæoniscidæ. So, for instance, in *Caturus*, which has been shown by Dr. Smith Woodward to resemble *Eugnathus* so closely in structure, the scales are deeply overlapping, and most of them "cycloidal" in shape. To such an extent does this go that in the recent *Amia*, whose skeletal structure so clearly shows it to belong to this group, the rounded scales are so thin and flexible that after it was removed from the Clupeoid family, or Herrings, and placed among the "Ganoids" it was considered to be the type of a distinct sub-order of "Amioidei." Ten years ago, however, Dr. Beard came to the conclusion, from anatomical and embryological data, that this division could no longer be maintained, and that the Amioids must in fact be united with the Lepidosteids.[1] Dr. Smith Woodward has, therefore, in the third volume of his catalogue, done well to reduce the "Amioidei" to the rank of a family, including also the Jurassic genera *Liodesmus* and *Megalurus*, and to place this family close to the Eugnathidæ.

As the Asipenseroids dwindled away after the close of the great Palæozoic era, and are now scantily represented only by the degenerate paddle-fishes and sturgeons, so the Lepidosteid series, flourishing greatly in the Trias and Jura, in their turn declined in the Cretaceous, and in the Tertiary period became about as much a thing of the past as they are now, the North American *Lepidosteus* and *Amia*, of which remains of extinct species have also been found in Eocene and Miocene rocks, only remaining. These two genera can, however, hardly be called "degenerate."

But that the fishes which succeeded the Lepidosteids in populating the seas and rivers of the globe were evolved from them there can be no reasonable doubt, while it is equally clear that they branched off at an early period, as already in the Trias we find the first representatives of the order of Isospondyli, which contains our familiar Herrings, Salmonids, Elopids, Scopelids, &c. For Dr. Smith Woodward has not only definitely placed the Jurassic Leptolepidæ and Oligopleuridæ in the Isospondyli, but also the Pholidophoridæ, which appear in the Trias and extend to the Purbeck. And it is of special interest that in the Pholidophori the scales are still brilliantly ganoid and mostly retain the peg-and-socket articulation, while in the allied Leptolepidæ, although they have become thin and circular, a layer of ganoine mostly remains.

With the Isospondyli we now get fairly among the bony fishes of modern type—Teleostei as we used to call them—to which other sub-orders are added in Cretaceous and Tertiary times, and which in the present day have assumed an overwhelming numerical preponderance over all other fishes. The prevalent form of scale among these is thin, rounded, deeply imbricating, and with the posterior margin either plain (cycloid) or serrated (ctenoid). But that these "cycloid" and "ctenoid" scales are modifications from the rhombic osseous "ganoid" type we cannot doubt after what we have seen. It is indeed strange that the same tendency to the change of rhombic into circular overlapping scales should have occurred independently in more than one group.

For reasons given at the beginning, and also because I fear I have already exceeded the limit of time usually allotted to such an Address, I must now stop.

But in conclusion I may allude to a well-known fact regarding the tail of these modern fishes, the bearing of which on the doctrine of Descent is sufficiently clear and has long been recognised.

We have seen that the completely heterocercal tail of the typical Acipenseroid becomes, by abortion of the upper lobe and shortening of the axis, the semi-heterocercal one of the Lepidosteids, in most of which, however, the want of symmetry is still perceptible externally by a short projection or "sinus" of scales which is directed obliquely upward at the beginning of the top of the fin. In the ordinary bony fishes and in some Lepidosteids also the caudal fin becomes likewise symmetrical, as seen from the outside; generally also bilobate, though the upper lobe is not that of a Palæoniscid or Sturgeon. This condition of tail has been long known as "homocercal." But in many such homocercal tails, when we dissect away the skin and soft parts, the upward bend of the vertebral axis is revealed, and in some, as in the Salmon, the extremity of the vertebral axis is continued as a cartilaginous style among the rays near the upper margin of the fin. But there are many others, such, for instance, as the peculiarly specialised group of Pleuronectidæ or flat fishes, in which the skeleton of the caudal extremity *looks* quite symmetrical, but yet in the embryo the extremity of the notochord is seen to have an upward bend, showing that the homocercal tail is indeed a specialisation on the old heterocercal one. It is strange that though this embryological fact was long ago pointed out by Agassiz, and though he noted its great interest in connection with the prevalence of heterocercy among the Palæozoic fishes, yet he remained to the end an opponent of evolution. But this is just one of these instances in which Phylogeny and Ontogeny mutually illustrate each other. Why, otherwise, should the tail of the embryo stickleback or flounder be heterocercal?

Incompletely as I have treated the subject, it cannot but be acknowledged that the palæontology of fishes is not less emphatic in the support of Descent than that of any other division of the animal kingdom. But in former days the evidence of fossil ichthyology was by some read otherwise.

It is now a little over forty years since Hugh Miller died: he who was one of the first collectors of the fossil fishes of the Scottish Old Red Sandstone, and who knew these in some respects better than any man of his time, not excepting Agassiz himself. Yet his life was spent in a fierce denunciation of the doctrine of evolution, then only in its Lamarckian form, as Darwin had not yet electrified the world with his "Origin of Species." Many a time I wonder greatly what Hugh Miller would have thought had he lived a few years longer, so as to have been able to see the remarkable revolution which was wrought by the publication of that book.

The main argument on which Miller rested was the "high" state of organisation of the ancient fishes of the Palæozoic formations, and this was apparently combined with a confident assumption of the completeness of the geological record. As to the first idea, we know of course that evolution means the passage from the more general to the more special, and that although as the general result an onward advance has taken place, yet specialisation does not always or necessarily mean "highness" of organisation in the sense in which the term is usually employed. As to the idea of the perfection of the geological record, that of course is absurd.

We do not and cannot know the oldest fishes, as they would not have had hard parts for preservation, but we may hope to come to know many more old ones, and older ones still, than we do at present. My experience of the subject of fosil ichthyology is that it is not likely to become exhausted in our day.

We are introduced at a period far back in geological history to certain groups of fishes some of which certainly are high in organisation as animals, but yet of generalised type, being fishes and yet having the potentiality of higher forms. But, because their ancestors are unknown to us, that is no evidence that they did not exist, and cannot overthrow the morphological testimony in favour of evolution with which the record actually does furnish us. We may therefore feel very sure that fishes, or "fish-like vertebrates," lived long ages before the oldest forms with which we are acquainted came into existence.

The modern type of bony fish, though not so "high" in many anatomical points as that of the Selachii, Crossopterygii, Dipnoi, Acipenseroidei and Lepidosteoidei of the Palæozoic and Mesozoic eras, is more specialised in the direction of the fish proper, and, as already indicated, specialisation and "highness" in the ordinary sense of the word are not necessarily coincident. But ideas about these things have undergone a wonderful change since those pre-Darwinian days, and though we shall never be able fully to unravel the problems concerning the descent of animals, we see many things a great deal more clearly now than we did then.

[1] "The Inter-relationships of the Ichthyopsida," *Anatomischer Anzeiger*, 1890. Smith Woodward arrived at the same result in 1893 from the study of the Jurassic genera *Lepidotus* and *Dapedius*. See *Proc. Zool. Soc. Lond.*, June 20, 1893, pp. 559–565.

SECTION F.

ECONOMIC SCIENCE AND STATISTICS.

ABRIDGED FROM THE OPENING ADDRESS BY MAJOR P. G. CRAIGIE, V.P.S.S., PRESIDENT OF THE SECTION.

OF all statistical work the enumeration of the units of population must ever take the foremost place, and on the eve of the census to be taken before many more months have passed a reference to that great impending task could hardly be omitted on this occasion. In common with all students of the machinery of census-taking, I am sure I echo the feelings of the Section—as I do those of the Royal Statistical Society, who have long laboured in this direction—in deeply regretting that the first census of the twentieth century is not to possess the distinction many had hoped to see conferred upon it of being by preliminary announcement—as I hope it may prove to be in ultimate fact—the first of a series not of decennial but of quinquennial countings of the people.

The growing complexity of social conditions and speed of life in all its functions at the present date, contrasted with the leisurely movements of a hundred years ago, would alone and amply justify a more frequent stock-taking of the inhabitants of Great Britain than has been the practice in the past. The practical wants of our much multiplied system of local government cannot fail, I believe, ere long to bring about the granting of an intermediate numbering, even if for the moment other considerations overrule the more academic pleas of statisticians for this reform, or the arguments, sound as I believe them to be, for a permanent Census Office, a permanent Census Act, and a trained and continuous Census Staff, to whom preparation of the machinery beforehand and detailed elaboration of the results after the actual census year might with real economy be entrusted.

Although the proposal which has been before the International Statistical Institute in one form or another for a sychronous "world's census," at the moment of passing from one century to another, is hardly likely, for administrative reasons, and in view of the previous fixtures of the great census-taking Governments of the earth, to be literally realised, the dates of the great countings of the nations will nevertheless come sufficiently close for all practical comparisons. The great Russian enumeration, on the success of which M. Troinitsky is so heartily to be congratulated, is not yet long accomplished. The twelfth census of the United States is now being taken. The Scandinavian inquiry coincides with the century's end, the Italian and the Spanish censuses are already overdue, and both France and England take their count within a few months after the twentieth century has begun.

Attempts to utilise statistical data, to determine the relative development of agriculture in different parts of the world and at different periods of time, are sometimes made with regard solely to what is described as the world's aggregate of one or two leading individual products as typical as the rest; or, again, one or two typical countries, or at least countries where the available information is more complete than elsewhere, are chosen, and the course of development or decline of their crop areas or the several descriptions of their animal produce is traced and compared.

Certain obvious objections, which it is well to recognise, impede the student of figures who resolves to proceed on the first of these methods. At the outset he is arrested by embarrassment attending the choice of what single products are to be held as representative of agricultural outturn. The most usual of all selections is that which restricts inquiries to the case of wheat. This course appears to be rendered, comparatively speaking, easy, as more has probably been written and more statistics, official or unofficial, theoretical or commercial, actual or imaginary, have been compiled with regard to this bread grain than for any other crop. But it is time we recognised that wheat has too much and too exclusive attention directed to it as a type of agricultural production. Very widely as it is undoubtedly used in the form of bread, even as food its place is occupied at one time or another, and in one country or another, by other substitutes, and its cultivation, is, after all, not the employment which demands the most attention and most skill at the hands of the agriculturist. Not only do rye and even maize serve as substitutes or supplements in feeding man, but other crops, such as oats, barley, millet, rice, and so on, have claims to greater notice than they receive, and play a direct as well as indirect part in providing food. Cotton, flax and wool are other typical products, the use of which for clothing is all-important to an enormous population, and the extension or retrogression of such crops deserves some of the attention of the agricultural statistician. Tea, coffee, wine, spirits and beer are, it is not to be forgotten, agricultural products in one clime or another, either directly or indirectly; and crops so important as sugar or tobacco are almost to be classed as necessaries of existence. Of yearly growing importance is it also, in these days, when the animal portion of our food supply bulks so much more fully than before in the daily rations of populations as they grow in wealth and increase in consumptive power, that we should closely follow the fluctuations in the live stock maintained for food and learn the teaching of the agricultural returns on the manufacture of beef, of mutton, of pig meat, or of milk.

Although the attempt to grasp the relative magnitude of the agricultural production of one State as compared with another, or to note the growth or decline of its prominence in the cultivation of particular staples, or the manufacture of particular kinds of human food, is always an enterprise of difficulty in existing statistical conditions, it is one which has fascination for many classes of economists and politicians. If attempted at all, it is well to recognise that there are inevitable dangers in the task, and that if any figures are relied on as conclusive their meaning must be interpreted by some knowledge of the demographic conditions of each State and its geographical, climatic and agricultural circumstances.

