THURSDAY, SEPTEMBER 12, 1912.

THERMODYNAMICS OF THE ATMOSPHERE.

Thermodynamik der Atmosphäre. By Dr. A. Wegener. Pp. viii + 331. (Leipzig: J. A. Barth, 1911.) Price 11 marks.

THE progress of a science depends upon the intellectual calibre of the men who pursue it: that determines what shall be written for them as well as by them. It is therefore significant for meteorology that a text-book on the thermodynamics of the atmosphere should be added to a collection recently enriched by treatises on meteorological optics and on the foundations of dynamical meteorology. Special phases of the subject have been treated at some length by Helmholtz, Hertz, von Bezold, and others, but their papers are scattered among different scientific journals, rarely accessible in a single library. Dr. Wegener's treatise, which has been written with the object of giving a systematic account of the existing knowledge and methods, should therefore be generally welcomed.

In an introductory chapter the author deals with the constitution of the atmosphere, and discusses in interesting fashion the extreme heights at which various optical phenomena, aurora, meteors, and zodiacal light appear. He finds that in all cases the values lie roughly between 70 and 100 km., or in the layer in which the nitrogen atmosphere is changing to the hydrogen atmosphere. After an account of the thermodynamics of an ideal gas and its application to a consideration of the precise proportions in which different gases exist at different heights, he indulges in some speculation about the existence of a hypothetical gas, geocoronium, above the hydrogen atmosphere. Such speculation is out of place in a text-book, and the same criticism applies to the statement that the stratosphere extends from 11 to 70 km. There is no evidence as to the upper limit of the temperature conditions characteristic of the stratosphere.

In the third section the different phases of water vapour, the condensation on nuclei, and the formation of crystals are discussed thoroughly and comprehensively.

The fourth and fifth sections, which comprise rather more than two-thirds of the book, are undoubtedly the most valuable parts of the work. In them the author treats of the thermodynamics of adiabatic changes and of the physics of clouds respectively. The effect of the condensation of water vapour in diminishing the vertical temperature gradient for air rising adiabatically is important both in the general circulation and in local disturbances, and it is usually put forward as the explanation of the Föhn. The cooling of the air which rises on the windward side of the mountains is influenced by the condensation and precipitation of the water which it contains. This air descends on the lee side, where there is no moderating effect on the vertical temperature gradient, and is consequently hot and dry. Dr. Wegener deduces, from the fact that the average vertical gradient is less than that corresponding to the adiabatic gradient either for saturated or for dry air, that the rising of the air on the windward side actually exerts a moderating influence on the Föhn.

A very full account is given of "inversions," *i.e.* cases in which the temperature remains constant or increases with increasing altitude. Their connection with waves and wave-clouds is discussed at length, and the form of the surface between currents of different densities and velocities is made the subject of mathematical investigation. A chapter is devoted to the stratosphere. The different types of the temperature-height curve between the troposphere and stratosphere are illustrated by an excellent diagram derived by Schmauss from a consideration of the results obtained at Munich. In the discussion of the meteorological conditions in the stratosphere itself it is assumed that the relative humidity at the base of the stratosphere, the region of minimum temperature, is 50 per cent. As there is no process by which the nitrogen-oxygen atmosphere is "dried" except by the precipitation of water condensed by cooling, it is not easy to see how a relative humidity of 50 per cent. could be obtained at the place of minimum temperature, where diffusion and convection would both tend to produce saturation.

The discussion of clouds is excellent. It includes a note on the rate of fall of drops and its connection with the passage from cloud to rain. The photographs of the different forms of clouds, some of which were taken from balloons above the clouds, are well reproduced, and add considerably to the educational value of the descriptive matter and the theoretical discussion.

Dr. Wegener has performed a signal service in producing a good book on a branch of the subject which had not previously been dealt with systematically. The work as a whole loses by the deliberate exclusion of radiation, which is fundamentally and indissolubly connected with the application of thermodynamic considerations to the problems which confront the meteorologist every day. The author regards it, however, as a subject for separate treatment.

THE STORY OF "EIGHT DEER."

The Story of "Eight Deer" in Codex Colombino. By J. Cooper Clark. Pp. 33+plates A–J (coloured). (London: Taylor and Francis, 1912.) Price 21*s.* net.

AMONG the papers presented to the International Congress of Americanists during the session held in London at the end of last June was a pamphlet by Mr. J. Cooper Clark entitled "The Story of 'Eight Deer' in the Codex Colombino." This is an attempt to throw some light into the obscurity of the pre-Columbian American manuscripts.

Mr. Cooper Clark commenced his researches with a careful examination of the Codex Colombino, a picture-writing painted on prepared deerskin, folded like a screen, and measuring 6·80 metres in length when spread open, now preserved in the National Museum in the City of Mexico. In this manuscript Mr. Cooper Clark traced the history of a warrior chieftain named "Eight Deer." All the personages identified by Mr. Cooper Clark in this codex are named after days of the month, and the name "Eight Deer" is expressed by a deer's head with the numeral eight (that is, by eight round discs) attached to it, a deer's head (Maçatl) being one of the twenty day signs of the Nahua month, and according to the Nahua method of noting time, this date would occur only once in a cycle of fifty-two years. It is not, however, explained why this particular day was chosen as the name of the warrior, although it is stated that it was not the day of his birth.

The life-history of Eight Deer is most ingeniously traced through the pages of the codex, but the most interesting fact established by Mr. Cooper Clark is that the history of the same individual is also told in five of the other extant pre-Columbian codices, namely, the Zouche (British Museum), the Vienna, the Bodleian, the Baker, and the Selden. By a careful comparison of these codices, Mr. Cooper Clark has not only been able to show that in part they tell the same story, but to supply incidents in the history of Eight Deer which are missing from the Codex Colombino owing to the destruction of a part of the manuscript.

Mr. Cooper Clark has further come to the conclusion that Eight Deer can be identified as the glyph attached to the figure of a warrior carved on one of the stone slabs from Monte Alban in Oaxaca (in the Zapotec country), now exhibited in the National Museum of Mexico, and from this he argues that the codices dealing with the story of Eight Deer must be of Zapotec and not Aztec origin, adding, "Not many Nahua codices are likely to have survived the destruction by Archbishop Zumárraga of the temple libaries of Tenochtitlan, Texcoco, and the other cities around the lakes, whereas, warned by the example of Mexico, the Zapotecs would have had ample time to secrete their records."

There is no difficulty in fixing the dates mentioned in the Codex Colombino within the fifty-two year cycle; the difficulty arises in determining in which cycle of fifty-two years the dates occur. If the events depicted are placed in the next cycle before the arrival of the Spaniards, the birth of Eight Deer would have taken place in the year 1491 A.D.; but Mr. Cooper Clark thinks that it more probably took place in the previous cycle, when the date would correspond to 1439 A.D.

The pamphlet is illustrated with plates most carefully drawn and coloured from the original manuscripts, showing how the same events in the life of Eight Deer are depicted in the Colombino, Zouche, Bodleian, and Becker codices.

Mr. Cooper Clark is to be heartily congratulated on his most painstaking achievement. The pamphlet was written for the few who are interested in ancient American civilisations, and can only be fully appreciated by those who have access to copies of the codices discussed; but even to the general reader it must be of interest as showing a native American method of recording historical events, and, moreover, as demonstrating how, by careful and intelligent examination and comparison, order and meaning may be evolved from the most obscure and unpromising material.

SUBMERGED RIVER-VALLEYS.

Monograph on the Sub-Oceanic Physiography of the North Atlantic Ocean. By Prof. Edward Hull, F.R.S. With a Chapter on the Sub-Oceanic Physical Features off the Coast of North America and the West Indian Islands, by Prof. J. W. W. Spencer. Pp. viii+41+xi plates. (London: E. Stanford, 1912.) Price 21*s.* net.

THIS is a folio publication with eleven excellent maps and nine short chapters of explanatory text, and an additional chapter by Prof. J. W. Winthrop Spencer. The author has based the work on a detailed study of the Admiralty charts showing the soundings over the continental shelf and the upper part of the continental slope off the western coasts of Europe and Africa, and this leads up to a statement of his views as to the cause of the Glacial Period.

It is pointed out that there are two principal schools of geographical evolution, the one believing that the ocean basins and the position of the chief continental areas retain traces of their primeval structure and have undergone only slight modification, the other, to which the author belongs, believing that land and sea have changed places at various geological periods. The latter view, he considers, is upheld by a consideration of the distribution of geological formations on both sides of the North Atlantic.

A detailed description is then given of the submerged river-valleys occurring off western Europe and Africa and in the Mediterranean as traced from the soundings shown on the charts. These were formed not only by rivers, the greater part of the course of which is visible on land, such as the Loire and the Congo, but also by rivers which rose on land now completely submerged, such as the "Irish Channel River" and the "English Channel River." They all indicate a former great uplift of land. The Norwegian fjords also are regarded as river-valleys of great geological age.

Professor Spencer shows that the continental shelf off the east coast of America is likewise cut up by submarine river-valleys and that there was a land connection between the West Indies and the American continent, and he upholds the view that great changes of level, amounting in some cases to thousands of feet, have taken place in recent geological times.

In the final chapter Prof. Hull gives his explanation of the cause of the Glacial Period. As shown from a study of the submerged river-valleys, a general elevation of the earth's crust took place all round the North Atlantic, the date of which is concluded to be about the close of the Tertiary Period. This brought about a much colder climate and at the same time a great change in the direction and temperature of the Gulf Stream. When the Antilles were directly connected with the American continent this current could not enter the Caribbean Sea, where at present it gains about 13° Fahrenheit of temperature; hence arose an additional cause for decreased temperature along all the coasts of the North Atlantic. The combined effect of these two factors, viz., the increased elevation of land on both sides of the Atlantic and the decrease of temperature in the Gulf Stream, would be sufficient, the author considers, to call into existence a rigorous glacial climate over the northern parts of America and Europe, which in its turn would affect a great part of the rest of Europe and western Asia, and more or less the entire northern hemisphere. Thus Dr. Hull shows that he belongs to those who regard purely terrestrial factors as the cause of the Glacial Period, in contrast to those who explain it on an astronomical basis. The book is useful to all who are interested in physical geography, whether they can agree with Dr. Hull's conclusions or not.

OUR BOOKSHELF.

The Elements of Statistical Method. By Willford I. King. Pp. xvii+250. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1912.) Price 6*s.* 6*d.* net.

IN this volume Mr. King has endeavoured "to furnish a simple text in statistical method for the benefit of those students, economists, administrative officials, writers, or other members of the educated public who desire a general knowledge of the more elementary processes involved in the scientific study, analysis, and use of large masses of statistical data." After a brief historical introduction, he outlines the uses and sources of statistical data, and then gives a few short chapters on "the gathering of material"; the third part, forming the bulk of the book, deals with "analysis," *i.e.*, tabulation, averages, dispersion, correlation, and so forth.

The writing of a satisfactory elementary work on such a subject—a work that can be placed in the hands of the junior student with confidence that he will not have to unlearn at a later stage some of the notions that he has gathered—is an exceedingly difficult feat, much more difficult in many respects than the writing of a work for more advanced students, and we cannot say that, in our opinion, Mr. King has altogether succeeded. The style is simple enough, but some matters are very insufficiently explained—probable errors, for example—and in other cases, notably in the chapters dealing with correlation, extensive revision and correction are required. A coefficient "of concurrent deviations" suggested on p. 208 does not fulfil the fundamental condition of becoming equal to zero if the deviations are independent. The student, in dealing with correlation, is repeatedly told to divide deviations by the mean, and the graph of regression obtained when the deviations have been divided by their respective means is termed the "Galton graph." What Sir Francis Galton did was to divide deviations by their respective quartile deviations—not their means—and he obtained the correlation coefficient graphically in that way. The relation of regression to correlation is never clearly exhibited, and Mr. King's use of the term is not in accordance with general usage. As it at present stands, the book cannot be recommended as a completely trustworthy guide.

Anthropologie Anatomique. Crâne—Face—Tête sur le Vivant. By Dr. Georges Paul-Boncour. Pp. xix+396. (Paris: Octave Doin et Fils, 1912.) Price 5 francs. (Encyclopédie Scientifique.)

THE enterprising publishers of the "Encyclopédie Scientifique" have arranged for the issue of a series of forty-eight volumes dealing with anthropology, the editorship of the series being assigned to Prof. Papillault, of l' cole d'Anthropologie, Paris. This volume, by Dr. Georges Paul-Boncour, forms the first of the series, and if its successors maintain an equally high standard, the "Bibliothèque d'Anthropologie" is destined to become a standard work.

Dr. Paul-Boncour's task is limited to a systematic study of the cranium, the facial part of the cranium, and the head of the living; his volume gives an accurate reflection of the methods and conclusions of the French school of anthropologists. The nature of his book is best indicated by a bare recitation of the subject-matter of its chapters.

The volume commences with a discussion on the growth and evolution of the skull, and then passes on to a description of its various parts. The succeeding chapters are devoted to the formation of the cranial cavity, to the methods of measurement and estimation of indices and of angles. The mandible and brain cavity are the subject-matter of special chapters. The second part—the more valuable—is devoted to the methods employed in registering the racial and individual characters as seen in living people—the form of the head, the development of muscles, the colour of the skin, the shape of the eyes, contour of the nose, form of ear, mouth, hair, and chin.

Dr. Paul-Boncour's volume is a simple, explicit, and methodical presentment of methods and opinions which have been perfected by the three generations of men who have made Paris the Mecca of anthropologists.

Science of the Sea. Edited by Dr. G. Herbert Fowler. Pp. xviii+452. (London: John Murray, 1912.) Price 6*s*. net.

THERE is a large though scattered body of people interested in oceanography or fascinated by marine biology, but prevented from making any advance by the want of practical direction and assistance: not only explorers and yachtsmen, but officers in the Navy with time on their hands in port or in foreign stations, medical officers on board ship or on coastal stations, and gentlemen who have retired from active service. To all such who wish to learn the methods of oceanographic inquiry, this book will be gladly welcomed, for it brings together instructions that otherwise are hard to find, given with the greatest care, and tested by the practical experience of many lives. The handbook is, in fact, the collective wisdom of the most active members of the Challenger Society, a body that has met quarterly in an unobtrusive fashion in London for some years, and now expresses its interest in oceanographic research by this publication.

The book begins with a chapter on meteorology by Dr. Mill and Capt. Wilson Barker, whose names, like those of the succeeding contributors, are guarantees of soundness and fulness of knowledge, and then proceeds to a well-illustrated account of hydrography, the joint work of Prof. H. N. Dickson and Mr. D. J. Matthews, of Plymouth. A very interesting and practically helpful account of tropical shore-collecting and outfit is given by Prof. Stanley Gardiner, whose methods, with a little adaptation, are applicable to similar work in temperate seas. Then follow four chapters on marine biology, including one by Sir John Murray on oceanic deposits and the organisms of the sea-floor. Fishing, whaling, and sealing are referred to in a rather summary fashion. Finally, the editor gives valuable counsel on methods of note-taking, whilst yacht-equipment, dredging, trawling, and the preservation of specimens are dealt with in a most helpful manner by the Director of the Marine Biological Association and others.

We congratulate the editor, Dr. Fowler, on the manner in which he has correlated and brought together such a valuable elementary compendium, and we can recommend this handbook as a trustworthy and practical guide to travellers, and not less a book of great interest to all biologists. F. W. G.

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.*]

Practical Mathematics.

I WAS particularly sorry to be absent from the meetings of the International Mathematical Congress at Cambridge, because an address was expected from me upon the teaching of practical mathematics, and because Sir Wm. White, in his address on the relation of mathematics to engineering practice, referred to practical mathematics in a most contemptuous way.

Twenty years ago mathematics continued to be taught in what may be called the orthodox way, a way that succeeded fairly well with students who were fond of abstract reasoning, 3 per cent. of all students, and quite failed with the other 97 per cent. At the British Association discussion of 1901 (verbatim report published by Messrs. Macmillan), most of the great mathematicians and teachers of mathematics spoke or sent remarks in writing. In opening that discussion, I published my proposed Science and Art Department syllabus on practical mathematics. There was essential agreement with my views; there was scarcely one dissentient remark. A committee was formed, and recommended methods of teaching which are now extensively adopted. It is perhaps a pity that I gave such a misleading name as practical mathematics to the reformed methods, but I wanted to differentiate them from the orthodox methods of twenty years ago, and I did not dream that the new methods would be adopted so quickly. They are in use now in all the public schools where natural science is taught; they are in use in all science colleges and in all engineering colleges.

In evening schools it used to be that when a class of thirty apprentices was started in elementary mathematics, the attendance dwindled to ten in November, and in May it was usual to find only one or two faithful students. Now, in such schools, there is almost no teaching of the kind we used to call orthodox, but some hundred thousand apprentices study practical mathematics. The class of thirty formed in September remains in good attendance all the winter, and remains an excited and interested class of thirty in May. The new method suits the boy of great mathematical promise, but it is really arranged to give the average boy a love for computation and the power to use mathematical reasoning with pleasure and certainty. It recognises that every boy, every man, already possesses the fundamental notion of the infinitesimal calculus, and that it is quite easy to develop this notion so that he can use the methods of the calculus in his reasoning and computation. The subject was first recognised by the Science and Art Department in 1899; the number of students has increased year by year by the compound interest law, and it is now the most important science subject of the Board of Education.

When I was appointed professor of mathematics and mechanics, seventeen years ago, at the Royal College of Science, it was known that I would adopt that experimental method of teaching mechanics and applied mechanics and engineering science with which my name had become identified at the Finsbury College of the City Guilds. It is the method now in use in nearly all polytechnics and engineering colleges. It went hand in hand with the practical mathematics which it was also understood that I should establish at Kensington. My books describing these methods have been translated into many languages, and the methods have been largely adopted in America, Germany, and other foreign countries. Much of my time has been spent in showing foreign visitors how my methods of teaching were carried out in practice.

I feel sure that few of the men listening to Sir Wm. White, even of the foreigners, were ignorant of these facts. It is known that the most elementary class at the college, attendance at which is compulsory on all students of the Royal School of Mines and the chemical and other students, was taught on the lines laid down for all evening classes in practical mathematics, the work being made interesting for the average student, and including the elementary methods of the calculus. Not only here, but in the very highest mathematical work of the college, a competent person will see that the study is exceedingly different from what used to be the study of the mere mathematician on the same subjects. All our syllabuses and methods of teaching have been highly praised by most eminent judges, like the late Lord Kelvin, and they are now in no way different from what they were seventeen years ago.

According to the report in *The Times*, Sir Wm. White said that in the teaching of engineering students, some authorities now favoured special courses in practical mathematics; others believed that engineers should be taught by professional mathematicians because this method must lead to broader views and greater capacity for original investigation. His experience led him to rank himself with the supporters of the latter, and he said that this view is now adopted at the Imperial College of Science and Technology.

I know that Sir William contemplates great changes at the Imperial College, and no doubt great changes will rapidly take place, as I have been asked to retire, and Prof. Henrici has already retired. An attempt will, no doubt, be made to give up those methods to which I gave the misleading name practical mathematics, and in all probability the places of Prof. Henrici and myself will be taken by more orthodox persons. It is also probable that a "professional mathematician" will be put in charge of the teaching of mechanics. As I am still on the staff of the college I do not think that I can criticise the actions of the governing body. It is, however, my duty to deny a hurtful statement about my own department, and to oppose what I consider to be a wrong opinion, expressed at a public meeting by one of the forty members of the governing body.

I wish to observe that no change has yet been made. The syllabus and methods of teaching are exactly as they have been for seventeen years, and when Sir William says that his view is now adopted at the Imperial College he really means that he himself has adopted this view.

This is a most important matter. Sir William White's remarks may influence the action of the governing bodies of the other engineering colleges of the country. In England, if a man is a great lawyer it is assumed that his views about Tibet must be right; if he is a great chemist it is held that his views about women's suffrage must not be disputed; and if he is a great designer of ships it is assumed that he is an authority on technical education.

It used to be that colleges were governed by a council of the professors, but now the opinions of the professors are of no account, and the staff dare not even suggest to the governors that it is possible for honest, sensible, diligent, self-sacrificing shopkeepers, merchants, and manufacturers to be so misled that they may ruin technical education for the next ten years. Such ruin will only be temporary, it is true, but when I think of our competition with the foreigner I look with great dismay on the possibility that Sir William White's opinions may have too much weight with the persons who have charge of technical education.

The old engineering college did not compel its students to have more than the most elementary mathematical knowledge, because only civil engineering was taught, and the average civil engineer needs no mathematics. When mechanical engineering and shipbuilding students began to be taught, the mathematics standard was only slightly raised. But modern high-speed machinery has made it necessary for mechanical engineers to understand the effects of vibration, critical speeds of shafts, &c., and to pursue numerous studies which require a knowledge of higher mathematics even in the average student. And nowadays we have the electrical engineer requiring a knowledge of the methods of very advanced mathematics. Sir Wm. White thinks of the requirements of the civil engineer or shipbuilder of his youth; we teachers have to think of the requirements of the student of to-day. Now I affirm that the average student cannot be taught this necessary advanced work unless by the reformed methods. He cannot be carried beyond the most elementary things, and these he does not understand.

I have now expressed my opinion in regard to Sir William's remark about practical mathematics. In weighing our opinions it must be remembered that Sir William's practical experience as an engineer has been in naval architecture only, and as a teacher it lay also in naval architecture only, and a considerable time ago.

Sir William says that all the mathematical teaching of engineers should be by what he calls professional mathematicians, and he evidently means by this that these teachers shall not be engineers or men acquainted with engineering science. He means that they shall be mere mathematicians. Well, this has been tried often enough, and it has always been found that the one or two good students take a distaste to practical engineering, and the average student is never brought beyond the driest elementary work, and he hates the appearance of a mathematical symbol all his life after. The average student cannot understand abstract reasoning; his teacher has no knowledge of him, and pursues his serenely ignorant way, wondering how it is that so many students are stupid, or else he wonders that he and a few other men should be so supremely clever. He never studies his pupil. There are men who can train almost any animal; they study its habits of thought; they are kind and sympathetic. The poor average English boy is never studied by the professional mathematician.

JOHN PERRY.

Imperial College of Science and Technology,
September 2.

Polymorphism in a Group of Mimetic Butterflies of the Ethiopian Nymphaline Genus Pseudacræa.

