THURSDAY, OCTOBER 2, 1913.

THEORY AND PRACTICE OF CHEMISTRY.

(1) *Service Chemistry: Being a Short Manual of Chemistry and Metallurgy, and their Application in the Naval and Military Services.* By Prof. V. B. Lewes and J. S. S. Brame. Fourth edition, revised. Pp. xvi+576+vii plates. (London: Edward Arnold, 1913.) Price 15*s.* net.

(2) *Handbuch der Arbeitsmethoden in der anorganischen Chemie.* By Dr. A. Stahler. Erster Band. Pp. xii+786. (Leipzig: Veit and Co., 1913.) Price 25 marks.

(3) *Cours de Chimie Organique.* By Prof. F. Swarts. 2e édition revue et augmentée. Pp. vii+751. (Paris: A. Hermann et Fils; Gand: Ad. Hoste, 1913.) Price 15 francs.

(4) *Allen's Commercial Organic Analysis.* A Treatise on the Properties, Modes of Assaying, and Proximate Analytical Examination of the Various Organic Chemicals and Products Employed in the Arts, Manufactures, Medicine, &c. Volume vii. Fourth edition. Edited by W. A. Davis and S. S. Sadtler. Pp. ix+563. (London: J. and A. Churchill, 1913.) Price 21*s.* net.

(1) TEACHERS of chemistry in colleges of applied science, who nowadays are so frequently requested to arrange specialised courses in this science suitable to the needs of students working chiefly at other subjects, will undoubtedly be interested to learn how this problem has been solved by the authors of this manual, now in its fourth edition, after long experience in the teaching of chemical science to naval officers. The writers very rightly refuse to compile a Service technology without first inculcating a knowledge of the facts and laws governing the results obtained in applied chemistry. At the same time, they carefully select their illustrations so as to arrest immediately the attention of the naval and military student, for whom the work is primarily intended.

Within the first dozen pages the topic of liquefied gases leads to a consideration of the production of "artificial ice and cold storage both on land and sea." The chemistry of galvanic batteries includes a description of Leclanché's cells used in firing torpedoes and submarine mines. The subject of combustion brings in a reference to the spontaneous ignition of coal on shipboard. Special prominence is given to explosives. The evolution of gunpowder is traced, and a concise account is given of the taming of guncotton for use as a propellant. Special sections are devoted to fuel problems, military ballooning, boiler incrustations, corrosion, protective paints, anti-fouling compositions, and many other matters arising out of Service vicissitudes.

From the doctrinal point of view, it would obviate much confusion if the term "atomicity" were employed exclusively to denote the number of atoms in an elementary molecule, and not used as a synonym for "valency." In this connection it may be mentioned that sulphur vapour at 500° C. is stated incorrectly to be hexatomic (p. 322). It is doubtful whether the affinity of the halogens for oxygen decreases regularly from iodine to fluorine. The non-existence of perbromic acid and bromine oxides rather suggests that bromine in this respect falls between chlorine and fluorine (pp. 333, 345). These points, which are open to criticism, are, however, of minor importance, and the work contains so much new material not generally found in chemical text-books that the authors are justified in hoping that the book may appeal to readers outside the circle of Service students.

(2) This work, which is the first of five volumes of a comprehensive text-book on working methods in inorganic chemistry, is a noteworthy example of the "integrated knowledge" now placed at the disposal of chemists called upon to plan the erection and organisation of laboratories for the practice of this important branch of chemical science. The information is characterised throughout by a note of thoroughness, first-hand knowledge being ensured by the author's collaboration with a staff of experts in different branches of practical chemistry. In their efforts to make every item of equipment purposive, the writers take nothing for granted, and discuss in detail such matters as the ample provision of light and space round the laboratory building, the ready accessibility of stairways and exits, the storage in cellars of volatile liquids and liquefied gases, and even the position of bicycle stands! Certain illustrations of various shapes of retort stands and specimen bottles might well be left to the dealers' catalogues.

The varieties of glass suitable for chemical purpose are fully discussed, and it may be noted that the rare alkali metal rubidium has been utilised in the production of a hard glass softening only at 1000° C. Shenstone's pioneering efforts in the production of silica ware are mentioned, and further developments are suggested by references to the use of zirconia and titania in the fabrication of crucibles and refractory apparatus. Considerable improvements have been recently made in the manufacture of porcelain, and vessels of this material are now obtainable which withstand rapid fluctuations of temperature. The section on the noble metals refers not only to vessels of gold and platinum, but also to apparatus constructed of rhodium, iridium, and tantalum. The chemical and physical properties of the newer alloys (duralumin, the ternary steels, &c.) are reviewed. Scattered through the work are many valuable recipes likely to interest the practical chemist, as, for example, the use of aniline-black as a stain for woodwork, various lutings and cements for joining together chemical apparatus, and a composition for filling holes in platinum crucibles.

Special chapters are devoted to electrical fittings and to the mechanical operations of pulverisation, agitation, filtration, &c. The book affords a striking testimony of the pre-eminence of Germany in the newer industries which minister to the wants of applied chemistry. Some noteworthy products of British enterprise have, however, been overlooked, and mention may be made in this connection of Fletcher's earthenware combustion furnaces and Pilkington's glass screens with an embedded meshwork of invar steel, which form such efficient shields in working with explosive materials.

(3) In this text-book of organic chemistry the author has given prominence to the development of the theory of the subject, descriptive matter being restricted to a few substances of industrial importance. A chapter on chemical kinetics has been added because the fundamental principles of this branch of the science have been chiefly verified in connection with organic substances. From the outset stereochemical considerations are introduced, and the facts of isomerism, multiple linking, and ring formation are regarded from the point of view of the tetrahedral carbon atom. The constitution ascribed to double cyanides (pp. 174, 177) must, however, be regarded as obsolete, in view of Werner's recent researches on coordination compounds. The author omits all references to original memoirs, and the work can scarcely be recommended as a substitute for the larger English treatises on organic chemistry.

(4) This work is the seventh volume of the fourth edition of Allen's well-known treatise on organic analysis. The book is divided into seven sections, each of which is written by an expert on the subject, the entire compilation not only serving as a useful guide to the analyst, but forming also a comprehensive treatise on the general chemistry of the organic materials under review. The present volume is largely devoted to nitrogenous compounds either formed by the vital activities of plants and animals or arising from the decay of these organisms. In recent years considerable addition has been made to our knowledge of these products, among which may be mentioned the alkaloids of ergot, cyanogenetic glucosides, ptomaines, amino-acids, and purine derivatives. One section is devoted to lactic acid, and another to the bitter principles of aloes and hops, whilst the concluding chapter is a useful monograph on cyanogen and its derivatives. G. T. M.

SOME NEW ELECTRICAL BOOKS.

(1) *Electrical Photometry and Illumination: A Treatise on Light and its Distribution, Photometric Apparatus, and Illuminating Engineering.* By Prof. H. Bohle. Pp. xi+222. (London: C. Griffin and Co., Ltd., 1912.) Price 10*s*. 6*d*. net.

(2) *The Principles of Applied Electrochemistry.* By Dr. A. J. Allmand. Pp. xii+547. (London: Edward Arnold, 1912.) Price 18*s*. net.

(3) *Electroplating: A Treatise on the Electro-Deposition of Metals, with a chapter on Metal-Colouring and Bronzing.* By W. R. Barclay and C. H. Hainsworth. Pp. viii+399. (London: Edward Arnold, 1912.) Price 7*s*. 6*d*. net.

(4) *The Design of Alternating Current Machinery.* By J. R. Barr and R. D. Archibald. Pp. xvi+496+xvi plates. (London: Whittaker and Co., 1913.) Price 12*s*. 6*d* net.

(5) *A Laboratory Manual of Alternating Currents.* By Prof. J. H. Morecroft. Pp. viii+247. (London: Longmans, Green and Co., 1912.) Price 7*s*. 6*d*. net.

(6) *La Télégraphie et la Téléphonie Simultanées et la Téléphonie Multiple.* By K. Berger. Traduit par P. Le Normand. Pp. 134. (Paris: Gauthier-Villars, 1913.) Price 4.50 francs.

(7) *The Baudôt Printing Telegraph System.* By H. W. Pendry. Pp. iii+147+plates. (London: Whittaker and Co., 1913.) Price 2*s*. 6*d*. net.

(1) DURING comparatively recent years there has sprung into existence a new branch of science which is known, or knows itself, as illuminating engineering. The writer has a suspicion that if the electrical engineer who handled lighting problems had not been on the lookout for another stick with which to beat his brother gas engineer, and had not thought that stick was to be found in the greater ease with which scientific measurements can be applied to electric lamps, no such science would ever have sprung into a definite and separate existence. Be that as it may, the profession appears to be establishing itself with some degree of firmness. The illuminating engineer of theory is a man of unbiassed mind as regards the particular illuminant he employs, provided he attains his desired end in the most economical

manner: a man who instals electricity in your dining-room, gas in your kitchen, acetylene in your billiard room, and candles in your bedroom. But the illuminating engineer of practice is generally either a gas or electrical engineer with his own particular axe to grind. So much is this the case that he may show a marked preference (against all sound illuminating engineering doctrine) for a particular species of illuminant in the genus which he represents—as, for example, for flame arc lamps against all other electrical illuminants.

We do not know whether Prof. H. Bohle calls himself an illuminating engineer, but at least he has written a book (1) which claims in its subtitle to be a treatise on illuminating engineering, almost as if this were a mere appanage of electrical photometry and illumination; and, as one of the latest works on the new science, we turn to it naturally in the hope that it will more than justify that science's existence. It is disappointing to find little, if anything, more than used in our student days to be regarded as legitimately within the sphere of electrical engineering. It is disappointing, too, to find much inadequate treatment and, we are afraid, insufficient knowledge. Take, for example, the discussion of radiation laws in chapter ii. This is far from clear, and the statement on p. 21: "Coloured bodies absorb different parts of the impinged radiation: consequently they will radiate different fractions of black body radiations, according to the frequency, *i.e.* according to the temperature," is, if we understand the author's meaning rightly, not correct.

The description of the manufacture of carbon filament lamps in the same chapter must have been obtained from some out-of-date account. The criticism of the flame arc lamp on p. 97 is equally behind the times. It is stated that "on long winter evenings the lamps do not hold out until the next morning, but must be recarboned during the night." This is untrue of any flame lamps except those specially designed for short-hour lighting, and there are many flame lamps now on the market, and have been for years, which burn without recarboning for 70–100 hours, so that it will be seen that the criticisms of the author, who writes from Cape Town, would only be justified at the poles. Flame lamps burning vertical carbons are actually commended for steadiness as against lamps with inclined carbons, the exact reverse being the case. We were not surprised after this to find on p. 171 that the yellow flame arc is described as "suitable for decorative illumination," as apparently its only sphere of usefulness.

We need not, however, labour criticism of details such as these: it is only to be regretted that in discussing such a progressive subject as the manufacture and behaviour of electric lamps the author did not take more pains to bring his information up to date.

It is of interest to turn to what may be regarded as the more distinctly "illuminating engineering" sections of the book. We are told in the preface that this is a combined science of physics and physiology, and emphasis is laid on the neglect of the physiological side, which led us to expect that this would be remedied by the author. The physiological discussion in the book is, however, no more than is usually to be found in similar works. In truth, this plea for physiological investigation is, in our opinion, frequently exaggerated. The knowledge of a few elementary facts is necessary, but beyond this physiological knowledge is not needed, and it would be equally true to say that it was required as part of the equipment of a good tailor.

The last two chapters, "The Design of Reflectors and Shades" and "Illuminating Engineering," show how little the new science really has accomplished. With a few exceptions, which existed before the illuminating engineer had arrived, electric lamp shades are still, scientifically, as chaotic as ever. The design of shades is, in fact, for the most part, an art and should continue to be so: if the illuminating engineer ever succeeds in making it purely a science, he will remove what is one of the recommendations of electric lighting—that it lends itself to beauty as well as to utility. The chapter on illuminating engineering gives a number of directions for different classes of lighting which the unbiassed would admit are no more than a restatement of the common-sense practice of years—almost centuries.

We cannot omit reference to a novel procedure in the numbering of figures and equations. Thus the fifth figure in the fourth chapter is numbered Fig. 4.05: this is intended to facilitate reference. It has quite the contrary effect and we trust will not be imitated.

(2) Dr. Allmand's treatise is one of the most comprehensive and at the same time one of the best treatises on applied electrochemistry that we can call to mind in the English language. The first part, covering fourteen chapters and 194 pages, deals with the theoretical side of the subject. To write a complete exposition of the theoretical side of electrochemistry, it would almost be necessary to write a complete chemical treatise coupled with a much shorter discussion of the fundamental electrical phenomena. It is

essential, therefore, to assume a certain amount of chemical knowledge in the reader, and we are inclined to think, on the whole, that Dr. Allmand has not assumed too much.

It must be remembered however, that the student who approaches this subject from the electrical side is often seriously lacking in chemical grounding and, complete though Dr. Allmand's treatment is, we could not help feeling at times that the chemical reasoning and illustrations would be above the heads of many readers. This argument must not be given undue weight, as it is open to all who care to study the subject thoroughly to supplement the volume by the reading of other chemical and physico-chemical works, a matter which is greatly facilitated by the copious references to current literature and the bibliographical references at the end of each chapter. By the time the student has thoroughly mastered the theoretical discussion in the first part of the book he will be in a position to understand properly the reactions and phenomena involved in the various practical applications to which the second part is devoted.

The "special and technical" part of the work opens with two chapters on primary and secondary cells respectively. The treatment here is necessarily brief—whole volumes have been written dealing with each of these subjects—but it is clear and covers the more important points. An interesting discussion of the "fuel cell," a cell in which coal, or some simple derivative from coal such as carbon, or CO, is used to generate electrical energy, concludes the chapter on primary cells. There follow chapters on the electro-metallurgy of the principal metals, and on electrolytic bleaching, etc., and in chapters xxiv. to xxvi. the more important electro-thermic processes are discussed. The last two chapters deal with the oxidation of atmospheric nitrogen and the production of ozone.