Taking a few of the most conspicuous products of the soil, it will generally be found that a very few leading States are so particularly identified with one or other type of production that the examination of their records are therefore available as guides to the course of a single crop.

Probably quite two-thirds of the cotton of the world is grown in the United States alone, where the surface so employed reaches 25,000,000 acres as compared with under 9,000,000 acres in British India, the next largest cotton-growing region of which statistical record exists. In wool the produce of the Australasian Colonies of Great Britain—with flocks which still exceed 100,000,000 head—makes much the largest contribution to the total. In rice, so far as statistics carry us, our Indian possessions head the list of producers. In hops the English crop still probably exceeds the German in production, although the latter with larger area closely contests the place. In tobacco, while the acreage apparently employed in British India is nearly double the 595,000 acres in the United States, no other country in our statistical records comes within one-seventh of the American area. The vineyards of Italy are returned as covering 8,500,000 acres, and those of France 4,300,000 acres, while those of Austria and Hungary, next in magnitude, cover but a seventh part of the last-mentioned figure. Russia bulks largely as a grower of flax, and alone shows a whole third of the area of barley recorded in all the countries which supply returns, and if in the case of potatoes the Russian acreage is not very different from that of Germany the total production of the latter empire reaches the largest aggregate of any single country.

If the subject of inquiry be the place of wheat-growing in the world at one date or another, it would not be to the older European countries, other than Russia at all events, we should turn to see where the surface so utilised was extending. Reckoned by the percentage of her cereal area which she still devotes to wheat, France, with 47 per cent. under the crop, or Italy, with 55 per cent., would naturally be selected as typical wheat-growers; but both are practically in a stationary or, collectively, even in a slightly retrograding position. It is on the other side of the Atlantic where the most noteworthy movements have occurred. In comparatively new exporting countries, such as Argentina and Canada, though the statistics from neither are complete, wheat areas still extend, and that of the United States, though fluctuating with great sensitiveness under varying price conditions, and moving from one centre to another westward or north-westward across the American continent, is now reported as covering 44,600,000 acres. This total, it must be allowed, whatever views may be held as to future progress, makes the United States a typical grower of this particular cereal, to which it gives an importance second only to the still more extensive product of American soil, to which we give the name of maize, but to which alone in American parlance is allowed the title of corn.

The leading changes in the production of typical crops as measured by the acreage, and the stock of cattle, sheep and

swine recorded at or near the commencement, the middle, and the close of the past thirty years, may be contrasted for exporting countries with expanding populations and growing agriculture, and in countries where these conditions are absent, or in a typical consuming centre like our own country. Relying on the agricultural returns of the United States, a table could be constructed, as under, for three dates within the past thirty years which furnish the following indication of agricultural changes:—

United States	1870	1885	1899
Population, in million persons ...	38·6	56·1	76·0
Area under maize, in million acres	38·6	73·1	82·1
Area under wheat ,,	19·0	34·2	44·6
Area under oats ,,	8·8	22·8	26·3
Area under cotton ,,	9·9	18·3	25·0
Cattle (million head)	25·5	43·8	43·9
Sheep ,, ...	40·9	50·4	41·9
Swine ,, ...	26·8	45·1	38·7

In 1870 the United States held, it would thus appear, a population of 38,600,000, and grew an acre of maize for each unit of the population, and an acre of wheat for every two persons, and somewhat more than an acre of cotton for every four. At this period the surplus exported to other nations, it may be added, represented two-thirds of the cotton, rather more than one-fifth of the wheat, but less than one per cent. of the maize.

In 1885 the population had augmented to an estimated total of 56,000,000, or by 45 per cent. The area under the crops above quoted had meantime been extended in nearly twice this ratio. The United States exported still about two-thirds of the cotton grown; the wheat export was slightly greater in proportion to the product than before, or 26 per cent.; while nearly 3 per cent. of the maize crop found a market abroad.

The population of the States is now estimated to have risen to 76,000,000, or twice what it was thirty years ago, although the census has yet to say if this calculation has been realised. The cultivation of maize had meantime reached 82,000,000 acres, wheat was reported to cover 44,000,000 acres, and cotton 25,000,000 acres, while the foreign market received 65 per cent. of the cotton, 33 per cent. of the wheat, and now as much as 9 per cent. of the maize grown on these areas.

In none of these cases, it will be noted, has the area under crop failed to increase, but in all the rate of increase was distinctly slower in the second than in the first half of the period. If time sufficed to trace the annual course of movement between the contrasted dates, it might be well remembered that from 1871 onward to 1889, with only a single slight check in 1887, the growth of the maize acreage has been continuous. From 1889 to 1894 fluctuations were reported yearly, ending in the latter year at a total acreage no higher than that of 1880, but returning again in a single year, if the record can be trusted, to the highest point reached. The wheat acreage movement has been more irregular, and the latest figures are complicated by the admitted corrections which were made to an amount of 5,000,000 acres for too low previous estimates in 1897. Allowing for this, the regular upward movement of the wheat acreage was apparently checked in 1880, and has only begun again since 1898 under the stimulus of higher prices in that year.

In live stock the development would seem to have been arrested altogether between 1885 and the end of the century in the case of cattle, and turned into an absolute decline in the number of sheep and swine, although in the fifteen years before 1885 cattle had increased more than 71 per cent., swine 74 per cent., and sheep 25 per cent. As a matter of fact the maximum number of cattle was reached in 1892, when the numbers were 54,000,000, or ten millions more than at present, the stock of swine declining in a still greater ratio from the same year, and sheep declining and rising again in the separate periods between 1883 and 1889, and between 1893 and 1897. If the ratio under each head to population is considered, it would appear that the United States possessed 661 cattle for every 1000 of her citizens in 1870. This was raised to 829 per 1000 persons in 1885, while the ratio now has fallen again below the starting-point, or to 604 per 1000 persons. Sheep have fallen in the thirty years from 1060 in 1870 to 880, and now to 537 head only per 1000 inhabitants. These remarkable changes are worthy of note in connection with the exports of living animals and animal products, which last have been maintained at a still higher level than before.

Turning to a country of nearly stationary population, provided for in the main from its own agricultural produce with only slight assistance from abroad, a like contrast for the beginning, the middle, and the end of the period under review will give roughly the results shown below. Here, although we are provided with an annual figure, the start has to be made after the Franco-German war with the data two years later, or in 1872. (For table, see below).

Thus in France, where wheat-growing has always had such a predominance among the cereals, the area is neither increasing nor diminishing. The total of 17,000,000 acres falls, however, somewhat short of the provision of an acre to two persons, which held good in the United States; but this is more than corrected by the higher average yield, which is nearly 5 bushels per acre greater in France than in America. Taking wheat and rye together, there are a million acres less of bread corn grown in France than there was when her slow-moving population was two millions smaller, or less than 58 acres to 100 persons now as against 60 acres to the 100 twenty-eight years ago.

France	1872	1885	1899
Population, in million persons ...	36·1	38·2	38·5
Area under wheat, in million acres ...	17·1	17·2	17·1
Area under oats ,, ...	7·9	9·1	9·7
Area under rye ,, ...	4·7	4·1	3·6
Area in vineyards ,, ...	6·5	4·9	4·3[1]
Cattle (million head)	11·3	13·1	13·4[1]
Sheep ,, ...	24·6	22·6	21·3[1]
Swine ,, ...	5·4	5·8	6·2[1]

[1] 1898.

The changes which the last quarter of the nineteenth century has seen in the leading features of French agriculture may be easily summarised. The population of 1872 but little exceeded 36,000,000, that of 1885 reached 38,000,000, and the latest data only bring it up to little over 38,500,000. The wheat-growing area remains, it would appear, under all conditions practically at 17,000,000 acres, the only break to the general uniformity of the cultivation of this cereal (with which the returns include spelt) occurring in the season of 1891, when, under exceptional climatic conditions, only 14,000,000 acres were harvested.

There is one typical French agricultural product—wine—which has materially declined under circumstances which are well known. The vineyards of 1872, which were reported as covering 6,500,000 acres, are now returned as less by a third of that area, and covering 4,300,000 acres only.

In cattle a material growth up to 1885, but a very small increase since that year, is reported; while if sheep, as in all European countries, are fewer, the fall is less than in Germany, and it is most marked in the first half of the period. Swine in France have steadily increased. As regards the cattle, it may be noted that France had 313 cattle to each 1000 of her people in 1872, 345 in 1885, and 352 per 1000 now. Of sheep the number per 1000 is 560, against 681 at the earlier date.

Treating a few of the distinctive points of our own agriculture in the same way at the beginning, middle, and end of the past thirty years, the statistics of the United Kingdom would give these results:—

United Kingdom	1870	1885	1899
Population, in million persons ...	31·2	36·0	40·7
Area under wheat, in million acres	3·8	2·6	2·1
Area under oats ,, ,,	4·4	4·3	4·1
Area under other corn crops ,,	3·6	3·1	2·6
Cattle (million head)	9·2	10·9	11·3
Sheep ,, ...	32·8	30·1	31·7
Swine ,, ...	3·7	3·7	4·0

Here the most striking contrast with France is in the growth of population. From being a country with 5,000,000 fewer

inhabitants the United Kingdom is now one actually greater by 2,000,000 persons than is France. This is an increase of more than 30 per cent., while the surface under wheat has heavily fallen, the main loss occurring under circumstances which have been amply discussed between 1879 and 1895. With some revival, as in America, consequent on an improvement of price in recent years, the slight apparent decline I have shown in the cultivation of oats is in fact confined to Ireland, the area in Great Britain being greater than at the beginning of the period. The cattle stock of the United Kingdom is increased by some 23 per cent., and the swine by about 8 per cent., while our flocks of sheep have been maintained at a level far exceeding that of other European States, and distinctive in a peculiar manner of the agriculture of Great Britain, for they still represent, as it appears, on the average 400 sheep to every 1000 acres of land, against 164 in France, 81 in Germany, 32 in Belgium, and 17 in the United States.

Passing to a comparison with another great country, which, like the United States, is a typical exporter of more than one form of agricultural produce, it may be asked how far the available statistics of Russia allow such information to be furnished. For the earliest of the three years contrasted the dates from the Russian empire are meagre and unsatisfactory. Poland must be excluded as blank in our statistics at that time, while as regards animals no figures at all would appear to have been made public for any of the last twelve years. With such qualifications as these, the available data for the nearest year in the larger crops stood as under :—

Russia in Europe (*ex* Poland)	1870	1885	1899
Population, in million persons ...	65·7	81·7	94·2 [3]
Area of rye, in million acres ...	66·4 [1]	64·6	63·4
Area of wheat ,, ...	28·7 [1]	28·9	38·0
Area of oats ,, ...	32·8 [1]	34·9	36·1
Area of other cereals, in million acres	?	31·4	34·2
Cattle (million head)	22·8	23·6 [2]	(24·6) [4]
Sheep ,, ...	48·1	46·7 [2]	(44·5) [4]
Swine ,, ...	9·1	9·4 [2]	(9·2) [4]

[1] In 1872. [2] In 1883. [3] Census of 1897. [4] In 1888.

Thirty years ago the population of European Russia, *ex* Poland, would appear from such data as we possess to have been estimated in round numbers at under sixty-six million persons. It is given as somewhere about eighty-two millions in 1885, and according to the recent census it is ninety-four millions now. The bread corn of the country continues to be much more largely rye than wheat, and the area in the year 1872, for which statistics are available, occupied by the former crop was practically an acre to the person, or in all 66,400,000 acres, less than half an acre per inhabitant, or 29,000,000 acres, being under wheat. The combined surface devoted to these two bread grains together was thus 95,000,000 acres in the aggregate, or 145 acres to every 100 persons.