A LITTLE more than two years ago Dr. Karl Jordan informed me that he had been studying the male genital armature of the Pseudacræas, and that he could not find any difference between the "species" of a large group made up of Linné's *eurytus* and its numerous allies on the west coast, of Neave's *hobleyi, terra,* and *obscura* in Uganda, of Trimen's *rogersi* of the Mombasa district and his *imitator* of Natal. All these forms possess patterns mimetic of species of the Acræine genus Planema. The conclusion was a very startling one. If each mimetic Pseudacræa had been confined to a single area and had interbred on its margin with the Pseudacrææ of surrounding areas with different mimetic patterns, we should have been confronted with a more remarkable and complex example than any as yet known (except perhaps *Papilio dardanus*), but one that raised no special difficulty. Dr. Jordan's discovery, however, involved far more than this: it led to the remarkable conclusion that the sexually dimorphic *P. hobleyi*, mimicking the sexually dimorphic *Planema macarista* in the Entebbe district, was the same species as the two monomorphic Pseudacræas flying in the same forests with it, viz. *P. terra* and *P. obscura*, mimicking respectively the sexually monomorphic *Planema tellus* and *P. paragea*.

Dr. Jordan communicated his discovery to the First International Entomological Congress, meeting at Brussels in 1910, and at the same meeting I brought forward the results of researches in 1909 by Mr. C. A. Wiggins, D.P.M.O. of the Uganda Protectorate, upon the Pseudacræas and other mimetic butterflies of the forests near Entebbe. The preparation of this latter paper afforded the opportunity of testing Dr. Jordan's conclusions by the careful study of a splendid mass of material.

Out of the long series of Pseudacræas, two specimens yielded strong support: (1) a male *P. terra* with a pattern approaching the male of *P. hobleyi*; (2) a female *P. hobleyi* bearing the mimetic colours of its own male. Nevertheless, I felt, and stated in the paper published in the Proceedings of the Congress, that conclusions so far-reaching ought not to be finally accepted until they had been tested by breeding.

Mr. Wiggins has continued his fruitful study of mimicry in the forest butterflies of Uganda from the point reached in the Brussels paper up to the present time.

There was, however, a break in 1911, when he came home and worked with me upon his material in the Oxford museum, preparing a tabular statement for the Second International Congress which has just met at Oxford. The results which have been gained from his enthusiasm and energy will throw far more light on the proportions of mimics and models at different seasons and in different years than has been shed by any other naturalist in any part of the world. A few more intermediate Pseudacræas, and one or two more male-coloured females of *P. hobleyi*, appeared in the wonderful series obtained by him, but the collection as a whole shows that in the forests within a few miles of Entebbe two out of these three mimetic Pseudacræas, viz. *hobleyi* and *terra*, are wonderfully constant and sharply marked off, and that the sexual dimorphism of one of them is nearly always pronounced. In the Entebbe district the third form, *P. obscura*, is so much rarer than the others that it is at present impossible to speak with any certainty of its constancy.

While Mr. Wiggins was continuing his researches on the mainland, Dr. G. D. H. Carpenter, a member of the Royal Society's Sleeping Sickness Commission, began to study Pseudacræas in the intervals of his work on the tsetse-flies of the islands in the north-west of the Victoria Nyanza. During a large part of 1911 Dr. Carpenter was on Damba Island, on the Equator, about twenty miles south-east of Entebbe. Early in the present year he moved to Bugalla, one of the Sesse islands, to the south-west of Damba. In both these islands he found the Planema models rare as compared with their mimics. The Planemas are apparently more exclusively forest butterflies than the Pseudacræas, and the forested areas on the islands may not be extensive enough for them to establish themselves freely. Furthermore, the proportions of the three forms of Pseudacræas are very different.

On the adjacent mainland *hobleyi* is by far the commonest form, and *obscura* much the rarest. Although on the islands the exact proportions have not been ascertained, it is clear that *terra* is by far the commonest, and *obscura* quite abundant. Male-coloured females of *hobleyi* are rare, although apparently less rare than in the Entebbe district; but the chief interest of the island Pseudacræas lies in the extraordinary number of transitional forms—between *terra* and *obscura*, between *terra* and the female *hobleyi*, between *terra* and the male *hobleyi*, between *obscura* and the female *hobleyi*. Dr. Carpenter has also observed on Bugalla the male of *hobleyi* pursuing the female of *terra*, the male of *terra* the female of *hobleyi*, and the male of *obscura* the female of *terra*.

All these facts offer the most convincing support to Dr. Jordan's conclusions, as well as to an interpretation of mimicry based on natural selection. Where the models—which are different species sharply cut off from one another—are predominant the mimetic forms of an interbreeding community are also sharply cut off, and intermediates are rare; where the models—although all of them exist—are in a small minority, the forms of the mimetic community tend to run into one another. The results here summed up were communicated to the Entomological Society, and will be found in the Proceedings for 1911 (pp. xci.–xcv.) and 1912 (pp. xix.–xxiii., and later pages as yet unpublished).

Finally, my friends Mr. Guy A. K. Marshall, scientific secretary of the Entomological Research Committee of the Colonial Office, and Mr. S. A. Neave have given me the opportunity of studying the collections made in 1911–12 by the latter over a wide area in the Uganda Protectorate—from the Mount Elgon district far to the north-east of Entebbe, to Buddu in the south, and Ankole, Unyoro, and Toro, as far as Ruwenzori and the Semliki Valley, to the west. As yet only a few of the specimens have been "set," so that it has been impossible to study the patterns in detail, but one important conclusion has emerged, viz. that male-coloured females of *P. hobleyi* were relatively far commoner outside the Entebbe district than we know them to be within it. The most remarkable manifestation of this tendency was encountered (August 13, 1911) on the Siroko River (3600 ft.), near the western foot of Mount Elgon, when Mr. Neave collected ten males of *P. hobleyi*, eight male-coloured females, and four normal females. This change in the proportion of the females corresponds with a change in that of the models, *Planema poggei*, with both sexes resembling the male of *P. macarista*, being commoner and *P. macarista* rarer outside than they are within the Entebbe district, so well investigated by Mr. C. A. Wiggins. Mr. Neave never saw the latter species near Mount Elgon, in Kavirondo, or indeed anywhere to the east of the Nile at Jinja.

We now come to the evidence furnished by breeding, which indeed is the object of the present letter. Ever since the Brussels Congress I have tried to induce

African naturalists to settle this question. In Natal Mr. G. F. Leigh, the late Mr. A. D. Millar, and Miss Fountaine have been successful in breeding the two Pseudacræas, *lucretia* and *imitator*, but the latter, which is the only Natal member of Dr. Jordan's group, appears in a single form mimetic of *Planema aganice*, and is therefore incapable of supplying the desired test. I attempted to induce both Miss Fountaine and Mr. Millar to travel to Entebbe in order to decide the question. My friend Mr. W. A. Lamborn, who has done such splendid work in breeding Lepidoptera in the Lagos district, has reared *P. lucretia* and also *P. semire*—the latter, I believe, for the first time—but has not yet been successful in finding the larvæ or in obtaining the eggs of any local form of *P. eurytus*.

Lately, however, I have felt confident that success would be achieved by Dr. Carpenter, with his wide experience of breeding and residence in an exceptionally favourable locality. He first succeeded in finding and rearing the larvæ of *P. lucretia*, and then made many attempts to obtain eggs from captured females of the *hobleyi* group. Discouraged by many failures, he was beginning to despair when, some weeks past, he observed in the Bugalla forest a female *obscura* "with a touch of *hobleyi*" settling in an unusual position on a leaf of the food-plant of *lucretia*—almost certainly a Sapotaceous plant. The butterfly escaped, but Dr. Carpenter found the egg on the leaf, and hoped to rear the perfect insect before or during the meeting of the Second International Congress at Oxford (August 5–10), and he promised that if the offspring turned out to be *terra* or *hobleyi*, he would cable the result. He wrote that he anticipated *terra*, because this form is much the commonest on Bugalla.

Unfortunately the eagerly-expected butterfly did not emerge until after the meeting, but on August 19 I received a cable from Entebbe with the word "terra." Furthermore, Dr. Carpenter has now succeeded in obtaining eggs laid by known parents upon enclosed branches of the food-plant in the forest, so that we shall not have to wait long for evidence that is tolerably certain to afford direct proof of Dr. Jordan's conclusions as regards all the forms of the *hobleyi* group on the island, and is likely to establish the genetic relationship between them.

Dr. Jordan, Mr. Wiggins, Mr. Neave, and Dr. Carpenter are all to be warmly congratulated on the parts they have played in solving a bionomic problem of extraordinary interest and complexity.

E. B. POULTON.

St. Helens, Isle of Wight, August 28.

Wireless Telegraphy and Terrestrial Magnetism.

THE report in *The Times* of the discussion on wireless telegraphy at the British Association meeting in Dundee mentions the hypothesis—introduced apparently by Dr. Eccles—that several of the phenomena of the propagation of electric waves round the earth are largely influenced by the existence of an ionised layer in the atmosphere. The hypothesis seems analogous to, if not identical with, one made by several magneticians independently, with the object of explaining phenomena exhibited by the diurnal variation of the magnetic elements. This diurnal variation is now generally regarded as most probably due to electric currents in the upper atmosphere, and it has been suggested that the fact that the magnetic changes are normally larger by day than by night is due to an increased ionisation of the atmosphere due to sunshine.

The regular diurnal magnetic variations are much larger in years of many than of few sun-spots. The difference between the size of the day and night movements is relatively reduced in years of sun-spot maximum, and in all years during large magnetic storms. Again, the diurnal variation is much larger in high latitudes—where aurora abounds—than elsewhere, and the difference between day and night phenomena is there much reduced. Finally, it has been recently found that a substantial part of the magnetic sun-spot relationship may be explained by a direct connection between the amplitude of the diurnal magnetic range and the spotted area of the sun some four days previously. These phenomena, or at least some of them, have been ascribed to corresponding changes in the ionisation of the upper atmosphere.

The natural inference, in short, is that the ionisation is much enhanced in years of sun-spot maximum and during magnetic storms, and is substantially influenced by the sun-spot area four days previously. Also one would infer that in high latitudes the upper atmosphere is normally much more highly ionised than elsewhere. If wireless telegraphy is largely dependent on an ionised layer, then unless this layer is distinct from that which influences terrestrial magnetism, we should expect wireless phenomena to show peculiarities corresponding to those just described in terrestrial magnetism. My object in writing this note is to direct the attention of those in control of wireless installations to the field of research which is thus suggested. Wireless telegraphy may yet lend itself to the direct experimental investigation of the causes of a variety of the phenomena of terrestrial magnetism.

September 7. C. CHREE.

On the Structure of the Stromatoporoid Skeleton, and on Eozoon.

I HAVE pointed out (Annals. Mag. Nat. Hist., September, 1912) that Stromatoporoids are Foraminifera, but I did not give an explanation of the structure of the skeleton. I now find that the clue to this structure lies in the "astrorhizæ" or stellate patterns on the surface of many of these fossils.

Each astrorhiza consists of a spiral series of chambers formed round a central and a circumambient chamber, and the existence of a number of astrorhizæ is due to budding—as in corals. Anyone who has been bewildered—as I have been—at the apparent complexity of Stromatoporoid structure will at once appreciate—I cannot forbear saying—the beautiful simplicity of this solution of a difficult problem, and will realise that these organisms have at last come to rest in their proper place. I am publishing in the October number of the Annals a revised classification of the group.

Eozoon canadense likewise is a colony-forming Foraminiferan, the unit in this case being a coiled Nummulitid shell. Convincing evidence for this statement also will be given in the October number of the Annals Mag. Nat. Hist.

In view of a possible recrudescence of the Eozoon controversy, it is very fortunate that the evidence in favour of the theory of organic origin is now so overwhelming that the former opponents of that theory will readily change their views. R. KIRKPATRICK.

British Museum (Nat. Hist.).

The Striation of Stones in Boulder Clay.

IN NATURE of September 5, Dr. A. Irving, in criticism of statements by Mr. Reid Moir, asks "how could the soft matrix of the Boulder Clay scratch a flint, or even hold a harder stone with sufficient grip to give it effect as a graving-tool?"

It is true that one may see flints emerging from arctic glaciers unscratched and unrounded, while softer rocks are reduced to strongly striated boulders; but Dr. Irving seems to conceive the Boulder Clay as something distinct from the ice-sheet in which it originated, and as merely pressed on by superincumbent ice. It cannot be too strongly urged that the lower portions of glaciers of the continental or ice-sheet type consist largely of stones and mud and abrading sand-grains, and that these materials are held in the grip of the ice and are moved against one another as it flows. The ice-sheet is, in fact, a conglomerate with an ice cement; the Boulder Clay is an essential part of it, and remains as its representative when the portion that can melt has yielded before climatic change. GRENVILLE A. J. COLE.

Royal College of Science, Dublin, September 6.

Boulder Clay in Essex.

YOUR correspondent Dr. Irving, in his letter entitled "Boulder Clay in Essex" (NATURE, August 22), states that he has made a keen but futile search for a human artefact in the Boulder Clay, and, I presume, infers that these relics do not occur therein.

I have had no opportunity of carefully examining the Boulder Clay of Essex, but for the last six years I have been able to search that of Suffolk, and know that the occurrence of humanly flaked flints in this latter deposit is capable of unassailable demonstration. As until the notification of a human skeleton having been found beneath the Boulder Clay no search had been made in the clay for worked flints, and as that notification was made only a few months ago, I think that perhaps further and more prolonged search in the Essex deposits will reveal some of the type of implements which are found in Suffolk.

But even if this is not so, it cannot be brought as an argument against man's presence here before the deposition of the Boulder Clay. It would be as foolish to argue that because palæolithic implements are not found in a certain section of river-gravel, they do not occur in any other portion of the same deposit.

J. REID MOIR.

12 St. Edmund's Road, Ipswich.

The "Titanic."

YOUR article (NATURE, August 29, 1912) on the report of the Advisory Committee having emphasised the contention from the first of some of us (students of science and old naval commanders) as to the insanity of high speed "at night in the known vicinity of ice," it behoves surely men of science to ask the question whether we have not reached the imperative limits of that false security which the "practical man" is wont to feel in his contempt for scientific "theory"; and, further, whether the time has not therefore come for legislation requiring commanders of the largest ocean-going steamers to hold a diploma, guaranteeing such a systematic course of study (say in a class at Greenwich or Kensington) in marine physiography and the elementary laws of mechanics as would quicken their imagination as to the uncertainty and the magnitude of the risks to be run in an abnormally ice-drifted sea. Lord Mersey's report may whitewash the facts, but the facts *en évidence* remain; and the chain of cause and effect in the lamentable and tragic loss of the *Titanic* leads us in the last resort to the notorious contempt for scientific acquaintance with the facts and laws of nature on the part of the "practical man." A. IRVING.

Hockerill, Bishop's Stortford, September 2.

STUDIES OF AURORA.[1]

ONE or two photographs of aurora seem to have been taken before, but Prof. Störmer is the first to meet with marked success. In the earlier of the volumes before us he describes with full detail the apparatus and methods employed in photographing aurora during a stay of some months at Bossekop, in the extreme north of Norway, early in 1910. Photographs were taken by Störmer and an assistant from the two ends of a base of about $4\frac{1}{2}$ kilometres, simultaneity of exposure being secured by telephonic signal. Using special plates, satisfactory photographs were obtained with a few seconds' exposure. One or more prominent stars were always included in the photograph, and the time was carefully noted. From the known co-ordinates of the stars, it was thus possible to fix the position of the aurora. The base was long enough in general to give a parallax which could be measured with sufficient accuracy to determine the approximate position and height of selected prominent points. The heights calculated for the different auroras varied from 36 to 461 kilometres. Fig. 1 shows a photograph—from the original

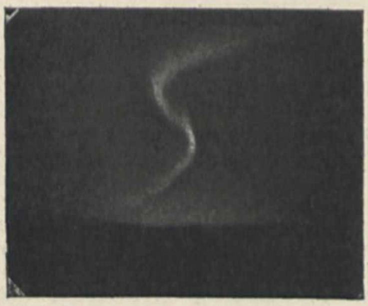

FIG. 1.—Reproduction of a photograph of an aurora: original size.

negative—taken with 3 seconds' exposure; Fig. 2 is an enlargement, the original of which had a 5 seconds' exposure.

The second of the two volumes referred to below repeats some of the information given in the first, but is mainly theoretical. Störmer was apparently first attracted to the subject of aurora and magnetic storms by the work of his well-known colleague at Christiania, Prof. Kr. Birkeland, but the views he now holds are independent.

An electrified particle projected in a uniform magnetic field H describes with uniform velocity a helix about the lines of magnetic force. If projected perpendicular to the lines of force, it describes a circle of radius ρ. If m be the mass, e the charge, v the velocity of the particle, and V the velocity of light, then, according to Störmer, $H\rho=(m/e)v(1-v^2/V^2)^{-\frac{1}{2}}$. This differs from the usual formula in English books unless $(v/V)^2$ be

1 "Bericht über eine Expedition nach Bossekop zwecks photographischer Aufnahmen und Höhenmessungen von Nordlichtern. By Carl Störmer. (Utgit for Fridtjof Nansens Fond.) Pp. 112+88 plates. (Kristiania: Jacob Dybwad, 1911.) Extract from Videnskap. Skrift. Mat. Natur. Klasse, 1911

"Sur les Trajectoires des Corpuscles électrisés dans l'espace sous l'action du Magnétisme Terrestre avec application aux Aurores boréales (second Mémoire). By Carl Störmer. Pp. 163+10 plates. Extrait des Archives des Sciences physiques et naturelles, Geneva, 1912.

negligible, which is far from the case in some of the hypothetical cases dealt with by Störmer. $H\rho$ may for mathematical purposes be regarded as the characteristic constant for a definite species of ray.

In his earliest work, Störmer treated the earth as a uniformly magnetised sphere, of moment $8{\cdot}52 \times 10^{25}$ C.G.S. Assigning to $H\rho$ values ordinarily conceded to kathode rays and β-rays of radium, he found that no electrified particle coming from the sun could reach the earth's atmosphere except in the immediate vicinity of a magnetic pole. If, for instance, $H\rho$ is 1000, the greatest angular distance from the pole is only $3{\cdot}8°$, and to increase the angle to $22°$—which answers roughly to the position of maximum aurora—one must assign to $H\rho$ the enormous value 10^6. To account for the observed occurrence of aurora in low latitudes, Prof. Birkeland has had to assume no less a value than 7×10^6, which implies a very close approach in v to the velocity of light.

Prof. Störmer sets out in quest of another explanation. His first idea was to substitute for the field of a uniformly magnetised sphere that derived from the earth's Gaussian potential, based ultimately on the work of Carlheim Gyllensköld. The mathematical difficulties were thereby much increased, while the physical difficulties showed no abatement. Störmer's next idea was suggested apparently by experiments of Birkeland's, which showed that kathode rays in a vacuum tube containing a magnetised sphere can form a luminous ring in the magnetic equator. Störmer supposes a gigantic ring of kathode rays to form and persist for some time in the plane of the earth's magnetic equator, and the auxiliary magnetic field thus produced is believed to render access to low latitudes possible to other kathode rays coming from the sun.

In the absence of a ring, as already remarked, rays require $H\rho$ to equal 10^6 to permit of their getting as far as $22°$ from the magnetic pole, but this becomes possible to rays the $H\rho$ of which is only 1000, provided there is an equatorial ring of 140 times the earth's radius, carrying a current of about 60 million amperes. The rays forming the ring are supposed to be quite distinct. Their value of $H\rho$ increases from 100 when the ring's radius is 1400 times the earth's to 10^6 when the former radius is 14 times the latter. For a given size of ring, the distance from the magnetic pole which rays coming from the sun can attain increases with the current in the ring. In the case of the largest angular distance considered in detail, $41{\cdot}6°$, the rays forming the ring and those coming from the sun have both 10^6 for their value of $H\rho$, and the

FIG. 2.—Enlargement of a photograph of an aurora on February 28, 1910.

current required in the ring is 100 million amperes. The magnetic field due to this current at the earth's surface is given as 681γ, which represents a magnetic storm of the first order.

In considering how the question is affected by the presence of the earth's atmosphere, Störmer inclines to the views of Wegener (while not committing himself to the existence of a gas, "geocoronium," of one-fifth the density of hydrogen). At altitudes above 100 kilometres there is supposed to be no trace of anything but the lighter gases, especially hydrogen (and geocoronium, if it exists). In agreement with Lenard, Störmer concludes that ordinary kathode rays coming from space would be absorbed in the upper hydrogen atmosphere before reaching the 100 kilometres level, that β-rays of radium would be absorbed in the nitrogen atmosphere at heights of 50 to 70 kilometres—a common altitude for the lower border of auroral "curtains"—and that the rays forming the lowest aurora he has measured must have a greater penetration than β-rays. Fairly substantial evidence has been advanced by Paulsen and others that auroras in the auroral belt, especially in Greenland, sometimes come much below the lowest height, 36 kilometres, observed by Störmer at Bossekop. This tends to support Birkeland's latest views as to an enormously high velocity in the rays if they originate in the sun. On the other hand, there seems reason to accept Störmer's view that auroras seen in low latitudes are usually at considerably greater heights than those seen in the Arctic. Thus aurora in low latitudes would seem to arise from rays of less, not of higher, penetration than those in high latitudes, which seems inconsistent with Birkeland's hypothesis.

Störmer's mathematical work, like Birkeland's, assumes the motion of the individual corpuscle to be unaffected by the presence of other corpuscles. This is one of the principal criticisms urged by Prof. Schuster,[2] who concluded that the scattering inevitably produced is fatal to Birkeland's theory, so far at least as magnetic storms are concerned. The same criticism would seem to apply, with at least equal force, to Störmer's theory. It would thus be of great interest to have Prof. Störmer's views on the validity of Prof. Schuster's criticisms. Meantime, considering the calibre of the protagonists, the prudent course seems to be to "wait and see." But whatever the fate of Störmer's theoretical work may be, his photographs of aurora clearly constitute a fundamental advance towards exact knowledge. In temperate and southern Europe, aurora and large magnetic storms are both rare events, and their coincidence of occurrence seems the rule rather than the exception. A total absence of physical connection between the two phenomena seems thus almost inconceivable. The careful intercomparison of measurements of aurora—rendered possible by Störmer's work—with contemporaneous records from magnetic observatories is clearly one of the most promising methods of getting at the root of the matter. C. CHREE.

[2] Roy. Soc. Proc., A. 85, 1911, p. 44.