Although, owing to natural conditions, this country is not to the fore in electrochemical and electrothermal development, the field for English engineers is not confined to England. There is good reason to hope, moreover, that the future, and very possibly the near future, will see much greater advances in this direction in England than one would have anticipated a few years ago. It is becoming more evident every year that not only is water power not an indispensable adjunct to electrochemical enterprises, but that other sources of power may possess decided advantages. The appearance of so thoroughly sound a treatise as Dr. Allmand's is therefore very much to be welcomed.

(3) Messrs. Barclay and Hainsworth have set out to write a thoroughly up-to-date handbook for the practical electroplater, and have succeeded admirably in realising their aim. Rightly insisting that even the most practical of practical men cannot in these days work without a more or less thorough groundwork in the theoretical side of his subject, they have devoted the first six chapters of their book to a succinct but thoroughly sound exposition of the fundamental chemical and electrical principles. These are treated in a manner well suited to the scope of the book, the elementary knowledge assumed being such as can hardly fail to be possessed by anyone seriously attempting to study the volume.

After two chapters dealing with plant and apparatus and preliminary processes such as cleaning, etc., the remaining chapters deal with the deposition of the various metals. Each of the more important metals is considered separately, and in each case the theoretical explanation of the various reactions involved is not forgotten. The composition of the various depositing baths having been considered from this viewpoint, the methods of making them up and the details of the actual electroplating process are dealt with. The book covers the deposition of all the metals of importance industrially and also of many the deposition of which has a very limited application. We can thoroughly recommend the book either to the practical electroplater or to the student anxious to familiarise himself with the details of a process of great commercial importance and great historical interest.

(4) Messrs. Barr and Archibald's volume on alternating current machinery is an advanced treatise suitable for the use of senior students and those actually engaged in the design of such machinery. The whole field is well covered: after preliminary chapters on complex wave forms and insulation, the subject of transformer design is dealt with in three chapters. These are followed by eight chapters on alternators and three on rotary converters.

(5) Mr. Morecroft's book is a collection of laboratory experiments designed to elucidate the more important current phenomena. We are glad to see that a method too frequently followed by the writers of such laboratory notes, that of confining the text to the merest statement of instructions, has been avoided and a clear exposition of the significance of the experiment has been given in each case. Although this may render the book less convenient for actual use in the test-room, it gives it much higher educational value.

(6) and (7) These two books deal with specific developments in the field of telegraphy and telephony, and may be regarded more as mono-

graphs for the specialist than as treatises for the general student. The detailed investigation of the more intricate telegraph systems is, in fact, probably outside the range of the general electrical engineer's ambitions. M. Berger's book is the more comprehensive of the two, not only because it deals with a somewhat wider subject, but also on account of the broader method of treatment which has been adopted. The subject is handled more theoretically, and there is very little purely descriptive writing. M. Pendry, on the other hand, deals mainly in description, and the book lacks something from the absence of the theoretical side. The descriptive writing is, however, clear, and numerous illustrations help to the better understanding of a very complex subject.

MAURICE SOLOMON.

THE TEACHING OF PSYCHOLOGY.

(1) *The Learning Process.* By Prof. S. S. Colvin. Pp. xxv + 336. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1911.) Price 5*s.* 6*d.* net.

(2) *Introduction to Psychology.* By Prof. R. M. Yerkes. Pp. xii + 427. (London: G. Bell and Sons; New York: H. Holt and Co., 1911.) Price 6*s.* 6*d.* net.

(3) *Experiments in Educational Psychology.* By Dr. D. Starch. Pp. vii + 183. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1911.) Price 4*s.* net.

(1) PROF. COLVIN'S book is written from the point of view of "thorough-going functionalism and pragmatism." "All learning," we are told, "both expresses itself through adjustment and is acquired through adjustment." Now it is possible to give too narrow a meaning to the term adjustment. The solving of a problem, however theoretical, is adjustment in the important sense. That movement, on the other hand, is not the one thing needful has been made evident once for all by Mr. Squeers' pedagogic system:—"W-i-n-d-o-w, window, go and clean it." In short, the essential thing is that every piece of school work should be capable of being felt as a stage in the working out of a problem.

Prof. Colvin, it is true, does not definitely commit himself to too narrow a use of the term; indeed, in places he clearly guards himself against it. Yet one cannot but feel that these passages come rather as qualifications than as explanations of other earlier ones.

One problem which lends itself particularly well to treatment from this functional point of view is that of the expression and suppression of deep-seated emotional and conative tendencies. An interesting account is given of some of Freud's main positions, and sympathy is shown with the view that the attempt simply to suppress fundamental instincts is apt to be disastrous rather than merely futile. The problem of sex education is recognised, and the possibility faced that childhood may not be so completely asexual as has been supposed. That the existence of any problem has been so completely ignored is certainly strange, but, as things are, is perhaps hardly an unmixed evil. The child has in this domain at least been spared the interference of the many well-intentioned, the parents, parsons, and pedagogues, who would otherwise surely have rushed in, fearing to tread as little as any bull in a china-shop.

Many other topics are interestingly and instructively discussed—the economy and technique of learning; the main results of recent work on testimony; the problem of the transfer of training; the comparison of child and adult as to memory and reason; "hard" versus "soft" pedagogy, and so on.

The book is clearly written, and gives, without ostentation, a large amount of information based upon modern experimental work.

(2) The most original feature of Prof. Yerkes' book is its scope and arrangement. It is intended to be an introductory outline as distinguished from a manual, that is, to arouse interest and indicate the problems with which psychology deals rather than to give a systematic account of the main facts and theories. It has the defects as well as the qualities of this plan. On one hand it contains much interesting material not commonly to be found in elementary books. On the other, its treatment is of excessively varying thoroughness. Excellent features are the texts which head each chapter, consisting of quotations, often of some length, from some more advanced book or clever piece of research, and the practical exercises, intended, however, exclusively for class work, with which the chapters end.

Special topics of which the treatment seems less satisfactory are: the difficult question of the exact theoretical difference between introspection and "external perception"; the criticism of the "tripartite division" of consciousness; the use of "sentiment" in the sense of "an emotion which attaches itself to a particular object." A sentence on the final page is apparently incomplete.

(3) Prof. Starch's little book aims at providing a course of experiments in educational psychology for a small class, the work to occupy two hours weekly through one semester. For its purpose it seems to be excellent, though the verbal material of the experiments, having been selected from an

American point of view, occasionally requires adaptation for English students, *e.g.*, some of the test words in the chapter on apperception. This would be of little consequence were it not that the actual pages of the book are intended to be used in the experiments. In spite of this drawback, however, it will be found extremely useful by anyone in charge of, or wishing to form, an experimental class of the kind indicated.

AVIATION DYNAMICS.

(1) *La Théorie de l'Aviation, son application à l'Aéroplane.* By Robert Gaston. Préface de Maurice Farman. Librairie des Sciences aéronautiques. (Paris: F. Louis Vivien.) Price 1.50 francs.

(2) *Aëroplanes in Gusts.* Soaring Flight and the Stability of Aëroplanes. By S. L. Walkden. Pp. xv+188. (London: E. and F. N. Spon, Ltd., 1912.) Price 7*s.* 6*d.* net.

IT is remarkable how many books have been written in connection with problems on aviation in which the principles of elementary dynamics have been ignored, misinterpreted, or otherwise misunderstood in a way that no candidate for an intermediate B.Sc. examination would believe to be possible. These two books afford excellent examples of this disregard of elementary principles.

(1) M. Robert Gaston, who has a highly flattering preface from Mr. Maurice Farman, finds that if a body is allowed to fall and then stopped at intervals of one second, its average velocity will be 4·9 metres per second (with $g=9·81\ m/s^2$). If stopped more frequently its average velocity will be less, until we come to the case when it is being stopped at every instant—*i.e.* continually supported—when its average velocity is *nil*. Having definitely proved this, he contradicts himself by saying that to maintain a body in the air an upward velocity of 4·9 metres per second must be imparted, so that if the weight is W kilograms, the rate of working must be $4·9W$ kilogram metres per second. If he had adopted a minute, instead of a second, as unit of time, he would have found that the work required was $4·9W \times 60^2$ kilogram metres per minute, or sixty times his estimate; similarly, by taking an hour as unit he would have found a result 3600 times as great as he has estimated. Can anything be more absurd? Yet Maurice Farman congratulates him on the clearness and simplicity of his book!

(2) Mr. Walkden's main theme is based on a complete misunderstanding of the physical significance of the law of composition of accelerations. He measures the effect of a gust of wind by the accelerations of the air particles relative to the aëroplane, and by compounding this acceleration reversed with gravity he gets what he calls the resultant relative gravity. But the result means nothing at all.

The only effect which a gust of wind can have on an aëroplane is due to the pressures of the air on the surfaces and other parts of the aëroplane. These are in general functions of the relative velocity components of the air rather than the accelerations. The best that Mr. Walkden's method can do is to determine their *rates of increase*, not their actual values. To solve the problem of the aëroplane in gusts it is necessary, in the first place, to determine the six force and couple components of the air pressures as functions of the six components of relative linear and angular velocity of the aëroplane, and, having done this, to investigate the six equations of motion of the aëroplane under the action of these forces and couples. This book does nothing towards solving this problem, and, on the other hand, the appearance of such books is calculated to deter competent mathematicians and physicists from attacking such problems.

OUR BOOKSHELF.

Didaktik der Himmelskunde und der Astronomischer Geographie. Verfasst von Dr. Alois Höfler. Pp. xii+414. (Leipzig and Berlin: B. G. Teubner, 1913.) Price 12 marks.

THIS is the second volume of a useful series of handbooks which is appearing under the general title of "Didaktische Handbücher für den Realistischen Unterricht an Höheren Schulen," and arranged by Professor A. Höfler of Vienna and Professor F. Poske of Berlin. This volume follows that from the pen of the first named, which dealt with mathematical instruction, and its object, like its predecessor, is to reform the teaching of astronomy and astronomical geography in the schools. The volume is essentially for teachers and displays a graduated series of courses of instruction for students commencing when eleven years old and finishing at eighteen. The book is divided into four stages, each stage arranged to cover two years of the student's training. The author strives at great length to impress on the teacher the importance of leading the students to observe for themselves as much as possible, and to show them simple experiments whenever the opportunity arises.

No pains seem to have been spared to provide the teacher with numerous references to works that may be consulted by him, and to draw his attention to numerous points which are not often sufficiently clearly explained to the youthful student.

While the full course here suggested would be difficult to carry out under the conditions of education in this country, our teachers could nevertheless, provided they are sufficiently well conversant with the German language, gather a large amount of useful hints, even if only from the method of treatment of the material. For use in Germany we have no doubt that the teachers will hail gladly the appearance of this volume, and the distinguished list of co-workers with Prof. Höfler is sufficient indication to stamp the volume as one of a high order.

Einführung in die Agrikulturmykologie. By Prof. Dr. A. Kossowicz. 1. Teil: Bodenbakteriologie. Pp. vii+143. (Berlin: Gebrüder Borntraeger, 1912.) Price 4 marks.

PROF. KOSSOWICZ is to be congratulated on having condensed into such a small book a review of the chief publications on soil mycology. The book partakes, in fact, more of the nature of an introduction to the literature of the subject than to the subject itself. The mere enumeration of the various workers for and against a hypothesis, without any criticism from the author, is not calculated to afford much help to a beginner. The subject-matter is divided into sections dealing with the part played by bacteria in the cycle of the elements carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorus, and iron; the mycology of soil; the mycology of manure; and the influence of the manurial treatment on the micro-flora of the soil. For such a small book the bibliography is very comprehensive, constituting, as it does, about one-fourth of the total number of pages. The book is well illustrated, and as a short work of reference ought to prove of value to agricultural chemists and mycologists.

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.*]

The Piltdown Skull.

IT had been my intention not to add anything further in print to my preliminary note (Quart. Journ. Geol. Soc., vol. lxix., 1913, p. 145) on the cranial cast obtained by Dr. Smith Woodward from his reconstruction of the Piltdown skull until I was in a position to make a full and comprehensive statement as to the precise significance of the information afforded by the cranial fragments as to the kind of brain possessed by the earliest known human inhabitant of Britain. But, although my investigations are now sufficiently advanced to permit me to undertake the writing of my report, it will be some months before it can be published; and in the meantime it is most undesirable that the present widespread misunderstandings should be allowed to breed further trouble and confusion for those who are interested in the elucidation of Mr. Charles Dawson's momentous discoveries.

Recent events have made it difficult for those who have relied wholly upon what has appeared in print to form any accurate conception of the meaning and importance of the Piltdown skull-fragments. It is quite certain that they afford the first evidence we have obtained of a hitherto unknown group of the Hominidæ, so fundamentally distinct from all the early fossil men found in Europe as to be worthy of generic distinction—a "dawn-man" of a very primitive and generalised type. Certain features are so clearly ape-like as definitely to confirm the generally admitted kinship to the African anthropoid apes, as well as to distinguish Eoanthropus sharply and clearly from all other human remains. In other respects, however, there is a closer resemblance to the features of modern man than is found in the specialised group of Neanderthaloid palæolithic men. This curious association of features is not paradoxical, as some people pretend. The small and archaic brain and thick skull are undoubtedly human in character, but the mandible, in spite of the human molars it bears, is more simian than human. So far from being an impossible combination of characters, this association of human brain and simian features is precisely what I anticipated in my address to the British Association at Dundee (NATURE, September 26, 1912, p. 125), some months before I knew of the existence of the Piltdown skull, when I argued that in the evolution of man the development of the brain must have led the way. "The growth in intelligence and in the powers of discrimination no doubt led to a definite cultivation of the æsthetic sense, which, operating through sexual selection, brought about a gradual refinement of the features." Just as the young child still uses its teeth for purposes of attack, so in the dawn of human existence teeth suitable for offensive purposes were retained long after the brain had attained its distinctively human status and had made the hands even more serviceable instruments for attack.