Fifteen years later, when the population was apparently greater by 16,000,000 persons, or 24 per cent., the statistics of rye acreage indicate 2,000,000 acres less than before, or 64,600,000 acres. The wheat acreage, if the official data be accepted, was little if at all in excess of the 1872 figure, the rye and wheat together roughly giving 115 acres to 110 persons. The suggestion of this decline, while the exports of both grains were maintained or extended, affords an opportunity for closer inquiry into the basis of the published returns which are received from that country.

But carrying the review of the official figures further, the very latest data for this section of the Russian territory would appear to indicate a yet further shrinkage in the acreage of rye, but accompanied now, as was apparently not the case until lately, by a considerable increase in land under wheat. The total of this cereal is now put as high as 38,000,000 acres, but the net available area of bread-stuffs, although brought up to 101,000,000 acres, represents a still diminishing ratio to population, or 107 acres to every 100 persons. Moreover, as Russia must be regarded as growing both wheat and rye for export as well as consumption, the larger proportions of her acreage which is employed in feeding a non-Russian population deserve to be specially marked in this connection, when the low yields of both cereals are remembered.

Whether the foregoing figures do indeed represent the facts of each period is, I think, a worthy object of inquiry for some of our younger statisticians, and it is a problem one would like to see solved as regards this particular country before venturing on any too confident conclusion as to what is the real meaning of the changes of the past, and what may be the future position in regard to the growth of bread-stuffs and the growth of population in the world as a whole.

Calculations, however, such as those just quoted cannot fail to remind the student how very different in productive power the "acre" of wheat may be, and is, in different countries. Assuming that we take the existence of 38,000,000 acres as reported of wheat land in Russia in Europe (*ex* Poland) to be proved, a comparison of the estimated yields shows that such an area represents less than 12,000,000 acres of the productive power we are accustomed to in Great Britain. So, too, for the vast wheat area of the United States, it takes two and a third acres to produce what is now our average yield in this country. Three Indian or three Italian acres of wheat of the calibre now in use would in the same way be required to supply the number of bushels that a single acre of our soil in the climate we enjoy, and worked under the system of farming that we practise here, would in ordinary seasons produce. In other extensive areas of wheat-growing the yields, though greater than the above, are very considerably below our own, the Austrian, Hungarian and French yields standing at 16, 17 and 18 bushels respectively, against the 30 bushels which is apparently the average yield of the last five years in the United Kingdom. Only when we come to very small total areas do we find instances where the average wheat yields approach or over any considerable periods exceed our own. When Denmark, for example, is referred to as reaching 42 bushels per acre in the season of 1896, it is not to be forgotten that only a minute area of selected land, in this case only 84,000 acres, is devoted to this cereal. Results realised on this small scale can hardly be spoken of as an average in contrast with those of countries where millions of acres are grown, and can usually be paralleled in some sections of the bigger country.

Nor should it be forgotten, if the agricultural position of one State be compared with another, how widely the conditions of different parts vary from the picture presented by the average figures credited to the State as a unit, and how often sections of one country differ more from each other agriculturally than from the country with which they are contrasted. Within the United Kingdom alone we are, or ought to be, familiar with essential local differences of this type, which have to be kept in mind. Even in respect of the relative density of population and the number of mouths to be sustained in a given area, it may be quite correct to describe every 1000 acres in the United Kingdom as carrying on their surface on the average 519 persons, but it may be remembered with advantage that, considered geographically apart, Scotland, for example, is a country of but 220 persons, and Ireland of but 219, to the 1000 acres of area.

Such a position suggests that it might be fair to draw our agricultural comparisons between Scotland or Ireland as units of area, and such a country as Denmark, where the population is 248 to the 1000 acres. Thus one-third of the cereal area of England is still devoted to the growth of wheat, while Denmark has but 3 per cent. so occupied, thereby resembling Scotland or Ireland, where some 4 per cent. only of the corn is wheat. Similarly, on this population basis, Austria with 320 persons, or Switzerland with 312, to the 1000 acres may be not inappropriately classed with Wales, where the density is 345. In particular, an examination of the live stock maintained by each 1000 acres of the surface in all these cases affords parallels and contrasts which are both interesting and instructive. (For table, see p. 512.)

Thus Wales bears easily the palm as regards the total stock of sheep carried, while Ireland, with a population practically bearing a similar ratio to that of Scotland to her surface, has more than three times as dense a stock of cattle and more than eight times as many pigs, although not much more than half as many sheep to the 1000 acres. Although beaten as regards the number of pigs maintained on a given area by Denmark and by Hungary, Ireland's cattle are more than twice as numerous relatively as those of France, where the population is not so very different in proportion to the soil.

Country	Per 1000 Acres of Total Area			
	Persons	Cattle	Sheep	Swine
Ireland	219	217	207	61
Scotland	220	64	390	7
Hungary	232	85	102	92
Denmark	248	186	115	88
France	293	103	164	48
Switzerland	311	132	27	57
Austria	320	117	43	48
Wales	345	147	685	50

Among countries where the areas are still greater in proportion to the resident population it may not be without interest to group together—as regards their present density—persons, cattle, sheep and swine.

Countries	Per 1000 Acres of Total Area			
	Persons	Cattle	Sheep	Swine
New South Wales ...	7	10	221	1
New Zealand	11	18	294	3
Victoria	21	32	234	6
Norway	26	13[1]	18[1]	2[1]
United States	32	19	17	17
Sweden	49	25	13	8
Russia (*ex* Poland) ...	66	20[2]	36[2]	7[2]

[1] In 1890. [2] In 1888.

Such figures serve to emphasise the vast difference between the flocks maintained in our Australasian Colonies and the other countries in this group.

The animal wealth of England by herself, omitting the Celtic fringes above quoted, may be compared with a nearer competitor. Belgium has 893 persons to 1000 acres, England 925; and Belgium has 195 head of cattle and 160 head of swine, but only 32 sheep, on an average area of this size in her little kingdom, against 144 cattle, 64 pigs, and as many as 488 sheep in England. Were the comparison to be made more closely yet, the cattle stock of Belgium agrees closely in point of density with, say, the particular division of our area comprising the north-western counties of England, which have 194 cattle to 1000 acres, or considerably more than the great butter-exporting country of Denmark, and at least a very close approach to the 197 head per 1000 acres which are to be found in the fat pastures of the Netherlands.

These limited comparisons on single points of agricultural production in single countries do not, I know, satisfy the demands which are often made for world-wide surveys and comparisons on a larger scale. I confess I somewhat distrust the strength and due coherence of the statistical bricks on which these heroic conclusions are built up. It is most usual in corn trade journals, and the practice is sometimes followed in serious debate and reproduced in the year-books of the United States Government, to give a yearly picture of at least the world's wheat crop. For the close comparison of one season with another much must depend on the sufficiency of the weakest item in the account, and weakness is sure to creep in somewhere when crops are estimated on varying systems, at different dates, and on authorities of unequal value. The definitions adopted by one calculator as to the limits of the "world" vary from those of another, and commercial estimates, as they are called, may be, at the discretion of the computer, substituted for or adopted in the absence of official data, so that the guesses at a single country's harvest may differ more widely from each other than would account for the total margin between one year's aggregate supply and another, to the confounding of satisfactory conclusions as to what is really happening. Last but not least of the obstacles to uniform grouping of harvests in complete years—ending as these years do at different periods—is the fact, not to be overlooked, that wheat harvests are being gathered somewhere in every month in the twelve.

One is driven back then to the attempt to rest opinions on the growth of one form of culture or another on recorded acreage, rather than assumed production. Yet even here a good illustration of the difficulty of any extensive compilation may be found in the tentative memorandum Sir Robert Giffen put before the last Royal Commission on Agriculture as indicating, with many necessary reservations and qualifications, the relative movements of grain area, live stock, and population in the twenty years before 1893. Briefly, the earlier totals brought into conjunction for this purpose were made up, as regards the population figures taken to represent the starting-point of 1873, from the statistics of groups of countries and colonies at dates for the most part about 1871-3, but in some instances ranging back to 1866 and on to 1881, and aggregating 365,800,000 persons. Against these were set a total of 461,800,000 persons, enumerated, for the most part, about 1890-93, but in a few instances, where later data were wanting, going back to 1880-88, the growth of population between the totals being 26 per cent.

The acreage about 1873 and about 1893, contrasted with these figures, included wheat, rye, barley and oats, but not maize—a larger crop than any of the last three. The countries contrasted were limited necessarily by the extent of information, and the list did not include all of which the population was accounted for, the increases per cent. being 28 per cent. in the case of oats, 19 per cent. in the case of wheat, 5 per cent. in the case of barley, with a decrease of 5 per cent. in rye. It should be observed, however, that the calculation as to the increase of wheat would have been much closer to that of population had not a very large area, nearly stationary in amount, been credited to India and Japan at both dates; the local population of these Asiatic countries being disregarded as, generally speaking, non-wheat-eating.

It was only as an outline pointing the direction in which inquiry might be useful that Sir Robert Giffen called attention to these figures, which, as he acknowledged, were of the roughest possible description, and rather suggestive of a closer inquiry, which should take account of the difference between the consumptive power of the countries aggregated, the varying productive power of nominally equal areas of surface, and the varying type of live stock maintained.

If the wheat acreage table, in the memorandum referred to, is examined in detail, a very effective picture of the difficulty of exact comparison as between any two given dates is incidentally presented. Out of twenty-four countries enumerated (including Canada and Australasia as units) a twenty or twenty-one years' comparison is only really effected in five cases—Russia, the United States, France, United Kingdom and Australasia. In five other instances the period dealt with is only from seventeen to eighteen years; in three other cases only fourteen or fifteen years. In Canada, Egypt and Denmark, the comparison will be found to be more limited still, and only to cover eleven or twelve years; while in the Argentine Republic, where the recent expansion of wheat-growing has been prominent, the available statistics allowed only of a comparison of two periods, no more than nine years apart. For seven other countries the wheat acreage was necessarily either omitted or inserted as presumably the same as both the earlier and the later date. Had the retrospect been confined to the cases where a twenty or twenty-one years' comparison was possible—and these, after all, included the most important and typical wheat-growing communities—the increase would have stood, not at 19, but at 24 per cent., or scarcely below that of the growth of population generally. This result is reached without taking account of any South American figures, where the increase of area is relatively much greater, or of those of India, where the comparison is difficult and the acreage growing but slightly. But, further, it is to be remembered that if the comparison of the memorandum were to be continued up to 1899, instead of stopping at 1893, the figures would have shown that wheat-growing had apparently made a new start in the five important countries for which the long comparison was possible, as many million acres having been added in the past six years as in the whole preceding twenty—a result which may afford much occasion for suspending our final judgment and no little warning of the danger of single year contrasts.

Since the above calculations were before the Commission there has been an extension of 10,000,000 acres in the official estimates of wheat areas in the United States, and 5,400,000 acres in Russia, while, although official details are still wanting beyond 1895 for Argentina, nearly 3,000,000 acres more were in that year accounted for in that republic; and there is an impression, apparently well founded, that by the present time

the total may have reached 8,000,000 acres, or nearly five million acres more than the final figure in Sir Robert Giffen's calculation. If anything like 20,000,000 acres have thus been added to the wheat-growing surface of the globe in the last five or six years, which these further figures suggest, even if no correction be made for the Indian quota, there may be much less difference than was suggested in the memorandum between the growth of population and wheat-growing.