PROF. THOMAS WINTER.

PROF. THOMAS WINTER, of the University College of North Wales, Bangor, whose death we recorded in our last issue, was the son of Mr. Thomas Winter, of Lotherton Park, Aberford, Leeds. Born in 1866, he was educated at the Darlington Grammar School under Dr. Wood, and afterwards proceeded to the University of Edinburgh, where in 1888 he graduated in arts with honours in natural science. On leaving the University he became a master at a Scarborough school, and later at the Norfolk County School at Dereham. The son of a successful practical farmer, and equipped with a university training in natural science, he was naturally attracted to the development of schools of agriculture in the provincial colleges and universities which marked the later decades of the last century. In 1891 he was appointed assistant lecturer in agriculture at the University College of North Wales, Bangor. In 1892 he accepted a similar appointment at the Yorkshire College, Leeds, as it then was, but returned in 1894 to Bangor as head of the department of agriculture, a post which he occupied for the next eighteen years. It is thus in North Wales that his life-work chiefly lay, and where the stimulus which he gave to the cause of agricultural education will be longest felt.

The work of a school of agriculture has its internal and external sides. On the internal side courses of instruction have to be provided with a view to certificates, diplomas, and degrees. On the external side the agricultural community within the area served by the school has to be considered, and extension lectures, field experiments, and instruction in dairy-work have to be provided for the benefit of those who cannot reach the college. In both these aspects of the work of his chair, Prof. Winter achieved a rare success. Within the University of Wales his sound judgment contributed to the framing of the existing scheme of instruction for the degree in agriculture and rural economy, the marked feature of which is the requisition of an adequate acquaintance with the pure sciences, prior to the study of their applications to agriculture. It was also to Prof. Winter's fostering care that the chair of forestry was established at Bangor.

In the external work of the department his gift of organisation and his tact and good sense have greatly contributed to the removal of the distrust of agricultural education among old-fashioned farmers. Not the least contribution to this end was his successful management of a college farm, where experiments in cropping and breeding have been carried out, and where the visits of farmers and their sons and daughters have always been welcomed. Prof. Winter's death while still in the prime of life will be greatly deplored by his colleagues on the senates of his college and university, by his former pupils scattered in many parts of the world, and not least among the farmers of the North Welsh counties.

THE BRITISH ASSOCIATION AT DUNDEE.

IT is often pointed out that the meetings of the British Association can never be so important in the future in the estimation of the public as they were in the past. First, because there used to be only one yearly congress attracting general attention; now there are many, and any such meeting is a great expense to a town. Secondly, the most important function of the meeting, the temporary creation of an interest in natural science, is less wanted, because everybody now takes an interest in science, and almost every city now visited has a science college where evening lectures are given. Thirdly, the disappearance of the pioneers of the Huxley type, whose names were well known outside scientific circles. Fourthly, the death of that interest which used to be excited by the quarrel between science and religion.

The Dundee meeting shows that the British Association excites as much interest, not merely among scientific men, but in the general public, as it has ever done in the past. In the hotels here there is still hanging a notice of some weeks ago referring to the expectation that the membership of this meeting may reach 1200 in number. As I write, the number is more than 2460, a number greater than that of the members of the Dundee meeting of forty-five years ago, which is often referred to as a great meeting.

There has been a little grumbling that there were some hundreds of members who could not get seats for the president's address and some of the evening lectures. Naturally, the local secretaries are blamed, but they have the valid excuse that nobody could have expected the meeting to be so successful as to numbers, and they were probably afraid that the hall provided might actually be too large. Much of the success of a British Association meeting is due to the recognition by the local authorities that some one man of great energy and knowledge and tact and good humour must devote himself to its organisation for eighteen months beforehand. Large subscriptions of money are wanted; enthusiasm must be created and maintained in an army of hard-working members of committees. Nobody denies that it is to Prof. D'Arcy Thompson that the enormous success of this meeting is due. Everybody knows the grumbling which in some irritable members is sometimes very loud, when they meet with slight inconveniences. Whether it is that the arrangements are more perfect than usual or that members are in better temper, I do not know, but there is certainly less than the usual amount of complaint.

Almost everybody expected the weather to be bad. Except that we had rather windy weather for a day, and some occasional threats of rain which came to nothing, the weather has been very good. The hotel accommodation is not great for so important a town, but there is much private hospitality, and on the whole the physical comforts of the visitors are better looked after than a person acquainted with Dundee could have anticipated.

At every meeting of the British Association it is found by the visitors that most of the good reserved seats for the presidential address are booked by local people before the first day of the meeting. It is probable that the pressure of the local desire for seats is always too great for the resistance of the local secretaries. The consequent heartburning has been greater than usual this year, because the number of members so largely exceeds all expectation.

The success of a meeting depends greatly on the attention paid to certain details some of which might seem unimportant. First, the reception room should be large, and should have such ample accommodation of many kinds that members, when there, shall feel almost as if they were in a club. It ought to be in a central position, as near as possible to the most frequented section. It is essential that the meetings of the council and general committee and the committee of recommendations should be held in some neighbouring place, if not in the same building. Secondly, there are now twelve sections, and meeting rooms must be provided for each of them, each with its committee room, and sometimes one section may split up into two or three. These rooms must all be large and conveniently arranged, because changes cannot be made near the time of the meeting, and any of the sections may turn out to be exceedingly popular, and be unexpectedly well attended. Thirdly, although there are many members who wish to attend only one section, and the Recorders try to keep papers of one particular kind of interest to one section, on any one day, a member always finds that there are papers interesting to him in two or more sections, and he desires to hear them.

It is therefore important to have facilities for getting rapidly from one section to another. I am now speaking of the scientific members. But besides these, the non-scientific people must be thought about, the people who divide their attention over all the sections, and who desire to hear as many interesting papers as possible on quite diverse subjects. It is evident that the best of all cities for a British Association meeting is one which can house all the twelve sections and reception room in one great building or in a few large buildings which are close together. But as this is generally impossible, the best compromise is to place the sections near one another in groups of allied subjects. It is evident that great attention has been paid to this most important idea at Dundee, and, considering the accommodation of the town, it is impossible to suggest a change for the better.

The sections for mathematics and physics, chemistry and engineering, are in the University College buildings, not too easily reached from the reception room, a fifteen minutes' walk or by infrequent tram-car; with these we have zoology and physiology. The College buildings are well away from the other groups. One other such group is of geology, botany, and agriculture;

another is geography and anthropology; another is economics and education, and, except the College group, they are all quite near the reception room. No matter what arrangements had been made, there must have been inconvenience for some members. It is now difficult for a man whose chief interest is in physiology to hear a botany paper, or for a man interested in mathematics or physics or chemistry to hear an education paper, but I have heard much less complaint about such matters than I have ever heard before at a British Association meeting.

The presidential address is usually rather a disappointment to a general audience, many of whom cannot hear, and the subject is often of only special interest to some scientific people. On this occasion the voice of the president was low but penetrating, and I never remember an occasion since the time of Tyndall when one felt so strongly that there was subdued but intense feeling in the audience. When at length the Lord Provost sprung upon the meeting the hitherto carefully hidden fact that Dr. Caird had made us a gift of 10,000*l.*, there was a thrill through the audience which made itself immediately manifest. Satisfaction and delight were to be expected on the faces of the visitors, but it might have been expected that Dundee people would not altogether like to see so large a benefaction leaving their town. But, as a matter of fact, the pride already felt by the local people in the acknowledged success of the meeting was augmented in a wonderful manner, and there was only delighted satisfaction in their faces and congratulation in their language. The feeling of the more permanent members of the association is soberly expressed in the remarks of the treasurer when he proposed the vote of thanks to Dr. Caird at the meeting of the general committee.

As for the scientific work, I can only speak as one member attending sections A and G. The presidents' addresses and the reading of papers have so far been well attended by mathematicians, physicists, and engineers, as well as by the ordinary members. A joint discussion between these sections on unsolved problems in wireless telegraphy was so well maintained and so interesting that when Lord Rayleigh was speaking, one thought at once of the possible return of the older times when Kelvin or Fitzgerald suddenly illuminated our proceedings. From men attending the other sections I have heard so far only of successful sectional meetings. There is no doubt that much more than the average number of members capable of speech and interested in the scientific work of the Association are present at this meeting of the British Association.

JOHN PERRY.

At the meeting of the general committee on Friday, September 6, it was unanimously resolved "That the best thanks of the British Association be expressed to Dr. J. K. Caird for his most generous gift to the Association." Speaking to the motion, Prof. Perry, the general treasurer, said:—"This is the only gift of money that the British Association has ever received. It is greatly needed. In my eight years of office as treasurer the nominal assets of our Association have neither increased nor diminished. I have made the fat years of our visits to large cities make up for the lean years of our visits to smaller towns. But although our nominal wealth is the same, our actual wealth is less because of the depreciation of Consols and our other investments.

"There are two great functions of the British Association. One is to stir up all the people of this Empire occasionally to take an interest in scientific discovery and research of all kinds; the other is less known. It is perhaps the treasurer of the British Association who knows better than anybody else the enormous importance of the work that is done every year by the committees appointed by the various sections to make scientific researches during the ensuing year.

"Groups of men of the highest scientific attainments and reputation give their time and enthusiasm to the work, and they only ask that quite a small part of their out-of-pocket expenses shall be paid. I know of no work in the world that is so important or that is so little known.

"Every year your treasurer meets the Committee of Recommendations, each section strong in its reason for getting money, and yet the aggregate amount asked for is so much above our means. It really goes to my heart every year to limit the supply of money, and my colleagues here, the secretaries, blame me every year because I give more money than I ought. I particularly feel for the biological committees. I know nothing of biology, but I know of the enormous importance of the work done by the biological committees; and these biological people can get no outside money. If I want money for any important scientific object relating to physics or engineering, I know at once where to apply for a few hundreds or even many hundreds of pounds, and I get it readily, for men have become rich through engineering. But the biological people seem to have no outside pecuniary resources. I am, however, glad to think that this gift is not earmarked in any way. It is generous and unconditional.

"Gentlemen, your treasurer assures you that this splendid gift of Dr. Caird will return him more interest than all the other benefactions."

At the same meeting of the general committee, Sir William White, K.C.B., F.R.S., was elected President for the meeting of the Association to be held at Birmingham next year from September 10 to September 17. The following have been appointed Vice-Presidents of this meeting:—The Right Hon. the Lord Mayor of Birmingham, the Lord Lieutenant of Warwickshire (the Most Hon. the Marquess of Northampton), the High Sheriff of Warwickshire, the Lord Lieutenant of Worcestershire (the Right Hon. the Earl of Coventry), the Lord Lieutenant of Staffordshire (the Right Hon. the Earl of Dartmouth, V.D.), the Right Rev. the Lord Bishop of Birmingham, the Chancellor of the University of Birmingham (the Right Hon. J. Chamberlain, M.P.), the Vice-Chancellor of the University of Birmingham, the Principal of the University of Birmingham (Sir Oliver Lodge, F.R.S.), the Hon. President of the Birmingham Chamber of Commerce (the Right Hon. Jesse Collings, M.P.), Alderman the Right Hon. William Henrick, J.P., the Deputy Lord Mayor of Birmingham, Prof. J. H. Poynting, F.R.S., Prof. C. Lapworth, F.R.S.

Local officers:—Treasurers, Alderman Sir G. H. Kenrick and Councillor Neville Chamberlain, J.P.; secretaries, Prof. F. W. Gamble, Mr. Howard Heaton, Mr. John Humphreys, and Mr. W. Byng Kenrick.

SECTION B.

CHEMISTRY.

OPENING ADDRESS BY PROF. A. SENIER, PH.D., M.D., D.SC., PRESIDENT OF THE SECTION.

I AM sure it will be agreeable to the feelings of the members of this section that, before beginning my address, I should refer to the great losses we have sustained by death since our gathering last year at Portsmouth.

An active member and past-president has passed away in the death of Edward Divers, after a serious operation, undergone at his advanced age with characteristic fortitude. His devotion of his long life, in this country and Japan, to the advancement and diffusion of science is indelibly inscribed in its records. But Divers was more than an investigator and teacher; he was a beloved centre of our social life, and was particularly happy when he could bridge over the distance between the young beginner in research and the older experienced master. He understood and had the sympathy of both.

In Henry Forbes Julian, one of the victims of the awful disaster to the *Titanic,* we have lost a valued contributor to our proceedings; though he was best known as a geologist and metallurgical engineer. It was, however, by chemistry, under the inspiring influence of Sir Henry Roscoe, that his first enthusiasm for science was aroused. Forbes Julian was a leading technical adviser in mining undertakings, and his advice was much sought after, especially in South Africa, and even in Germany.

Another tragedy, from the shock of which we have not yet recovered, has deprived science of the young and promising inquirer, Humphrey Owen Jones. We know the dreadful details—he and his young wife—how they became sacrifices to the treacherous crags and snows of Mont Blanc.

And this, alas, is not all. On the very day of the fatal accident to Humphrey Jones, another young and promising chemist—John Wade—passed from us from the effects of a cycling accident. He was an inquirer of singular ability, and found time also to give us one of our deservedly most popular manuals of organic chemistry.

PART I.

The Nature and Method of Chemistry.

Perhaps there is no intellectual occupation which demands more of the faculty of imagination than the pursuit of chemistry, and perhaps also there is none which responds more generously to the yearnings of the inquirer. It is surely no commonplace occurrence that in experimental laboratories day by day the mysterious recesses of Nature are disclosed and facts previously quite unknown are brought to light. The late Sir Michael Foster, in his presidential address at the Dover meeting, said:—"Nature is ever making signs to us, she is ever whispering the beginnings of her secrets." The facts disclosed may have general importance, and necessitate at once changes in the general body of theory; and happily, also, they may at once find useful application in the hands of the technologist. Recent examples are the discoveries in radio-activity, which have found an important place as an aid to medical and surgical diagnosis and as a method of treatment, and have also led to the necessity of our revising one of the fundamental doctrines of the theory of chemistry—the indivisibility of atoms. But the facts disclosed may not be general or even seem important; they may appear isolated and to have no appreciable bearing on theory or practice—our journals are crowded with such—but he would be a bold man who would venture to predict that the future will not find use for them in both respects. To be the recipient of the confidences of Nature; to realise in all their virgin freshness new facts recognised as positive additions to knowledge, is certainly a great and wonderful privilege, one capable of inspiring enthusiasm as few other things can.

While the method of discovery in chemistry may be described, generally, as inductive, still all the modes of inference which have come down to us from Aristotle, analogical, inductive and deductive, are freely made use of. A hypothesis is framed which is then tested, directly or indirectly, by observation and experiment. All the skill, all the resource the inquirer can command, is brought into his service; his work must be accurate; and with unqualified devotion to truth he abides by the result, and the hypothesis is established, and becomes part of the theory of science, or is rejected or modified. In framing or modifying hypotheses imagination is indispensable. It may be that the power of imagination is necessarily limited by what is previously in experience—that imagination cannot transcend experience; but it does not follow, therefore, that it cannot construct hypotheses capable of leading research. I take it that what imagination actually does is—it rearranges experience and puts it into new relations, and with each successive discovery it gains in material for this process. In this respect the framing of a hypothesis is like experimenting, wherein the operator brings matter and energy already existing in Nature into new relations, new circumstances, with the object of getting new results. The stronger the imaginative power, the greater must be the chance of success. *The Times*, in a recent leading article on Science and Imagination, says:—"It has often been said that the great scientific discoverers . . . see a new truth before they prove it, and the process of proof is only a demonstration of the truth to others and a confirmation of it to their own reason." While never forgetting the essentially tentative nature of a hypothesis, still, until it has been tested and found wanting, there should be some confidence or faith in its truthfulness; for nothing but a belief in its eventual success can serve to sustain an inquirer's ardour when, as so often happens, he is met by difficulties well-nigh insuperable. In a well-known passage Faraday says:—"The world little knows how many of the thoughts and theories which have passed through the mind of a scientific investigator have been crushed in silence and secrecy by his own severe criticism and adverse examination; that in the most successful instances not a tenth of the suggestions, the hopes, the wishes, the preliminary conclusions have been realised."

But a hypothesis to be useful, to be admitted as a candidate for rank as a scientific theory, must be capable of immediate, or at least of possible, verification. Many years ago, in the old Berlin laboratory in the Georgenstrasse, when our imaginations were wont, as sometimes happened, to soar too far above the working benches, our great leader used to say:—"I will listen readily to any suggested hypothesis, but on one condition—that you show me a method by which it can be tested." As a rule, I confess we had to return to the workaday world, to our bench experiments. No one felt the importance of the careful and correct employment of hypotheses more than Liebig. In his Faraday lecture Hofmann says of Liebig:—"If he finds his speculation to be in contradiction with recognised facts, he endeavours to set these facts aside by new experiments, and failing to do so he drops the speculation." Again, he gives an illustration of how on one occasion, not being able to divest himself of a hypothesis, he missed the discovery of the element bromine. While at Kreuznach he made an investigation of the mother-liquor of the well-known salt, and obtained a considerable quantity of a heavy red liquid which he believed to be a chloride of iodine. He found the properties to be different in many respects from chloride of iodine; still, he was able to satisfy all his doubts, and he put the liquid aside. Some months later he received Balard's paper announcing the discovery of bromine, which he recognised at once as the red liquid which he had previously prepared and studied. Thus, though imagination is indispensable to a chemist, and though I think chemists should be, and let us hope are, poets, or at least possess the poetic temperament, still, little can be achieved without a thorough laboratory training; and he who discovers an improved experimental method or a new differentiating reaction is as surely contributing to the advancement of science as he who creates in his imagination the most beautiful and promising hypothesis.

It may never be possible to trace in civilisation's early records the exact period and place of the origin and beginnings of our science, but the historical student has been led, it appears to me, by a sure instinct to search for this in such lands of imaginative story as ancient Egypt and Arabia. For is there anything more fittingly comparable with the marvellous experiences of a chemical laboratory than the wonderful and fascinating stories that have come down to us in "The Arabian Nights"? Those monuments of poetic building of which Burton, in the introduction to his great translation, says that in times of official exile in less-favoured lands, in the wilds of Africa and America, he was lifted in imagination by the jinn out of his dull surroundings, and was borne off by him to his beloved Arabia, where under diaphanous skies he would see again "the evening star hanging like a golden lamp from the pure front of the western firmament; the after-glow transfiguring and transforming as by magic the gazelle-brown and tawny-clay tints and the homely and rugged features of the scene into a fairyland lit with a light which never shines on other soils for seas. Then would appear," &c. I cannot help thinking that the study of such books as this, the habit of exercising the imagination by reconstructing the scenes of beauty and enchantment which they describe, might do much to strengthen and sharpen the imaginative faculty, and greatly increase its efficiency as an indispensable tool in the hands of the pioneer who seeks to extend the boundaries of knowledge. *The Times*, in the leading article already quoted, says that, as with a Shakespeare, "it is the same with imaginative discoverers in science. . . . But the faculty is not merely a fairy gift that can be exercised without pains. As the sense of right is trained by right action, so the sense of truth is trained by right thinking and by all the labour which it involves. That is as true of the artist as of the man of science; and one of the greatest achievements of science has been to prove this fact and so to justify the imagination and distinguish it from fancy."

Again, let it not be forgotten that chemistry in its highest sense—that is, in its most general and useful sense—is purely a world of the imagination, is purely conceptual. And in addition to this, moreover, it is based, like all science, on the underlying assumption of the uniformity of Nature, an assumption incapable of proof. If we think of the science as a body of abstract general theory, and exclude for the moment from our purview its innumerable practical applications, and also all special individual facts not yet known to be related to general theory, then what remains are the more or less general facts or laws. These it is which give the power of prediction in newly arising cases of a similar character; the power of foresight by which the claim of chemistry to its position as a science is justified. Chemistry, as such, is a complicated ideal structure of the imagination, a gigantic fairy palace, and, be it noted, can only continue to exist so long as there are minds capable of reproducing it. Think of all the speculation—and speculation too of the highest utility when translated into concrete applications—about the internal structure of molecules. I venture to say that the most magnificent creations of the world's greatest architects are not more elaborate or more beautiful or more fairylike than the chemist's conception of intramolecular structure and the magical transformations of which molecules are capable; and yet no one has had direct sensuous experience of any molecule or atom, or possibly ever will. It is well from time to time to recall these truths and realise where we are. But although the conceptual nature of science is unquestionable, it certainly contains truth in some form as tested by deductive concrete realisation, by correctness of prediction, and during the last century or two has undoubtedly given to man a mastery over Nature never before dreamt of.

A Brief Historical Retrospect.

The foundations of chemistry, as we now know it, were laid under the influence, the guidance, of three great theories: first, the theory of the alchemists of the transmutation of metals by means of the philosopher's stone; second, the theory of phlogiston, connected so much with the names of Becher and Stahl, which held sway for some two centuries; third, the theory of combustion, the quantitative period of chemistry, inaugurated by the great Scottish chemist Black by his introduction of the balance. How this led to a veritable renascence of chemistry in the hands of Lavoisier and the other giants of that stirring period—the close of the eighteenth and commencement of the nineteenth centuries—is well known. Looking back at the warfare which was waged about these older theories, for and against them, one realises now that there were elements of truth on both sides; for have we not in the work of Sir William Ramsay and others the revival of transmutation, and does not the essential truth of phlogiston survive in the modern doctrine of heat? In one of Dr. Johnson's letters to Boswell there is a curious reference to transmutation. He says that a learned Russian had at last succeeded, but, fearing the consequences to society, he had died without revealing the secret.

After the discovery of oxygen and the beginnings of quantitative chemistry, the science was ready for Dalton's great discoveries respecting combination by weight; the corresponding discoveries by Gay-Lussac on combination of gases by volume, and, through the latter, for Avogadro's famous hypothesis. Dalton had indeed, by reviving an old Greek suggestion, proposed to explain his discoveries by his atomic theory, but neither this nor our molecular theory, though the latter was inherent in the laws of gaseous combination of Gay-Lussac and in Avogadro's hypothesis, was finally put upon its present basis until Cannizzaro took up the subject half a century later. Meanwhile Dulong and Petit had completed their studies of atomic heat, and Mitscherlich had pointed out the relation between isomorphism and molecular structure. When it is considered how little is known of solid or liquid structure, and that our present knowledge of molecules is only of gaseous molecules, it is fortunate that these methods of study of solids are available. The same may be said of the results of the work of Kopp and his successors on molecular volumes. Of other aids to fixing our conception of molecules and atoms I need only refer to the periodic law, the studies of the properties of dilute solutions, of electrolytic dissociation, and of surface tension of liquids.