That the ape-like conformation of the chin region signifies the inability to speak is surely a patent fallacy. Articulate speech must have come while the jaws were still simian in character; and the bony changes that produced a chin were the result mainly of that process of refinement to which I have already referred, to the reduction of the teeth, which was part of the same process, and, quite in a minor degree, to that process of growth and specialisation of the genio-glossi muscles which resulted from their use in speech.

A great source of misunderstanding will be got rid of if these obvious facts and the considerations based upon them be admitted.

In conclusion, I may answer many questioners by affirming that I still hold to every word of my preliminary note published in the Quarterly Journal of the Geological Society, as well as of the statements made in my lectures delivered before the Royal Dublin Society and the Manchester Literary and Philosophical Society last winter, and also to the facts demonstrated in my exhibit at the Royal Society's soirée in May.

G. ELLIOT SMITH.

University of Manchester, September 23.

Solar Electrical Phenomena.

IN a lecture last January to the Christiania Academy, Prof. Birkeland[1] gave an interesting summary of his recent researches on solar and planetary electrical phenomena. He describes how in a study intended to elucidate the evolution of celestial bodies he examined the nature of the electric discharge taking place *in vacuo* in a large discharge vessel from a magnetisable globe serving as kathode. The experiments, which were made under widely differing conditions, were on a scale more ambitious than anything hitherto attempted. Two vessels of 300 and 1000 litres' capacity respectively were employed. In the larger of these the globe used was of 36 cm. diameter,

[1] "De l'origine des mondes," par K. Birkeland, Arch. Sci. phys. et nat. Genève. Quatrième Periode, t. xxxv., Juin, 1913.

and discharges up to nearly half an ampere were obtained. Some of the published photographs are very remarkable. One of them showing the electric corona and streamers round the magnetised globe might easily be mistaken for a genuine photograph of a typical solar eclipse. Many of the phenomena of sunspots are also very strikingly imitated in the experiments.

Birkeland proceeds to discuss the cause of the general magnetic field of the sun, the fact of the existence of which has been established by Hale. He attributes it to induced currents circulating in the interior of the rotating mass, which, he argues, can only have a comparatively feeble electric conductivity. He says (*loc. cit.* p. 540):—

"We know that electric currents circulating in large globes formed of good electric conductors are of great persistence. Lamb found that for a globe of copper as large as the earth, ten million years would elapse before the currents fell to $1/\epsilon$ of their former intensity. The induction effects produced by electric rays emanating from sunspots may therefore give rise to currents of long duration if circumstances permit. It is probable that as regards the sun, we shall be obliged to suppose a somewhat feeble conductivity of the gaseous interior, to the intent that the electric currents created and circulating within it are reduced with a fairly high rapidity and are transformed into heat."

In a recent communication to the Royal Astronomical Society,[2] the writer brought forward some evidence deduced from laboratory experiments, which led to a contrary conclusion, namely, that the gaseous matter composing the sun must be a highly conducting medium. The experiments of Kaye[3] and the writer showed that carbon and a number of metals emit on heating ionisation currents of a relatively very high order of magnitude, and this in absence of any external applied potential and at atmospheric pressure. The currents are almost certainly carried by swarms of negatively charged particles of relatively considerable mass, the emissivity of the emitting surface increasing very rapidly with increase of temperature.

In the interior of a carbon-tube resistance-furnace heated by alternating current, the apparent gaseous resistance of the order of megohms at 1400° C. fell at the highest attainable temperature to a small fraction of an ohm, due to the emission from carbon alone. In one series of experiments where temperature measurements were made, the conductivity increased exponentially nearly two hundred-fold for each rise of 1000° C. Impurities such as iron and silicon, which are generally present in ordinary samples of carbon, may further increase the conductivity four or five fold during the first heating of a new furnace. Though influenced somewhat by the surrounding gas, the emissivity appears to be invariably present in neutral or reducing media. The experiments of King, briefly referred to by Hale in his paper in the current number of *The Astrophysical Journal,* show that though the emissivity of carbon falls with increase of pressure, it is still apparent at 20 atmospheres.

Seeing that the temperature of the sun is probably between 5600° and 6000° abs. and that of those elements shown to possess an appreciable electric emissivity, carbon, and iron at any rate are present in the solar atmosphere in considerable quantity, it is difficult to avoid the conclusion that the degree of ionisation, and consequently of electric conductivity, must be very high; probably at least as good as that of the globe of copper considered in Lamb's computation.

The bearing of these conclusions on Birkeland's solar theory seemed worthy of some consideration.

J. A. HARKER.

Teddington, September 16.

[2] Harker, "On the Origin of Solar Electricity." Monthly Notices of the Royal Astron. Soc., June, 1913.

[3] Harker and Kaye "On the Emission of Electricity from Carbon at high Temperatures." Proc. Roy. Soc. A. vol. lxxxvi, 1912, pp. 379 to 396. "On the Electric Emissivity and Disintegration of Hot Metals." Proc. Roy. Soc. A. vol. lxxxviii, 1912, pp. 522 to 538.

A New Aquatic Annelid.

ABOUT the middle of September I received from Dr. H. F. Parsons, of Croydon, a fresh-water Annelid which had been found in the water supply of Ringwood, Hants, and sent to the Local Government Board for identification. It proved to be an immature but very beautiful specimen of *Rhynchelmis limosella,* Hoffm., a member of the Lumbriculidæ. It is of peculiar interest, inasmuch as it confirms a suspicion expressed by Beddard in 1895. He remarks ("Monograph of the Order Oligochæta," p. 215) that "the genus Rhynchelmis is, so far as our present knowledge goes, confined to the fresh waters of Europe. . . . I have seen a specimen from some part of England, but cannot give any details. I believe this specimen to be in the Oxford Museum. There is every probability that it is a native of this country."

I have collected annelids in almost every part of the British Isles, but hitherto have never had the good fortune to come across the species here named. It is, therefore, very gratifying to be able to record it as a new addition to our Annelid fauna.

HILDERIC FRIEND.

Pocklington, York, September 20.

MODERN ELECTROMETERS.

RECENT research on the electron and radioactivity has necessitated so many refined electrostatic measurements that much attention has been directed to the design of electrometers, and several different instruments distinguished by their sensitiveness and convenience in working have been devised. Two types have served as the starting-points for modern improvements, the first being the gold-leaf electroscope, and the second the quadrant electrometer of Lord Kelvin; great progress has been made by bettering the insulation, the sensitiveness, and the accuracy and ease of observation, and further by important modifications of design. Polished amber or ambroid, a substance made from compressed fragments of amber, is now generally used as insulating substance, and for the first type of instrument the deflection is now measured with a reading microscope; for the second the mirror and scale is employed.

The gold-leaf instrument is used in many forms. In a modification by Exner a leaf is fastened on either side of a narrow, vertical, insulated metal plate, while opposite each leaf is a metal plate the distance of which from the central plate can be adjusted, thus controlling the sensitiveness; for potentials of some hundred volts this is a convenient form. For higher potentials of thousands of volts Braun's pattern, with a light rigid needle pivoted a short distance above its centre of mass, is much used. For very sensitive measurements C.T.R. Wilson has recently modified the gold-leaf electroscope in his so-called "tilted electrometer." In this instrument a single hanging gold leaf is attracted out of the vertical by an inclined insulated plate, which is kept charged at a constant potential. On varying the inclination of the plate by tilting the instrument, a position can be found for which the leaf is only just in stable equilibrium; slightly increasing the tilt would cause the leaf to fly over to the plate. In such a case, as is well known, the sensitiveness of an instrument is very high, a familiar example being the suspended magnet galvanometer, in which, by adjusting the field magnet, the controlling field is so arranged that the magnet is only just in stable equilibrium. The capacity of this instrument of Wilson's is very small, and a reading microscope attached to the stand enables accurate readings to be taken. Fig. 1 shows in section the instrument as made by the Cambridge Scientific Instrument Co.

To avoid difficulties, known to all physicists, which occur in working with a gold leaf, Wulf

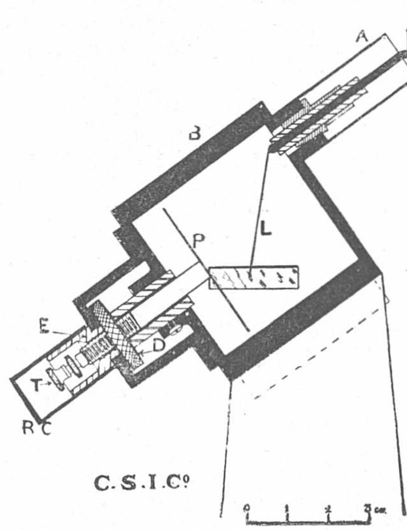


FIG. 1.—The tilted gold leaf electrometer.

has devised a very effective instrument, put on the market by the firm of Günther and Tegetmeyer, in which the leaf is replaced by quartz fibres rendered conducting by sputtering with a thin film of platinum in a kathode-ray tube. Two such fibres hang side by side, loaded with a minute weight: on being charged the fibres repel one another, and the separation is read with a microscope. The fibres give a very sharp image, and thus all difficulty connected with reading by one irregular edge of a gold leaf is avoided. The capacity is smaller than that of the smallest leaf instrument, and practically independent of the potential. The sensitiveness never approaches that of the tilted electrometer, but this instrument is excellent for measuring potentials of either a few volts or a few hundred volts, according to the fineness of the fibres, the size of the weight, and other details of construction. It fills the gap between the tilted and the Braun electrometer, and is very convenient and portable. A somewhat similar design is the Einthoven string electrometer, in which a silvered quartz fibre is stretched between, and parallel to, two metal plates, kept at a constant difference of potential.

The pattern of quadrant electrometer devised by Dolazalek is so widely used at present that it suffices to mention very briefly the improvements introduced, the small dimensions of the needle and quadrants, the quartz suspension, the amber insulations, and the light needle of silvered paper, rendered rigid by its peculiar form. Dolazalek has, however, recently devised an instrument differing in many important particulars from that familiar to English physicists, which he calls the binant electrometer, from the fact that the four

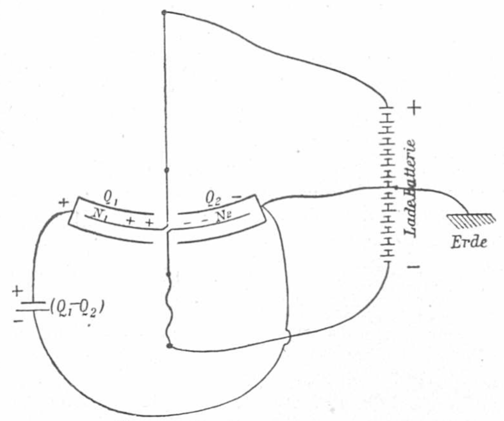


FIG. 2.—The binant elec rom ter.

quadrants are replaced by two semicircular "binants" [1]; it is made by Herr Georg Bartels, of Göttingen. This instrument has many advantages over the quadrant pattern, and is being widely used in Germany, although at present it seems to be unknown in England. The "needle" is a disc formed of two semicircular segments of the thinnest sheet-aluminium, stiffened by means of embossed ridges, and insulated from one another with amber. The box which encloses them is likewise made up of two semicircular parts supported on amber, arranged so that their line of separation is perpendicular to the line of separation of the needle segments. Needle and box are not plane, but formed from shallow concentric spherical shells, the centre of which coincides with the point of suspension of the needle. Owing to this simple device an oscillation of the needle does not bring it any nearer to the enclosing walls, and the needle is stable at very much higher potentials than in the case of the quadrant electrometer; this form also lends increased rigidity to the delicate needle. When in use, one of the segments of the needle is charged positively, the other negatively, by earthing the middle of the battery used for charging; contact is made for the one segment through the suspension, which is an exceedingly fine Wollaston wire, and for the other through a still finer coiled wire arranged

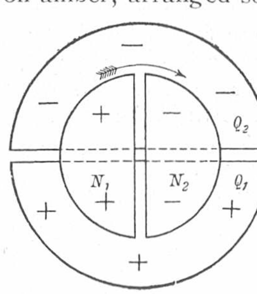


FIG. 3.—The binant electrometer. Plan.

[1] "Annalen der Physik," (iv) 26, 1903. F. Dolazalek, "Binantelektrometer." Figs. 2, 3, and 4 are from this paper.

in a similar way to the lower connection in a moving-coil galvanometer. The binants of the box are connected to the potential difference to be measured.

Advantages of the instrument are the wide proportionality between deflection to one side and potential difference, and the large range of potential which may be given to the needle with satisfactory results; in addition we have the stability of the needle already mentioned. The deflections to one side are proportional to the applied potential difference over a range seven times as great as is the case when, with the quadrant instrument, readings to both sides are taken. This property has led to the construction of a portable binant instrument with a pointer, which can be used as a voltmeter, measuring directly potentials to a fraction of a volt without passage of current. If used idiostatically, the deflections are, of course, proportional to the square of the potential, and, connected in this way, the instrument measures alternating potentials very effectively.

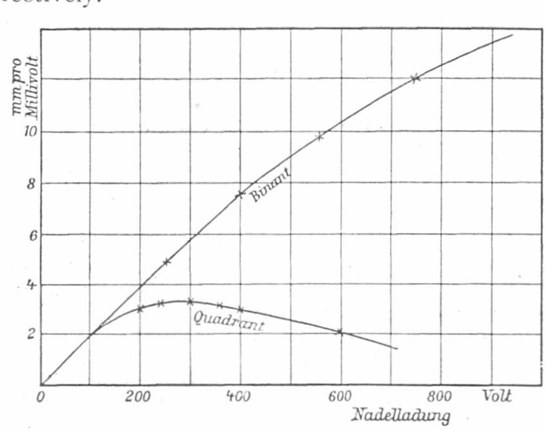


FIG. 4.—The sensitiveness of the "binant" and quadrant electrometer compared.