Without attempting in any way to controvert what was one of the lessons of the memorandum I have been examining, as to the tendency to increase the numbers of cattle at a ratio above that of population, it has also to be remembered that the apparent 37 per cent. increase there shown between 1873 and 1893 may have to be discounted by subsequent deductions in the United States, in Australasia, and at the Cape in recent years; while it is one of the problems I have never yet seen satisfactorily answered, why in almost all old countries except our own the diminution of the stock of sheep seems continuous and remarkable. I mention these matters only, however, to suggest the amount of uncertainty which must attend the efforts to arrive at conclusions, made even by the highest authorities, on the only data which exist. If there is, as I have shown, such uncertainty still in the facts on which a conclusion could be built as to the past history of the relative growth of live stock, or of cereal culture and the supply of bread-stuffs, how much greater must the difficulty be of those who attempt, on the basis of such data, to forecast the course of events for a generation yet to come! I confess I am not intrepid enough to follow some of the conjectures which have been hazarded on this point, and can only, in concluding this address, recur once more to the prime qualifications for safe statistical deductions with which I opened my remarks—redoubled caution in handling calculations, a very guarded use of data giving records of single and isolated years, and a wise reservation in any prophetic pictures of the future of agricultural production, whether of wheat or cotton, in meat or in wool, of the contingency, always present, of altered conditions which ever and anon in the past have altered and falsified the predictions of earlier observers.

SECTION H.

ANTHROPOLOGY.

OPENING ADDRESS BY PROF. JOHN RHYS, M.A., LL.D., PRESIDENT OF THE SECTION.

PERHAPS I ought to begin by apologising for my conspicuous lack of qualification to fill this chair, but I prefer, with your permission, to dismiss that as a subject far too large for me to dispose of this morning. So I would beg to call your attention back for a moment to the excellent address given to this Section last year. It was full of practical suggestions which are well worth recalling: one was as to the project of a Bureau of Ethnology for Greater Britain, and the other turned on the desirability of founding an Imperial Institution to represent our vast Colonial Empire. I mention these in the hope that we shall not leave the Government and others concerned any peace till we have realised those modest dreams of enlightenment. People's minds are just now so full of other things that the interests of knowledge and science are in no little danger of being overlooked. So it is all the more desirable that the British Association, as our great parliament of science, should take the necessary steps to prevent that happening, and to keep steadily before the public the duties which a great and composite nation like ours owes to the world and to humanity, whether civilised or savage.

The difficulties of the position of the president of this Section arise in a great measure from the vastness of the field of research which the Science of Man covers. He is, therefore, constrained to limit his attention as a rule to some small corner of it; and, with the audacity of ignorance, I have selected that which might be labelled the early ethnology of the British Isles, but I propose to approach it only along the precarious paths of folklore and philology, because I know no other. Here, however, comes a personal difficulty: at any rate I suppose I ought to pretend that I feel it a difficulty, namely, that I have committed myself to publicity on that subject already. But, as a matter of fact, I can hardly bring myself to confess to any such feeling; and this leads me to mention in passing the change of attitude which I have lived to notice in the case of students in my own position. Most of us here present have known men who, when they had once printed their views on their favourite subjects of study, stuck to those views through thick and thin, or at most limited themselves to changing the place of a comma here and there, or replacing an occasional *and* by a *but*. The work had then been made perfect, and not a few great questions affecting no inconsiderable portions of the universe had been for ever set at rest. That was briefly the process of getting ready for posterity, but one of its disadvantages was that those who adopted it had to waste a good deal of time in the daily practice of the art of fencing and winning verbal victories; for, metaphorically speaking,

> "With many a whack and many a bang
> Rough crab-tree and old iron rang."

Now all that, however amusing it may have been, has been changed, and what now happens is somewhat as follows: AB makes an experiment or propounds what he calls a working hypothesis; but no sooner has AB done so than CD, who is engaged in the same sort of research, proceeds to improve on AB. This, instead of impelling AB to rush after CD with all kinds of epithets and insinuating that his character is deficient in all the ordinary virtues of a man and a brother, only makes him go to work again and see whether he cannot improve on CD's results; and most likely he succeeds, for one discovery leads to another. So we have the spectacle not infrequently of a man illustrating the truth of the poet's belief,

> "That men may rise on stepping-stones
> Of their dead selves to higher things."

It is a severe discipline in which all display of feeling is considered bad form. Of course every now and then a spirit of the ruder kind discards the rules of the game and attracts attention by having public fits of bad temper; but generally speaking the rivalry goes on quietly enough to the verge of monotony, with the net result that the stock of knowledge is increased. I may be told, however, that while this kind of exercise may be agreeable to the ass who writes, it is not conducive to the safety of the publisher's chickens. To that it might suffice to answer that the publisher is usually one who is well able to take good care of his chickens; but, seriously, what it would probably mean is, that in the matter of the more progressive branches of study, smaller editions of the books dealing with them would be required, but a more frequent issue of improved editions of them or else new books altogether, a state of things to which the publisher would probably find ways of adapting himself without any loss of profits. And after all, the interests of knowledge must be reckoned uppermost. It is needless to say that I have in view only a class of books which literary men proper do not admit to be literature at all; and the book trade has one of its mainstays, no doubt, in books of pure literature, which are like the angels that neither marry nor give in marriage: they go on for ever in their serene singleness of purpose to charm and chasten the reader's mind.

My predecessor last year alluded to an Oxford don said to have given it as his conviction that anthropology rests on a foundation of romance. I have no notion who that Oxford don may have been, but I am well aware that Oxford dons have sometimes a knack of using very striking language. In this case, however, I should be inclined to share to a certain extent that Oxford don's regard for romance, holding as I do that the facts of history are not the only facts deserving of careful study by the anthropologist. There are also the facts of fiction, and to some of those I would now call your attention. Recently, in putting together a volume on Welsh folklore, I had to try to classify and analyse in my mind the stories which have been current in Wales about the fairies. Now the mass of folklore about the fairies is of various origins. Thus with them have been more or less inseparably confounded certain divinities or demons, especially various kinds of beings associated with the rivers and lakes of the country. They are creations introduced from the workshop of the imagination; then there is the dead ancestor, who also seems to have contributed his share to the sum total of our notions about the Little People. In far the greater number of cases, however, we seem to have something historical, or, at any rate, something which may be contemplated as historical. The key to the fairy idea is that there once was a real race of people to whom all kinds of attributes, possible and impossible, have been given in the course of uncounted centuries of story-telling by races endowed with a lively imagination.

When the mortal midwife has been fetched to attend on a fairy mother in a fairy palace, she is handed an ointment which she is to apply to the fairy baby's eyes, at the same time that she is gravely warned not to touch her own eyes with it. Of course

any one could foresee that when she is engaged in applying the ointment to the young fairy's eyes one of her own eyes is certain to itch and have the benefit of the forbidden salve. When this happens the midwife has two very different views of her surroundings: with the untouched eye she sees that she is in the finest and grandest place that she has ever beheld in her life, and there she can see the lady on whom she is attending reposing on a bed, while with the anointed eye she perceives how she is lying on a bundle of rushes and withered ferns in a large cave, with big stones all round her and a little fire in one corner, and she also discovers that the woman is a girl who has once been her servant. Like the midwife we have also to exercise a sort of double vision, if we are to understand the fairies and see through the stories about them. An instance will explain what I mean: Fairy women are pretty generally represented as fascinating to the last degree and gorgeously dressed: that is how they appear through the glamour in which they move and have their being. On the other hand, not only are some tribes of some fairies described as ugly, but fairy children when left as changelings are invariably pictured as repulsive urchins of a sallow complexion and mostly deformed about the feet and legs: there we have the real fairy with the glamour taken off and a certain amount of depreciatory exaggeration put on.

Now when one approaches the fairy question in this kind of way, one is forced, it strikes me, to conclude that the fairies, as a real people, consisted of a short, stumpy, swarthy race, which made its habitations underground or otherwise cunningly concealed. They were hunters, probably, and fishermen; at any rate, they were not tillers of the ground or eaters of bread. Most likely they had some of the domestic animals and lived mainly on milk and the produce of the chase, together with what they got by stealing. They seem to have practised the art of spinning, though they do not appear to have thought much of clothing. They had no tools or implements made of metals. They appear to have had a language of their own, which would imply a time when they understood no other, and explain why, when they came to a town to do their marketing, they laid down the exact money without uttering a syllable to anybody by way of bargaining for their purchases. They counted by fives and only dealt in the simplest of numbers. They were inordinately fond of music and dancing. They had a marvellously quick sense of hearing, and they were consummate thieves; but their thievery was not systematically resented, as their visits were held to bring luck and prosperity. More powerful races generally feared them as formidable magicians who knew the future and could cause or cure disease as they pleased. The fairies took pains to conceal their names no less than their abodes, and when the name happened to be discovered by strangers the bearer of it usually lost heart and considered himself beaten. Their family relations were of the lowest order: they not only reckoned no fathers, but it may be that, like certain Australian savages recently described by Spencer and Gillen, they had no notion of paternity at all. The stage of civilisation in which fatherhood is of little or no account has left evidence of itself in Celtic literature, as I shall show presently; but the other and lower stage anterior to the idea of fatherhood at all comes into sight only in certain bits of folklore, both Welsh and Irish, to the effect that the fairies were all women and girls. Where could such an idea have originated? Only, it seems to me, among a race once on a level with the native Australians to whom I have alluded, and of whom Fraser of "The Golden Bough" wrote as follows in last year's *Fortnightly Review*: "Thus, in the opinion of these savages, every conception is what we are wont to call an immaculate conception, being brought about by the entrance into the mother of a spirit, apart from any contact with the other sex. Students of folklore have long been familiar with the notions of this sort occurring in the stories of the birth of miraculous personages, but this is the first case on record of a tribe who believe in immaculate conception as the sole cause of the birth of every human being who comes into the world. A people so ignorant of the most elementary of natural processes may well rank at the very bottom of the savage scale." Those are Dr. Fraser's words, and for a people in that stage of ignorance to have imagined a race all women seems logical and natural enough—but for no other. The direct conclusion, however, to be drawn from this argument is that some race—possibly more than one—which has contributed to the folklore about our fairies, has passed through the stage of ignorance just indicated; but as an indirect conclusion one would probably be right in supposing this race to have been no other than the very primitive one which has been exaggerated into fairies. At the same time it must be admitted that they could not have been singular always in this respect among the nations of antiquity, as is amply proved by the prevalence of legends about virgin mothers, to whom Frazer alludes, not to mention certain wild stories recorded by the naturalist Pliny concerning certain kinds of animals.