Liebig, in his first inquiry, begun before he went to Gay-Lussac in Paris, proved that silver fulminate and silver cyanate, though distinct substances, had exactly the same composition; thus was opened that great chapter in the history of chemistry which Berzelius named isomerism. Perhaps nothing in chemistry has given rise in recent years to more intellectual and practical activity than isomerism. Wöhler's classical synthesis of urea, by the metastasis of ammonium cyanate, added another instance of isomerism, and Berzelius soon afterwards announced the isomerism of tartaric and racemic acids. Wöhler's synthesis of urea, followed, as it was, by numerous other laboratory syntheses, showed that substances which occur in living organisms are not different from those which may be prepared artificially, and the old distinction between inorganic and organic chemistry disappeared—there is, of course, only one chemistry. The words, it is true, have survived, but only for reasons of practical convenience.

After isomerism the next great step forward in the study of intra-molecular structure was the discovery of groups partially individualised which are capable of remaining intact through many reactions. Gay-Lussac had previously noticed the cyanogen group as common to cyanides; but it was the celebrated paper by Wöhler and Liebig on the radical of benzoic acid which finally established the existence of compound radicals or groups such as benzoyl, and obtained for the theory of compound radicals the position in chemistry it now holds. Bunsen followed somewhat later with the discovery of cacodyl, and now such groups are almost innumerable. In many respects, by the experimental skill which it shows, the clearness of its logical method, and the beauty of its form and diction, this memoir is a model of what a scientific communication should be. I will read the opening paragraph, using Hofmann's translation:—"When a chemist is fortunate enough to encounter, in the darksome field of organic nature, a bright point affording him guidance to the true path by following which he may hope to explore the unknown region, he has good reason to congratulate himself, even though he may be conscious of being still far from the desired goal." Of this memoir Berzelius, in a letter quoted by Hofmann (Faraday lecture), says:—"The facts put forward by you give rise to such considerations that they may well be regarded as the dawn of a new day in vegetal (organic) chemistry."

The history of the advance of chemistry since the days of the Giessen laboratory is bewildering in its extent. This has been largely due to the Giessen laboratory itself, which sent trained investigators, each carrying with him some touch of its master's magic, into all civilised lands. I cannot attempt to even catalogue the results here. One thing may be said, that chemistry is not worked out, as some have thought; but rather the opportunities of discovery seem greater and more promising than at any previous period.

PART II.

Sub-atoms, Atoms, Molecules, Molecular Aggregates; Valency.

Whether in the light of recent researches it may become necessary to give up that portion of Dalton's theory of atoms in which he regards them as undecomposable and indivisible; or whether we may consider them, as Prout suggested a hundred years ago, as different aggregates of sub-atoms of a uniform kind of matter; or whether they must be regarded as complexes built in the manner supposed by the electron hypothesis; also what should be our attitude towards the related problem of transmutation—all this I pass over, the more willingly that these subjects were discussed so recently by so high an authority as Sir William Ramsay in his address to the Association last year at Portsmouth.

I assume that we are fairly satisfied with our present atoms and their respective weights, and this no matter how the atoms are constructed, and that we shall be satisfied with them so long as they disport themselves in chemical changes as indivisible entities. And further, I assume that we are satisfied with our molecules and their respective weights, as determined by the application of Avogadro's hypothesis. Whether the molecular weight is obtained by direct determination of gaseous density or by taking advantage of the properties of dilute solutions, in either case the molecular weight which results is the weight of a supposed gaseous molecule, for the latter method depends for its justification on the former. All our molecular weights are weights of molecules in the gaseous state or are supposed to be; they are not necessarily applicable to liquids, and much less to solids: solids and liquids may well consist of far more complex particles.

Gradually the central problem of chemistry has become more and more the study of internal structure of molecules—of gaseous molecules. The enormous number and variety of the compounds of carbon, with which so many workers have enriched the science during the last hundred years, and the special adaptability of these compounds to the experimental study of molecular structure, have led investigators to make use of them rather than of the so-called inorganic compounds: thus out of inquiries into the intra-molecular structure of these compounds arose and were developed the theories of types of Gerhardt, Williamson, and Kekulé. These are now, however, looked upon more as aspects of the general problem. More fruitful has been the study of the compound radicals or individualised groups of Wöhler and Liebig. But gradually these molecular structures have been regarded, in agreement with the views of Dumas, as complete wholes; like fairy temples, which from different points of view show different parts in relief, accentuating, it may be, this or that column or frieze or pediment. Kekulé's brilliant and suggestive theory of chain compounds and ring compounds did more than any other theory to guide and stimulate research in chemistry in recent times. Like Gay-Lussac's theory of gaseous combination, though built in the first place only upon a few facts, this theory has proved true of the thousands of others with which we have since become acquainted; there seems indeed to be a need of a new psychology to account for such truly marvellous foresight as is here exhibited. The atoms forming these varied structures were, however, regarded as being arranged in a plane, until the great discoveries of Pasteur made it necessary for chemists to extend their conceptions and to frame hypotheses of three dimensions. Thus have arisen in the hands of Le Bel and van't Hoff and others our modern theories of stereo-chemistry. When isomerism occurs in an element Berzelius names it allotropy. It seems to me that now, when molecules of the elements do not differ essentially from molecules of compounds, there is no longer any distinctive meaning in the term, and that it might well be abandoned. I would like also to make another suggestion respecting nomenclature: that when we distinguish ring compounds as *cyclic* we might appropriately adopt the word *hormathic* (from the Greek word for a chain or a row) for chain compounds.

But in order to understand the linking of atoms in these molecular edifices some combining value had to be assigned to the different atoms. This idea of valency of the atoms was, no doubt, implied in Gerhardt's theory of types; but it did not gain much attention until later, when Frankland and Kolbé formulated an empirical theory of variable valency. Kekulé thought that atoms could not vary in their valency; but the alternative formulæ which he put forward to explain cases of difficulty would appear to be, rather, an attempted explanation of variable valency. It might be more correct to say that Kekulé's formulæ constitute an anticipation of Werner's theory of auxiliary valencies, the theory which seems to find most favour at the present day. Fixed valency can scarcely now be defended, in view of the existence of such compounds, for example, as the two fluorides and the two chlorides of phosphorus; the two oxides of carbon, ammonia and ammonium chloride; and, for example, the two series of compounds respectively of iron, mercury, and copper. Variable valency of atoms is, empirically at least, an establish fact.

By the latest conceptions of variable atomic valency and its extension almost without limit—so that, for example, oxygen may be regarded as quadrivalent and even sexivalent—no doubt the existence of numerous compounds which previously presented difficulties can be explained. There are, however, others long known to chemists, such as double salts and the combination of water with salts, formerly called "molecular compounds," definite and individual, in which these views do not assist us. These compounds do not exist as gases, and unless they admit of experimental study by the methods of dilute solution, even their gaseous molecular weights cannot be ascertained.

It is noteworthy that in most of the instances recently investigated where variable valency has been assumed the compounds studied have been easily decomposable solids or liquids, and for one reason or another their gaseous molecular weights could not be determined. Many of these compounds, indeed, only exist at low temperatures. As instances of work of this kind I may mention Collie and Tickle on quadrivalent oxygen in dimethylpyrone derivatives; Gomberg on triphenylmethyl; Landolf on acetone dihydrofluoride; Thiele and Peter on methyl-iodo-dichloride; and similar studies by Kehrmann, Willstätter and Iglauer, Bülow and Sicherer, Baeyer and Villiger, Archibald and McIntosh, Chattaway, Pfeiffer and Truskier, and others.

Another most interesting class of solids which are capable of existing in two isomeric forms distinguished from each other by such physical properties as density or colour are the Schiff's basis or anils. Some of these were studied by Hantzsch, who proposed to explain their existence by the Hantzsch-Werner stereo hypothesis:—

$$\begin{array}{cc} HO.C_6H_4.CH & HC.C_6H_4OH \\ \quad\quad\quad\ \| & \| \quad\quad\quad \\ \quad\quad\quad NR' & NR' \quad\quad\quad \end{array}$$

But since only a few, and these not very satisfactory, compounds show this isomerism, which do not contain the hydroxyl group, other suggestions have been put forward to account for the isomerism, by Anselmino and by Manchot.

In my own laboratory, associated with Mr. F. G. Shepheard and also with Miss Rosalind Clarke, I have made a study of various Schiff's bases for the purpose of investigating the remarkable property which some of these bases exhibit of *phototropy*. By phototropy is meant the capability of reversible change of colour in solids depending upon the presence or absence of light. Incidentally, too, I wished to study another physical property which many Schiff's bases possess, in common with other substances, of reversible change of colour with raising or lowering of temperature. This property we have called *thermotropy*, and many old instances will be remembered of substances of simpler constitution which exhibit it: thus, when subjected to the temperature of solid carbon dioxide, ordinary sulphur becomes colourless, red oxide of mercury becomes yellow, vermilion becomes scarlet, and on return to the ordinary temperature the original colours reappear.

As has been pointed out in a recent communication by Biilman, it is most important in these discussions that we should be perfectly clear in the use of terms. I take it for granted that *isomerism* is a general term for compounds differing in some respect but having the same composition. If the molecules (gaseous) have the same weights they are *metamerides*; if of different weights they are *polymerides*. When solids crystallise in more than one form they are *polymorphous*. Now it does not seem reasonable to suppose that reversible colour changes such as those exhibited by phototropes or thermotropes involve such violent intra-molecular changes as the breaking and reconnecting of atomic linkages. For example, take the three bases, salicylidene-*m*-toluidine, which in the dark or immediately it is exposed to light is yellow, but on continued exposure to light quickly becomes orange, and changes back again to its original colour in the dark; salicylidene-*m*-aminophenol, which at ordinary temperatures is orange, but is much paler at the temperature of solid carbon dioxide, on raising the temperature to nearly the melting-point (128·9°) becomes orange red, and these changes take place in the reverse order again on cooling; salicylidene-*p*-aminobenzoic acid, studied by ourselves and by Manchot and Furlong independently, shows a wider range of thermotropic change between bright yellow and blood-red, and is also phototropic. To explain such changes as these and the others of a similar nature previously referred to, I think some less drastic hypothesis should be sought than intra-molecular breaking, and consequent metastasis or polymerisation. Though doubtless the hypothesis of Hantzsch and Werner could be invoked, or the modified hypotheses of Manchot or Anselmino, I think there should be some simpler explanation. Someone suggests polymorphism. Now polymorphism means that a change of crystalline form takes place which might doubtless connote change of colour. If one watches phototropic crystals changing colour under the influence of light from yellow to red, and notices that after remaining in the dark the same crystals have changed back to the original colour, and, remember, that these changes can be repeated with the same crystals apparently without limit, it will not be considered likely that this phenomenon depends on a reversible change of crystalline form. In a communication to the Chemical Society some three years ago Mr. Shepheard and I put forward the following suggestion:—"Evidence is accumulating of reversible isomeric reactions, like those described in this paper, which are indicated by physical differences, such as changes of colour. It is possible that these may be explained by hypotheses, similar to that of Hantzsch and Werner, assuming intra-molecular rearrangement; but in the case of phototropy and thermotropy it should not be forgotten that the substances exhibiting these phenomena are solids. No one will doubt, however, that these differences of colour depend on isomeric change of some kind, but in the case of solids we know practically nothing of their molecules, not even of their relative molecular weights. The molecules of solids are probably far more complex than those of liquids or gases; indeed, they may be rather complex groups or aggregates of ordinary gaseous molecules, which would give rise to far more numerous possibilities of isomerism. It appears to us that phototropic and thermotropic reactions are more probably due to isomeric changes affecting the aggregation of molecules in solids than to intra-molecular change of molecules derived from a study of gases."

It seems to me that just as atoms may be structures built of sub-atoms of some kind, and just as molecules of gases are built of atoms variously linked together, it is reasonable to conceive that molecules might combine to form aggregates, particularly when constituting solids; that as the sub-atoms may be conceived to have a combining valency—and the atoms are already accredited with this property, and in addition, as is supposed with Thiele's partial or Werner's auxiliary valencies—molecules may have valencies also whereby to combine into molecular aggregates. It may be presumed that such aggregates are more complicated in structure, and thus may give rise to greater variety of isomerides, and be more readily transmutable than gaseous molecules. If such aggregates of gaseous molecules exist they might explain not only the easily changed isomerides recently studied, but also the large class of "molecular compounds" of the older chemists. I imagine someone saying that in suggesting this hypothesis—which by the way is not new, for it is mentioned in Ostwald's "Outlines"—I am violating the canon to which I have myself subscribed, as a condition of a scientific hypothesis, that it should be verifiable. Perhaps we carry our critical faculty sometimes too far. It is most highly scientific to doubt, but doubt which is merely destructive has little value; rather, with Descartes, it should lead on to construction, for he who builds even imperfectly is better than he who simply destroys. And I do not doubt that some way will be found to study solids and obtain data that will lead to the determination of their molecular aggregate weights. The study of molecular volumes of solid solutions; the remarkable results obtained by Pope and Barlow; Tutton's work on crystallography, and much besides, induce the hope that some day solids, like gases, will find their Avogadro.

PART III.

Pursuit of Chemistry Justified by its Useful Applicability.

In the pursuit of all this abstract theory, and still more so in the bewildering multitude of undigested individual facts, there is danger that important and fundamental, even moral, considerations may be lost sight of. For example, take the fundamental question: Why should we pursue chemistry? No doubt it is considered by its votaries, those who seek in our laboratories to advance the science, that they are entitled to have provided for them, and will be rewarded by the provision of, the ordinary means of livelihood; but these, it will scarcely be denied, could generally be far better assured by other pursuits. It is suggested that intellectual discipline is a reason; but, I ask, for what purpose? Will anyone pretend that intellectual discipline without utilitarian object, without the possibility of using it for the betterment of society, is a worthy pursuit? I think not. But, in any case, none of us have devoted ourselves to chemistry merely for the sharpening of our wits. Again, someone suggests that chemistry and learning generally should be pursued for their own sake. In a recent most interesting and inspiring academic address[1] Prof. Sir Walter Raleigh commends "those who seek nothing from knowledge but the pleasure of understanding." If such a statement bears its most obvious meaning then, I venture to think that, in common with intellectual discipline without the intention of applying to a useful object the intellect so trained, such a reason is selfish, inadequate, and unworthy, and does not justify the pursuit of anything. No; research in chemistry apart from the possibility of applying it to the advantage of humanity cannot be defended. The mastery of the seemingly unlimited resources of Nature which chemistry achieves more and more and its use to alleviate the misery and add to the happiness of mankind are the only worthy and effective defence. And that this is the underlying ideal, in point of fact, that leads the chemist onward, not necessarily that he is always conscious of it, but always when he reflects, I think cannot be doubted. But, of course, no narrow idea of utility must be aimed at. Practically any chemical inquiry may lead to results of material advantage. Certainly nothing could be more mischievous than to make a narrow immediate utility the test. It would be easy to illustrate all this from the records of science, but instances in point are so well known that it is unnecessary.

On the other hand, it should not be forgotten that in making use of the manifold advantages derived from the growth of science, humanity, on its part, owes a great debt to scientific inquirers, and ought to feel it a sacred duty to do in return all in its power by support and encouragement to further scientific research. As Sir Walter Raleigh, in the address already referred to, says:—"It is so easy to use the resources of civilisation that we fall into the habit of regarding them as if they were ours by right. They are not ours by right; they come to us by free gift from the thinkers."

Some Concrete Applications of the Science.

That this advantage to civilisation has been, and is, the result of the pursuit and consequent advance of chemistry is happily a truth that is well known. There is scarcely an industry or a profession that has not been materially influenced or even created by the discoveries of chemistry, and therefore the welfare of nations is most intimately concerned in promoting its advancement. Now, it is common knowledge that no country has appreciated this to the same degree as Germany. It will, therefore, be worth our while to consider a moment the inauguration in Berlin, a year ago, of an entirely new institution, the Kaiser Wilhelm Institut, for the promotion and organisation of chemical research. This research is to be effected throughout the German Empire, in the universities, the technical high schools, or in works, and it is supported mainly, at least at first, by subscriptions of the chemical manufacturers. An address of very great importance was delivered at its opening by Prof. Emil Fischer, than whom, perhaps, no one living has added more to the progress of chemistry. A translation of this address appeared in NATURE, and, with additions, has since been published in a convenient book form.[2] In this address an authoritative account is given of the main contributions of chemistry to the national welfare, which even to those familiar with the subject must be astonishing in their importance, variety, and universality. It includes the applications of the science to problems of nourishment, to agriculture, and food supply; to engineering, metallurgy, cements; to clothing, artificial silk, or to colouring—dyes; to indiarubber production, both natural and artificial; to perfumery—artificial violet and other artificial floral perfumes, even that of the rose; to synthetic camphor; to drugs and synthetic materia medica, including the recent arsenic and selenium organic compounds which promise so much in the treatment of cancer and other fatal diseases; to radio-activity, to therapeutics, to the destruction of pathogenic microbes; to methods of sewage disposal; to the preparation of efficient ex-

[1] "The Meaning of a University." (Clarendon Press, 1911.)

[2] "Chemical Research in its Bearings on National Welfare." (London, 1912.)

plosives; and to many other useful objects. In connection with the manufacture of explosives the public should know that the ability to wage war is becoming more and more dependent on the work of chemists. When the supply of mineral nitrates is exhausted, or even before that event, the requisite nitrogen compounds will have to be provided in some other way, and almost certainly they will be obtained synthetically from the atmospheric gases which even now are becoming a commercial source.

The Time-spirit and Science.

But students of history know that there are certain periods that for some unexplained reason are specially fruitful in certain departments of intellectual or artistic development. Prof. Sir Walter Raleigh, for instance, a high authority on this subject, says:—"The human body, so far as we know, has not been improved within the period recorded by history; nor has the human mind, so far as we can judge, gained anything in strength or grace." Further, regarding literature:—"The question is not by how much we can excel our fathers, but whether with toil and pains we may make ourselves worthy to be ranked with them." Again:—"In the beautiful art which models the human figure in stone or some other enduring material, who can hope to match the Greeks? In the art of building who can look at the crowded confusion of any great modern city, with all its fussy and meaningless wealth of decoration, like a pastrycook's nightmare, and not marvel at the simplicity, the gravity, the dignity and the fitness of the ancient classic buildings? How can the seasoned wisdom of life be better or more searchingly expressed than in the words of Virgil or Horace, not to speak of more ancient teachers?" Thus all things are not progressing. The time-spirit now, and for some two centuries past, seems to have chosen to take under its particular guardianship the physical and natural sciences, their cultivation and applications, rather than philosophy or architecture or sculpture, or painting or literature. We shall do well to recognise this, and not waste our resources in striving to fight against it.

Present Indiscriminate Elementary Teaching and Neglect of Research.

Large sums of money are expended in this country on the diffusion of some knowledge of chemistry among all classes of scholars and students; in fact, scarcely anyone escapes from a smattering, largely undigested if not indigestible, either forced on them by regulations or by allurements of bribes in the form of prizes, scholarships, or academic laurels. And if this is not good for scholars and students, it is worse for masters or professors. Our professors work "whole time" at this "stall-feeding" process, and if they happen to be strong men mentally and physically they may be able when weary with work to devote any overtime to—what I submit is far the more important matter for the State—the advancement of science by research. But this pursuit requires, for its successful prosecution, for resource and initiative to be at their best, that all the faculties should be in readiness in their fullest strength, freedom, and adaptability. How many, alas! are not strong men, and in their praiseworthy endeavours, notwithstanding, to contribute something to the achievements of their time succumb as martyrs to their devotion. The truth of this statement, I fear, is too well known to many of us here. In Germany this strain of elementary teaching is more recent, and is only now being felt. Prof. Emil Fischer in his address (*loc. cit.*) says of it: "During the last ten years a scheme of practical education of the masses has developed." "But this very education of the masses tends mentally to exhaust the teacher, and to a great extent, certainly to a higher degree than is desirable or indeed compatible with the creative power of the investigator, there prevails in modern educational laboratories a condition of overstrained activity." And again, "In the harassing cares of the day the teacher too readily loses that peace of mind and broad view of scientific matters necessary for tackling the larger problems of research." Laboratories, he says, are wanted "which should permit of research in absolute tranquillity, unencumbered by the duties of teaching." I have given these quotations from Prof. Fischer's address as indicating the matured judgment of a highly competent authority, communicated in the presence of the German Emperor on an historic occasion. His words are words of great weight, and no country which regards its future welfare can afford to ignore them.

Sir Walter Raleigh (*loc. cit.*) says that every university is bound to help the poor . . . but that does not mean that a university is doing good if it helps those who have no special bent for learned pursuits to acquire with heavy labour and much assistance—just so much as may enable them to pass muster; on the contrary, it is doing harm. I would like to invite the attention of all who are seriously interested in the country's welfare to reconsider the present policy in the teaching of chemistry; and this applies also to other sciences. For the advancement of civilisation, for the increased welfare of the race by the technical applications of our science, it is not the indiscriminate teaching of the masses and the multiplication of examinations that is wanted, but the training of the few, of capable investigators. I do not propose necessarily that we should interfere with, or much less abandon, much of our present elementary teaching, and I know that elementary, largely technical, training in chemistry is needed for medicine and engineering; but I do propose that our first endeavour should be to secure under present conditions in the present college or works laboratories, or in laboratories to be specially provided, that capable men, of whom we have many, should be able to devote themselves to research without the worry of teaching and examining or of providing the ways and means of livelihood. There is, happily, reason to believe that this vital need is to some extent becoming known; for there have been several recent instances where a particular investigator has been afforded the means, financially, of prosecuting his particular researches in tranquillity. The diversion of endowments to such purposes, instead of their going to the foundation of additional school or undergraduate scholarships, cannot be too highly commended.