The potential of the needle in the binant instrument can be taken as small or as large as may be desired. The variation of the sensitiveness with the potential of the needle is shown in the diagram (Fig. 4) for a quadrant and a binant instrument of similar dimensions throughout. The abscissæ are the difference of potential of the two halves of the needle for the binant, the potential of the needle above earth for the quadrant, and the ordinates are millimetres deflection per millivolt applied potential. With the binant form the deflection is proportional to the potential of the needle up to about 400 volts, and still continues increasing up to 1500 volts (off the diagram); in the case of the quadrant instrument the sensitiveness increases slowly with the potential of the needle, and reaches a maximum at about 300 volts, after which increasing the potential of the needle is disadvantageous. Further, for the quadrant electrometer the potential of the needle cannot be taken very small, as in this case the readings are too asymmetrical on reversal, as will be seen from the ordinary formula of the text-books. For the binant the potential of the needle may be taken as small as desired; in fact, by altering the potential of the needle alone measurements of potential can be made over a region of five powers of ten.

The cause of the peculiar variations of the sensitiveness of the quadrant electrometer with the potential of the needle, increasing to a maximum and then decreasing again, is to be found in the fact that the change of capacity per unit angular displacement is not constant, as assumed in Maxwell's accepted treatment, but decreases with increasing needle potential and increasing displacement. This is due to the lines of force from the radial edges of the needle, which are to a large extent diffused not perpendicularly to the top and bottom of the box, but horizontally. The connection of such horizontal lines of force with one of the quadrants is unaltered by the displacement of the needle, and this influences the changes of capacity. The form of the needle and its position avoid these disturbances in the binant instrument; the narrow gap between the two halves of the needle, and their opposite potentials, cause the lines of force from the diametral edges to spring from one half to the other, instead of to the walls of the box, and the position of the gap perpendicularly to the gap in the box further diminishes the effect. The wide proportionalities of the binant electrometer are largely attributable to this result of its peculiar construction.

E. N. DA C. ANDRADE.

THE TECHNICAL PRODUCTION AND UTILISATION OF COLD.[1]

THE appearance of an English translation of the work by Georges Claude (1), the successful French inventor in the field of the liquefaction and rectification of air, affords an occasion for reviewing the progress made in this, which seems destined to become one of the leading departments of twentieth-century scientific industry. Eighteen years have elapsed since the inventions of Linde and Hampson solved the problem of the production of liquid air in quantity, and extended the range of low temperatures practically attainable to as great an extent as the electric furnace did in the opposite direction. It is sufficient to recall the names of Faraday, Andrews, Dewar, Hampson, and Ramsay to show that this country has not been behindhand in pioneers in this field, both in regard to the attainment of low temperatures and to their utilisation for scientific investigation. But there, as in other cases, progress in this country seems to have come to a standstill, and the commercial application and utilisation of these results has been developed entirely abroad, in this case chiefly in Germany and France.

It is on this side of the subject that the present book furnishes much information difficult to acquire easily elsewhere. Part i., dealing with elementary principles and the history of the subject, and part iii., with the properties of liquid

[1] (1) "Liquid Air, Oxygen, Nitrogen." By Georges Claude. Translated by H. E. P. Cottrell. With a Preface by D'Arsonval. Pp. xxv.+418. (London: J. and A. Churchill, 1913.) Price 18s. net.
(2) "Le Froid industriel." By L. Marchis. Pp. xx+328+104 figs. (Paris: Félix Alcan, 1913.) Price 3.50 francs.

air, are popular presentations of a hackneyed theme, almost painfully familiar in this country, where liquid air long since descended to the level of a music-hall turn. But in parts ii. and iv. the author deals in an interesting and original way with the theory and practice of actual processes for the technical liquefaction of air, and its separation into oxygen and nitrogen. Naturally an author must be allowed to tell his story in his own way, and fight his battles over again, when these battles have resulted in success, though almost everyone may now be supposed to know that working at $-200°$ C. does not confer upon liquids any peculiar behaviour or render the separation of oxygen and nitrogen from the air a problem essentially different in its scientific principles from that of the separation of alcohol and water in one of the oldest of chemical operations.

The English translation certainly retains to the full the racy style of the original, but sadly needs careful revision, especially in the mathematical expressions. As many as six slips have been noted, for example, on pp. 132-4. The units employed should be defined to render them intelligible to English readers, and misleading contractions like *calorie* for *kilogramcalorie,* and *Kgms.* for *Kilogram-metres,* avoided. In more than one instance the real meaning of the author, just where it is important, is obscured by some slip or looseness of expression, as on p. 184, where an improvement is stated to increase the yield of liquid air in Claude's process *by* 0·85 litre per H.P. hour, when apparently *to* 0·85 litre is intended. In a preface by D'Arsonval yields of "finally 0·95 litres per H.P. hour" in Claude's process are referred to, but in the text, apart from the above imperfect statement, we are left in doubt as to the best that Claude has so far been able practically to achieve.

Dealing first with the problem of air liquefaction Claude's especial contribution is the solution of the problem of expansion with external work, following the suggestion made by Lord Rayleigh so long ago as 1898. As is well known, Linde's and Hampson's processes depend only on the "internal work," that is, on the relatively minute cooling effect—the Joule-Thomson effect—produced on the expansion of an imperfect gas, like air, due to the work done by the molecules in increasing their distances apart against their own feeble attraction. As in the whole of these processes, the Siemens exchanger of temperature, fifty-six years old, is employed, and enables this cooling to be used regeneratively until ultimately the liquefaction temperature is reached. But at the expansion jet, or, at least, inside the exchanger, just where it is emphatically not wanted, the enormous mechanical energy of the escaping gas is quantitatively reconverted into heat. The expansion is adiabatic, and temperatures, as in Cailletet's apparatus, far below the liquefaction temperature are instantaneously attained, but, in distinct inferiority to Cailletet's simple process, are not made use of because the work is quantitatively reconverted into heat inside the system. At first sight, but at first sight only, it appears that an enormous improvement might be effected in this direction, increasing the yield of liquid air some ten times, and regaining thereby a substantial proportion of the work employed in compression. Lord Rayleigh's suggestion was that the air on expansion should drive a turbine, which, however inefficient, could not fail both to increase the cooling effect and recover some of the power employed.

Claude has successfully employed the energy of expansion to do work in a compressed air motor capable of working below $-100°$ C. We read that "while the makers have troubles, which are relatively frequent, with the ever well-known but still somewhat barbarous and brutal appliances which air compressors are, they have, so to speak, none at all with the new-born appliances, the expansion machines for liquid air." At first petrol and even liquid air itself were employed as lubricants in the cylinders of the compressed air machines. Lubrication troubles seem, however, now to have been entirely avoided, owing to a discovery (1912) of the unique properties of leather, which, after being suitably treated, preserves all its good qualities at low temperatures. In the present machines the pistons of the expanders are provided with stamped leathers instead of metallic rings, and do not require any lubrication. The chief advantage of the system is that lower pressures—40 atmospheres, the critical pressure of air—can be employed, whereas the Linde and Hampson processes depend on the use of a pressure of 200 atmospheres. But the yield, spoken of in the preface as finally 0·95 litre per H.P. hour, is not very greatly superior. In the Linde process a practical yield of 0·6 litre per H.P. hour is realised in large machines, which is some three times better than in the Hampson laboratory machine.

The evolution of Claude's system has many points of interest. Exchangers are employed, and the gas arrives at the expander at a temperature of about $-100°$ C. Now if this process of exchange is carried too far, for example to $-140°$ C, "the air which enters the machine is not yet a liquid, but it is almost no longer a gas; its expansive properties are, so to speak, done away with, and the external work of expansion becomes detestable." Even were air a perfect gas, it can readily be seen that the more it is cooled before expansion the less energy it has to lose when expanded, and the smaller the cooling effect obtained. Enormously more of it is required to fill the cylinder the lower the temperature, whilst all the time the external work it can do, and the cooling effect it can produce, are steadily vanishing. But actually, at $-140°$ under 40 At., the volume is already only one-fourth of that of a perfect gas. This, of course, though Claude does not say so, is tantamount to admitting that the defect in the "internal work" processes in not utilising the energy of expansion is more apparent than real, and that the advantages of utilising the external work are to a large extent illusory. The practical solution was found in admitting the compressed gas to the expander at a temperature as high as is consistent with the attainment of a final temperaure below the critical temperature. This is effected by passing the cold expanded air at about $-140°$ around tubes supplied by a T branch from the intake of the machine, *i.e.* with air at 40 At. and at $-100°$ C. It liquefies part of this compressed air, and is warmed up thereby to about $-130°$, at which temperature it is admitted to the exchanger. A further improvement is obtained, much as in multiple expansion steam engines, by expanding in stages and warming up the expanded gas in between by making it circulate over coils filled with air above its critical pressure.

Thus at the present time liquid air may be produced in large machines for an expenditure of power perhaps one-fourth to one-fifth of that required in the Hampson simple laboratory machine, but it must still be regarded as a somewhat expensive and troublesome commodity to base a process upon. Naturally the question arises how it is that such great results may be confidently anticipated of its use. It has already displaced all other processes for the production of oxygen and nitrogen on a large scale, and, in the same field, the preparation of pure hydrogen and carbon monoxide from water gas offers no insurmountable difficulty. The industry can supply oxygen to-day, in plants of 1000 cubic metres per hour, at 0·2*d*. per cubic metre, and this means that to burn coal in pure oxygen rather than in air would increase the cost of the fuel only some four times. The saving in certain cases, through not having to heat at the same time a mass of nitrogen at least two and a half times greater than that of the coal and oxygen together, is evident. But this to-day's figure gives no conception of what could be done if chemists really set themselves to separate the oxygen and nitrogen of the atmosphere before use, even in such common processes as the combustion of fuel. It can be stated confidently that the cost of the oxygen would not exceed that of the coal, without taking into account the possible use of the nitrogen produced at the same time. When it is considered how all industrial chemistry has been based upon the necessity of taking oxygen always diluted with some five times its volume of nitrogen, the revolution in methods that these facts suggest is obvious. A blast furnace, for example, consuming oxygen instead of air, would be very different from the present affair.

The reason why the liquefaction of the atmosphere and its subsequent rectification holds out such great industrial possibilities, in spite of the somewhat expensive character of liquid air, is, of course, that the cold is used regeneratively. There is an apparatus into which air at ordinary temperatures passes, and out of which oxygen and nitrogen, at a few degrees only from that temperature, issue. In other words, the losses of cold through the issuing gas being at slightly lower temperature than the entering gas are so small that in the rectification of thirty litres of liquid air into its components some twenty-nine litres would be recovered. Actually, there is a very slight expenditure of power required, amounting theoretically to 0·1 H.P. hour per cubic metre of oxygen separated. In addition, the losses through heat entering the well-insulated apparatus from outside must be considered, but these, naturally, are the smaller the larger the scale of operations. The yield of pure oxygen, the nitrogen being left with 2·4 per cent. of oxygen, per H.P. hour is, for a plant of 50 cubic metres per hour, about 1 cubic metre; of 100 cubic metres per hour, 1·2 cubic metres. For larger plants 1·5 cubic metres is confidently predicted. For the purpose of the industries fixing atmospheric nitrogen, naturally, great purity of the nitrogen rather than that of the oxygen is aimed at, and in these a purity of 99·9 per cent. can be realised, the oxygen testing some 80 per cent.

Space does not permit any detailed discussion of the factors which have enabled the older Linde process to compete successfully, and now to cooperate with, the newer processes utilising the principle of external work, though, as admirably set forth in this book, these are fascinating enough. Nothing less than real genius could have enabled Linde eighteen years ago to grasp and work out the intrinsic possibilities of success in the "internal work" method, which appears theoretically to be so barbarously wasteful, or to have designed the apparatus which, as Claude remarks, strikes one at first sight like a coach with five wheels. It furnishes a most interesting example, in this region of topsy-turvy thermodynamics, of how thoroughly the theoretical aspect of a problem may change the more deeply and completely it is examined.