Some help to make out the real history of the Little People may be derived from the names given them, of which the most common in Welsh is that of *y Tylwyth Teg* or the Fair Family. But the word *cor*, "a dwarf," feminine *corres*, is also applied to them; and in Breton we have the same word with such derivatives as *korrik*, "a fairy, a wee little wizard or sorcerer," with a feminine *korrigan* or *korrigez*, analogously meaning a she-fairy or a diminutive witch. From *cor* we have in Welsh the name of a people called the Coranians figuring in a story in the fourteenth-century manuscript of the Red Book of Hergest. There one learns that the Coranians were such consummate magicians that they could hear every word that reached the wind, as it is put; so they could not be harmed. The name Coranians of those fairies has suggested to Welsh writers a similar explanation of the name of a real people of ancient Britain. I refer to the *Coritani*, whom Ptolemy located, roughly speaking, between the river Trent and Norfolk, assigning to them the two towns of *Lindum*, Lincoln, and *Ratae*, supposed to have been approximately where Leicester now stands. It looks as if all invaders from the Continent had avoided the coast from Norfolk up to the neighbourhood of the Humber, for the good reason, probably, that it afforded very few inviting landing-places. So here presumably the ancient inhabitants may have survived in sufficient numbers to have been called by their neighbours of a different race "the dwarfs" or *Coritani*, as late as Ptolemy's time in the second century. This harmonises with the fact that the Coritani are not mentioned as doing anything, all political initiative having long before probably passed out of their hands into those of a more powerful race. How far inland the Coritanian territory extended it is impossible to say, but it may have embraced the northern half of Northamptonshire, where we have a place-name *Pytchley*, from an earlier *Pihtes léa*, meaning "The Pict's Meadow," or else the meadow of a man called Pict. At all events, their country took in the fen district containing Croyland, where towards the end of the seventh century St. Guthlac set up his cell on the side of an ancient tumulus and was disturbed by demons that talked Welsh. Certain portions of the Coritanian country offered, as one may infer, special advantages as a home for retreating nationalities: witness as late as the eleventh century the resistance offered by Hereward in the Isle of Ely to the Norman Conqueror and his mail-clad warriors.

In reasoning backwards from the stories about the Little People to a race in some respects on a level with Australian savages, we come probably in contact with one of the very earliest populations of these islands. It is needless to say that we have no data to ascertain how long that occupation may have been uncontested, if at all, or what progress was made in the course of it: perhaps archæology will be able some day to help us to form a guess on that subject. But the question more immediately pressing for answer is, with what race outside Wales may one compare or identify the ancient stock caricatured in Welsh fairy tales? Now, in the lowlands of Scotland, together with the Orkneys and Shetlands, the place of our fairies is to some extent taken by the Picts, or, as they are there colloquially called, "the Pechts." My information about the Pechts comes mostly from recent writings on the subject by Mr. David MacRitchie, of Edinburgh, from whom one learns, among other things, that certain underground—or partially underground—habitations in Scotland are ascribed to the Pechts. Now one kind of these Pechts' dwellings appear from the outside like hillocks covered with grass, so as presumably not to attract attention, an object which was further helped by making the entrance very low and as inconspicuous as possible. But one of the most remarkable things about them is the fact that the cells or apartments into which they are divided are frequently so small that their inmates must have been of very short stature, like our Welsh fairies. Thus, though there appears to be no reason for regarding the northern Picts themselves as an undersized race, there must have been a people of that description in their country. Perhaps archæologists may succeed in classifying the ancient

habitations in the North accordingly: that is, to tell us what class of them were built by the Picts and what by the Little People whom they may be supposed to have found in possession of that part of our island.

In Ireland and the Highlands of Scotland the fairies derive their more usual appellations from a word *síd* or *sídh* (genitive *síde*), which may perhaps be akin to the Latin *sēdes* and have meant a seat, settlement, or station; but whatever its exact meaning may have originally been, it came to be applied to the hillocks or mounds within which the Little People made their abodes. Thus, *Aes Síde* as a name for the fairies may be rendered by mound people or hill folk; *fer síde*, "a fairy man," by a mound man; and *ben síde* by a mound woman or banshee. They were also called simply *síde*, which would seem to be an adjective closely allied with the simpler word *síd*.

But to leave this question of their names, let me direct your attention for a moment to one of the most famous kings of the fairies of ancient Erin: he was called Mider of Brí Leith, said to be a hill to the west of Ardagh, in the present county of Longford. There he had his mound, to which he once carried the queen of Eochaid Airem, monarch of Ireland. It was some time before Eochaid could discover what had become of her, and he ordered Dálan, his druid, to find it out. So the druid, when he had been unsuccessful for a whole year, prepared four twigs of yew and wrote on them in Ogam. Then it was revealed to him through his keys of seership and through the Ogam writing that the queen was in the *síd* of Brí Leith, having been taken thither by Mider. By this we are probably to understand that the druid sent forth the Ogam twigs as letters of inquiry to other druids in different parts of the country; but in any case he was at last successful, and his king hurried at the head of an army to Brí Leith, where they began in earnest to demolish Mider's mound. At this Mider was so frightened that he sent the queen forth to her husband, who then departed, leaving the fairies to digest their wrath; for it is characteristic of them that they did not fight, but bided their time for revenge, which in this case did not come till long after Eochaid's day. Now, with regard to the fairy king, one is not told, so far as I can call to mind, that he was a dwarf, but the dwarfs were not far off; for we read of an Irish satirist who is represented as notorious for his stinginess; and to emphasise the description of his inhospitable habits he is said to have taken from Mider three of his dwarfs and stationed them around his own house, in order that their truculent looks and rude words might repel any of the men of Erin who might come seeking hospitality or bring any inconvenient request. The word used for dwarf in this story is *corr*, which is usually the Irish for a crane or heron, but here, and in some other instances, which I cannot now discuss, it seems to have been identical with the Brythonic *cor*, "a dwarf." It is remarkable, moreover, that the *rôle* assigned to the three Irish *corrs* is much the same as that of the dwarf of Edeyrn son of Nudd in the Welsh story of *Geraint and Enid* and Chrétien de Troies' *Erec*, which characterises him as *fel et de put'eire*, "treacherous and of an evil kind."

By way of summarising these notes on the Mound Folk I may say that I should regard them as isolated and wretched remnants of a widely spread race possessing no political significance whatever. But, with the inconsistency characteristic of everything connected with the fairies, one has on the other hand to admit that this strange people seems to have exercised on the Celts—probably on other races as well—a sort of permanent spell of mysteriousness and awe stretching to the verge of adoration. In fact, Irish literature states that the pagan tribes of Erin before the advent of St. Patrick used to worship the *síde* or the fairies. Lastly, the Celt's faculty of exaggeration, combined with his incapacity to comprehend the weird and uncanny population of the mounds and caves of his country, has enabled him, in one way or another, to bequeath to the great literatures of Western Europe a motley train of dwarfs and little people, a whole world of wizardry, and a vast wealth of utopianism. If you subtracted from English literature, for example, all that has been contributed to its vast stores from this native source, you would find that you left a wide and unwelcome void.

But the question must present itself sooner or later, with what race outside these islands we are to compare or identify our mound-dwellers. I am not prepared to answer, and I am disposed to ask our archæologists what they think. In the meantime, however, I may say that there are several considerations which impel me to think of the Lapps of the North of Europe. But even supposing an identity of origin were to be made out as between our ancient mound-inhabiting race and the Lapps, it would remain still doubtful whether we could expect any linguistic help from Lapland. The Lapps now speak a language belonging to the Ugro-Finnic family, but the Lapps are not of the same race as the Finns; so it is possible that the Lapps have adopted a Finnish language, and that they did so too late for their present language to help us with regard to any of our linguistic difficulties. One of these lies in our topography: take for instance only the names of our rivers and brooks—there is probably no county in the kingdom that would be too small to supply a dozen or two which would baffle the cleverest Aryan etymologist you could invite to explain them; and why? Because they belong in all probability to a non-Celtic, non-Aryan language of some race that had early possession of our islands. Nevertheless it is very desirable that we should have full lists of such names, so as to see which of them recur and where. It is a subject deserving the attention of this Section of the British Association.

We have now loitered long enough in the gloom of the Pecht's house: let us leave the glamour of the fairies and see whether any other race has had a footing in these islands before the coming of the Celts. In August 1891 Prof. Sayce and I spent some fine days together in Kerry and other parts of the south-west of Ireland. He was then full of his visits to North Africa, and he used to assure me that, if a number of Berbers from the mountains had been transferred to a village in Kerry and clad as Irishmen, he would not have been able to tell them by their looks from native Irishmen such as we saw in the course of our excursions. This seemed to me at the time all the more remarkable, as his reference was to fairly tall blue-eyed persons whose hair was rather brown than black. Evidence to the same effect might now be cited in detail from Prof. Haddon and his friends' researches among the population of the Arran Islands in Galway Bay. Such is one side of the question which I have in my mind: the other side consists in the fact that the Celtic languages of to-day have been subjected to some disturbing influence which has made their syntax unlike that of the other Aryan languages. I have long been of opinion that the racial interpretation of that fact must be, that the Celts of our islands have assimilated another race using a language of its own in which the syntactical peculiarities of Neo-Celtic had their origin; in fact that some such race clothed its idioms in the vocabulary which it acquired from the Celts. The problem then was to correlate those two facts. I am happy to say this has now been undertaken from the language point of view by Prof. J. Morris Jones, of the University College of North Wales. The results have been made public in a book on The Welsh People recently published by Mr. T. Fisher Unwin. The paper is entitled "Pre-Celtic Syntax in Insular Celtic," and the languages which have therein been compared with Celtic are old Egyptian and certain dialects of Berber. It is all so recent that we have as yet had no criticism, but the reasoning is so sound and the arguments are of so cumulative a nature, that I see no reason to anticipate that the professor's conclusions are in any danger of being overthrown.

At the close of his linguistic argument, Prof. Morris Jones quotes a French authority to the effect, that, when a Berber king dies or is deposed, which seems to happen often enough, it is not his son that is called to succeed him, but the son of his sister, as appears to have been usual among certain ancient peoples of this country; but of this more anon. In the next place my attention has been called by Prof. Sayce to the fact that ancient Egyptian monuments represent the Libyans of North Africa with their bodies tattooed, and that even now some of the Touaregs and Kabyles do the same. These indications help one to group the ancient peoples of the British Isles to whose influence we are to ascribe the non-Aryan features of Neo-Celtic. In the first place one cannot avoid fixing on the Picts, who were so called because of their habit of tattooing themselves. For as to that fact there seems to be no room for doubt, and Mr. Nicholson justly lays stress on the testimony of the Greek historian Herodian, who lived in the time of Severus, and wrote about the latter's expedition against the natives of North Britain a long time before the term *Picti* appears in literature. For Herodian, after saying that they went naked, writes about them to the following effect: "They puncture their bodies with coloured designs and the figures of animals of all kinds, and it is for this reason that they do not wear clothes, lest one should not behold the designs on their

bodies." This is borne out by the names by which the Picts have been known to the Celts. That of *Pict* is itself in point, and I shall have something to say of it presently; but one of the other names was in Irish *Cruithni*, and in Welsh we have its etymological equivalent in *Prydyn* or *Prydain*. These vocables are derived respectively from Irish *cruth* and Welsh *pryd*, both meaning shape, form, or figure, and it is an old surmise that the Picts were called by those names in allusion to the animal forms pricked on their bodies, as described by Herodian and others. The earlier attested of these two names may be said to be Prydyn or Prydain, which the Welsh used to give in the Middle Ages to the Picts and the Pictland of the North, while the term *Ynys Prydain* was retained for Great Britain as a whole, the literal meaning being the island of the Picts: that is the only name which we have in Welsh to this day for this island in which we live—*Ynys Prydain*, "The Picts' Island." Now one detects this word Prydain in effect in the Greek Πρεταvικαί Νῆσοι given collectively to all the British Isles by ancient authors, such as Strabo and Diodorus. It may be rendered the Pictish Islands, but a confusion seems to have set in pretty early with the name of the Brittanni or Brittones of South Britain: that is to say, *Pretanic*, "Pictish," became *Brittannic* or British; and this is, historically speaking, the only known justification we have for including Ireland in the comprehensive term "The British Isles," to which Irishmen are sometimes found jocularly to object.