We may learn a lesson which bears on this from that remarkably prolific period of our science, the close of the eighteenth and the beginning of the nineteenth centuries. It was then no easy matter to pass the precincts of a chemical laboratory; only the fittest survived the ordeal. At the beginning of the nineteenth century the traditions of Berthollet and Lavoisier in Paris were kept alive by Gay-Lussac; in England those of Cavendish and Priestley by Davy; and Berzelius in Sweden worthily maintained the older school of Bergmann and Scheele. By a happy fate the interest of Alexander v. Humboldt was the means of both Liebig and Dumas being admitted to the intimacy of Gay-Lussac; and in Sweden Wöhler was fortunate to gain the confidence of Berzelius; and in London, Faraday that of Davy. The achievements of these men—Liebig, Dumas, Wöhler, and Faraday—are part of the history of science. To me it contains a lesson, in point, of great importance. The opportunity offered them was beset with difficulties. No bribes such as scholars or students expect to-day were offered them; they knew no examinations, and their available apparatus and laboratory equipment were of the smallest and crudest description; but they were eager students with whom the master was in sympathy, and it is common knowledge that they completed the foundations of our science. Now I ask, considering the thousands of students whom we teach and examine to-day, are we doing as well in the interest of the country as our predecessors a century ago? Who can confidently answer in the affirmative? No; whatever else is done, the country needs the provision of men whose untrammelled energy should be devoted to original chemical research. Even as intellectual discipline the value of research is of the highest importance. In his address to the British Association at Winnipeg, Prof. Sir J. J. Thomson bears testimony to this. He says: "I have had considerable experience with students beginning research in experimental physics, and I have always been struck by the quite remarkable improvement in judgment, independence of thought, and maturity produced by a year's research. Research develops qualities that are apt to atrophy when the student is preparing for examinations, and, quite apart from the addition of new knowledge to our store, is of the greatest importance as a means of education."

And the object and ideal are wrong also in our system of technical training. We aim too much at giving elementary instruction to artisans, which, though important in itself, can never take the place of the higher education of leaders or managers of industrial works. This is different in Germany, where, although the training of artisans is by no means neglected, the chief energy is directed to the training and teaching of the smaller class of managers. There is, too, in Germany a far more intimate relation between academic and industrial work, and the leaders in each often interchange posts. In one respect we have an advantage over Germany; it is important that this should be understood. The higher technical instruction across the Rhine has not been undertaken by the universities, but is carried out in separate institutions. With us the universities have gradually undertaken, in addition to the older technical subjects, theology, medicine, and law, the various branches of engineering and agriculture, and even commerce. This, it is to be hoped, will be extended so that the highly trained technologist may have the advantage of the undoubted humanising influence of the university.

Conclusion.

I have not attempted in this address any complete survey of chemistry, either its growth in the past or its present condition, but I have endeavoured to give some account of the sort of thing chemistry is—of its method—and to maintain three theses: (1) That the logical method by which chemistry advances is not a simple one, and requires as one essential element the use of a highly developed imagination. To render this more efficient I have advocated special training. (2) Without violating, I hope, the canons of the proper use of hypothesis, I have proposed, in order to account for certain isomeric and other phenomena, the conception of solid molecular aggregates, although I am not able at present to indicate precise methods for its further investigation. These molecular aggregates are supposed to be formed by the combination of gaseous molecules just as the latter are formed by the combination of atoms. (3) As a matter of vital interest to the continued well-being of this country I have insisted strongly that our educational resources devoted to chemistry should be directed, in the first place and chiefly, to the highest possible training of promising students in the prosecution of research, and that the giving to the many of elementary instruction should be at least a secondary consideration.

Now I do not wish to dictate how this last proposition could be best carried into effect. I think we should distinguish three classes of chemists, or technical chemists, whose domains would more or less overlap. Occasionally there will be a man, like the late Sir William Perkin, who would combine all three. The three classes are: first, the pure chemist, devoted to scientific discovery only; second, the technical chemist, who prepares the discoveries of the pure chemist for the technologist, and has to determine such questions as economical production and, for example, the conversion of colours into dyes; third, the technologist or works manager. These three classes should be in close relation to one another. By such a scheme we should probably overcome by education one of our most serious present difficulties—the ignorance of owners of works of the value of science.

It is a matter deserving most earnest consideration whether, under the propitious influence of our own time-spirit, it would be possible to organise research and develop it without interfering with its essential freedom and initiative, and this in each of the three classes I have mentioned, either by means of some of our existing institutions, or by the inauguration here of such an organisation as the Kaiser Wilhelm Institut in Berlin.

SECTION C.

GEOLOGY.

OPENING ADDRESS BY B. N. PEACH, LL.D., F.R.S., PRESIDENT OF THE SECTION.

The Relation between the Cambrian Faunas of Scotland and North America.

Introduction.

EVER since the announcement made by Salter in 1859 that the biological affinities of the fossils found in the Durness Limestone are more closely linked with American than with European forms, the relation between the older palæozoic faunas of Scotland and North America has been a subject of special interest to geologists. The subsequent discovery of the *Olenellus* fauna in the north-west Highlands furnished striking confirmation of Salter's opinion. This intimate relationship raises questions of prime importance bearing upon the sequence and distribution of life in Cambrian time in North America and north-west Europe, on the probable migration of forms from one life-province to another, and on the palæogeographical conditions which doubtless affected these migrations.

On this occasion, when the British Association revisits the border of the Scottish Highlands, it seems appropriate to refer to some of these problems. With this object in view I shall try to recapitulate briefly the leading features of the life-history of Cambrian time in Scotland and North America, to indicate the relation which these life-provinces bear to each other, and, from these data, to draw some inferences regarding the probable distribution of land and sea which then obtained in those regions.

The two great rock groups in Scotland that are universally admitted to be older than Cambrian time are the Lewisian Gneiss and the Torridon Sandstone. The Lewisian Gneiss, as mapped by the Geological

Survey, consists mainly of igneous rocks, or of gneisses and schists of igneous origin. But, in addition to these materials, we find, in the Loch Maree region, schists o' sedimentary origin, comprising siliceous schist, mica-schist, graphite-schist, limestone, chert, and other sediments. The association of graphite-schist with limestone and chert suggests that we are here dealing with rocks that were formed at or near the extreme limit of sedimentation, where the graphite, the limestone, and the chert were probably accumulated from the remains of plankton. But this assemblage has been so completely altered into crystalline schists that all traces of original organic structure in them have been destroyed.

The Torridonian strata were evidently accumulated under desert or continental conditions, and could therefore furnish little or no evidence bearing upon the development of marine life. That life existed, however, is clear from the presence of phosphatic nodules, containing remains of cells and fibres of organic origin, in the upper division of the system, and from the presence of worm burrows and casts in the Diabaig beds (Lower Torridon).

Geologists are familiar with the fact that the Cambrian faunas all over the globe present highly specialised types belonging to most of the great groups of marine invertebrate life. Scotland is no exception to this general rule. For the fossils prove that their ancestors must have had a long history in pre-Cambrian time.

The Cambrian Fauna of Scotland.

Beginning with the false-bedded quartzites forming the basal sub-division of the Cambrian strata in the north-west Highlands, we find no traces of organic remains in them, except at one locality, where worm casts (*Scolithus linearis*) were obtained. In the upper subdivision of the quartzites—the pipe-rocks—the cylinders of sand are so numerous that the beds have been arranged in five subzones, based on a definite order of succession of different forms probably of specific value. One of them, *Arenicolites* of Salter, may be of generic importance. Worms of this habit are confined to comparatively shallow water, and therefore near the shore line. Their occurrence helps to confirm the belief that the quartzites were laid down on an ancient shelving shore line during a period of gentle subsidence. Their presence also indicates the existence of plankton, from which they derived nourishment. Besides the relics of these burrowing annelids, one of the subzones of the pipe-rock has yielded specimens of *Salterella* (*Serpulites Maccullochii*)—a tubicolar annelid, which becomes more abundant in the overlying fucoid beds, serpulite grit, and basal limestone, where it is associated with *Olenellus* and other typical Lower Cambrian forms.

The fucoid beds, which immediately overlie the pipe-rocks, consist chiefly of shales and brown dolomitic bands, with intercalations of grit locally developed. This type of sedimentation indicates that the mud line was superimposed on the shore line by subsidence. With this change of conditions there is a change of organisms, for though the burrowing forms (*Scolithus*) are still to be found in the sandy layers, the most characteristic types are those occurring along the bedding planes, known under the name of *Planolites* (Nicholson). They are very varied forms, and were probably produced by many types of errant annelids. The tubicolar annelids are represented by *Salterella, Coleoloides*, and *Hyolithes*—an organism which perhaps links the worms with the hingeless brachiopods. This suggestion gains additional support from the researches of Dr. Walcott in the Middle Cambrian rocks of Canada. It is interesting to note that small annelids seem to have bored the spines of dead trilobites. Walcott has found similar borings in the chetæ of annelids in the Middle Cambrian rocks of Canada.[1]

The researches of Dr. Walcott have proved beyond doubt that representatives of nearly all the divisions of the annelids are entombed in the Middle Cambrian rocks of Mount Stephen, in British Columbia. We may therefore reasonably infer that the worm casts of *Scolithus* type found in the north-west Highlands are due to annelids. He has also shown that worm-like holothurians are to be found in the same beds.[2] In this connection it may be observed that some of the recent holothurians have much the same habit of obtaining nourishment from the sands and silts containing organic matter.

Fragments showing the characteristic microscopic structures of the plates and ossicles of echinoderms have been found in the fucoid beds. These are possibly Cystidean. Hingeless forms of brachiopods also occur, among which may be mentioned *Paterina labradorica* and *Acrothele subsidua*. The type of *Acrothele* suggests a genetic descent from such a tubicolar worm as *Hyolithes*. Of the gasteropods, only one specimen, belonging to a subgenus of *Murchisonia*, has been obtained at one locality in Skye. *Helenia bella*, a curved calcareous tube, open at both ends, doubtfully referred to the *Dentalidae* by Walcott, is comparatively plentiful. It occurs also in the *Olenellus* zone in Newfoundland.

But the organic remains that render the fucoid beds of exceptional interest and importance are the trilobites, because they clearly define the horizon of this zone in the Cambrian system and display strong affinities with American types. They are represented by five species and varieties of *Olenellus*, very closely resembling the forms in the Georgian terrane, or *Olenellus* zone, on the east and west sides of the North American continent. The genus *Olenelloides* has also been recorded from these beds. The crustacea are represented by phyllocarids, among which we find *Aristozoe rotundata*, likewise characteristic of the *Olenellus* zone of North America.

Next in order comes the serpulite grit, which indicates a recrudescence of the pipe-rock conditions of deposition, and presents the *Scolithus* type of annelid borings. From the diameter of the pipe and the depth of the burrow it is probable that the worm may have belonged to a different species from any of those the casts of which are to be found in lower horizons. This large variety is associated with smaller and more irregular worm casts which have often weathered out and leave the rock honeycombed with hollow casts. The characteristic form from which the zone takes its name is *Salterella* (*Serpulites Maccullochii*). It occurs abundantly along certain calcareous layers that mark pauses in the deposition of the sand. This calcareous type culminates at the top of the zone, where there is a thick, carious, weathering band, crowded with specimens of *Salterella*, forming a passage bed into the calcareous shales at the base of the Durness dolomites. At one locality near Loch an Nid, Dundonnell Forest, Ross-shire, thin shales, intercalated in the serpulite grit, yielded a fine carapace of *Olenellus Lapworthi*—a form of frequent occurrence in the underlying fucoid beds. Prof. Lapworth recorded the finding of *Orthoceras* and linguloid shells in the top part of this zone at Eireboll.[3]

Immediately above the serpulite grit in Eireboll and Assynt we find a few feet of dark calcareous shale, with iron pyrites, probably deposited at the limit of

[1] Smithsonian Miscell. Collect., vol. lvii., No. 5, p. 125, 1911.
[2] *Ibid.*, No. 3, 1911.
[3] *Geol. Mag.*, vol. x., new series, p. 126, 1883.

sedimentation. This layer, which is singularly devoid of organisms, ushers in the great succession of dolomites and limestones, upwards of 1500 feet in thickness—perhaps the most remarkable type of sedimentation among the Cambrian rocks of the north-west Highlands. The Geological Survey has divided this calcareous sequence into seven well-marked groups, some of which have as yet yielded no fossils beyond worm casts. Attention will presently be directed to the absence of calcareous forms in many of the bands of dolomite and to the probable cause of their disappearance.

The thin calcareous shale just referred to is followed by dark blue dolomite limestone, forming the basal portion of the Ghrudhaidh group. It contains sparsely scattered, well-rounded sand grains, with a bed about three feet thick, near the bottom, charged with *Salterella pulchella* and *S. rugosa*. In the overlying twenty feet of dolomite the sand grains gradually disappear, and the rock assumes a mottled character, due to innumerable worm casts of the *Planolites* type. Here a second layer, yielding *S. pulchella* and *S. rugosa*, supervenes, both forms occurring in the *Olenellus* zone of North America.

The brief summary of the palæontological evidence which has just been given clearly shows that the strata ranging from the middle of the pipe-rock zone to the upper *Salterella* band of the Durness dolomites represent in whole or in part the *Olenellus* zone of North America. Owing to the absence of fossils we have no means of deciding more definitely the base and top of the Lower Cambrian rocks of the north-west Highlands. All the quartzites lying below the middle of the pipe-rock, notwithstanding the absence of zonal forms, have been included in the Lower Cambrian division. This correlation receives some support from the remarkable discovery of Dr. Walcott, who found primitive trilobites several thousand feet beneath the beds yielding *Olenellus Gilberti*, the form closely allied to the Highland trilobites.

On the other hand, when we pass upwards for a certain distance from the *Salterella* bands the evidence is insufficient to establish the stratigraphical horizon of the beds. For in the overlying strata, comprising the remainder of the Ghrudhaidh group, the whole of the Eilean Dubh group, and the lower part of the Sail Mhor group, and consisting of dolomites, limestones, and cherts, with little or no terrigenous material, the only fossils that can be shown to be due to organisms are worm casts of the nature of *Planolites*, although the limestone and chert may have originated from the débris of the calcareous and siliceous organisms of the plankton. A noticeable feature of the Ghrudhaidh and Eilean Dubh groups is the occurrence in them of bands of brecciated dolomite on several horizons, which do not imply any break in the continuous sequence of deposits. The total thickness of this portion of the Durness dolomites and limestones, yielding no fossils beyond worm casts, amounts to 350 feet.

But in the upper part of the Sail Mhor group siliceous and calcareous organisms of a higher grade make their appearance. Among the former we find the *Rhabdaria* of Billings. The calcareous forms are represented by (1) gasteropods, including a single specimen of a murchisonid, two species of a pleurotomarid (*Euconia Ramsayi* and *E. Etna*) of a type occurring in the calciferous rocks of Newfoundland and Canada; (2) cephalopods, comprising two slightly bent forms with closely set septa and wide endogastric siphuncles, showing affinities with those of *Endoceras* and *Piloceras*; (3) arthropods, represented by the epitome of a large asaphoid trilobite resembling that of *Asaphus canalis* of Conrad. This evidence is insufficient to determine the exact horizon of these beds, but clearly indicates that we are no longer dealing with Lower Cambrian strata. The cephalopods are like those found in the Ozarkic division of Ulrich (Upper Cambrian), in North America. According to Schuchert, the cephalopods with closely set septa are of Cambrian type and older than those of the Beekmantown terrane of American geologists. On the other hand, the asaphoid type of trilobite is suggestive of a somewhat higher horizon.

No fossils have been found in the overlying Sangomore group, about 200 feet thick, which consists mainly of granular dolomite, with bands of chert, some being oolitic, together with thin fine-grained limestones near the top.

Above this horizon, at a height of more than 800 feet above the top of the *Olenellus zone*, we encounter the great home of the fossils peculiar to the Durness limestone in the Balnakeil and Croisaphuill groups. The former consists mostly of dark limestones, with nodules of chert, and, with a few alternations, of white limestone bands. A few thin layers are charged with worm casts. The overlying group is more varied, the lower part being composed of dark grey limestones full of worm casts, and with some small chert nodules arranged in lines; the middle portion, of dark granular and unfossiliferous dolomite; and the upper part, of massive sheets of fossiliferous limestone full of worm casts. The total thickness of these two groups in Durness is about 550 feet.

These two subdivisions have yielded more than twenty genera and about one hundred species. In Durness sixty-six species have been obtained from the Balnakeil group alone, fifteen of which have not as yet been found in the overlying Croisaphuill group, thus leaving fifty-one species common to both divisions. The Ben Suardal limestones in Skye, which were mapped by the Geological Survey as one division, are regarded, on palæontological grounds, as the equivalents of both these groups. Owing to the number of species common to both subdivisions, the fauna will be here referred to as a whole.

Both siliceous and calcareous organisms are present in this fauna. Among the former we find *Archaeoscyphia* (Hinde), described by Billings as *Archaeocyathus*, an early Cambrian coral, but shown by Hinde to be a siliceous sponge.[4] The genus *Calathium* is represented by four species. Other genera and species of sponges occur, so that the siliceous nodules, which are very common in both groups, may be in great part due to them. In this connection it may be mentioned that Hinde obtained sponge spicules from some of the nodules. Hinged brachiopods have also been collected from these beds, and include *Nisusia* (*Orthosina*) *festinata*, *N. grandaeva*, and Camarella.

But the characteristic feature of the fauna is the assemblage of calcareous mollusca comprising lamellibranchs, gasteropods, and cephalopods, showing a wide range of variation, and consequently a long ancestry. The lamellibranchs, though represented only by two genera, *Euchasma* and *Eopteria* of Billings, with several intermediate forms, are of extreme interest, as they are only known to occur elsewhere in Newfoundland and eastern Canada. The gasteropods, however, furnish the largest number of species—about 48 per cent. of the whole. The primitive euomphalids, *Maclurea* and *Ophileta*, are most characteristic. The former genus has a large number of species, many of which are to be found in the Beekmantown limestone of Newfoundland and eastern North America. Only one of the species (*Maclurea Peachi*) is peculiar to Durness. Several species of

4 Quart. Jour. Geol. Soc., vol. xlv., p. 125, 1889.

Ophileta are found, some of which likewise occur in the Beekmantown limestone. Euomphalus has also been recorded, while several forms belonging to the nearly allied family of the Turbinidæ, and placed in Lingström's genus *Oriostoma*, are also met with in the Beekmantown limestone.

Murchisonids and Pleurotomarids number twenty-seven species and show a very wide range of variation. The chief subgenera of the former are *Hormotoma* and *Ectomaria*, many species of which occur with remarkable variations. All the types of variation found in Durness are to be found in North America, and several of the species are common to both regions. The pleurotomarids vary in a similar manner, the chief genera being *Raphistoma* and *Euconia*, and a form resembling *Hormotoma*, only with a shorter spire. Species belonging to each of these subgenera are likewise common to both areas, while some are only known from the north-west Highlands.

The cephalopods are of equal interest. They are also of primitive type, and, at the same time, show a wide range in form. The prominent feature in the straighter specimens is the great width of the laterally placed siphuncle, which is generally furnished with endocones and organic deposits. The genus *Piloceras* is the most characteristic type and shows this peculiar feature best. It has only been recorded from Scotland, Newfoundland, Canada, and the eastern States of North America. The following additional genera are represented, viz. *Endoceras*, chiefly by siphuncles in great variety; *Actinoceras, Cyrtoceras*, and, doubtfully, *Orthoceras*. Several forms have been attributed to *Orthoceras* which, on re-examination have been found to be the siphuncles of other genera, resembling American types described by Hall and Whitfield.

The whorled nautiloids provisionally classed with the genus *Trocholites* of Conrad are represented by several distinct forms as yet unnamed.

The trilobites are of rare occurrence in these two groups of dolomite and limestone. They are fragmentary and poorly preserved. This is doubtless one of the disappointing features connected with this remarkable assemblage of organic remains, for the presence of a zonal form would have helped to define the horizon of these beds. Only one species, *Bathyrus Nero* (Billings) has been identified, which also occurs in the Beekmantown limestone of Newfoundland. The other trilobite remains, though poorly preserved, leave a Cambrian facies characteristic of North America.

In connection with this fauna certain features have been observed which throw some light on the absence of calcareous organisms from thick zones of the Durness dolomite and limestone. In my detailed description of the palæontology of the Cambrian rocks of the north-west Highlands in the Geological Survey Memoir I stated that "in most cases the septa and walls of chambered shells have been wholly or in part dissolved away, so as to leave only the more massive structures of the siphuncles, and worm castings are often found within the chambers where the septa have been preserved. These features seem to indicate that the accumulation of the calcareous mud in which the fossils were embedded was so slow that there was time for the solution of part of an organism before the whole of it was covered up."[5] There is good reason to believe that many organisms wholly disappeared by this process, so that it is reasonable to conclude that the fossils obtained from the Durness dolomites cannot be regarded as furnishing a complete life-history of the forms that originally existed in that sequence of deposits. Attention has already been directed to the fact that beneath the two subdivisions now under consideration there are groups of dolomite and limestone which so far have yielded no organic remains beyond worm castings. And even in the important Croisaphuill group, with its fossiliferous zones, there are thick groups of dolomite which have furnished no calcareous organic remains. Obviously the palæontological record in this instance is glaringly incomplete, for we have no reason to suppose that the life of the time flourished in some of the calcareous zones and not in others.

The highest subdivision of the Durness limestone, measuring about 150 feet in thickness (Durine group), has yielded two species of *Hormotoma*—viz. *H. gracilis* and *H. gracillima*—both of which occur in the two underlying groups. *H. gracilis* occurs in the Beekmantown, the Chazy, and the Trenton limestones of America.

Before assigning any stratigraphical horizons to the fauna of the Durness dolomites, it is desirable, owing to the American facies of the fossils, to recapitulate the evidence bearing upon the life of Cambrian time in North America. But the Cambrian life-history of Scotland would be incomplete without a brief reference to the recent discovery of fossils along the eastern border of the Highlands.

In 1911 Dr. Campbell announced in *The Geological Magazine* that fossils had been found in the Highland border series north of Stonehaven, and, during this year, Dr. Jehu made a similar discovery in rocks belonging to this series near Aberfoyle. Papers on these subjects will be communicated to this section. For my present purpose it will be sufficient to indicate the nature of the fossils and the lithological characters of the rocks containing them.

The Highland border series north of Stonehaven and near Aberfoyle includes sheared igneous rocks, both lavaform and intrusive, with black shales, cherts, and jaspers. North of Stonehaven the fossils occur in thin, dark, flinty pyritous shale, while at Aberfoyle they have been found in shaly films at the edge of the chert bands. Several years ago radiolaria were detected in the cherts between Aberfoyle and Loch Lomond. From time to time these Highland border rocks have been carefully searched for fossils, but until recently with little success, owing to the intense movement to which they have been subjected, resulting in marked flaser structure in all except the most resistant bands.