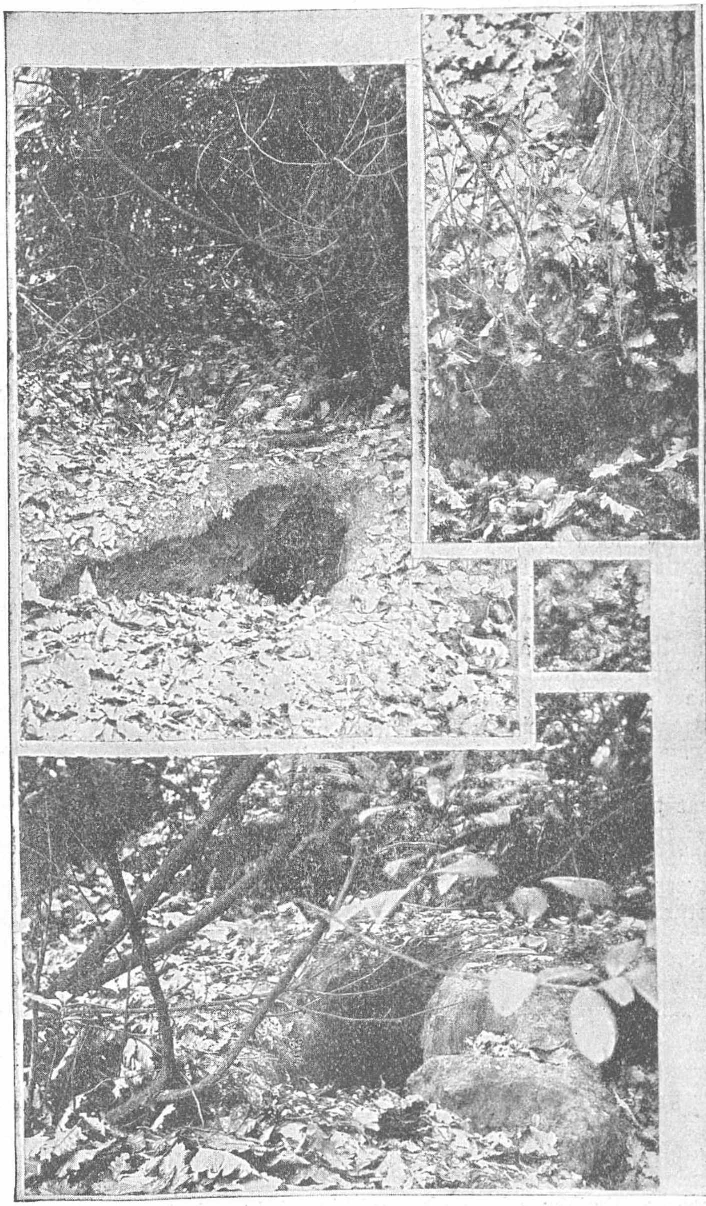
(2) The volume by Prof. Marchis is complementary to the other, and does not deal with the production of the extreme temperatures necessary for the liquefaction of air. It gives a most readable and useful account of the science of refrigeration as applied to the preservation of perishable commodities. It is packed full of practical information about refrigerating machines and insulating materials, the construction and management of cold-storage chambers and ice factories, and the preservation of the great variety of comestibles dealt with nowadays, each of which requires its special treatment if the best results are to be attained. The book can be confidently recommended as being in itself almost sufficient for an engineer without experience to undertake this field of work. At the same time, it contains much recent information of general utility to all interested in the subject. A description of the recent high-speed rotary compressors of M. Leblanc, with vanes of ramie fibre, agglutinated by the solution of acetate of cellulose in acetone, and running in a casing with practically no play at a peripheral speed of 500 metres per second, ends an abundantly illustrated section dealing with the various types of refrigerating machines. In the last two chapters the special cases of the preservation of meat and of fish are treated in detail. The author combats the prevalent idea that cold storage

tends to make food go bad more quickly when it is re-exposed to the ordinary temperature. Cold does not improve articles already commencing to decompose; but, on the other hand, if scientifically carried out—that is, if the food is in excellent condition to begin with, and is preserved with all due precautions as regards the correct temperature, its uniform maintenance, and the proper hygrometric condition and frequent renewal of the air in the store-room, and if the lowering and raising of the temperature do not take place too suddenly—no harmful consequences follow refrigeration. F. SODDY.

THE NATURAL HISTORY OF A LONDON SUBURB.[1]

THE increasing demand for works on local natural history, of which class of publication the present volume is an excellent specimen, must have been noted by workers in science as a healthy sign of popular awakening. But while in the eighteenth century it was possible for a Gilbert White to cover the whole ground so far as concerned his own district, the great development of specialised knowledge in modern times necessitates the cooperation of many workers to produce such a volume as that under consideration. Thus, in addition to the opening chapter on topography, by Messrs. Maynard and Findon (the hon. sec. of the natural history section of the society), there are ten chapters by different authors dealing respectively with the geology, climate, plant-life (three chapters), bird-life, mammals, &c., insects, molluscs, and pond-life together with a very useful bibliographical appendix.

A commendable feature of the present work is the general introductory section heading many of the chapters. By this treatment the reader is enabled to pass from the general to the special—a method which may be condemned by some critics as an inversion of scientific method but, in a local natural history, has the distinct advantage of enabling the general reader and the would-be student to realise that the local and restricted data supplied by his own district fit in to the larger and more comprehensive generalisations which scientific observers have built up from detailed observations over wider fields. The chapter by Mr. A. G. Tansley dealing with the vegetation (chap. iv.) is a very good example of the treatment referred to, as he begins with the ecology, shows the relationship of the vegetation to the geological features, and then groups vegetation generally under the various types of "associations" before dealing with the particular plant-associations of the district. The lists of species then come as natural sequences to the various "associations." A living interest is thus imparted to a subject which in former times was presented in the uninteresting form of a catalogue of names, amounting, in fact, to nothing more than the statement of the occurrence of a certain species in a particular district, without any relationship to its environment or to its associates. The chapter on the trees and shrubs (chapter v.), by Mr. Hugh Boyd Watt, will surprise many readers as a revelation of the extreme richness of the district, all



Badger Earths in Ken Wood. From "Hampstead Heath: Its Geology and Natural History."

[1] "Hampstead Heath: Its Geology and Natural History." Prepared under the Auspices of the Hampstead Scientific Society. Pp. 328+xi plates+3 maps. (London; T. Fisher Unwin, n.d.) Price 10s. 6d. net.

the native English trees, and also a large number of foreign species, finding the conditions suitable for their growth. How long these conditions will remain favourable is problematical, a remark which applies also to Mr. Whitton's goodly list of some 300 species of flowering plants given in chapter vi.

The geology of the district is necessarily "tame," but since Mr. F. W. Rudler is responsible for that chapter (chap. ii.), it is perhaps scarcely necessary to say that it will be found both interesting and instructive. The only regret is that the author did not "let himself go" more freely in discussing some of the generalisations which have of late years been based upon the detailed study of gravels and superficial deposits generally. In connection with the climate of Hampstead (chap. iii., by Mr. E. L. Hawke), it is of interest to note that the sunshine record, as compared with that of the city, more nearly approaches that of Berkhamstead, which is tolerably clear of London influence. Thus the total number of hours of bright sunshine during 1910 was 1372, as compared with 1348 at the Hertfordshire station, 1183 at Camden Square, and 993 at Bunhill Row. So much for the effects of atmospheric pollution in the City of London! Bird-life (chap. vii.) is dealt with by Mr. Herbert Goodchild, who gives a very clear account of the particular conditions favourable and unfavourable to an avifauna. One of his observations is very significant: "Adjoining the heath are several private woods, a form of ownership which tends to the preservation of species that might otherwise be lost to the district, since in such woods and coppices the birds are safer from molestation. As some of these woods adjoin the public domain, an observer may see on the latter many species of birds that might be driven away if all the woods were public." The writer of this notice has long ago come to the conclusion that the preservation of open spaces solely from the point of view of the "recreation and enjoyment of the public" is in many cases quite the reverse of a boon from the point of view of the naturalist. Mr. Goodchild is, of course, an advocate of the study of bird-life by the modern method —*i.e.* the field-glass and camera, and not by the gun. It is fortunate for the district, also, that it comprises the Brent reservoir, and that that well-known observer Mr. J. E. Harting was a former resident, and kept observations of the birds for many years.

The chapter on mammals, fishes, and reptiles, by Mr. Hugh Findon, will also surprise many readers who are unprepared for the survival of such a number of species within sight of the metropolis. The existence of badger-earths, still apparently tenanted, is certainly remarkable, but here, again, the preservation of this notoriously shy animal is due to the inclusion of the earths (a figure of which we reproduce) in the private grounds of Ken Wood, the owner of which estate has always been a sympathetic conservator of this interesting denizen. Dr. O'Brien Ellison's chapter on insect-life serves to emphasise the complaint so frequently made by entomologists in this country that local collectors so generally concentrate their attentions upon the Lepidoptera to the neglect of other orders. There are surely more than twenty-seven species of Coleoptera in the district, to say nothing of Hymenoptera, Diptera, and Microlepidoptera. The list of Lepidoptera, by the way, is marred by a number of misprints. It only remains to add that there are chapters on molluscs and on pond-life by Mr. Hugh Findon and Mr. James Burton respectively.

The Hampstead Scientific Society has certainly done good service in publishing this volume, which is a typical specimen of the kind of work which local societies should undertake. For a district such as that dealt with—viz. within the three-mile radius from the flagstaff on the summit of the heath—a book like that before us is not only of immediate utility, but is certain to acquire increased value as time moves on and the influence of urbanisation becomes more and more pronounced. Already many of the species recorded are taken from old publications, and are now extinct. The general impression produced by the perusal of the volume is one of marvel at the persistence of so much that is "natural" in the area described.

R. M.

PROF. HUGH MARSHALL, F.R.S.

BY the untimely death of Prof. Hugh Marshall, which took place in London on September 5, chemistry has lost, at the early age of forty-five, one of the nowadays comparatively few prominent men who devoted their energies to the investigation of subjects connected with the inorganic and mineralogical branches of the science, and the University of St. Andrews an active and useful member of the professorial staff of Dundee University College.

It is not a disparagement to say that Dr. Marshall's most brilliant discovery—that of the persulphates, in 1891—was due to one of those fortunate chances, not infrequent in science, where experiments designed to elucidate a certain definite question lead to some new discovery of a wholly different description and often of much greater consequence; for, no sooner was the discovery made than its author was quick to discern that substances of far-reaching importance had fortuitously presented themselves to him and to prosecute their examination with exceptional vigour and success. The subject under immediate investigation was the oxidation of cobalt salts by electrolysis in the then comparatively little employed "divided" electrolytic cell, and on passing a current of electricity through "a fairly acid solution of cobalt and potassium sulphates," with a view to prepare potassium cobalt alum, small crystals slowly separated, which proved on analysis to consist of potassium persulphate. The discovery of the persulphates at once brought Dr. Marshall's name into prominence, while the assiduity and skill with which he continued his examination of them speedily marked him as a rising inorganic chemist.

Having a distinct leaning towards mineralogy and crystallography, he devoted a considerable amount of study to these subjects also, and published several useful crystallographical papers; but inorganic chemistry claimed most of his attention, and his later papers as a rule savoured more or less of persulphates in some of their varied interactions. Thus, either alone or in collaboration with others, he published papers describing the action of persulphates on iodine, silver salts, thiosulphates, &c.; and the neat modification of Crum's test for manganese, in which potassium persulphate is employed as oxidising agent instead of lead peroxide, was devised and elaborated into a quantitative colorometric method by him. Other papers dealt with thallic sulphate; rubidium, cæsium, and thallium persulphates; quantitative analysis by electrolytic methods; succinic acid and succinates; the compound of iodine with thiocarbamide, &c.

In addition to his chemical investigations he found time to examine some technical subjects, and his work upon the burning of mixtures of air and light hydrocarbon vapour led to the perfecting of the "Petrolite" safety incandescent lamp, for which he was awarded prizes by the Edinburgh Association of Science and Art, and the Royal Scottish Society of Arts. He also devised a simplified form of Bunsen burner which was particularly suitable for use by beginners in laboratory practice. The Keith prize and gold medal for the period 1899–1901 was awarded to him by the Council of the Royal Society of Edinburgh for his researches on persulphates. He was elected to fellowship of the Royal Society in 1904, and to the chair of chemistry in Dundee in 1908. With, to all appearance, many years for good work still before him, Dr. Marshall was a man whom inorganic chemistry could ill afford to lose.

LEONARD DOBBIN.

NOTES.

REUTER'S Agency is informed that Sir David Bruce will leave England on November 1 for the purpose of concluding his sleeping sickness investigations in Central Africa. He will be accompanied by Lady Bruce, who is herself a memоer of the Commission. Sir David and Lady Bruce will sail in the *Edinburgh Castle* from Southampton, and will proceed to Cape Town, whence they will travel by train to Beira. From that place they intend to go up the Zambesi and Shire rivers to Lake Nyasa.

The Paris correspondent of *The Times* reports the death of the toxicologist, Dr. Jules Ogier, at sixty years of age. Our contemporary gives the following particulars of Dr. Ogier's career:—After some years' work with Berthelot, during which period his writings on arsenic and other poisons attracted considerable attention, he was appointed director of toxicology at the Prefecture of Police, where his work was of the greatest value to justice. He planned most of the large water systems in France, and his labours in connection with the purification of drinking water have been of great service to public health. He was in a way the creator of modern toxicological chemistry, and his many works include a treatise which has become a classic in that branch of science.

THE seventeenth annual autumn foray of the British Mycological Society was held at Haslemere on September 22–27, the Haslemere Educational Museum, founded by the late Sir Jonathan Hutchinson, serving as headquarters during the meeting. A well-arranged programme of excursions was planned by Mr. E. W. Swanton, and a large number of fungi were collected, including many rare and interesting forms. The mornings were generally devoted to the examination and arrangement of specimens, some of the most noteworthy of which were:—*Rhizopogon rubescens, Hydnum melaleucum, H. Queletii, Sparassis laminosa, Clavaria formosa, Cortinarius bolaris, Mycena crocata,* and *Sclerotinia baccarum*, and also the Mycetozoa, *Licea pusilla, Hemitrichia clavata, Oligonema nitens,* and *Diderma simplex.* On Wednesday evening, September 24, Mr. A. D. Cotton (president for the year) delivered an address entitled "Suggestions as to the Study and Critical Revision of Certain Genera of Agaricaceæ," pointing out the urgent need of critical work, and emphasising the diagnostic value of certain microscopic characters. Other members contributed papers, namely, Mr. F. T. Brooks, on pure cultures of several Basidiomycetes and Ascomycetes; Prof. Buller, on the hymenium-structure in Hymenomycetes; and Mr. J. Ramsbottom, on the history of the classification of Discomycetes. In passing a vote of thanks to the trustees of the museum, the hope was expressed that the scientific and educational work hitherto carried on there would be continued, and that it would be possible to establish the museum upon a permanent basis. The officers elected for 1914 were:—President, Prof. A. H. R. Buller; vice-president, Miss G. Lister; honorary secretary and treasurer, Mr. Carleton Rea; the localities for the spring and autumn meetings being the Forest of Dean and Doncaster respectively.