In the next place may be mentioned the Tuatha Dé Danann of Irish legend, which cannot always be distinguished from the Picts, as pointed out by Mr. MacRitchie. The tradition about them is, that, when they were overcome in war by Míl and his Milesians, they gave up their life above ground and retired into the hills like the fairies, a story of little more value than that of the extermination of the Picts of Scotland. In both countries doubtless the more ancient race survived to amalgamate with its conquerors. There was probably some amount of amalgamation between the Tuatha Dé Danann or the Picts and the Little Moundsmen; but it is necessary not to confound them. The Tuatha shared with the Little People a great reputation for magic; but they differed from them in not being dwarfs or of a swarthy complexion: they are usually represented as fair. In the case of Mider, the fairy king, who comes in some respects near the description of the heroes of the Tuatha Dé Danann, it is to be noticed that he was a wizard, not a warrior.

Guided by the kinship of the name of the Tuatha Dé *Danann* on the Irish side of the sea and that of the Sons of *Dôn* on this side, I may mention that the Mabinogion place the Sons of Dôn on the seaboard of North Wales, in what is now Carnarvonshire: more precisely their country was the region extending from the mountains to the sea, especially opposite Anglesey. In that district we have at least three great prehistoric sites all on the coast. First comes the great stronghold on the top of Penmaen Mawr; then we have the huge mound of Dinas Dinlle, eaten into at present by the sea south-west of the western mouth of the Menai Straits; and lastly there is the extensive fortification of Tre'r Ceiri, overlooking Dinlle from the heights of the Eifl. By its position Tre'r Ceiri belonged to the Sons of Dôn, and by its name it seems to me to belong to the Picts, which comes, I believe, to the same thing. Now the name Tre'r Ceiri means the town of the Keiri, and the Welsh word *ceiri* is used in the district in the sense of persons who are boastful and ostentatious, especially in the matter of personal appearance and fine clothing. It is sometimes also confounded with *cewri*, "giants," but in the name of Tre'r Ceiri it doubtless wafts down to us an echo of the personal conceit of the ancient Picts with their skins tattooed with decorative pictures; and Welsh literature supplies a parallel to the name *Ynys Prydain* in one which is found written *Ynys y Ceuri*, both of which may be rendered equally the Island of the Picts, but more literally perhaps some such rendering as "the Island of the Fine Men" would more nearly hit the mark. Lastly, with the Sons of Dôn must probably be classed the other peoples of the Mabinogion, such as the families of Llyr, and of Pwyll and Rhiannon.

All these peoples of Britain and Ireland were warlike, and such, so far as one can see, that the Celts, who arrived later, might with them form one mixed people with a mixed language, such as Prof. Morris Jones has been helping to account for.

Let us now see for a moment how what we read of the state of society implied in the stories of the Mabinogion will fit into the hypothesis which I have roughly sketched. In the first place I ought to explain that the four stories of the Mabinogion were probably put together originally in the Goidelic of Wales before they assumed a Brythonic dress. Further, in the form in which we know them, they have passed through the hands of a scribe or editor living in Norman times, who does not always appear to have understood the text on which he was operating. To make out, therefore, what the original Mabinogion meant, one has every now and then to read, so to say, between the lines. Let us take, for example, the Mabinogi called after Branwen, daughter of Llyr. She was sister to Brân, king of Prydain, and to Manawyddan, his brother: she was given to wife to an Irish king named Matholwch, by whom she had a son called Gwern. In Ireland, however, she was, after a time, disgraced, and served in somewhat the same way as the heroine of the Gudrun Lay; but in the course of the time which she spent in a menial position, doing the baking for the Court and having a box on the ear administered to her daily by the cook, she succeeded in rearing a starling, which one day carried a letter from her to her brother Brân at Harlech. When the latter realised his sister's position of disgrace, he headed an expedition to Ireland, whereupon Matholwch tried to appease him by making a concession, which was, that he should deliver his kingdom to the boy Gwern. Now the question is, wherein did the concession consist? The redactor of the Mabinogi could, seemingly, not have answered, and he has not made it the easier for any one else to answer. In the first place, instead of calling Gwern son of Matholwch, he should have called him Gwern son of Branwen, after his mother, for the key to the sense is, that, in a society which reckoned birth alone, Gwern was not recognised as any relation to Matholwch at all, whereas, being Brân's sister's son, he was Brân's rightful heir. No such idea, however, was present to the mind of a twelfth-century scribe, nor could it be expected.

Let us now turn to Irish literature, to wit, to one of the many stories associated with the hero Cúchulainn. He belonged to Ulster, and whatever other race may have been in that part of Ireland, there were Picts there: as a matter of fact Pictish communities survived there in historical times. Now Cúchulainn was not wholly of the same race as the Ultonians around him, for he and his father are sharply marked off from all the other Ultonians as being free from the periodical illness connected with what has been called the couvade, to which the other adult braves of Ulster succumbed for a time every year. Then I may mention that Cúchulainn's baby name was *Setanta Beg*, or the Little Setantian, which points to the country whence Cúchulainn's father had probably come, namely, the district where Ptolemy mentions a harbour of the Setantii, somewhere near the mouth of the Ribble, in what is now Lancashire. At the time alluded to in the story I have in view, Cúchulainn was young and single, but he was even then a great warrior, and the ladies of Ulster readily fell in love with him; so one day the nobles of that country met to consider what was to be done, and they agreed that Cúchulainn would cause them less anxiety if they could find him a woman who should be his fitting and special consort. At the same time also that they feared he might die young, they were desirous that he should leave an heir, "for," as it is put in the story, "they knew that it was from himself his rebirth would be." The Ulster men had a belief, you see, in the return of the heroes of previous generations to be born again; but we have here two social systems face to face. According to the one to which Cúchulainn as a Celt belonged, it was requisite that he should be the father of recognised offspring, for it was only in the person of one of them or of their descendants that he was to be expected back. The story reads as if the distinction was exceptional, and as if the prevailing state of things was wives more or less in common, with descent reckoned according to birth alone. Such is my impression of the picture of the society forming the background to the state of things implied by the conversation attributed to the noblemen of Ulster. Here again one experiences difficulties arising from the fact that the stories have been built up in the form in which we know them by men who worked from the Christian point of view, and it is only by scrutinising, as it were, the chinks and cracks that you can faintly realise what the original structure was like.

Among other aids to that end one must reckon the instances of men being designated with the help of the mother's name, not the father's: witness that of the King of Ulster in Cúchulainn's time, namely Conchobar mac Nessa, that is to say, Conor, son of a mother named Nessa; similarly in Wales with Gwydion son of Dôn. Further we have the help of a considerable number of ancient inscriptions, roughly guessed to date from the fifth or

sixth century of our era, and commemorating persons traced back to a family group of the kind, perhaps, which Cæsar mentions in the fourteenth chapter of his fifth book. Within these groups the wives were, according to him, in common (*inter se communes*). Take for instance an inscription from the barony of Corcaguiny in Kerry, which commemorates a man described as "Mac Erce, son of *Muco Dovvinias*," where *Muco Dovvinias* means the clan or family group of *Dovvinis* or *Dubin* (genitive *Duibne*), the ancestress after whom Corcaguiny is called *Corco-Duibne* in Medieval Irish. We have the same formula in the rest of Ireland including Ulster, where as yet very few Ogams have been found at all. It occurs in South Wales and in Devonshire, and also on the Ogam stone found at Silchester, in Hampshire. The same kind of family group is evidenced also by an inscription at St. Ninian's, in Galloway; and, to go further back—perhaps a good deal further back—we come to the bronze discovered not long ago at Colchester, and dating from the time of the Emperor Alexander Severus, who reigned from 222 to 235. This is a votive tablet to a god Mars Medocius, by a Caledonian Pict, who gives his name as Lossio Veda, and describes himself further as *Nepos Vepogeni Caledo*. He alludes to no father, and *Nepos Vepogeni* is probably to be rendered Vepogen's sister's son. At any rate, the Irish word corresponding etymologically to the Latin *nepos* has that sense in Irish; but so far as I know it has never been found meaning a nephew in the sense of brother's son. That may serve as an instance how the ideas of another race penetrated the fabric of Goidelic society; for here we must suppose a time to have come when there was no longer any occasion for a word meaning a brother's son, which, of course, there never was in the non-Celtic society which ranked men and women according to their birth alone.

Now this Caledonian Pict was not exceptional among his kinsmen, for they succeeded in observing a good deal of silence concerning their fathers down, one may say, to the twelfth century. It is historical that the king of the northern Picts was not wont to be the son of the previous king. In short, when the Celtic elements there proved strong enough to ensure that the son of a previous king should succeed, a split usually took place, the purer Picts being led by the rule of succession by birth to set up a king of their own. The fact is not so well known that the same succession prevailed also some time or other at Tara in Ireland: it is proved by a singular piece of indirect evidence, the existence of a tragic story to explain why "no son should ever take the lordship of Tara after his father, unless some one came between them." The last clause is due, I should say, to somebody who could not understand such a prohibition based on the ancient rule that a man's heir was his sister's son. This would be, according to Irish legend, in the lifetime of Conor mac Nessa.

It is curious to notice how the stories about the Pictish *ménage* seemed to have puzzled ancient authors. I will only cite one instance, to wit, from Golding's sixteenth century translation of what then passed as the production of Solinus, and what may now pass, even according to Mommsen, as quite old enough for my present purpose. It runs thus: "From the Promontorie of *Calydon* to the Iland *Thule* is two dayes sayling. Next come the Iles called *Hebudes*, five in number, the inhabiters whereof know not what corne meaneth, but liue onely by fishe and milke. They are all vnder the gouernment of one King. For as manie of them as bee, they are seuered but with a narrowe groope one from another. The King hath nothing of hys own, but taketh of euery mans. He is bounde to equitie by certaine lawes: and least he may start from right through couetousnesse, he learneth Justice by pouertie, as who may have nothing proper or peculiar to himselfe, but is found at the charges of the Realme. Hee is not suffered to haue anie woman to himselfe, but whomsoeuer he hath minde vnto, he borroweth her for a tyme, and so others by turnes. Wherby it commeth to passe that he hath neither desire nor hope of issue."

The man who wrote in that way presumably failed to see that the king was not subject to any special hardship as compared with the other men in his kingdom, where none of them had any offspring that he could individually call his own. This, be it noticed, refers to the Hebrides, not, as sometimes happens, to the more distant island of Thule, where there was also a king, as any reader of "Faust" will tell us.

We now come to the Celts, and begin with Pliny's version of Cæsar's words about the division of Gaul into three parts, as follows: *Gallia omnis Comata uno nomine appeliata in tria populorum genera dividitur, amnibus maxime distincta. A Scalde ad Sequanam Belgica, ab eo ad Garunnam Celtica eademque Lugdunensis, inde ad Pyrenaei montis excursum Aquitanica, Aremorica antea dicta.* We may for the present dismiss the third or Aquitanic Gaul from our minds; but Belgic and Celtican Gaul may be taken as representing the two sets of Celts of our own islands. The Belgic Gauls began last to come to this country, and their advent seems to fall between the visits of Pytheas and Julius Cæsar: that is, roughly speaking, between the middle of the fourth century and that of the first century B.C. In this country they came to be known collectively as Brittanni or Brittones, the linguistic ancestors of the people who have spoken Brythonic or the *Lingua Brittannica*, such as the Welsh, the Cornish, and the Strathclyde Britons. As to the others Celts, it is much harder to say when or whence exactly they came—I mean the linguistic ancestors of the Gaels of Ireland, Man, and Scotland, that is to say, the peoples whose language has been Goidelic. Some scholars are of opinion that there were no Goidelic-speaking peoples in Britain till some such came here from Ireland on sundry occasions, beginning with the second century, in the time of the Roman occupation, but how the Goidels would be supposed by them to have reached Ireland I do not exactly know. My own notion is that the bulk of them reached that country by way of Britain, and that they arrived in Britain, like the Belgic Gauls later, from the nearest parts of the Continent; for this would be previous to the appearance of the Belgic Gauls on the western sea-board of Europe: that is to say, at a time when Celtica extended not merely to the Seine, but to the Scheldt or to the Rhine, if not further. Then as to the time of the coming of the ancestors of the Goidels, it has been supposed coincident with a period of great movements among the Celts of the Continent, in particular the movements which resulted, among other things, in some of them reaching the shores of the Mediterranean and penetrating to the heart of the Iberic peninsula. Perhaps one would not be far wrong in fixing on the seventh and the sixth centuries B.C. as covering the time of the coming of the earlier Celts to our shores.