The fossils consist chiefly of horny, hingeless brachiopods, phyllocarid crustacea, worm-tubes, and the jaws and chetæ of annelids. The genera of brachiopods comprise *Lingulella, Obolus, Obolella, Acrotreta*, and *Linarssonia*. The association of these brachiopods with phyllocarid crustaceans resembling *Hymenocaris* and *Lingulocaris* is suggestive of an Upper Cambrian horizon—an inference which is supported by the absence of graptolites.

In the published Geological Survey maps these Highland border rocks are queried as of Lower Silurian age. This correlation was based partly on their resemblance to the Arenig volcanic rocks and radiolarian cherts of the Southern Uplands, and partly because, as shown by Mr. Barrow, they are overlain by an unconformable group of sediments, termed by him the Margie series. The cherts, the green schists, and the Margie series have shared in a common system of folding, and are unconformably surmounted by Downtonian strata near Stonehaven. Though the original correlation may not be strictly correct, it is probable, in my opinion, that representatives of both the Arenig and Upper Cambrian formations may occur in the Highland border series, and, further, that Upper Cambrian strata may yet be found in the Girvan area, as originally suggested by Professor Lapworth in correspondence with Dr. Horne.

[5] "Geological Structure of the North-west Highlands," Geol. Sur. Mem., 1907, p. 380.

The Cambrian Fauna of North America.

The classification of the Cambrian fauna found in North America is based on the researches of a band of distinguished palæontologists, comprising among the older investigators Billings, Hall, and Whitfield, and among modern workers Walcott, Ulrich, Schuchert, Brainerd, Seely, Ruedemann, Matthew, Clarke, and Grabau. Prominent among these investigators stands Dr. Walcott, alike for his original and exhaustive contributions to this branch of inquiry and for his complete mastery of the sequence and distribution of life in Cambrian time in North America. Indeed, geologists all over the world owe him a deep debt of gratitude for the services which he has rendered to Cambrian palæontology.

Throughout the greater part of Cambrian time there existed in North America two distinct life provinces. The eastern one ran along the Atlantic coast from the north of Newfoundland to a point south of New York, extending only a short distance inland, with a faunal facies resembling that of north-west Europe, exclusive of the north-west Highlands of Scotland. The western province lay to the north-west of that just described, and ranged from northern Newfoundland, south-westwards to Central North America and the Pacific Ocean. On the east side of the Rocky Mountains it swept northwards to British Columbia, perhaps as far as the Arctic Ocean. The remarkable feature of the life of the western province is its essentially American facies.

Geologists are familiar with the triple classification of the Cambrian system by means of the trilobites in North America, as in Europe. The Lower Cambrian division represents the *Olenellus* epoch of Walcott, characterised by some form of Olenellid, or, to use the name now given to the family by that investigator, the *Mesonacidae*. The western life-province contains the true *Olenellus* of which *O. Thompsoni* is the type. The strata yielding this fauna extend over such a wide area of North America that within this same province we find a western and an eastern facies. The western facies is found in Nevada and California, where *Olenellus* is represented by such specific forms as *O. Gilberti* and *O. Freemonti*. But it is noteworthy that these forms occur near the top of the Lower Cambrian series, and are soon followed by *Zacanthoides* and *Crepicephalus*, trilobites of Middle Cambrian affinities. Towards the lower part of the sequence of deposits, which there consist mainly of limestone, and extend downwards for a distance of more than 4000 feet beneath the beds containing the true *Olenellus*, Walcott found specimens of *Holmia Rowei* and *Nevadia Weeksi*. The latter form is regarded by him as the most primitive of all the *Mesonacidae* yet known. Near the base the limestones have yielded the primitive corals, *Archaeocyathus* and *Ethmophyllum*; and the brachiopods *Mickwitzia* and *Trematobolus*. The other forms found on this horizon belong to the following genera: (trilobites) *Protypus* and *Microdiscus* (brachiopods) *Kutorgina, Swantonia, Nisusia, Billingsella*, and (tubicolar annelids) *Hyolithellus* and *Salterella*. The eastern facies of the western life-province is best known from the region of Georgia, in Vermont. It is the home of the type species of *Olenellus* (*O. Thompsoni*). It is associated with *Mesonacis vermontana*, which has now given the name to the whole family, with *Elliptocephalus asaphoides*, one of the earliest known trilobites of the family, and with other forms such as *Bathynotus, Holopygia, Protypus*, and *Microdiscus*. The tubicolar worms are represented by *Hyolithellus* and *Salterella*, the brachiopods by *Nisusia, Swantonia, Kutorgina cingulata*, and *Paterina labradorica*. There can be no doubt that the assemblage of organic remains found in this Georgian terrane is merely the counterpart of that found in the *Olenellus* zone of the north-west Highlands.

Proceeding now to the eastern life-province, we find that the Lower Cambrian rocks are characterised by the trilobite genus *Callavia*, belonging to the family of the *Mesonacidæ*, and bearing a close resemblance both to *Holmia* and *Nevadia*. In southern Newfoundland two species of *Callavia* occur, of which *C. Bröggeri* is the type. It is accompanied by *Microdiscus, Hyolithellus, Paterina labradorica*, and *Helenia bella*. In New Brunswick the *Protolenus* fauna, with *Protolenus* as the characteristic trilobite, probably represents the upper part of the *Olenellus* zone. In this connection the recent discovery of the *Protolenus* fauna by Mr. Cobbold, in Shropshire, in strata associated with *Callavia*, and overlain by beds yielding *Paradoxides*, is of special importance, as it shows the close relation between the Lower Cambrian fauna of Wales and that of the Atlantic or eastern province of North America.[6]

The Middle Cambrian division of the western life-province is characterised chiefly by the trilobite genus *Olenoides*; indeed, the western part of it is the home of *Olenoides* and the large-tailed trilobites. The characteristic genera of this group to be found in that region are *Kootenia, Zacanthoides, Bathyuriscus, Asaphiscus, Neolenus, Dorypygella, Dorypyge, Damesella*, and *Ogygopsis*.

In this region the Middle Cambrian limestones and shales occurring on Mount Stephen, in British Columbia, have yielded a magnificent series of trilobites, eurypterids, limuloids, crustacea ranging from congeners of the brine shrimps to phyllocarid nebalids, annelids belonging to most of the still extant families, holothurians, medusae, and other organic remains. For the most part many of these forms are so fragile that only their tracks remain as indications of their existence in palæozoic deposits. Not till we reach the Solenhofen slates in Jurassic time do we find similar favourable conditions for the entombment and preservation of their highly modified successors. The remarkable evidence bearing on the evolution of groups of organisms furnished by this assemblage of fossils from Mount Stephen has been admirably described and illustrated by Walcott in his series of papers published in the Smithsonian Miscellaneous Collections.

In the New Brunswick portion of the eastern or Atlantic life-province the strata yielding *Paradoxides* follow those bearing the *Protolenus* fauna. Six species of Paradoxides have been obtained from this horizon, including *P. davidis*, together with the following genera: *Agnostus, Agranlos, Liostracus, Conocoryphe*, and *Ctenicephalus*. Schuchert points out that this fauna is "closely allied to the *Paradoxides* faunas of Wales and Sweden, but less so with that of Bohemia."[7]

In southern Newfoundland Walcott showed that the base of the Middle Cambrian division is marked in Manuel's Brook by a conglomerate containing fossils of the lower or Georgian terrane, thus indicating elevation and erosion of the Lower Cambrian rocks. Higher up the strata yielded *Paradoxides davidis* and *P. bennetti*.

Important evidence pointing to the conclusion that the *Paradoxides* fauna of the eastern or Atlantic province encroached to some extent on the eastern part of the western life-province has been obtained by Walcott at St. Albans, Vermont. But the suggestion has been made by Schuchert that their present position is there due to north-westerly thrusting.[8]

[6] Quart. Jour. Geol. Soc., vol. lxvii., p. 296, 1911.
[7] Bull. Geol. Soc. of Amer., vol. xx. (1910), p. 522.
[8] *Ibid.*

It should be borne in mind that in Middle Cambrian time the eastern and western parts of the western life-province were evidently separated from each other by a land barrier, owing to crustal movement, which was probably connected with the elevation of the Lower Cambrian rocks in the region where they were subjected to erosion.

In the upper division of the Cambrian system in North America there is a marked change in the fauna. Its characteristic features are thus clearly summarised by Schuchert: "In a general way it may be said that the Ozarkic period of Ulrich (Upper Cambrian) begins with the trilobite genus *Dikelocephalus* and the first distinct molluscan fauna. . . . The trilobites and inarticulate brachiopods (greatly reduced in species) are still Cambrian in aspect, while the new faunal feature consists in a rapid evolution, in form and size, of the coiled gasteropods, and of both straight and coiled cephalopods. The latter are distinguished from those of subsequent periods by the exceedingly close arrangement of the septa."[9]

The distinctive trilobite genus of the Upper Cambrian strata of the western life-province is *Dikelocephalus*, where it is associated with an American facies of fossils. The eastern or Atlantic province is characterised by Olenids, though *Dikelocephalus* also occurs, and by typical European forms. In Minnesota and Wisconsin, where the strata consist of sandstones, dolomites, and shales, two species of *Dikelocephalus* have been obtained, together with other genera of trilobites such as *Agnostus* and *Illaenurus*; the limuloid *Aglaspis*; and the gasteropods *Holopea*, *Ophileta*, and *Raphistoma*.

In certain areas this period is characterised by a great succession of calcareous deposits, comprising parts of the Shenandoah limestone and Kittatinny dolomite in New Jersey, portions of the Knox dolomite in Tennessee, and of the dolomite and limestone in Oklahoma. In some of these localities, at least, the lower portions of this calcareous series are grouped with the Upper Cambrian sediments, while the upper parts are classed with Lower Silurian or Ordovician strata. The researches of American palæontologists have shown that in certain areas there is a mixed Cambrian and Ordovician fauna in some of the beds, as in the Tremadoc rocks of Wales. This commingling of faunas is exemplified in the case of the Beekmantown limestone, which is grouped with the Ordovician (Lower Silurian) rocks by most American geologists. Ulrich and Schuchert, on the other hand, regard it as a formation (the Canadic) distinct from the overlying Ordovician system.

The type areas of the Beekmantown limestone are Lake Champlain, the Mingan Islands, and Newfoundland, where the strata consist mainly of a succession of limestones and dolomites more than 1000 feet thick. The fossils are chiefly molluscan, comprising lamellibranchs, gasteropods, and cephalopods. The lamellibranchs are represented, among others, by the genera *Euchasma* and *Eopteria*; the gasteropods by *Ophileta, Maclurea, Euomphalus, Holopea, Hormotoma, Ectomaria, Murchisonia, Lophospira, Euconia, Raphistoma, Helicotoma*; the cephalopods by *Orthoceras, Cyrtoceras, Gomphoceras, Piloceras, Trocholites*. Of the foregoing genera many of the species are common to this region and the north-west Highlands of Scotland.

The trilobites associated with this fauna comprise the genera *Dikelocephalus, Bathyrus, Asaphus, Harpes*, and *Nileus*.

In northern Newfoundland, in zones F to N of Billings, this fauna, with localised species, is found in great development in limestones and dolomites resembling those of Durness. Its upper limit is there clearly defined, for the limestones and dolomites are overlain by dark shales containing graptolites of undoubted Arenig age.

[9] *Op. cit.*, p. 524.

A careful comparison of the faunas of the Durness and Beekmantown limestones shows that the assemblage of fossils in the Balnakeil and Croisaphuill groups of Durness is practically identical with that in the zones F to N of Billings, as developed in Newfoundland. These groups must therefore be older than the Arenig rocks of Wales, and must represent at least the Welsh Tremadoc strata, if not part of the Lingula Flags, both of which, according to the English classification, are grouped with the Cambrian system.

But even in the purely European province of North America, in New Brunswick, where the Beekmantown calcareous fauna is entirely absent, and where the faunal sequence and type of sedimentation are almost identical with those of North Wales, the basal Ordovician or Lower Silurian rocks of American geologists include the *Peltura scarabaeoides* and the *Parabolina spinulosa* zones, which, in Wales, are classed with the Lingula Flags. It is obvious, therefore, that the boundary-line between the Cambrian and Ordovician (Lower Silurian) systems is not drawn at the same stratigraphical horizon by American and British geologists. In fixing the age of the Durness dolomites and limestones the English classification has been adopted.

The palæontological evidence now adduced regarding the relation of the Cambrian fauna of the north-west Highlands to that of North America leads to the following conclusions:—

1. The Lower Cambrian fauna of the north-west Highlands, distinguished by the genus *Olenellus* and its associates, is almost identical in character with that of the Georgian terrane of the western life-province of North America, and essentially different from the Lower Cambrian fauna of the rest of Europe.

2. No forms characteristic of the Middle Cambrian division, either of Europe or North America, have as yet been found in the north-west Highlands; but this division may be represented by the unfossiliferous dolomites and limestones of the Ghrudhaidh, Eilean Dubh, and the lower Sail Mhor groups.

3. The fossiliferous bands of the Sail Mhor group may be the equivalents of the lower part of the Upper Cambrian formation.

4. The Balnakeil and Croisaphuill groups of the Durness dolomites and limestones contain a typical development of the molluscan fauna of the Beekmantown limestone, belonging to the western life-province of North America. As the Beekmantown limestone is succeeded by shales, with Arenig graptolites, it follows, in accordance with British classification, that these groups must be of Upper Cambrian age.

5. The highest subdivision of the Durness limestone (Durine) has not yielded fossils of zonal value, and the members of this group are not overlain in normal sequence by graptolite-bearing shale or other sediments.

Cambrian Palaeogeography between North America and North-West Europe.

In attempting to restore in outline the distribution of land and sea in Cambrian time between North America and north-west Europe reference must be made to various investigators whose researches in palæogeography are more or less familiar to geologists. Among these may be mentioned Suess, Dana, De Lapparent, Frech, Walcott, Ulrich, Schuchert, Bailey Willis, Grabau, Hull, and Jukes Browne. The views now presented seem to me to be reasonable inferences from the palæontological evidence set forth in this address.

In the north-west Highlands there is still a remnant of the old land surface upon which the Torridonian sediments were laid down. There is conclusive evidence that the pre-Torridonian land was one of high relief. As the Torridonian sediments form part of a continental deposit it may be inferred that the Archæan rocks had a great extension in a north-westerly direction. The increasing coarseness of the deposits towards the north-west suggests that the land may have become more elevated in that direction. At any rate, the pile of Torridonian sediments points to a subsidence of the region towards the south-east, and probably to a correlative movement of elevation towards the north-west.

The sparagmite of Scandinavia is an arkose resembling the dominant type of the Torridon sandstone; is of the same general age, and has evidently been derived from similar sources in the Scandinavian shield. In eastern North America coarse sedimentary deposits form part of the newer Algonkian rocks, which are still to be found rising from underneath the Cambrian strata in the region of the great lakes. These materials were obtained from the great Canadian shield, which must have formed a large continental area during their deposition.

It is reasonable to infer that these isolated relics of old land surfaces were united in pre-Torridonian time, thus forming a continuous belt from Scandinavia to North America. During the period which elapsed between the deposition of the Torridon sandstone and the basement members of the Cambrian system a geosyncline was established which gave rise to a submarine trough, trending in an east-north-east and west-south-west direction, both in the British and North American areas. In the latter region it extends from Newfoundland to Alabama, its south-eastern limit being defined by the old land surface of Appalachia. The extension of this Appalachian land area in a north-east direction beyond the limits of Nova Scotia and Newfoundland was postulated by Dana and other American writers. This geosyncline remained a line of weakness throughout palæozoic time, both in Britain and North America, which resulted in the Caledonian system of folding in Britain, and in the Taconic, Appalachian, and Pennsylvanian systems in North America. Hence it is manifest that the original shore-lines of this trough are now much nearer each other than they were in Cambrian time.

The Cambrian rocks of the north-west Highlands were laid down along the north-west side of this trough during a period of subsidence, for the great succession of Durness dolomite and limestone, with little or no terrigenous material, is superimposed on the coarser sediments of that formation. On the other hand, the Cambrian strata of Wales seem to have been deposited along the southern limit of this marine depression. The Archæan rocks that now constitute the central plateau of France may have formed part of its southern boundary. The extension of this land area towards the north-east may have given rise to the barrier that separated the Baltic life-province from that of Bohemia, Sardinia, and Spain. In my opinion this southern land area in Western Europe was continuous across the Atlantic with Appalachia. For the life sequence found in the Cambrian rocks of New Brunswick is practically identical with that of Wales and the Baltic provinces, thus showing that there must have been continuous intercourse between these areas. Along this shore-line the migration of forms seems to have been from Europe towards America. On the other hand, along the northern shore the tide of migration seems to have advanced from America towards the north-west Highlands. The question naturally arises, what cause prevented the migration of the forms from one shore of this trough to the other? American geologists are of opinion that this is probably due to the existence of land barriers; but, in my opinion, it can be more satisfactorily accounted for by clear and open sea, aided by currents.

The south-western extremity of the American trough in Lower Cambrian time opened out into the Missisippian sea, which was connected with the Pacific Ocean, and stretched northwards towards the Arctic regions. Reference has already been made to Walcott's discovery in Nevada of the primitive trilobite *Nevadia Weeksi*, from which he derives both branches of the *Mesonacidae*, one branch linking *Nevadia*, through *Callavia*, *Holmia*, and *Wanneria*, with *Paradoxides*, the other connecting *Nevadia* with *Olenellus*, through *Mesonacis*, *Elliptocephalus* and *Paedumias*.

In Nevada the genus *Holmia*, as already shown, is associated with the primitive type *Nevadia*. *Wanneria* is found in Nevada, in Alabama, and in Pennsylvania, thus showing that this genus is common to the Missisippian sea and to the long trough north-east of Alabama. *Mesonacis* has been obtained in the submarine depression at Lake Champlain, at Bonne Bay, Newfoundand, and at the north side of the Straits of Belle Isle. *Elliptocephalus* has been recorded from the New York State. *Olenellus* has been found in Nevada, in Vermont, and in the north-west Highlands. All the genera now referred to may have migrated along the north-western shore of this trough.

As regards the distribution of the genus *Callavia*, this form has been met with in Maine, in Newfoundland, and in derived pebbles in a conglomerate in Quebec. Two species have been recorded in Shropshire. These forms probably moved along the southern shore of this sea from Wales to North America.

Reference has already been made to the fact that, in the interval between Lower and Middle Cambrian time, in certain areas in North America the Lower Cambrian rocks were locally elevated and subjected to erosion. During this interval the southern end of the trough seems to have had no connection with the Mississippian sea, for in Middle Cambrian time, as already indicated, the *Paradoxides* fauna is found in the trough on the east side of North America, whereas on the west side it is represented by the *Olenoides* fauna.

In Upper Cambrian time a great transgression of the sea towards the north supervened. The *Dikelocephalus* fauna is found on both sides of America, thus showing that the previous land barrier had been submerged. While this genus occurs in Wales and the Baltic provinces, it has not as yet been recorded from the north-west Highlands, but I quite expect that this discovery may be made at some future time.

Along the northern side of the American trough clear water conditions prevailed, owing to the northward recession of the shore-line, which led to the accumulation of a great succession of calcareous deposits, including the Beekmantown limestone, to which reference has already been made. Schuchert, as already stated, has pointed out that, in the lower part of the Ozarkic (Upper Cambrian) system, in Minnesota and Wisconsin, the gasteropod genera *Hoopea*, *Ophileta*, and *Raphistoma* are associated with two species of *Dikelocephalus*. This molluscan fauna is evidently the precursor of that of the Beekmantown limestone. It was probably from this central region of America that the calcareous fauna of Beekmantown migrated to the submarine trough in the typical Champlain region, and through Newfoundland to the north-west Highlands of Scotland.

The section at St. John, New Brunswick, where the Baltic and Welsh types of the *Olenus* fauna occurs, shows that the southern shore line of the trough must then have occupied much the same relative position as in Lower and Middle Cambrian time. In the same region the strata containing this fauna, with *Peltura scarabaeoides* and *Dictyonema flabelliforme*, are overlain by dark shales with Arenig graptolites. These graptolite-bearing terrigenous deposits eventually extended across the trough northwards, until, in Newfoundland, they came to rest on the Beekmantown limestones.

In the Lake Champlain region, in the Chazy limestone, which there immediately succeeds the Beekmantown limestone without the intervention of the Arenig graptolite shale, there is a survival of the Beekmantown molluscan fauna with only such slight modifications as to indicate genetic descent. In the same trough the descendants of this fauna are to be found in the Trenton limestone.

In this connection it is worthy of note that the molluscan fauna and the corals of the Stinchar and Craighead limestones of Upper Llandeilo age in the Girvan district of the Southern Uplands have an American facies, as first suggested by Nicholson. The appearance of American types in these limestones may be accounted for in the following manner: attention has already been directed to the divergent types of sedimentation presented by the Upper Cambrian strata of the north-west Highlands, and of the south-east Highlands, at Stonehaven and Aberfoyle. In the former case there is a continuous sequence of dolomites and limestones, while in the latter we find a group, comprising radiolarian cherts and black shales, associated with pillowy spilitic lavas and intrusive igneous rocks, indicating conditions of deposition at or near the limit of sedimentation. But, notwithstanding the different types of sedimentation and the divergent faunas in the two areas, I believe that during the Upper Cambrian period, and probably for some time thereafter, continuous sea extended from the north-west Highlands to beyond the eastern Highland border. The Upper Cambrian terrigenous sediments which we now find at Stonehaven and Aberfoyle must have been derived from land to the south. In Llandeilo time the Arenig and Lower Llandeilo rocks of the Girvan area were elevated and subjected to extensive denudation. On this highly eroded platform, as first proved by Prof. Lapworth, coarse conglomerates, composed of the underlying materials, were laid down in association with the Stinchar and Craighead limestones. In my opinion the appearance of the American forms in these limestones is connected with the movement that produced this unconformability in the Girvan area. This local elevation was probably associated in some form with the great crustal movements that culminated in the overthrust of the north-west Highlands and caused the intense folding and flaser structure of the rocks along the Highland border. By these movements shore-lines may have been established between the north side of the old Palæozoic sea and the Girvan area, which permitted the southern migration of the American forms.