AT a conference held on September 19 in the rooms of the Linnean Society, Burlington House, Dr. A. B. Rendle, F.R.S., gave an account of the inception and activities of the plant protection section of the Selborne Society, under the auspices of which the meeting had been called, and outlined the various causes at work tending to the diminution or extermination of native plants in Britain—the building over of suburban and rural districts, drainage of marshes and bogs, smoke pollution, excessive collecting of rare plants by botanists and their agents, the wholesale digging up of both rare and common species by hawkers, &c. A brisk discussion followed regarding the proposed remedial measures for the preservation of the British flora; and though this was marked by considerable divergences of opinion, it was generally agreed that on one hand much remained to be done in the way of arousing public interest in the matter, while on the other there was much to be said for the introduction of legislation which should secure at least the same degree of protection and scheduling of plants as that afforded to bird-life by the Wild Birds Protection Acts. Several speakers pointed out that much might be done with the powers now possessed by local authorities but rarely exercised by them, and that in many cases small areas might be secured as nature reserves by public-spirited persons interested in the local flora before such areas were destroyed as plant habitats.

Dr. J. Mitchell Bruce will deliver the Harveian oration at the Royal College of Physicians of London on Saturday, October 18.

Under the auspices of the National Association for the Feeble-Minded, a conference of public authorities upon the subject dealt with by the association will be held at the Guildhall, London, on October 23.

The first Italian congress of radiology will be held at Milan on October 12–13. In connection with the congress there will be an exhibition of apparatus connected with Röntgen rays and investigations in radioactivity.

The twenty-first James Forrest lecture of the Institution of Civil Engineers will be delivered in the lecture theatre of the new building of the institution, Great George Street, Westminster, on Thursday, October 23, at 9 p.m., by Mr. Alexander Gracie, upon the subject of "Progress of Marine Construction."

The death is reported, at the early age of forty-two, of Mr. E. L. Morris, the biologist and curator in natural science in the museum of the Brooklyn Institute of Arts and Sciences. In addition to holding this office, Mr. Morris was one of the special plant experts of the U.S. Herbarium and the U.S. Department of Agriculture.

Mr. W. A. Tookey is to lecture to the Junior Institution of Engineers to-morrow—October 3—on gas-engine testing. On October 20 a paper is to be read by Mr. G. S. Cooper on modern coke-ovens. The new president of the institution, Sir Boverton Redwood, will deliver his presidential address on December 5, taking as his subject "The Future of Oil Fuel."

The Russian Government, reports *The Japan Chronicle* (September 11), has decided to establish a physical observatory at Vladivostok and experimental stations on the Pacific coast with the view of co-operating with the authorities of meteorological stations in China and Japan. Mr. S. D. Griboyedov, a prominent meteorologist, has been commissioned to investigate suitable sites for the proposed structures and to submit a report thereon.

It was announced in *The Times* of September 22 that a Malay python (*Python reticulatus*) in the Zoological Society's Garden had laid a number of eggs some days previously, which, after a considerable delay, she eventually brooded in the manner distinctive of this group of snakes. Unfortunately, there is every reason to believe that the eggs were not fertilised. A similar event took place in the Tower Menagerie so long ago as 1828, a second at the Jardin des Plantes in 1841, a third in the Society's Gardens in 1881, and a fourth in the Colombo Gardens in the autumn of 1904.

In *The Times* of September 25 it is stated, on the authority of a local correspondent, that steps are being taken, under the auspices of the Resident-General of France and of his Highness the Bey of Tunis, to establish in Tunisia a reserve in which the fast disappearing fauna of the country may find immunity from persecution. For this purpose some 4000 acres of wild mountainous country, with an adjoining marsh of 5000 acres, have been secured; and as this area already contains representatives of many of the wild animals of the country, the work of stocking the reserve will be much less heavy than would otherwise have been the case.

The first general meeting of the London Wireless Club was held on Tuesday of last week at the City of Westminster School, Mr. F. Hope Jones in the chair. Prof. Silvanus P. Thompson, F.R.S., Mr. A. A. Campbell Swinton, and Sir John Macpherson-Grant, Bart., have consented to become vice-presidents of the club. The honorary secretary is Mr. R. H. Klein, 18 Crediton Road, West Hampstead, N.W. The objects of the society were explained by the chairman to be the guarding of the interests of all experimenters in wireless telegraphy and telephony, and the organisation of desultory and for the most part useless work into co-operative scientific research. The committee was authorised to negotiate for the acquisition of suitable club-rooms, and their equipment with suitable aërial and instruments. A letter was read from Sir A. F. King, K.C.B., on behalf of the Postmaster-General, welcoming the formation of such a society, and indicating that certificates of its advisory committee would be accepted by him as qualification for the granting of licences. There will be two classes of members and full membership will be limited to persons having scientific qualifications. The subscriptions are at present 10*s.* 6*d.* for London members, and 5*s.* for members living outside a 25 miles' radius. The entrance fee is fixed at 2*s.* 6*d.*

A National Gas Congress and Exhibition will be held at Shepherd's Bush, London, during the whole of October, under the presidency of Sir Corbet Woodall. Space will be devoted in the exhibition to special exhibits related to hygienic and scientific lighting, the raw materials used in gas manufacture, the preparation and uses of residual products, the application of scientific apparatus, and to engineering in relation to gas manufacture, gas distribution, and gas measurement. A comprehensive series of conferences and popular lectures has been arranged. Among the subjects of the conferences are smoke abatement, to discuss the use of gas for fuel in relation to the problem of the smoke nuisance; food and cookery, to consider means for increasing knowledge of economical and correct methods of preparing and cooking food; the hygienic aspect of gas for lighting, heating, cooking, and ventilation; the lighting, heating, and ventilation of schools; the physiological and mental disadvantages of unscientific illumination; the teaching of cooking in schools; the economic value of adequate illumination; the use of gas as a fuel for industrial purposes; the use of gas for power; and the principles of scientific illumination in their relation to the use of gas for lighting.

MANY ways have already been suggested and demonstrated for causing each eye to see its appropriate picture of a stereoscopic pair, but we learn from *The Times* of September 26 that Messrs. Friedmann and Reiffenstein are showing yet another at the Austro-German Medical Congress now being held in Vienna. The new method depends upon the fact that a white image is invisible on a white background, and a black image is invisible on a black background, while both are visible if the backgrounds are reversed. The authors therefore bleach the negative of one of the pair, make an ordinary transparency from the other, and superpose the two plates. This compound plate will show either the one or the other picture according as the background put behind it is light or dark, and if the background is arranged so that it appears light to one eye and dark to the other—that is, light or dark according to the side that it is viewed from—then each eye will see its own picture without any instrumental means. A background that serves this purpose is a sheet of glass that is "ribbed convexly," while its back surface is "prepared in a special manner" that is not described. The great advantage of such stereoscopic pictures is that they only need looking at as if they were single pictures to show the full stereoscopic effect. It is stated that the few specimens shown are very satisfactory.

THE provisional programme of the Royal Geographical Society for the coming session has just been issued. We learn from it that the following papers have been arranged:—"The Work and Adventures of the Northern Party of Capt. Scott's Antarctic Expedition," R. E. Priestley (November 10); "Explorations in the Eastern Karakoram," Mrs. Bullock Workman and Dr. Hunter Workman (November 24); "Is the Earth Drying up?" Prof. J. W. Gregory, F.R.S. (December 8); "An Expedition to Dutch New Guinea," A. F. R. Wollaston (December 16). In addition to the foregoing, the following papers may be expected:—"Famous Maps in the British Museum," J. A. J. de Villiers; "Journey through Arabia," Capt. G. E. Leachman; "Geographical Aspects of Two Sub-Expeditions in the Antarctic," Griffith Taylor; "The Federal District and Capital, Camberra, of the Commonwealth of Australia," Griffith Taylor; "Journeys in the Upper Amazon Basin," Dr. Hamilton Rice; "The Gulf Stream," Commander Campbell Hepworth, C.B.; "The Red Sea and the Jordan," Sir William Willcocks, K.C.M.G.; "Fresh Discoveries in the Eket District, Southern Nigeria," P. A. Talbot; "The Panama Canal," Dr. Vaughan Cornish; "The Atlantic Ocean," Prof. E. Hull, F.R.S.; "The Anglo-German Boundary Survey in West Africa," Capt. W. V. Nugent.

IN *L'Anthropologie*, vol. xxiv., Nos. 2 and 3, Prof. G. H. Luquet proposes an explanation of the rock markings at Gavr'inis. Comparing the figures with those on the megalithic monuments in Brittany and Ireland, he suggests that they are ultimately based on an anthropomorphic attempt to represent the human figure, particularly of the eyes and eyebrows. This contribution is lavishly illustrated by woodcuts, and the explanation now offered well deserves respectful study by archæologists in this country.

MR. ANANDA COOMARASWAMY'S useful periodical, *Visvakarma,* devoted to the reproduction of examples of Indian architecture, sculpture, painting, and handicrafts, has reached its fifth number. We have a fine series of photographs, among which the most noticeable are the splendid lion column from Sarnath, the Trimurti or sacred triad from the Caves of Elephanta, and interesting figures of deer, monkeys, a cat and mice from Mamallapuram. The Asokan statue from Besnagar is one of the most remarkable sculptural remains of the period.

THE *National Geographic Magazine* for September is devoted to Egypt, and contains a large collection of beautiful photographs. Perhaps the most interesting contribution is the account by Mr. C. M. Cobern of the sacred ibis cemetery and jackal catacombs at Abydos. The ibises are as carefully mummified as the royal personages at Deir-el-Bahari, and were it not for the ravages by white ants, hundreds of these sacred birds could now be examined in as perfect a state as when they were buried. The jackals were preserved because they were sacred to Anubis, the friend of the righteous dead, who guided the soul across the trackless desert to the fields of Aalu, the land of the dead.

THE excavation of the Roman city of Corstopitum, the modern Corbridge, begun by the Northumberland County History Committee and the Corbridge Excavation Committee in 1906, was actively prosecuted during the past season. Among the objects unearthed were forty-eight gold coins and a gold ring, probably deposited about A.D. 385, several altars, a vast quantity of pottery, a bronze pig containing 160 gold coins ranging from Nero to Marcus Aurelius, the well-known Corbridge lion, a smithy with arrow-heads and other articles of iron. Thus a vast amount of material for the study of Roman pottery has been found, and the buildings include some of the most imposing relics in Roman Britain, as well as some of the worst walls ever erected by human hands. The animal remains are of high scientific value, and some addition has been made to our knowledge of Roman metallurgy. The museum has been rearranged, and now contains a collection of Roman remains unequalled in the north of England, except, perhaps, at York.

WE have to acknowledge the receipt from Messrs. Dulau and Co., Ltd., of a copy of a catalogue of works and papers on various groups of the lower invertebrates.

IN the report of the museums of the Brooklyn Institute for 1912, reference is made to the large increase in the zoological collections, and the mounting of a group of marsh-hawks for the series illustrating the fauna of Long Island. Of the fauna and flora of that island a popular account is in course of publication in vol. ii. of the Science Bulletin of the Institute, the first portion of this dealing with the bats, and the second with two species of molluscs.

IN the September number of *The American Naturalist,* Prof. H. H. Newman, of Chicago University, discusses at length the remarkable phenomenon of polyembryonic development exhibited by *Dasypus novemcinctus* and certain other species of armadillos, and its bearing on sex-determination. The females of these species, when pregnant, invariably develop four embryos, enclosed in a single chorionic envelope, which are always of the same sex, the process of development being summarised by the author as follows :—"The ovogenesis is normal; a single egg is fertilised by a single spermatozoon; the cleavage is apparently normal, and gives rise to a blastodermic vesicle similar to that of other mammals, especially the rodents; germ-layer-inversion affords an easy mechanism for producing several embryos in a single chorion, for the quadruplets arise by means of dichotomous budding of the inner ectodermic vesicle without affecting the enveloping membranes of the vesicle, which form the common chorion; the subsequent embryonic development of the several embryos is as independent as it can be under monochorial conditions, since each individual has its own separate amnion, allantois, umbilicus, and placenta."

M. FUJIOKA contributes an elaborate study of the structure of the wood in the Japanese conifers to the Journal of the College of Agriculture, University of Tokyo, vol. iv., No. 4. The detailed descriptions of the wood in the various species examined are followed by a key to the Japanese genera of Coniferæ based upon the history of their wood, and the memoir is illustrated by seven plates containing eighty-four very fine photomicrographs.

WE have received a copy of the Proceedings and Transactions of the Croydon Natural History and Scientific Society, 1912–13, which contains various items of interest. Among these there is an account of the organisation of the Regional Survey of Croydon, which the society have undertaken, and which, when completed, will form one of the most elaborate records of the natural history of a limited area that has been made. The volume also includes reports of addresses given by Dr. H. F. Parsons and Mr. A. G. Tansley, dealing respectively with "Plant Growth and Soil Conditions" and with "Practical Study of Vegetation in the Field." There is an extensive appendix containing the records of the Meteorological Committee, and giving the daily rainfall throughout the year 1912 at various stations in the district.

MISS M. C. KNOWLES, in a paper on the maritime and marine lichens of Howth (Sci. Proc. Royal Dublin Soc., August, 1913), gives an interesting account of the lichen vegetation of Howth Head, Dublin Bay, illustrated by several beautiful photographs by Mr. R. Welch. More than half of the memoir is occupied by a detailed description of the ecology of the lichens which inhabit the siliceous rocks on the coast and form more or less sharply defined belts or zones dominated, from above downwards, by species of Ramalina, orange-coloured lichens, species of Lichina, *Verrucaria maura,* and marine Verrucarias. Three new species are described, and notes are given on some remarkable forms of Ramalina, while the memoir as a whole may be regarded as the most important contribution that has yet been made to the ecology of the littoral lichen vegetation of this country.