In Britain I should suppose these earlier hordes of Celts to have conquered most of the southern half of the island; and the Brythonic Celts, when they arrived, may have overrun much the same area, pushing the Goidelic Celts more and more towards the west. Under that pressure it is natural to suppose that some of the latter made their way to Ireland, but it is quite possible that their emigration thither had begun before. Some time or other previous to the Roman occupation the Brythonic people of the Ordovices seem to have penetrated to the sea between the rivers Dovey and Mawddach, displacing probably some Goidels who may have gone to the opposite coasts of Ireland; but more traces in Irish story appear of invasions on the part of the Dumnonii, who possessed the coast between Galloway and Argyle. These were so situated as to be able to assail Ireland both in front and from behind, and this is countenanced to some extent by Irish topography, not to mention the long legends extant as to great wars in the west of Ireland between the Tuatha Dé Danann and invaders including the Fir Domnann. I suspect also that it was the country of these northern Dumnonians which was originally meant by Lochlinn, a name interpreted later to mean Norway.

Such are some of the faint traces of the Goidelic invasions of Ireland from Britain, but it is possible—perhaps probable—that Ireland received settlers on its southern coast from the north-west of Gaul at a comparatively late period, at the time, let us say, when Cæsar was engaged in crushing the Veneti and the Aremoric League. This has been suggested to me by the name of the Usdiæ, which probably survives in the first syllable of *Ossory*, denoting a tract of country now, roughly speaking, covered by the county of Kilkenny, but which may have been considerably larger before the Déisi took possession of the baronies of the two Decies and other districts now constituting the county of Waterford, not to mention possible encroachments on the part of Munster on a boundary which seems to have been sometimes contested. Now the Continental name which invites comparison with that of the Usdiæ is that of the Ostiæi, who in the time of Pytheas appear to have occupied the north-western end of what afterwards came to be called Brittany; they were also called Ostiones, and more commonly Osismi. I see no reason to suppose that the ships of the Aremoric League could not

make the voyage from Brittany to the principal landing-places on the south of Ireland from the Harbour of Cork to that of Waterford, and I gather from Ptolemy's Geography that Ireland was relatively better known on the Continent than Britain, although the latter had been in a manner connected with the Roman world. This I should explain somewhat as follows:—Cæsar, who knew very little about the west of Britain and probably less about Ireland, says that in his time the great druidic centre of Gaul was in the country of the Carnutes, somewhere, let us say, near the site of the present town of Chartres, that druidism had been introduced from Britain to Gaul, and that those who wished to understand it had to go to Britain to study. The authors of antiquity tell us otherwise nothing about druids in Britain except that Tacitus speaks of such in the Annals, in his well-known passage as to Suetonius Paulinus landing with his troops in Anglesey and the scene of slaughter which ensued. Indeed, one may go further and say that there is no proof that any Belgic or Brythonic people ever had druids: they belonged to the Celtican Gauls and the Goidelicising Celts of Britain and Ireland, who had probably accepted the institution from the Pictish race. At any rate it is significant that the Life of St. Columba introduces the reader to a genuine druid at the court of the Pictish king, near Inverness, where, as well as on Loch Ness, the saint had to contend with him. In any case, it is highly probable that druidism was no less a living institution in Ireland than in the Goidelic and Pictish parts of Britain. Presumably it was more so, and it may be conjectured that Gaulish students of druidism visited Ireland no less than Britain; also, *vice versâ*, that Irish druids paid visits to the Celtican part of Gaul where druidism flourished on the Continent, and in a word that there was regular intercourse between Gaul and the south of Ireland. If the druids of Ireland, who, among other *rôles*, played that of schoolmasters and teachers in that country, travelled to Celtica, they must have spread on the Continent some information about their native country, while generations of them cannot have returned to Ireland, with their druidic pupils, without bringing with them some of the arts of civilised life as understood in Gaul: among these one must rank very decidedly the art of writing, which the druids practised. Now you know the usual account given of the ordinary Latin for Ireland, namely *Hibernia*—to wit, that it was suggested by such native names as that of one of the greatest tribes of that country, namely the Ἰούερνοι or *Iverni*, and that it had its *v* ousted when Latin began about the fourth century to write *b* for *v*, and that an *h* was then prefixed to make the word *Hibernia* properly connote the wintry climate which our sister island had always been supposed to enjoy. But now comes the question, where did Pomponius Mela, who flourished about the middle of the first century, get his *Iuverna*, which Juvenal also used? Doubtless from a druid like Dálan, or some other educated native of Ireland, for what the editors print as *Iuverna*, *Iuuerna*, or *Juverna* would appear in ancient manuscripts as *IVVERNA* or *iuuerna*, in which the first two syllables are spelt correctly with *v v* according to a system of spelling well known in Ogmic writing centuries later. But a particular system of spelling seems to me to imply writing, and thus one is encouraged to think that the Ogam alphabet may have been invented no later than the first century in the intercourse I have conjectured to have been going on between the north-west of Gaul and the south of Ireland, where the majority of Ogam inscriptions are now found. But what has archæology to say on the question of such intercourse?

After this digression I come back to the two main streams of Celtic immigration from the same parts of the Continent in two different periods of time. The later of these introduced the *Lingua Brittannica*, which was practically a dialect of old Gaulish; but the affinities of the other Celtic language of these islands, the Goidelic, are not so easy to determine. I have long thought that I can identify traces of it on the Continent, and that its principal home was in the region which Pliny called Celtica, between the Garonne and the Seine. I ventured accordingly to call it *Celtican*, as the simpler word *Celtic* had already been wedded to a wider signification. Since then the existence of that language has been placed beyond doubt by the discovery of fragments of a calendar engraved on bronze tablets. This find was made about the end of 1897 at a place called Coligny, in the department of the Ain, and the pieces are now in the museum at Lyons. It is difficult to say for certain whether Coligny is within the territory once occupied by the Sequani, or else by the Ambarri, a people subject to the Ædui, who were rivals of the Sequani and Arverni. The name of the Sequani would seem to have belonged to the Celtican language, and Mr. Nicholson, in his interpretation of the calendar, has ventured in this instance to call it Sequanian. But two inscriptions in what appears to be the same language have come to light also at a place called Rom, in the Deux Sèvres and on the Roman road from Poitiers to Saintes. This Celtican language is to be carefully distinguished from Gaulish, but it is not exactly what I expected it to be: it is better. For several of the phonetic changes characteristic of Goidelic had not taken place in Celtican. Among other things it preserves intact the Aryan consonant *p*, which has since mostly disappeared in Goidelic, as it had even then in Gaulish. This greater conservatism of Celtican enables one to refer to it the national appellation of the people of the region in question, namely, that of the *Pictones*, from which it is impossible to sever the name of the Picts of Britain and Ireland, who are found also called *Pictones* and *Pictanei*. Here I may mention that Mr. Nicholson calls attention to instances of tattooing on some of the faces on ancient coins belonging to Poitou and other parts of western France. In the light of the names here in question one sees that *pictos* was a Celtican word of the same etymology, and approximately, doubtless, of the same meaning, as the Latin word *pictus*, that the Celticans had applied it at an early date to the Picts on account of their habit of tattooing themselves, and that the Picts had accepted it (with its derivative *Pictones*) so generally that by the time when the Norsemen arrived in the North of Scotland, it was the name which the natives gave them as that by which they called themselves. That is practically proved by the Norsemen calling Caithness and Sutherland *Petta-land* or the Land of the Picts, and the sea washing its northern shore *Pettalands fiorth*, which survives modified into Pentland Firth.

Another Celtican word of great interest here has by a mere chance come down in a high German manuscript written before the year 814; it is *Chortonicum*, and occurs among a number of geographical names, several of which refer to Gaul, so that Chortonicum may very well have meant the country of the Pictones. At all events, the great German philologist, Pott, at once saw that it was to be explained by reference to the word Cruithne, "a Pict," with which it decidedly goes as distinguished from its Brythonic equivalent *Prydyn* (or the older *Priten*), with an initial *p*. The Celtican form originally meant was some such vocable as Qurtonico-n, with the *qu* which was usual in Celtican and early Goidelic, where it formed, in fact, one of the most conspicuous distinctions between those languages and Brythonic or Gaulish, in which *qu* had been changed into *p*.

My remarks have again run into tiresome details, but it is only by attending to such small points that one can hope to force language to yield us any information in the matter of ethnology. It may perhaps help in some measure if I sum up what I have been trying to say, thus:

The first race we have found in possession of the British Isles consisted of a small, swarthy population of mound-dwellers, of an unwarlike disposition, much given to magic and wizardry, and perhaps of Lappish affinities: its attributes have been exaggerated or otherwise distorted in the evolution of the Little People of our fairy tales.

The next race consisted of a taller, blonder people, with blue eyes, who tattooed themselves and fought battles. These tattooed or Pictish people made the Mound Folk their slaves, and in the long run their language may be supposed to have been modified by habits of speech introduced by those slaves of theirs from their own idiom. The affinities of these Picts may be called Libyan, and possibly Iberian.

Next came the Celts in two great waves of immigration, the first of which may have arrived as early as the seventh century before our era, and consisted of the real ancestors of some or our Goidels of the Milesian stock, and the linguistic ancestors of all the peoples who have spoken Goidelic. That language may be defined as Celtican so modified by the idioms of the population which the earlier Celts found in possession that its syntax is no longer Aryan.

Then, about the third century B.C., came from Belgica the linguistic ancestors of the peoples who have spoken Brythonic; but, in the majority of cases connected with modern Brythonic, they are to be regarded as Goidels who adopted Brythonic speech, and in so doing brought into that language their Goidelic idioms, with the result that the syntax of insular Brythonic is no less non-Aryan than that of Goidelic, as may

be readily seen by comparing the thoroughly Aryan structure of the few sentences of old Gaulish extant.

Those are the races which have been inferred in the course of these remarks, in which I have proceeded on the principle that each successive band of conquerors has its race, language and institutions eventually more or less modified by contact with the race, language and institutions of those whom it has conquered. That looks simple enough when stated so, but the result which we get proves complicate. In any case I have endeavoured in this address to substitute for the rabble of divinities and demons, of fairies and phantoms that disport themselves at large in Celtic legend, a possible series of peoples, to each of which should be ascribed its own proper attributes. But that will only be possible if we can enlist the kindly aid of the Muse of Archæology.

THE INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.