Note.—Since writing the above my attention has been directed to the recent work of Bassler on "The Early Palæozoic Bryozoa of the Baltic Provinces," published by the Smithsonian Institution in 1911. In his introduction the author has shown that the Ordovician (Lower Silurian) and Gothlandian (Upper Silurian) rocks of the Baltic provinces contain a larger percentage of bryozoan species, in common with the Black River, Trenton, and Niagara limestones of the same relative age in eastern North America. This fact suggests that during Lower and Upper Silurian time the old lines of migration were still open, and that the Bryozoa, being of clear-water habit, were able to cross the old trough from side to side.

NOTES.

FROM a Press cutting just received from Sydney we learn that Mr. Fisher, Prime Minister, Australia, referred to the forthcoming visit of the British Association in 1914 in his Budget speech on August 1. He said:—"We have been advised that about half as many more members of that association are likely to visit the Commonwealth than was anticipated when our invitation was accepted. This will entail an increase in the amount of money which I propose to give towards their expenses; and, speaking for this Parliament and country, I say that no greater compliment could be paid to Australia than the fact that our visitors are to be increased in number. It is usual a year or eighteen months before the visit is made to send a representative man of the same class as themselves to get into communication with them. We propose to incur that expenditure pending the expenditure of a larger amount to cover their expenses."

THE Chancellor of the Royal Prussian Ordre pour le Mérite has, through the German Embassy, informed Sir William Turner, K.C.B., F.R.S., vice-chancellor and principal of the University of Edinburgh, that the German Emperor has appointed him to be knight of the Order in the department of science. The number of those on whom this Order is conferred is strictly limited, and since 1885, when Lord Lister was appointed, Sir John Murray, Sir Joseph D. Hooker, Lord Avebury, Lord Rayleigh, the Right Hon. James Bryce, Sir David Gill, and Sir Wm. Ramsay have been its recipients. The death of Lord Lister having caused a vacancy, his Majesty the Emperor has been pleased to confer the Order on Sir Wm. Turner, in recognition of the contributions which he has made to anatomical science.

THE fourteenth meeting of the Australasian Association for the Advancement of Science will be held in Melbourne in January, 1913.

THE Royal Aero Club has decided to award its gold medal to Mr. S. F. Cody in recognition of his victory in the recent War Office aeroplane trials.

MR. T. H. MOTTRAM has been appointed to succeed the late Mr. Pickering as divisional inspector of mines in charge of the Yorkshire and North Midlands District. Mr. J. R. Wilson, of Leeds, will fill the position vacated by Mr. Mottram.

WE regret to see the announcement of the death, on September 4, of Dr. Stanley Dunkerley, formerly professor of engineering, Manchester University, and the Royal Naval College, Greenwich, and the author of a standard work on "Hydraulics."

THE departmental committee appointed by the Home Office to consider the best methods of testing miners' safety lamps reports that the official tests for flame safety lamps should be mechanical and photometric, and should be made by means of an explosive mixture. For the mechanical test they suggest that a lamp should be dropped from a height of 6 ft. on a wooden floor.

THE annual general meeting of the Society of Chemical Industry was held in New York last week under the presidency of Dr. R. Messel, F.R.S. The society's medal, awarded once in every two years for conspicuous service rendered to applied chemistry by research, discovery, invention, or improvements in processes, has this year been awarded to Sir William Crookes, O.M., F.R.S., for his discoveries in physical chemistry and the rare metals. It has been decided to hold the next annual meeting of the society in Liverpool.

ACCORDING to *The Lancet*, the following sums have been bequeathed by Madame Jonglart for the furtherance of science in France:—50,000 francs to the Collège de France; 95,000 francs to the faculty of science of the Sorbonne, of which amount 55,000 francs is to be devoted to the zoological laboratory; 95,000 francs to the museum; 50,000 francs to the Faculty of Medicine; 70,000 francs to the School of Advanced Studies; 150,000 francs to be divided between the Geographical and Anthropological Societies and the Association for the Advancement of Science, and 139,000 francs to various scientific and charitable institutions.

THE Board of Agriculture and Fisheries desires to direct attention to the fact that the employment, from time to time, in the newspaper Press and elsewhere, of the phrase "cattle plague" in connection with the recent outbreaks of foot-and-mouth disease in this country has given rise to considerable apprehension in Continental countries, and is calculated to be prejudicial to the interests of British stockowners. The Board wishes, therefore, specifically to state that no case of cattle plague (*Peste bovine, Rinderpest*) has recently occurred in the United Kingdom, which has been absolutely free from that disease since the year 1877, that is for more than thirty-five years past.

BY the will of Mr. A. O. Hume, C.B., an obituary notice of whom appeared in our issue of August 8, his collection of heads and horns of Asiatic and other animals is left to the trustees of the British Museum, provided that an undertaking be given by the trustees that the collection be preserved in an undivided condition. The testator confirmed a settlement dated January 10, 1907, by which he gave a sum of 10,000*l.* Two-and-a-Half per Cent. Consolidated Stock for the endowment of the South London Botanical Institute, and also the provisions of an indenture dated September 29, 1911, by which he gave his premises, 323, Norwood Road, for the purposes of the institute, and he left all his botanical books and books on ornithology and dictionaries upon trust for the institute, to encourage the study of botany (especially British botany) in the county of London south of the River Thames, and also all parts of his herbaria not already transferred to the institute. Subject to the payment of certain annuities, Mr. Hume left the residue of his property to the South London Botanical Institute.

THE council of the Institute of Chemistry is making an endeavour to raise a fund for new buildings for the institute. There can be no doubt that the institute has steadily raised the standard of education in chemical science in the British Empire, and by its means the practice of chemistry, as a profession, has become firmly established and honourably maintained for the public good. From a perusal of the papers relating to the appeal issued to the fellows and associates, it appears that owing to alterations which the London County Council propose to carry out by the widening of Southampton Row, at the rear of the present premises of the institute, 30 Bloomsbury Square, it will not be possible to effect a renewal of the present lease. The council of the institute wishes, therefore, to take this opportunity to secure more suitable and permanent headquarters. It is reckoned that with real economy, adequate provision for the work of the institute can be obtained for about 15,000*l.* The appeal has now been issued nearly three years, and the amount promised to date is about 10,000*l.* As the council will proceed to select a site and prepare plans at the close of this year, it is very desirous of being assured that the full sum of 15,000*l.* will be available, and it is hoped, therefore, to raise the 5000*l.* which is still required before the end of October. Contributions may be forwarded to the president at 30 Bloomsbury Square, London, W.C., or may be sent direct to the account of the Institute of Chemistry (Buildings Fund), with the London County and Westminster Bank, Ltd., 214 High Holborn, London, W.C.

IN the September issue of *Man* Mr. A. R. Brown has compiled from his own personal knowledge and information gathered from some published literature a useful map of Western Australia, showing the distribution of several of the native tribes. The map also marks the division between the tribes which practise circumcision and subincision on the east, and those on the west among whom these rites are unknown.

MAJOR A. J. N. TREMEARNE publishes in the September issue of *Man* selections from a diary written in the years 1843–48 by his great-uncle, the late Rev. John Martin, a Wesleyan missionary to the West Coast of Africa, which possess a special interest because they supply a record of a remarkable type of fetish practices before anthropologists had begun to interest themselves in such matters. The natives in his day, he says, had some confused ideas about metempsychosis, which to a reader of our time suggests totemism. Thus, when a child was carried off by a wild beast, it was believed that some deceased member of the family, annoyed at the neglect of his relatives, had entered the animal and caused the attack, and for this reason they would not kill such animals. The living sacred snake, Dagwe or Dagbi, used to get loose, enter houses and kill poultry until he was finally captured by his priest. The insolent and outrageous conduct of the fetish priests and priestesses during their processions through the towns is specially noteworthy.

THE Field Museum established at Chicago in 1893 has issued a well-illustrated catalogue of a valuable collection of antiquities from Boscoreale, in South

Italy, which has been recently presented. It is the work of Mr. De Cou, who was killed by Arabs while conducting excavations at Cyrene in north Africa in March, 1911. Mr. Tarbell, professor of classical archæology at Chicago, has now edited the work of his friend, with some additions. Nearly the whole collection comes from a villa at the foot of Mount Vesuvius which shared the fate of Pompeii in the eruption of 79 A.D. It contains some curious frescoes and a number of bronze articles, of which the most remarkable is a fine bronze table, the legs shaped in the form of a lion's feet. This was found in a room with the skeletons of two men and a woman, who had apparently perished in the attempt to remove to safety the more valuable property of the house. Two bronze bathing-tubs, which have counterparts in the Naples Museum from Pompeii, are interesting on account of their comparative rarity.

THE movement in favour of the protection and conservation of scenery, antiquities, and the native flora and fauna has made considerable progress in Germany and Switzerland, as well as in other parts of the Continent, during the last few years. A recent number of the *Naturwissenschaftliche Wochenschrift* (No. 27, 1912) is occupied by a series of four articles dealing with the scenic, geological, botanical, and zoological aspects of the question, and contributed by Profs. W. Bock, F. Wahnschaffe, P. Graebner, and M. Braess respectively. In each case the writer describes, with numerous concrete examples, the melancholy results of various acts of vandalism and destruction—the spoiling of otherwise beautiful scenery by huge advertisement hoardings, the erection of painfully conspicuous buildings on hillsides and on the shores of lakes, the conversion of fine lakes into unsightly marshes owing to the construction of waterworks in the neighbourhood, the building over of interesting or even unique geological outcrops, the rooting-up of rare plants, the threatened extinction of rare animals, &c. Righteous indignation is expressed at the wanton or careless mischief done by those responsible for such acts; but it is gratifying to note that vigorous steps are being taken by the State and by private organisations to protect beautiful and interesting natural objects, animate and inanimate, from continued vandalism, and to undo wherever possible the harm already done.

AN article in *The Scientific American* of August 10 discusses the proposal of Prof. Etchegoyen to flood a portion of the Sahara with sea-water by means of a channel from the Mediterranean and thereby to create an inland sea, which, as he claims, would favourably affect the climate, make for conditions of fertility, and for possibilities of colonisation, and provide a channel of communication. Quite apart from the possibility or desirability of the scheme itself, a considerable number of crimes seem to have been committed in the name of physical geography by opponents of the scheme, who have foreseen that the new subtropical area thus created would so far affect the climate of more northern lands as to bring the arctic belt southward to Denmark, and they even seriously discuss the probability of the upsetting of the earth's equilibrium by the displacement of so great a body of sea-water. The writer of the article is at pains to calm these fears, shows that the total area of the Sahara capable of flooding from the sea is no large proportion of the whole, and appears to welcome the idea as much for its own romantic sake as for any benefits which it might confer. He is not concerned to remark upon the ultimate condition of a practically stagnant pond of sea-water, with only a long narrow channel connecting it with the general marine circulation.

THE second volume of Dr. G. Linck's "Fortschritte der Mineralogie, Kristallographie und Petrographie" is now issued (Jena: G. Fischer, 1912. Price 10.50 marks). This annual of the German Mineralogical Society contains original memoirs, and also useful reviews of current work, in which a number of papers are brought together and compared. J. H. L. Vogt (p. 24) summarises his views on the production of ore-deposits by magmatic differentiation; A. Ritzel (p. 62) treats of plasticity in crystals; and both these papers have considerable geological interest. H. Stremme (p. 87) discusses what is known as to the chemistry of kaolin, and papers follow on petrography and on meteorites. The aim of the publication, like that of the *Geologische Rundschau*, is to correlate recent work in the interests of those engaged in teaching and research. The individuality imparted by the authors to their reviews makes an annual of this type far more interesting than a collection of ordinary abstracts.

DISEASES of the respiratory and digestive organs among apes and monkeys in confinement are discussed by Mr. W. R. Blair in vol. i., No. 9, of *Zoologica*. Among other items in the report, it may be noted that orang-utans and chimpanzees in the New York Gardens were infected in 1901 by an outbreak of ulcerating dysentery due to the presence of *Balantidium coli*. The source of the infection was traced to Galapagos giant tortoises in an adjacent enclosure, the colons of which swarmed with the parasite, although the health of the reptiles was unaffected.

DR. ANNANDALE has sent us a copy of the report of a lecture on recent advances in our knowledge of the fresh-water fauna of India, published in vol. viii. of the Journal and Proceedings of the Asiatic Society of Bengal. During the last five years Dr. Annandale has devoted great attention to this fauna, with special regard to the biological relations between different groups of fresh-water organisms, seasonal changes in the life-cycles of the lower invertebrates, and the effect of environment on sponges and other plastic groups. The geographical distribution of the fresh-water fauna as a whole is reserved for future investigation.

SELF-FERTILISATION in the fresh-water snail *Limnaea columella* forms the subject of an article by Mr. H. S. Colton in the May issue of the Proceedings of the Philadelphia Academy. As the result of investigation, it appears that the eggs, when isolated, are self-fertilised, and that the generation-period lasts only two or three months. When more than one species of pond-snail inhabit the same area, hybridisation may occur. *L. columella* seems to present some of the factors necessary for the investigation of a "pure-line" development, that is to say, a line formed by the descendants of a single "homozygotic" organism propagating by self-fertilisation.

THE annual report of the Marine Biological Association of the West of Scotland for 1911 shows that the marine station at Millport is being more largely used by competent investigators, and the amount of first-class scientific work which is being carried out is highly creditable to those who have charge of its organisation. The report contains summaries of the work of Dr. J. F. Gemmill on the anatomy and development of starfishes, of Prof. MacBride's researches on Echinus and Echinocardium and their hybrids, and of Dr. Valentin Dogiel's studies on the development of Pycnogonida. The most unsatisfactory feature of the report is the statement that the steam yacht *Mermaid* has been laid up from want of funds to run her. The use of an adequate steamboat for collecting work is a matter of vital importance to every marine station, and it is to be hoped that in such a wealthy district as that in which the station is situated this defect may soon be remedied by local enterprise.

To the *Naturwissenschaftliche Wochenschrift* of August 18, 1912, Dr. O. Antonius contributes an article on the tarpan of eastern Europe and its relationship to the wild Mongolian horse. The wild horses seen by Pallas in some part of Mongolia are considered to represent a race of the latter; the name *Equus ferus*, Pallas (shown by Mr. Lydekker to be invalid), being adopted for the Mongolian horse, which Hamilton Smith identified years ago as the true tarpan, although this is not referred to by the author. On the other hand, the Russian tarpans obtained in 1853, 1862, and 1866, and described by Schatilow and Radde, are regarded as a truly wild and distinct species, for which the name *E. gmelini* is proposed. The third of these, which was gelded soon after its capture, was acquired in 1884 by the Zoological Gardens at Moscow, where it died a few years later, and was the last representative of its kind. It may be added that these Russian tarpans are generally regarded as half-breds, to which category belongs the animal figured by the author as Przewalski's horse of Mongolia. The domesticated ponies of Bosnia are considered to represent the tarpan type.

THE fifth volume of Notes from the Royal Botanic Garden, Edinburgh, has just been completed by the issue of part xxv., containing an index to the volume and various items of information concerning the garden, together with a somewhat bald key-plan—plenty of blank space is left which might with advantage be utilised in indicating the outdoor plants grown in the garden, as is done in the case of Kew. The most important contents of the present volume are the articles dealing with the plants, including many new species, collected by George Forrest in Yunnan and Eastern Tibet, and described by various distinguished systematists.

THE seismological observatory of Rocca di Papa, near Rome, is one of the oldest in Italy. That it is also one of the most efficient is shown by the summary of the records of the last twelve years recently issued by the director, Dr. G. Agamennone, and his assistant, Mr. A. Cavasino. From this it appears that the average yearly number of earthquakes recorded is 186. Of these, 44, or one-quarter of the total number, originated at distances of less than 100 km., the extinct Latial volcanoes being the seat of a considerable number; while 85 originated at distances greater than 5000 km.

THE report on rainfall registration in Mysore for the year 1910, which has recently reached us, shows that the number of official stations was then 227, in addition to which a few coffee-planters maintain private stations on their estates. Compared with the district averages for the forty years, 1870–1909, the rainfall was in excess by about 8 inches, or 22 per cent. Some heavy falls in twenty-four hours were recorded in each of the eight districts into which the province is divided, the heaviest being 10·8 inches at Nagar and 10·5 inches at Aralagode in the Shimoga district early in July.

THE first report of the Meteorological Observatory in connection with the College of Nuestra Señora de Montserrat, Cienfuegos, Cuba, has just been issued. The volume has been prepared by the Rev. Simon Sarasola, S.J., director, and contains details of the establishment of the observatory, together with notes upon the meteorological observations taken at the college from 1886, and upon cyclones and their prognostication. The position of the observatory is an important one, especially with regard to the Panama Canal, and the results obtained will probably prove of great interest. The instrumental equipment is excellent, including nine self-recording instruments. The tables for 1911, printed in the report, include observations made every two hours, from 6 a.m. to 8 p.m., of barometer, temperature, vapour tension, relative humidity, and direction and force of wind, with cloud observations four times daily and notes on the weather. The tables are not arranged on the international system, although the international symbols are used in the weather columns. It is a matter for regret that the daily maxima and minima of temperature are not printed instead of the highest and lowest of the bi-hourly readings. The absolute extremes of temperature of each month are, however, given in one of the yearly tables.

THE Meteorological Office has commenced the issue of a series of geophysical memoirs, the first of which is by Commander Hepworth, and deals with the effect of the Labrador current on the surface temperature of the North Atlantic, and of the latter on the air temperature and pressure over the British Isles. The author shows from the records of the last eight years that abnormally low temperatures in the North Atlantic are due to the current of cold water from the coast of Labrador and not to the ice which that current brings with it. The low temperature of the water lowers the temperature of the air over these islands by cooling the winds from seawards, by influencing the paths of depressions, and by diminishing cloudiness. When the north-eastern arm of the

North Atlantic is colder than usual, the centres of depressions pass almost directly over the British Isles and produce excessive cloudiness and rain.

The Builder for August 30 has an illustrated article on the reconstruction of the campanile of St. Mark's, in Venice. Preserving the old foundations as a nucleus, a strong enclosure of Istrian stone has been constructed around them; the old foundations had a superficies of 222 square metres, and the present foundations cover 407 square metres, nearly double the surface. As the tower began to rise, a movable framework was employed; for the carrying up of the materials a Steigler elevator was used, which also lifted the bells into position. The bells weigh respectively 3625, 2556, 1087, 1366, and 1011 kilograms, and the angel 1300 kilograms. The tower itself from outside the ground to its summit weighs 8,900,000, and with its foundation included about 12,970,000 kilograms. The Loggetta of Sansovino has also been successfully restored. The loggia had been completely crushed by the campanile in its fall. All the fragments of sculpture were carefully collected before commencing the work of reconstruction; in the group of the Virgin and Child alone there were no fewer than 1600 separate pieces. The new campanile was opened on April 25 of this year.

"THEORIES OF SOLUTIONS," by Svante Arrhenius, director of the Nobel Institute of the Royal Swedish Academy of Science, Stockholm, is being published this week by Mr. Frowde for the Yale University Press. The volume constitutes the eighth of the series of Silliman Memorial Lectures at Yale.

OUR ASTRONOMICAL COLUMN.

DISCOVERY OF A COMET.—A telegram from the Kiel Centralstelle announces the discovery of a comet by Mr. Gale, of New South Wales, on September 9. The position at 7h. 24·8m. (Sydney M.T.) on that date was:—R.A. = 13h. 37m. 1s., decl. = 36° 31′ 2″ South.

THE MARKINGS OF JUPITER.—A valuable summary of the phenomena attending the various prominent markings on Jupiter is contributed by Mr. Denning to No. 452 of *The Observatory*. He first deals with the large dusky marking discovered by Major Molesworth, in the same latitude as the red spot, in February, 1901. This remarkable object, which can be seen well with a 3-in. refractor, has exhibited some extraordinary variations in length, having, for example, decreased from 115° in June, 1911, to 63° recently. It has also exerted a marked influence on the red spot, the motion of the latter being considerably accelerated at the conjunctions of the two features in 1902, 1904, 1906, 1908, and 1910. For the period 1894–1910 the rate of rotation of the red spot was 9h. 55m. 40·63s., exactly that adopted for system ii., but then a rapid acceleration set in, and for the two succeeding years the period was 9h. 55m. 37·5s. This drifting westward was at the rate of about 22,000 miles per year, but recent observations indicate that it is temporarily suspended.

OBSERVATIONS OF NOVA GEMINORUM NO. 2.—A number of observations of Nova Geminorum No. 2 are discussed in No. 4598 of the *Astronomische Nachrichten*, chiefly dealing with determinations of position and magnitude. Dr. H. E. Lau, from observations made between March 14 and May 18, finds secondary maxima on the light-curve on March 14, 23, and 31, April 18, and May 1. At first the period appeared to be about eight days and the amplitude 1·0 magnitude, but later the period lengthened and the amplitude decidedly decreased. Most of the observations indicate that the magnitude became fairly stationary about the end of May, its value being about 8·0, but Prof. Eginitis records an apparent augmentation from 8·0 on June 4 to 7·4 on June 7.

Prof. Newall states that spectroscopic observations by Messrs. Stratton and Brunt on August 13 showed the nebula line, 501μμ, to be much the strongest line in the visible spectrum; other lines observed were at λλ464 (?), 486 (Hβ), 496, 531 (?), and 575. The magnitude, difficult to estimate, was probably a little brighter than 9·0.

Prof. Strömgren records the magnitude as 7·70, on the PD system, on August 24, while, in No. 452 of *The Observatory*, Mr. Harold Thomson gives it as 7·7 on August 20, on the scale employed by the Variable Star Section of the B.A.A.

THE ORBIT OF ξ PERSEI.—The star ξ Persei is one of those interesting binaries in which the radial velocity as determined from the *H* and *K* lines of calcium differs from that determined from the other lines. Its spectrum is of the Oe 5 B class, according to Miss Cannon, and shows lines of H, He, Ca, and Fe, but the H and He lines are generally too diffuse to give trustworthy results for the velocity.

Using the *H* and *K* lines only, Mr. Cannon, of the Ottawa Observatory, has derived an orbit from his own measures and those made at the Yerkes Observatory, which he publishes in No. 3, vol. vi., of the Journal of the R.A.S., Canada. He finds the period to be 6·951 days, the range of velocity 15·7 km., and the velocity of the system 15·4 km. The diameter of the projected semi-major axis of the orbit is 751,800 km. An attempt was also made to determine the velocity from the broad lines, other than calcium, but nothing more definite can be said than that they show a much higher positive velocity than do the *H* and *K* lines.