WE have received a Spanish edition of the "International Codex of Resolutions adopted at Congresses, Conferences, and at Meetings of the Permanent Committee, 1872–1910," translated by the Central Observatory of Manila from the second German edition. The preparation of this useful work was recommended by the International Meteorological Committee at the meeting at Southport in 1903, and Drs. Hellmann and Hildebrandsson were requested to undertake it. At the conference at Innsbruck, in 1905, a manuscript copy of the Codex was presented, and its publication in English, French, and German was urged as "a most valuable means for promoting international meteorological work." In view of the extended use of Spanish in central and southern America, and also in eastern Asia, Señor J. Algué was thanked for his offer to arrange for its publication in that language. It should be mentioned that due reference was made by Dr. Hellmann to a somewhat similar work published by Dr. Wild (then president of the International Meteorological Committee) in the *Repertorium für Meteorologie,* vol. xvi., which contained particulars for 1872–1891, and was at the time of considerable value.

IN a well-known experiment of De la Rive's, one end of an electromagnet projects into an evacuated bulb containing two electrodes, one of which takes the form of a ring. When a discharge is passed the luminous column is seen to rotate round the magnet pole. This experiment receives various interesting extensions in a paper by Prof. Righi on "Rotazioni Ionomagnetiche (R. Accad. di Bologna, February, 1913). In a typical experiment the two electrodes, which are here cylindrical, are placed in the same vertical line, and the lower one is surrounded by a suspended metal cylinder. An external magnet produces a field parallel to the line joining the electrodes. When the discharge passes it is found that the cylinder rotates. The theory shows that the effect is due to the oblique impact, on the cylindrical walls, of the ions carrying the discharge.

WE have received a copy of Dr. P. W. Bridgman's paper on the thermodynamic properties of twelve liquids between 20° C. and 80° C. and up to 12,000 kilograms per sq. cm. The work was carried out at the Jefferson Physical Laboratory of Harvard University by the aid of the Rumford Fund. The liquids used were methyl, ethyl, propyl, isobutyl, and amyl alcohols, ethyl ether, acetone, carbon bisulphide, phosphorus trichloride, and ethyl bromide, all of which were obtained in an approximately pure state. The liquid was contained in a cylinder closed by a piston, the motion of which determined the change of volume. The pressure applied was measured by the change of electrical resistance of a standardised manganine wire.

The whole was enclosed in a bath the temperature of which could be varied between the limits stated above. Dr. Bridgman finds that the compressibility and thermal expansion of a liquid may decrease with increasing temperature and may increase with increase of pressure. He is disposed to attribute these remarkable results to deformation of the actual molecules when forced into contact at these high pressures.

PROBABLY no branch of the community is more open to be defrauded than those who must perforce exclude carbohydrates from their diet. The unsuspecting patient purchases foods which are not only glaringly misrepresented, but also may be positively harmful to him. It is to be feared, moreover, that the medical adviser is often but little better informed, though in default of a source of trustworthy information as to the nature of the commercial products he can scarcely be held responsible. The Connecticut Agricultural Experiment Station has done great service, therefore, in issuing a lengthy report dealing with the composition and merits of all the so-called diabetic flours, breads, biscuits, and other diabetic foods of both European and American origin—the list is an exhaustive one. To all but the few initiated the result of the inquiry must be very startling. By far the greater number of the foods examined were definitely fraudulent in that they did not fulfil the claims made for them, and many of them indeed contained as much starch as is present in ordinary white bread. The report also deals with the excessive cost of such foods, which has, in the past, rendered their use almost prohibitive to the poor man. A select list of genuine diabetic foods, which return good value, is given, in which it is satisfactory to find the products of British firms of repute. Our chief purpose in directing attention to the report is, however, to urge the necessity of some control being exercised over the indiscriminate misrepresentation of foodstuffs of which this is a type with its attendant menace to the public health. The report merits the widest possible publication.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES FOR OCTOBER :—

Oct. 2. 3h. om. Mars at quadrature to the Sun.
,, 14h. om. Jupiter at quadrature to the Sun.
6. 6h. 21m. Jupiter in conjunction with the Moon (Jupiter 4° 51′ N.).
8. 3h. 37m. Uranus in conjunction with the Moon (Uranus 3° 35′ N.).
13. 14h. om. Uranus stationary.
14. 9h. om. Venus nearest the Sun.
19. 9h. 19m. Saturn in conjunction with the Moon (Saturn 6° 56′ S.).
21. 13h. 7m. Mars in conjunction with the Moon (Mars 3° 55′ S.).
,, 18h. om. Neptune at quadrature to the Sun.
22. 7h. 54m. Neptune in conjunction with the Moon (Neptune 4° 53′ S.).
27. 5h. om. Uranus at quadrature to the Sun.
,, 8h. 31m. Venus in conjunction with the Moon (Venus 3° 17′ N.).
30. 20h. 17m. Mercury in conjunction with the Moon (Mercury 2° 2′ N.).
31. 13h. om. Neptune stationary.

COMETS 1913*b* (METCALF) AND 1913*c* (NEUJMIN).—Prof. H. Kobold's ephemeris for comet Metcalf during the present week is as follows (*Astronomische Nachrichten*, No. 4682) :—

M.T. Berlin.

	R.A. (true) h. m. s.	Dec. (true) ° ′	Mag.
Oct. 2	23 18 26	+72 6·0	8·2
3	22 54 25	69 52·2	
4	22 34 49	67 23·4	
5	22 18 45	64 42·1	8·0
6	22 5 26	61 51·4	
7	21 54 26	58 53·3	
8	21 45 16	55 50·0	
9	21 37 9	+52 43·7	8·0

This comet is now in Cepheus and rapidly reducing its northern declination, moving towards the constellation of Cygnus. It is well up above the horizon and gaining in magnitude.

On the other hand, comet Neujmin is decreasing in magnitude, becoming fainter than magnitude 12. This comet seems to be moving in an elliptical orbit, and Prof. Cohn finds a period of nine years. Its appearance has attracted the attention of numerous observers, since while the nucleus has appeared quite stellar, the gaseous envelope has been alternating between visibility and disappearance.

ANOTHER COMET.—A Kiel telegram, dated September 27, distributes the information communicated by Prof. Hussey that Mr. Delaren on September 26, 10h. 29·2m. M.T. Laplata, discovered a comet of the tenth magnitude, its position being given as R.A. 21h. 54m. 16s. and declination 2° 34′ 27″ S. In the issue of *The Times* for September 30 it is suggested that probably this comet may be identical with Westphal's comet, which is now due, and for which a search has been continually made. If it be Westphal's, then it will move northward during the next month and will increase considerably in brightness, possibly becoming visible to the naked eye. At its appearance in 1852 it was a fairly conspicuous naked eye object.

THE SPECTRUM OF α-CANUM VENATICORUM.—In two previous notes in this column (June 5 and July 24) reference has been made to Prof. Belopolsky's observations of the spectrum of this star, the lines in the spectrum showing striking variations of a periodic nature. The *Astronomische Nachrichten*, No. 4681, contains now the preliminary discussion of a large number of spectrograms, sixty-seven in number, which he has been able to secure in the interval between April 15 and June 23. All the photographs were taken with the 30-inch and a three-prism spectrograph, the exposures lasting one hour; an iron comparison was photographed twice at each exposure. In the present communication Prof. Belopolsky first describes in detail the appearance of the lines observed. From the measures of the intensity of the line λ413·00 he finds a period of 5·50 days, and he places several other lines in the same category, *i.e.* they become bright at the same time as λ413·00. Another group of lines behaves in an opposite manner, disappearing when the former group become more intense; the period is also very near 5·50 days. Other lines such as hydrogen, magnesium, calcium, and iron display little if any change. From the line of sight measures he finds a certain group of lines, which includes H., Mg., and Fe., which indicate no changes dependent on the 5·5 day period, while other lines display variations of radial velocity equal in period to that of the intensity of the lines. Prof. Belopolsky suggests as an explanation of the above and other observations that a gaseous satellite or a gas ring moves round a central body, but he finds that there are several details that are difficult to explain which will perhaps be cleared up when more material has been collected.

THE WAVE-LENGTHS OF CERTAIN IRON LINES.—It is important for the accurate determination of wave-lengths in a spectrum to have available a large number of standard wave-lengths well distributed over the whole length of the spectrum. The work which the Solar Union initiated in this respect has been most valuable, and the task of determining more constants and of securing greater accuracy is no light one. By the aid of a grant of the Martin Kellogg fellowship in the Lick Observatory and of the generosity of MM. Buisson and Fabry, who placed the necessary apparatus and also constant help and advice at his service, Mr. Keivin Burns has been able to make a series of interference measures of standards in the iron spectrum between the limits λλ5434A and 8824A. The results of this research are recorded in Lick Bulletin, No. 233, and, in addition to the international standards already determined between the above-mentioned limits, he has added another one hundred and nineteen lines in regions which were lacking in international standard lines. Small discrepancies in different measures of some standard lines have led to the consideration of their variability of wave-length. Mr. Burns has had access to the manuscript of Dr. Goos, in which a special study has been made of the source of this variability, and he agrees entirely with the view, namely, that "Dr. Goos insists on the necessity of determining exactly what conditions the arc is to used." In this journal for September 11 last, further details will be found regarding the specified conditions for the determinations of further standards which were recommended by the committee of the Solar Union on standard wave-lengths at the recent meeting in Bonn.

THE ANTIQUITY OF MAN IN SOUTH AMERICA.[1]

THE problem of the antiquity of man in South America has given rise to many papers and much discussion in various languages, and it became necessary for a trained anthropologist and geologist to study on the spot the human remains and the exact mode of their occurrence. Dr. A. Hrdlička was undoubtedly the anthropologist best fitted for the investigation, as he has an unequalled knowledge of the physical anthropology of the American Indian and had already summarised his own investigations on the antiquity of man in North America in Bulletin 33 of the Bureau of American Ethnology (1907), where he states his conclusion that "no human bones of undisputed geological antiquity are known," and that the remains exhibit a "close affinity to or identity with those of the modern Indian."

Mr. Bailey Willis, of the U.S. Geological Survey, who had done important work on the loess and related formations in North America and China, accompanied Dr. Hrdlička to Argentina in May, 1910. The Argentine men of science received them very cordially, and facilitated their work. Most of the specimens they were to examine had been described by Prof. F. Ameghino, to whose energy and enthusiasm South American palæontology owes so much, and it must have saddened his last hours to know—if indeed he admitted it—that zeal is a poor substitute for knowledge when the details of human anatomy are in question.

[1] "Early Man in South America." By Ales Hrdlička, in collaboration with W. H. Holmes, Bailey Willis, Fred E. Wright, and Clarence N. Fenner. Pp. xv+405+68. (Smithsonian Institution, Bureau of American Ethnology, Bulletin 52. Washington, 1912.)

Mr. Bailey Willis gives an excellent account of the geology of central eastern Argentina, more especially of the Pampean terrane, which is a remarkably uniform deposit of fine-grained earth, probably an eolian formation of desert plateau origin, transported by rivers to the lowlands, but during arid episodes the alluvium was partially converted into eolian loess. There is no evidence at present that man lived during Pampean times, but his remains have been found in the Upper Pampean and Post Pampean, also mainly eolian loess formations, which lie in hollows sculptured in the surface of the Pampean, also in many cases there is a distinct unconformity beneath the deposits of the Upper Pampean. A great deal has been written about the *tierra cocida,* or burnt earth which occurs in the Pampean terrane at various horizons; many of these may have been due to the burning of grasses, but there is nothing to connect the burnt earths of the Pampean with man.

Messrs. F. E. Wright and C. N. Fenner present details of their petrographic studies of specimens of the loess, tierra cocida, and scoriæ. They state that many specimens of tierra cocida are so large and compact that one is forced to assume long-continued and confined heating at a fairly high temperature, such as would be encountered near the contact of an intrusive igneous or volcanic mass, but not beneath an open fire made of grass or small timber.

Dr. Hrdlička discusses the peculiar stone industries of the Argentine coast. Ameghino considered that the "split-stone" industry "is in certain respects more primitive than that of the eoliths of Europe," referring it to the Middle Pliocene, and that it was preceded by a "broken-stone" industry. Dr. F. F. Outes denied the distinctiveness and great antiquity of these techniques, and Hrdlička confirms him. Dr. W. H. Holmes supplies a valuable critical study of the stone implements collected by the expedition, which should be read by European archæologists, as it contains information of general interest.

The greater part of the book consists of a discussion by Dr. Hrdlička of the human remains; his system is to note the history and earlier reports, then to give the result of his own examination, and to conclude with critical remarks. He first deals with the dolichocephalic skulls found in the caves at Lagoa Santa, Brazil, and states that there is no evidence that they belonged to a race which lived contemporaneously with the extinct species of animals found in the same caves. Similarly the Carcaraña, Rio Negro, Saladero, Fontezuelas, and other remains have no solid claims to geological antiquity. The *Homo caputinclinatus* and *H. sinemento* of Ameghino prove to be skulls of ordinary Indian type, with no title to antiquity; the same holds good for *H.* (*Prothomo*) *pampaeus,* despite Ameghino's statement that it is the "earliest human representative—if not even a predecessor of man." Concerning the fragmentary calvarium, *Diprothomo platensis,* of reputed Lower Pliocene origin, Hrdlička supports Schwalbe's statement that "all the features dwelt upon by Ameghino are referable to a *wholly false orientation* of the specimen." Bailey Willis cannot give his support to the statement that the calvarium was really dug out of undisturbed ancient Pampean. Finally, the atlas and femur of *Tetraprothomo argentinus,* of supposed Upper Miocene age, have been subjected to a searching analysis by Hrdlička, with the result that there is nothing to distinguish the former from the atlas of a modern Indian, and the femur is that of a carnivore, probably of an extinct form of one of the Felidæ. Bailey Willis "does not consider the age of the so-called Monte Hermoso formation [in which the remains were found] definitely established," nor does he "attach any significance to the occurrence of burnt earth as an evidence of man's existence in the Miocene (?) 'Monte Hermosean.'" "The conclusions of the writers with regard to the evidence thus far furnished are that it fails to establish the claim that in South America there have been brought forth thus far tangible traces of either geologically ancient man himself or of any precursors of the human race." A. C. HADDON.