THIS congress was held in Paris during the last week of July, M. Moissan being president and M. Berthelot honorary president. The work was divided into ten sections: analytical chemistry, chemical industry of inorganic products, metallurgy, mines and explosives, chemical industry of organic products, the sugar industry, chemical industry of fermentation, agricultural chemistry, hygiene, food analysis, medical and pharmaceutical chemistry, photography, and electrochemistry. More than two hundred papers were read and discussed, and numerous resolutions were passed, of which the following were the most important. In view of the great inconvenience caused commercially by uncertainty in the atomic weights used by analytical chemists, the congress, hoping that the adoption of the atomic weight of oxygen as a base (O = 16) would lead to a greater certainty and to a simplification in the calculation of atomic weights, agreed to work in unison with the International Commission on atomic weights. It further suggested the necessity for an International Commission for fixing methods and coefficients of analysis in commercial work. Committees were also appointed to deal with questions of indicators in volumetric work, analysis of manures, potash estimation, and the use of sulphurous acid in wine. In the second section the chief questions dealt with were the determination of high temperatures, construction of glass and porcelain furnaces, the manufacture of sulphuric acid, and of barium and hydrogen peroxides. In the section of metallurgy, mines and explosives, papers were read dealing with the sampling of minerals, the constitution of iron and steel, the use of the microscope in the study of metals, utilisation of waste heat, and the estimation of sulphur, manganese and phosphorus in metals. In the section dealing with the industry of organic substances the most important discussion was on the use of alcohol for other than drinking purposes, and a series of resolutions was passed stating that in the opinion of the congress no duty should be charged upon alcohol used in the preparation of pharmaceutical and chemical products. In the case of alcohol intended for use as fuel, the substances added should be of a character appropriate to its use, not too costly, and not containing any non-volatile substance. Any attempt to recover pure alcohol from methylated spirit should be liable to severe penalties, and all makers of stills should be compelled to give particulars to the excise authorities of stills sold or repaired. In the other sections discussions were held on the relation of the sugar industry to the State, the methods of analysis of wines and spirits, the carbide industry, manufacture of percarbonates, and numerous other papers of interest.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

IT is officially announced that Mr. L. R. Wilberforce, demonstrator in physics at the Cavendish Laboratory, Cambridge, and University lecturer in physics, has been appointed to the Lyon Jones chair of experimental physics at University College, Liverpool, vacated by the removal of Dr. Oliver Lodge to the University of Birmingham.

THE Admiralty has created an important new post in the Dockyard staff, namely, that of electrical engineer, to rank next to the four chief assistant engineers. To fill this post the Admiralty has chosen Mr. Louis J. Steele, M.I.E.E., late chief engineer of Messrs. Verity, and formerly assistant engineer with Messrs. Johnson and Phillips. Mr. Steele received his training at the Technical College, Finsbury, under Prof. Silvanus Thompson and Prof. Perry, and carried off the certificate of the College in 1890. He will be attached to the Dockyard staff at Portsmouth.

INSTRUCTION in chemistry is well provided for at the Goldsmiths' Institute, New Cross. During the session about to commence, Mr. W. J. Pope will give courses of lectures on oils, fats and waxes, organic chemistry with special reference to recent work and current views, inorganic chemistry and stereochemistry. In this last course of lectures, the principles which form the foundation of stereochemistry will be discussed, together with the methods which have led to the discovery of stereoisomerism amongst compounds of carbon, nitrogen, tin and sulphur. Particular attention will be paid to the bearing of stereochemistry upon current chemical problems. Lectures in chemistry will also be given by Mr. Stanley J. Peachey.

DURING the past year the Degree of Doctor of Philosophy was conferred by twenty-two Universities in the United States upon 233 candidates. The distribution of these degrees among the various Universities, and the subjects taken, are dealt with in an article in *Science*. It appears that 120 of the degrees were granted to students of the humanities, and 113 for scientific subjects. The tables show that the humanities are favoured at Havard and Yale Universities, and the sciences at Johns Hopkins, Columbia and Cornell Universities. Last year Johns Hopkins gave more than its proportionate share of degrees in chemistry, physics, zoology and physiology, Chicago in mathematics, geology, sociology and education, Harvard in physics, zoology and anthropology, Columbia in astronomy, botany, zoology and education, Yale in palæontology and psychology, Cornell in botany and psychology, and Clark in mathematics, psychology and education. The six science subjects in which most students presented theses are as follows:—Chemistry 26, physics 15, botany 12, mathematics 11, zoology 11, psychology 9.

EVER since the funds were provided for technical education in this country, it has been insisted upon in these columns, and by men of science generally, that such education could only be profitably carried on by giving rational instruction in scientific principles instead of attempting to teach actual processes and trade methods, which are constantly in a state of flux on account of new developments. The most gratifying characteristic of educated opinion at the present time is the acceptance of this view; and it is especially noteworthy in connection with the substitution of nature study for agriculture in rural schools. In an address recently delivered before the Cheshire College of Agriculture, Prof. Robert Wallace dwelt upon the relation between the work of an agricultural school and actual farm work, and showed himself in complete sympathy with the view which has been expressed over and over again in these columns. Here is the case in a few words:—"What a young farmer should learn is not ordinary farm work, viz. to plough and harrow a given area in the day. He can become an expert at that kind of thing at home to greatest advantage, without cost for instruction, and at the same time prove a valuable aid to his father. He requires to be taught just those things which are not to be learned on an ordinary farm, to have explained to him the meaning of processes which are founded on scientific principles, and to become familiar with the common facts of those sciences which bear upon agricultural practice." If this had been borne in mind by Technical Instruction Committees in rural districts from the time they came into existence, their efforts would have received more encouragement from practical men, and have been attended with better results, than have been attained in many cases.

SCIENTIFIC SERIALS.

Transactions of the American Mathematical Society, vol. i. No. 3.—Wave propagation over non-uniform electrical conductors, by M. I. Pupin, is a paper read before the society in December last. The main object of it is the solution of a problem which, looked at from a purely mathematical point of view, can be stated as follows:—Find the integral of the partial differential equation $L\frac{d^2y}{dt^2} + R\frac{dy}{dt} = \frac{1}{C}\frac{\delta^2 y}{\delta s^2}$ and determine it so as to satisfy $k+2$ boundary conditions, where $k+1$ is the number of coils. The principal difficulty is to determine

the proper mathematical formulation of these sundry conditions so as to obtain a system of equations which can be readily solved. The paper is illustrated by diagrams which put the problems discussed in a clear light.—"Ueber systeme von differentialgleichungen dessen vierfach periodische functionen genüge leisten," by M. Krause, was presented at the Chicago (April) meeting of the present year. References are given to Hermite ("Sur quelques applications de la théorie des fonctions elliptiques," 1885), and to a paper by Picard (*Comptes rendus*, Band 89), and to previous work by the author.—E. B. van Vleck follows with a paper on linear criteria for the determination of the radius of convergence of a power series. Its object is to establish criteria for the convergence of a power series when the $(n+1)$th coefficient A_n is connected with the preceding coefficients by a linear relation which tends to take a limiting form as n increases indefinitely. The criteria include Cauchy's ratio-test as a special case, and may be looked upon as an extension of the test, and are applicable in cases in which the simple ratio-test fails. The paper closes with two theorems which are an extension for the case of two variables, criteria for the convergence of power series in such a case are stated to be very rare.—On the existence of the Green's function for the most general simply connected plane region, by W. F. Osgood.—A short but suggestive note—"D" lines on quadrics, by A. Pell. These lines, so named by Cosserat, were originally considered by Darboux. They are the lines drawn upon a surface in such a way that the osculating sphere at every point is tangent to the surface at that point. In addition to the above, the lines have been studied by Enneper and Ribaucour (for surfaces in general). In the present paper the author applies the theory of elliptic functions to the integration of Darboux's differential equation, and obtains an idea of the appearance of the lines and also some of their properties.—Starting from an article, by Prof. F. Morley, in the previous number of the *Transactions*, F. H. Loud gives sundry metric theorems concerning n lines in a plane. By giving a different interpretation to formulæ got by Prof. Morley, Mr. Loud obtains a new series of theorems and other results of some interest.—An application of group theory to hydrodynamics, by E. J. Wilczynski. It was observed by Sophus Lie that the stationary motion of a fluid can serve as a perfect picture of a one-parameter group in three variables. Apparently this fact has not been utilised for the purposes of hydrodynamics. This paper does this. Amongst other advantages, the treatment, from the new standpoint, leads to special cases of exceptional interest and importance, which otherwise appear to be difficult and unpromising.—Dr. L. E. Dickson, following up work recently published in the *Proceedings* of the London Mathematical Society (vol. xxxi. pp. 30, 351), contributes an article on the determination of an abstract simple group of order $2^7 \cdot 3^6 \cdot 5 \cdot 7$, holohedrically isomorphic with a certain orthogonal group and with a certain hyperabelian group (contributed to the Chicago [April] meeting of the society).

In the *Journal* of the Royal Microscopical Society for August, Mr. E. M. Nelson has one of his useful technical articles on the "lag" in microscopic vision, as well as a historical account of the improvements in the structure of the microscope introduced by the firm of Ross. Mr. E. B. Stringer describes a new form of fine adjustment. Miss A. Lorrain Smith gives a description of some new microscopic fungi, including a new species of Entomophthora, not parasitic, but saprophytic on dead animal tissues. There is, in addition, the usual summary of current researches relating to zoology, botany and microscopy.

In the *Journal of Botany* for August, Messrs. W. and G. S. West have a second instalment of their notes on freshwater algæ, in which some new species and varieties are described. The remaining papers are descriptive or geographical.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 10.—M. Maurice Lévy in the chair.—Occultation of Saturn by the moon on September 3 observed at the Observatory of Lyons, by MM. J. Guillaume, G. Le Cadet and M. Luizet.—On differential systems with a general uniform integral, by M. Paul Painlevé. Four types of systems are examined, problems in mechanics such as the movement of a heavy body fixed by a point, the inversion of total differentials, the case where the general integral of a differential system does not admit of transcendental singularities, and the study of the integrals of a differential system in a real field.—On the liquefaction of air by expansion with production of external work, by M. Georges Claude.—On the dielectric cohesion of gases and vapours, by M. E. Bouty. The experiments previously described upon the relation existing between the distance at which insulation breaks down and the pressure of the gas have been extended to vapours of liquids. Results of measurements for water, and eleven organic liquids, are given in the present paper.—On the modification of the electrical and organic properties of cables under the prolonged action of currents, by M. Georges Rheins. When a cable is submitted to the action of an alternating current it preserves its electrical and organic properties intact. With a continuous current in one direction the cable gradually loses its electrical properties, this effect being produced by the slow penetration of the copper from the wire into the sheath. The effect is similar with both gutta and paper coatings.—New researches on the absorptive power of hæmoglobin for oxygen and carbonic acid, by M. L. G. de Saint-Martin. As the result of numerous experiments quoted, the author is of opinion that, contrary to the views generally held, it is impossible, especially in pathological cases, to estimate hæmoglobin by means of the absorbing power of the blood.—On the nitrocelluloses, by M. Léo Vignon. Both the nitrocelluloses and the nitro-oxycelluloses energetically reduce Fehling's solution, their reducing power being apparently independent of the degree of nitration. The reducing powers of the nitration products of cellulose and oxycellulose are of the same order, about one-fifth that of inverted sugar.—On the wood of the Conifers of peat bogs, by M. L. Géneau de Lamarlière. In the wood of Conifers taken from a peat bog, the intercellular layer formed of lignin and pectic compounds is intact, whilst the internal portion has been strongly attacked by microbial action. The lignin and cellulose have disappeared, an amorphous substance remaining behind which is soluble in potash after the action of chlorine. The material resembles callose.—Influence of a dry or moist medium upon the structure of plants, by M. Eberhardt. Compared with normal air, the effect of dry air is to increase the thickness of the epidermal cuticle and the number of stomata, to make the cork layer form earlier, to increase the production of ligneous tissue, and to cause an increase in the amount of pallisade tissue in the leaf.

CONTENTS.