CATALOGUE OF STELLAR PARALLAXES.—No. 24 of the Publications of the Astronomical Laboratory at Groningen contains a wealth of information concerning the parallaxes, probable intrinsic luminosities, &c., of 365 stars. The table has been made up from many sources, and relative weights are given to the different values. There are eleven stars with parallaxes greater than +0·300″, the five nearest, with their adopted parallaxes, being: α Centauri (+0·759″), Sirius (+0·376″), Piazzi, oh. 130 (+0·360″), τ Ceti (+0·334″), and Procyon (+0·324″). Ten stars have computed luminosities greater than one hundred times that of the sun, the five most luminous being: β Centauri (520), Regulus (423), Achernar (350), Capella (300), and Arcturus (230); the values in brackets are the computed luminosities, that of the sun being taken as unity.

THE ORBITS OF COMETS.—In No. 4598 of the *Astronomische Nachrichten*, Prof. Strömgren points out, in reference to a recent note by Prof. W. Pickering on the fundamental form of cometary orbits, that Prof. Pickering has misconstrued the sense of his conclusions. The final contention of Prof. Strömgren's (not Prof. Kobold's, as was inadvertently stated in our previous note on August 15) was that if the effects of Newtonian gravitation be strictly taken into consideration it is probable that all the cometary orbits yet considered would prove to be *elliptical*.

AMERICAN MINERAL STATISTICS.[1]

THE annual report of the production of minerals in the United States has been issued for 1910 by the United States Geological Survey in the form of two bulky volumes dealing with metallic and non-metallic products respectively. Most of the statistical information had been already published in the special pamphlets issued from time to time by the Geological Survey, so that the present volumes contain no new facts, although they add a great quantity of important and interesting details, whilst the study of the subject is, of course, greatly facilitated by the collection and juxtaposition of all the various items.

The total value of the mineral production is given as a little more than 2,000,000,000 dollars, an increase of 6·2 per cent. over that of 1909. This figure is quite comparable with the values of output of the United States for previous years, but is not comparable with those for other countries, because of a number of inexactitudes due to the method in which the returns are presented. As has more than once been pointed out, the grand total contains a number of reduplications, in spite of the statement in the report itself that "all unnecessary duplication has been excluded." The report directs attention to the fact that the value of the coke produced, practically 100,000,000 dollars, is excluded from the total, because "the quantity and value of the coal used in its manufacture are included in the statistics of coal production." It neglects the equally important fact that practically the whole of this coke is consumed in the production of metals, such as pig-iron, copper, and lead, and as the value of these metals is given, and not merely that of the ores from which they are extracted, the cost of the coke is really included in the value assigned to the metals. If the total value assigned to mineral products is to be correct, the value of all the fuel used for metallurgical purposes, and for burning clay products, lime, cement, &c., should be deducted from the grand total; this is by no means a trifling correction, for it would probably mean a diminution of the total by something like 10 per cent.

Care has been taken in this report to include only metals produced from domestic ores as far as possible; this brings out the very interesting fact that the recovery of metals from residues, by-products, waste materials, &c., is assuming very important dimensions. Thus in 1910 the production of zinc, here called "primary spelter," direct from domestic ores amounted to 252,479 tons, and that of zinc from imported—chiefly Mexican—ores to 16,705 tons, whilst the quantity of so-called "secondary zinc" recovered from waste and scrap materials of various kinds was no less than 68,723 tons, or about a quarter of the production of primary spelter. In the case of tin the figures are still more striking; the quantity of tin obtainable direct from ores is not stated, but appears to be of the order of some 40 tons, whilst the recovery of secondary tin from scrap of all kinds amounted to no less than 13,903 tons. It is calculated that the recovery of secondary tin throughout the world is only 27,000 tons, so that one-half of this production takes place in the United States. Seeing that the world's output of primary tin was about 115,920 tons in 1910, the recovery of tin from scrap is assuming very important dimensions.

Amongst the non-metallic minerals, coal is, of course, by far the most important, the output for 1910 exceeding 500 millions of tons, this being the first time that this figure has been attained. The mineral output shows steady and progressive development in practically all directions, and these volumes afford conclusive evidence of the prominent position that the mineral riches of the United States hold amongst the sources of national wealth. It should, however, in all fairness be added that these two fine volumes of mineral statistics are not unworthy of the flourishing industries, the progress of which they chronicle. Is it too much to hope that we may have some day in this country a record of mineral statistics that might worthily sustain comparison for accuracy and completeness with that issued by the United States Geological Survey?

H. L.

[1] "Mineral Resources of the United States, Calendar Year, 1910." Part i., Metals. Pp. 796+plate. Part ii., Non-metals. Pp. 1005+plates. Washington: Government Printing Office, 1911.)

INCOME OF AMERICAN COLLEGES OF UNIVERSITY RANK.

THE second volume of the report of the United States Commissioner of Education for the year ended June 30, 1911, has now been received from Washington. It is chiefly devoted to statistical details concerning the development and present provision of educational facilities in institutions of all the grades included in the American system of education. Especially interesting are the facts which may be gathered respecting education of university rank.

The total receipts of the universities in the United States are given as 18,934,410*l.*, derived from a variety of sources, as shown in the following table:—

Total Receipts of Universities and Colleges for the year ended June 30, 1911.

	£
Tuition and other educational fees ...	3,698,600
Room rent	381,700
Board and other non-educational fees ...	1,218,970
Productive funds	2,658,700
State or city for increase of plant	932,430
,, ,, current expenses	2,941,450
United States Government	1,175,040
Private benefactions for increase of plant ..	1,144,700
,, ,, endowment ...	2,753,970
,, ,, current expenses ...	693,950
All other sources	1,334,900
Total receipts	18,934,410

More detailed information is provided as to the benefactions given during the year under review, which exceeded four and a half millions sterling, or 4,592,620*l.* to be precise. We notice, for example, that the total is more by 845,200*l.* than was received during 1909–1910. Fifty universities and colleges each received gifts amounting to more than 20,000*l.*, and, as the following table shows, seven universities and colleges were fortunate enough to benefit to the extent of 100,000*l.* or more.

Universities and Colleges receiving 100,000*l.* *or more in Benefactions during* 1910–11.

	£
Columbia University	507,010
Harvard College, Massachusetts	349,090
University of Chicago...	271,790
Yale University	226,880
New York University...	185,690
Dartmouth College, New Hampshire ...	156,890
Amherst College, Massachusetts	101,950

A separate chapter in the report deals with agricultural and mechanical colleges, but the Commissioner is careful to point out that some of them are also included under universities and colleges, so that overlapping occurs. The following table shows the total income of the agricultural and mechanical colleges for the year under consideration. Grants for experiment stations, farmers' institutes, and other means for extending agricultural education are not included in the amounts shown.

Income of Agricultural and Mechanical Colleges for 1910–11.

	£
Income from State endowment	22,890
Appropriations for current expenses ...	1,004,990
Tax levy ,, ,, ...	575,820
Appropriations for increase of plant ...	558,410
Tax levy ,, ,, ...	100,440
Total State aid ...	2,262,550
From land grant of 1862	156,670
From other land grants	47,090
Additional endowment	450,000
Total Federal aid ..	653,760
From other endowment funds	149,800
Tuition and incidental fees	487,310
Other sources	562,500
Total income ...	4,115,920

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. R. G. MCKERRON has, with the approval of the King, been appointed professor of midwifery in the University of Aberdeen, in succession to Prof. W. Stephenson, who has resigned.

THE foundation stone of a new college for the training of teachers at Dundee was laid on Thursday last by Lord Camperdown. The cost of the building will be 60,000*l*., and provision will be made for 400 students.

PROF. J. LORRAIN SMITH, F.R.S. (at present professor of pathology and pathological anatomy in the University of Manchester) has been appointed to the chair of pathology in the University of Edinburgh, in succession to Prof. W. S. Greenfield, who is retiring from the position.

THE sum of 5000*l*. has been given by the Lord Lieutenant of Berkshire, Mr. J. H. Benyon, towards the new buildings of University College, Reading. The donor has apportioned his gift between the new hall, the Letters Buildings, the Agricultural Buildings, and the new St. Patrick's Hall.

THE Board of Agriculture has issued a scheme under which the University College of North Wales, Bangor, will undertake advisory work in forestry for the whole of Wales. Prof. F. Story, professor of forestry at the College, has been appointed to the position of advisory officer for all Wales under this scheme. Prof. Story will retain his professorship, but Mr. Thomson Thomson has been appointed assistant lecturer under him.

THE Senate of the projected University of Western Australia recently advertised eight professorships, and the Agent-General for the State reports that the response has been of a character justifying the belief of good appointments being made. The Senate now invites applications for lectureships in veterinary science and mental and moral philosophy. It is stated that Crawley Park, near Perth, which contains spacious grounds, is likely to be selected as the site of the new institution.

THE fourth international congress of physical education is to be held in Rome on October 24 to 27. Discussions are to take place on the organisation of physical education as a preparation for military service; a rational method of physical training in primary, middle, and secondary schools; the value of sports in physical education, and their physiological limitations; the physical education of woman in relation with her function in the family and in society; respiratory gymnastics and choral singing in schools; open-air schools; the physical exercises suitable for the prophylaxis of tuberculosis.

THE following are the arrangements for the opening of the winter session of certain of the medical schools:—That of St. Bartholomew's Hospital will be inaugurated on October 1 by an old students' dinner; at Charing Cross Hospital the prizes will be distributed on October 2 by the Bishop of Peterborough and Lady Mary Glyn; at St. George's Hospital the prizes will be distributed on October 1, and an address delivered by Mr. H. B. Grimsdale on "The present Duty of the Medical Citizen"; at Guy's Hospital there will be a conversazione on October 4 by the Pupils' Physical Society, the session commencing on October 1; at the London Hospital the Schorstein memorial lecture will be delivered on October 1 by Prof. T. W. Griffith; at the London School of Medicine for Women an address on "Common Sense" will be given on October 1 by Dr. Jane Walker; King's College Hospital will hold a dinner on October 1; at the Middlesex Hospital the prizes will be distributed on October 1 by Sir Charles Wyndham, and an address delivered by Dr. W. S. Lazarus-Barlow on "The Genius of the Infinitely Little"; at St. Mary's Hospital on October 1 the Lord Mayor of London will deliver an address and distribute the prizes; in connection with St. Thomas's Hospital there will be an old students' dinner on October 1; the Westminster Hospital School will have a dinner on October 3; a dinner, on October 2, will inaugurate the new session of the University College Hospital School; there will be a conversazione on October 1 in connection with the University of Birmingham; an address will be given on October 1 at the University of Manchester by Dr. H. D. Rolleston on "Universities and Medical Education," and at the University of Leeds an address will be delivered on October 1 by Sir Alfred Keogh, K.C.B.

THE new session of the Sir John Cass Technical Institute, Aldgate, E.C., which is especially devoted to technical training in experimental science and in the artistic crafts, will commence on Monday, September 23. The instruction in experimental science provides systematic courses in mathematics, physics, and chemistry for London University examinations, in addition to the courses on higher technological instruction, which form a special feature of the work of the institute. In connection with the latter, several new departures are being made for the coming session. The curriculum of the fermentation industries has been much developed, and now includes courses of instruction on brewing and malting, on bottling and cellar management, and power and mechanical plant in the brewery, on the microbiology of the fermentation industries, and on the chemistry and technology of hops, in addition to courses in chemistry and physics for those who have not sufficient previous knowledge of these subjects. In the department of physics and mathematics a special course of lectures and demonstrations will be given on colloids, which will deal with the methods employed in their investigation and their relation to technical problems; also a special course of lectures on the theory and application of mathematical statistics, in which the application of modern mathematical methods of dealing with statistical data in social, educational, economic, and physical problems will be discussed and opportunity given to students to investigate problems on their own account. In the metallurgy department, in addition to the ordinary courses of instruction in general metallurgy, several special courses of an advanced character are provided. The special courses on liquid, gaseous and solid fuel have also been extended, and in addition to a course of lectures, will include laboratory work on fuel analysis, and on technical gas analysis. It is also of interest to note that included amongst the language classes is a course on scientific and technical German.

A LONG resolution embodying the oft-repeated education demands of the Trade Union Congress was adopted unanimously at a meeting of the congress at Newport (Mon.) on September 4. The main points are as follows:—(1) A national system of education under full public control, free from the primary school to the university; (2) The adequate maintenance of school children; (3) Scientific physical education with annual individual medical inspection, and records showing the physical development of each child; (4) that secondary and technical education be an essential part of every child's education, and secured by such a reform and extension of the scholarship system as will place a maintenance scholarship within the reach of every child, and thus make it possible for all children to be full-time day pupils up to the age of sixteen; (5) That the best intellectual and technical training be provided for the teachers of the children, that each educational district shall be required to train the number of pupil teachers demanded by local needs, and to establish training colleges, preferably in connection with universities or university colleges; (6) that the provision of educational buildings and facilities be obligatory upon the local authority, which shall always retain administrative control of the buildings and facilities so provided; (7) that the cost of education be met by grants from the Imperial Exchequer, and by the restoration of misappropriated educational endowments. The congress placed on record its emphatic disapproval of the refusal of Ministers of Education to grant the demand for a Royal Commission to inquire into such endowments; and instructed the Parliamentary Committee once more to press for the appointment of such a Royal Commission, which shall inquire into:—(*a*) The finances of the universities and of the great public schools; and to issue a report containing a statement of the history and present value of those endowments which were originally intended for the poor; (*b*) the conditions of scholarships and other aids in universities and public schools; (*c*) the relations with lower education institutions; (*d*) the government of universities and public schools, and to bring forward recommendations showing how these institutions may be brought under full public control.

SECONDARY education in New South Wales has now been organised completely, and Mr. Board, the director of education, in announcing at the beginning of July last a series of appointments to the high schools, described the character of the system which has now been inaugurated. We learn, from *The Sydney Morning Herald*, that Mr. Board claims for the New South Wales scheme of secondary education that it assigns a definite time for the studies of a secondary school, making four years the minimum which any student should spend on these studies. Another good point is the certificating system, which connects the secondary school with the primary school on one hand and the university on the other, and also leads definitely to certain well-marked types of career—for example, the technical or the commercial. Attached to the scheme of certificates is the system of examination. The examinations are, in the first place, school examinations as well as tests of individual attainments. In the second place, the results of the examination will be modified by consideration of the school record of the pupil, and, again, the examination can only follow upon the completion of a specific programme of studies that has occupied a definite period of time, and in the last place the examinations for the certificates are closely associated with the thorough inspection of the schools. A specially constituted board of examiners, representing both the University and the Education Department, will determine the award of all certificates. In a few years there will be a large number of efficient high schools under the control of the Department of Public Instruction, and it is hoped that a leaving and intermediate examination will be carried on somewhat on the lines of that in Scotland. The alternative scheme, which was not adopted, was a system of inspection and examination by the University of Sydney. That is not, however, the true function of a university. Sydney has acted wisely in not undertaking it, though the University may assist, as it has done, to strengthen the State Education Department, and get it to organise secondary education as well as primary and technical.

SOCIETIES AND ACADEMIES.

CALCUTTA.

Asiatic Society of Bengal, August 7.—R. K. **Bhide**: Two more new species of Gramineæ from Bombay. Two new species of grasses are described, (1) *Chloris quinquesetica*, collected by Mr. G. A. Gammie, and subsequently by the author, from Bassein, and (2) *Sporobolus scabrifolius*, collected by the author from Rannebennur.—Manindra Nath **Banerjee**: A measure of chemical affinity. The chemical activity of an element bears a simple relation to its density; if its atomic volume be divided by its density, the figure obtained, for which the name "specific extensity" is suggested, gives a measure of the chemical activity of the element. For instance, platinum, which is a very inactive element, is near one end of the scale with a specific extensity of 0·42; hydrogen, a very active one, is near the other end with a specific extensity of 127·25. There are a number of exceptions to the rule, the most obvious being the inactive gases found in the atmosphere.—Rev. H. **Hosten**: The mouthless Indians of Megasthenes. According to Megasthenes, there lived near the sources of the Ganges a tribe of people, the Astomoi, who had no mouth, but merely orifices through which they breathed. They ate and drank nothing. When they went on a distant journey, they took with them certain roots and flowers or wild apples, on the perfumes of which they subsisted. "Should they inhale very foul air death is inevitable." The tribe is found mentioned in conjunction with the Trispithami (men of three spans long), the Pygmies, and the Scyritæ or Scyratæ (Kirātas), tribes whose characteristic features are distinctly Mongolian or Himālayan. A number of texts are quoted to prove that the "foul air" against which the Astomoi had to protect themselves represents the phenomenon known as *mal-de-montagne*, or breath-seizure, and that the "wild apples" they used as antidote were onions, dried apples, and apricots, nostrums employed in the Himālayas wherever breath-seizure prevails. The fact that some hill tribes used in their travels fruits of which they inhaled the perfume, lest the "foul air" should kill them, seems then to have led to the idea that they subsisted on nothing else. From this to the belief that they needed no mouth, and, in fact, had none, or "instead of mouths had orifices through which they breathed," the inference was easy.—Rev. Fr. Nicholas Krick: Account of an expedition among the Abors in 1853. The recent expedition among the Abors gives renewed interest to Fr. Krick's visit to them in 1853. His "Relation d'un voyage au Thibet en 1852 et d'un voyage chez les Abors en 1853" (Paris, 1854) has become scarce; hence we are under obligations to Rev. Fr. A. Gille, S.J., for having translated that part which concerns the Abors. Fr. Krick's remarks on their manners and customs are as applicable to-day as they were nearly sixty years ago.

BOOKS RECEIVED.

Catalogue Général des Antiquités Egyptiennes du Musée du Caire. Nos. 61051–61100: The Royal Mummies. By Prof. G. Elliot Smith. Pp. vii+118+103 plates. (Le Caire: Imprimerie de l'Institut Français.)

Eine physiologische Histologie des Menschen- und Saügetier-Körpers im Wort-Bild und Präparat. By Prof. F. Sigmund. Lief. i., Die Haut. Zweite verbesserte Auflage. Pp. 38. (Stuttgart.) 9.50 marks.

Kreislaufvorgänge in der Erdgeschichte. By Prof. G. Linck. Pp. iii+40. (Jena: G. Fischer.) 1.50 marks.

A Critical Revision of the Genus Eucalyptus. By J. H. Maiden. Vol. ii., part 5. (Sydney: W. A. Gullick.) 2*s*. 6*d*.

Elementary Entomology. By E. D. Sanderson and Prof. C. F. Jackson. Pp. vii+372. (London: Ginn and Co.) 8*s*. 6*d*.

A Text-Book of Botany. By Profs. E. Strasburger, H. Schenck, L. Jost, and G. Karsten. Fourth English Edition, revised with the tenth German edition, by Dr. W. H. Lang. Pp. xi+767. (London: Macmillan and Co., Ltd.) 18*s*. net.

A Text-book of Pathology. By Drs. J. G. Adami and J. McCrae. Pp. x+759. (London: Macmillan and Co., Ltd.) 25*s*. net.

A Hand-list of the Lichens of Great Britain, Ireland, and the Channel Islands. By A. R. Horwood. Pp. 45. (London: Dulau and Co., Ltd.) 1*s*. net.

The People's Books:—Practical Astronomy with the Unaided Eye. By H. Macpherson, jun. Pp. 94. Theosophy. By Annie Besant. Pp. 94. Rudolf Eucken: a Philosophy of Life. By Dr. A. J. Jones. Pp. 94. Dietetics. By Dr. A. Bryce. Pp. 94. Aristotle. By Dr. A. E. Taylor. Pp. 91. Aviation: its Principles, its Present and Future. By S. F. Walker. Pp. 96. The Evolution of Living Organisms. By E. S. Goodrich. Pp. 108. Embryology: the Beginnings of Life. By Dr. G. Leighton. Pp. 92. (London and Edinburgh: T. C. and E. C. Jack.) 6*d*. net each.

Dactylography, or the Study of Finger-prints. By H. Faulds. Pp. 127. (Halifax: Milner and Co.) 1*s*. net.

Fortschritte der naturwissenschaftlichen Forschung. By Prof. E. Abderhalden. Sechster Band. Pp. iii+300. (Berlin and Vienna: Urban and Schwarzenberg.) 1 mark.

The People's Medical Guide. By Dr. J. Grimshaw. Pp. xx+839. (London: J. and A. Churchill.) 8*s*. 6*d*. net.

Analytical Geometry. By C. O. Tuckey and W. A. Nayler. Pp. xiv+367. (Cambridge University Press.) 5*s*. net.

Examples in Applied Electricity. By C. G. Lamb. Pp. iv+61. (Cambridge University Press.) 2*s*. 6*d*. net.

The Building of the Alps. By Prof. T. G. Bonney. Pp. 384. (London: T. F. Unwin.) 12*s*. 6*d*. net.

Das Gesetz der Wüstenbildung in Gegenwart und Vorzeit. By Prof. J. Walther. Zweite Auflage. Pp. xv+342. (Leipzig: Quelle and Meyer.) 12 marks.

Chemical Theory and Calculations. By Drs. F. J. Wilson and I. M. Heilbron. Pp. iv+138. (London: Constable and Co., Ltd.) 2*s*. 6*d*. net.

The Lushei Kuki Clans. By Lieut.-Col. J. Shakespear. Pp. xxii+250. (London: Macmillan and Co., Ltd.) 10*s*. net.

From the Black Mountain to Waziristan. Being an account of the Border Countries and the more turbulent of the Tribes controlled by the North-west Frontier Province, and our Military Relations with them in the East. By Col. H. C. Wylly. Pp. xx+505+8 maps. (London: Macmillan and Co., Ltd.) 10*s*. 6*d*. net.

A Preparatory Arithmetic. By C. Pendlebury. Pp. xiv+185+xxx. (London: G. Bell and Sons, Ltd.) 1*s*. 6*d*.

Man's Place in the Universe. By Dr. A. R. Wallace, O.M. New and cheaper edition. Pp. vi+283. (London: Chapman and Hall, Ltd.) 1*s*. net.

Nature Photography. By S. C. Johnson. Pp. 115. (London: Hazell, Watson and Viney, Ltd.) 1*s*. net.

Contributions from the Jefferson Physical Laboratory of Harvard University for the Year 1911. Vol. ix. (Cambridge, Mass., U.S.A.)

Palæolithic Man and Terramara Settlements in Europe. By Dr. R. Munro. Pp. xxiii+507+75 plates. (Edinburgh: Oliver and Boyd; London: Gurney and Jackson.) 16*s*. net.

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