PAPERS ON INVERTEBRATES.

UNUSUAL interest attaches to the description by Dr. A. Brinkmann, in the *Bergens Museum Aarbok* for 1912, part 3, of a new genus and species of deep-sea nemertine worm—*Bathynectes murrayii*—which differs from all previously known forms in the external position of the male genitalia. A single example was obtained so long ago as 1895, while sixteen others were collected by the *Michael Sars* in 1910. The length of females ranges from 43 to 61 mm., with a breadth of from 7·5 to 10 mm., but males are considerably smaller. Although the new organism, of which figures are given, represents an entirely new type, it forms in some degree a connecting link between Planktonemertes and Nectonemertes.

In connection with the above may be noticed a paper by Dr. M. v. Gedroyć, in *Bull. Ac. Sci. Cracovie* for February, 1913, on certain new European leeches, referred to the genera Trocheta and Hæmentaria, special interest from a distributional point of view attaching to the second determination, owing to the fact that while the genus was originally described from South America, it is now known to occur in the United States, Canada, Lapland, and Poland.

The death-feigning instinct (*Katalepsie*) among stick-insects (Phasmidæ), as exemplified by the species *Carausius morosus,* forms the subject of a very interesting article by Mr. Peter Schmidt in *Biol. Centralblatt* of April 20. These insects, it appears, are extremely prone to assume the cataleptic phase, and may do so in almost any pose—sometimes lying flat on one side, with the limbs and antennæ stretched out parallel with the body, sometimes with the legs straddled outwards and the head and thorax raised, and at other times standing on the head. As these insects are specially modified to imitate vegetation, it seems that the cataleptic condition is another adaptation—of the muscular and nervous structures—to the same end.

The beetles, spiders and scorpions, earwigs, and flies collected during the Abor Expedition of 1911–12 form the subject of four articles by specialists in part 2 of vol viii. of Records of the Indian Museum, a number of new forms being described. In vol. iii., part 4, of Annals of the Transvaal Museum, Mr. L. B. Prout and Mr. E. A. Meyrick respectively describe new local Geometridæ and Micro-Lepidoptera.

We have received a copy of a concise "Synopsis of the Classification of Insects," drawn up by Prof. Maxwell Lefroy, and published by Messrs. Lumley, of Exhibition Road, at the price of one shilling. The arrangement of the orders is the one adopted by Messrs. Sharp and Shipley, and a brief, but apparently sufficient, definition is given of each order and family. The lack of an index is a decided drawback to the value of the work.

To the May number of *The Entomologist's Monthly Magazine* the Hon. Charles Rothschild contributes a note on the extremely rare bugs of the genus Cacodemus, which are parasitic on Old World bats. Three species are mentioned, one from South Africa, a second from India, and a third of which the home is at present unknown. Mr. Rothschild, it may be added, employs the name Clinocoridæ for the bugs, whereas Prof. Lefroy, in the synopsis just mentioned, uses Cimicidæ. R. L.

THE BRITISH ASSOCIATION AT BIRMINGHAM.

SECTION D.

ZOOLOGY.

OPENING ADDRESS BY H. F. GADOW, F.R.S., PRESIDENT OF THE SECTION.

"ADDRESS your audience about what you yourself happen to be most interested in, speak from the fullness of your heart, and make a clean breast of your troubles." That seemed good advice, and I shall endeavour to follow it, taking for my text old and new aims and methods of morphology, with special reference to resemblances in function and structure on the part of organs and their owners in the animal kingdom. First, however, allow me to tell you what has brought me to such a well-worn theme. Amongst the many impressions which it has been my good luck to gather during my travels in that enchanting country Mexico are the two following:—

First, the poisonous coral snakes, Elaps, in their beautiful black, red, and yellow garb; it varies in detail in the various species of Elaps, and this garb, with most of the variations too, occurs also in an astonishing number of genera and families of semi-poisonous and quite harmless Mexican snakes, some of which inhabit the same districts. A somewhat exhaustive study of these beauties has shown incontestably that these often astoundingly close resemblances are not cases of mimicry, but due to some other cooperations.

Secondly, in the wilds of the State of Michoacan, at two places, about twenty and seventy miles from the Pacific coast, I myself collected specimens of Typhlops which Dr. Boulenger without hesitation has determined as *Typhlops braminus.* Now, whilst this genus of wormlike, blind little snakes has a wide circumtropical distribution, *T. braminus* had hitherto been known only from the islands and countries of the Indian Ocean basin, never from America, nor from any of the Pacific Islands which possess other kinds of Typhlops. Accidental introduction is out of the question. Although the genus is, to judge from its characters, an especially old one, we cannot possibly assume that the species *braminus,* if the little thing had made its way from Asia to Mexico by a natural mode of spreading, has remained unaltered even to the slightest detail since that geological epoch during which such a journey could have taken place. There remains the assumption that amongst the of course countless generations of Typhlops in Mexico some have hit off exactly the same kind of permutation and combination of those characters which we have hitherto considered as specific of *braminus,* just as a pack of cards may in a long series of deals be dealt out more than once in the same sequence.

The two cases are impressive. They reminded me vividly that many examples of very discontinuous distribution—which anyone who has worked at zoogeography will call to mind—are exhibited by genera, families, and even orders, without our knowing whether the groups in which we class them are natural or artificial. The ultimate appeal lies with anatomy.

Introduced to zoology when Haeckel and Gegenbaur were both at their zenith, I have been long enough a worker and teacher to feel elated by its progress and depressed by its shortcomings and failures. Perhaps we have gone too fast, carried along by methods which have yielded so much and therefore have made us expect too much from them.

Gegenbaur founded the modern comparative anatomy by basing it upon the theory of descent. The leading idea in all his great works is to show that transformation, "continuous adjustment"

(Spencer), has taken place; he stated the problem of comparative anatomy as the reduction of the differences in the organisation of the various animals to a common condition; and as homologous organs he defined those which are of such a common, single origin. His first work in this new line is his classical treatise on the Carpus and Tarsus (1864).

It followed from this point of view that the degree of resemblance in structure between homologous organs and the number of such kindred organs present is a measure for the affinity of their owners. So was ushered in the era of pedigree of organs, of functions, of the animals themselves. The tracing of the divergence of homogenous parts became all-important, whilst those organs or features which revealed themselves as of different origin, and therefore as analogous only, were discarded as misleading in the all-important search for pedigrees. Functional correspondence was dismissed as "mere analogy," and even the systematist has learnt to scorn these so-called physiological or adaptive characters as good enough only for artificial keys. A curious view of things, just as if it was not one and the same process which has produced and abolished both sets of characters, the so-called fundamental or "reliable," as well as the analogous.

As A. Willey has put it happily, there was more rejoicing over the discovery of the homology of some unimportant little organ than over the finding of the most appalling unrelated resemblance. Morphology had become somewhat intolerant in the application of its canons, especially since it was aided by the phenomenal growth of embryology. You must not compare ectodermal with endodermal products. You must not make a likeness out of another germinal layer or anything that appertains to it, because if you do that would be a horror, a heresy, a homoplasy.

Haeckel went so far as to distinguish between a true homology, or homophyly, which depends upon the same origin, and a false homology, which applies to all those organic resemblances which derive from an equivalent adaptation to similar developmental conditions. And he stated that the whole art of the morphologist consists in the successful distinction between these two categories. If we were able to draw this distinction in every case, possibly some day the grand tree of each great phylum, maybe of the whole kingdom, might be reconstructed. That would indeed be a tree of knowledge, and, paradoxically enough, it would be the deathblow to classification, since in this, the one and only true natural system, every degree of consanguinity and relationship throughout all animated nature, past and present, would be accounted for; and to that system no classification would be applicable, since each horizon would require its own grouping. There could be definable neither classes, orders, families, nor species, since each of these conceptions would be boundless in an upward or downward direction.

Never mind the ensuing chaos; we should at least have the pedigree of all our fellow-creatures, and of ourselves among them. Not absolute proof, but the nearest possible demonstration that transformation has taken place. Empirically we know this already, since, wherever sufficient material has been studied, be it organs, species, or larger groups, we find first that these units had ancestors, and, secondly, that the ancestors were at least a little different. Evolution is a fact of experience, proved by circumstantial evidence. Nevertheless we are not satisfied with the conviction that life is subject to an unceasing change, not even with the knowledge of the particular adjustments. We now want to understand the motive cause. First, What, then How, and now Why?

It is the active search for an answer to this question (Why?) which is characteristic of our time. More and more the organisms and their organs are considered as living, functional things. The mainspring of our science, perhaps of all science, is not its utility, not the desire to do good, but, as an eminently matter-of-fact man, the father of Frederick the Great, told his Royal Academicians (who, of course, were asking for monetary help) in the following shockingly homely words: "Der Grund ist derer Leute ihre verfluchte Curieusiteit." This blamed curiosity, the beginnings of which can be traced very far back in the lower animals, is most acutely centred in our desire to find out who we are, whence we have come, and whither we shall go. And even if zoology, considering the first and last of these three questions as settled, should some day solve the problem: Whence have we come? there would remain outside zoology the greater Why?

Generalisations, conclusions, can be arrived at only through comparison. Comparison leads no further where the objects are alike. If, for instance, we restrict ourselves to the search for true homologies, dealing with homogenes only, all we find is that once upon a time some organism has produced, invented, a certain arrangement or *Anlage* out of which that organ arose, the various features of which we have compared in the descendants. Result: we have arrived at an accomplished fact. These things, in spite of all their variety in structure and function, being homogenes, tell us nothing, because according to our mode of procedure we cannot compare that monophyletic *Anlage* with anything else, since we have reduced all the homogenous modifications to one. Logically it is true that there can have been only one, but in the living world of nature there are no such iron-bound categories and absolute distinctions. For instance, if we compare the organs of one and the same individual, we at once observe repetition, *e.g.* that of serial homology, which implies many difficulties, with very different interpretations. Even in such an apparently simple case as the relation between shoulder girdle and pelvis we are at a loss, since the decision depends upon our view as to the origin of the paired limbs, whether both are modified visceral arches, and in this case serially repeated homogenes, or whether they are the derivatives from one lateral fin, which is itself a serial compound, from which, however, the proximal elements, the girdles, are supposed to have arisen independently. What is metamerism? Is it the outcome of a process of successive repetitions so that the units are homogenes, or did the division take place at one time all along the line, or is it due to a combination of the two procedures?

The same vagueness finds its parallel when dealing with the corresponding organs of different animals, since these afford the absolute chance that organs of the same structure and function may not be reducible to one germ, but may be shown to have arisen independently in time as well as with reference to the space they occupy in their owners. As heterogenes they can be compared as to their causes. In the study of the evolution of homogenes the problem is to account for their divergencies, whilst the likeness, the agreements, so to speak their greatest common measure, is *eo ipso* taken to be due to inheritance. When, on the contrary, dealing with heterogenes, we are attracted by their resemblances, which since they cannot be due to inheritance must have a common cause outside themselves. Now, since a leading feature of the evolution of homogenes is divergence, whilst that of heterogenes implies convergence from different starting points, it follows that the more distant are these respective starting points (either in time or in the material) the better is our chance of extracting the greatest common measure out of the unknown number of causes which combine in the production of even the apparently simplest organ.

These resemblances are a very promising field, and the balance of importance will more and more incline towards the investigation of function, a study which, however, does not mean mere physiology with its present-day aims in the now tacitly accepted sense, but that broad study of life and death which is to yield the answer to the question Why?

Meantime, comparative anatomy will not be shelved; it will always retain the casting-vote as to the degree of affinity among resemblances, but emphatically its whole work is not to be restricted to this occupation. It will increasingly have to reckon with the functions, indeed never without them. The animal refuses to yield its secrets unless it be considered as a living individual. It is true that Gegenbaur himself was most emphatic in asserting that an organ is the result of its function. Often he held up to scorn the embryographer's method of muddling cause and effect, or he mercilessly showed that in the reconstruction of the evolution of an organ certain features cannot have been phases unless they imply physiological continuity. And yet how moderately is function dealt with in his monumental text-book and how little is there in others, even in text-books of zoology!

> Habt alle die Theile in der Hand,
> Fehlt leider nur das geistige Band—Life!

We have become accustomed to the fact that like begets like with small differences, and from the accepted point of view of evolution *versus* creation we no longer wonder that descendants slowly change and diverge. But we are rightly impressed when unlike comes to produce like, since this phenomenon seems to indicate a tendency, a set purpose, a *beau idéal*, which line of thought or rather imperfect way of expression leads dangerously near to the crassest teleology.

But, teleology apart, we can postulate a perfect agreement in function and structure between creatures which have no community of descent. The notion that such agreement *must* be due to blood-relationship involved, among other difficulties, the dangerous conclusion that the hypothetical ancestor of a given genuine group possessed in potentiality the *Anlagen* of all the characters exhibited by one or other of the component members of the said group.

The same line of thought explained the majority of human abnormalities as atavistic, a procedure which would turn the revered ancestor of our species into a perfect museum of antiquities, stocked with tools for every possible emergency.

The more elaborate certain resemblances are, the more they seem to bear the hall-mark of near affinity of their owners. When occurring in far-related groups they are taken at least as indications of the homology of the organs. There is, for instance, a remarkable resemblance between the *bulla* of the whale's ear and that of the *Pythonomorph Plioplatycarpus*. If you homologise the mammalian tympanic with the quadrate the resemblance loses much of its perplexity, and certain Chelonians make it easier to understand how the modifications may have been brought about. But, although we can arrange the Chelonian, Pythonomorph, and Cetacean conditions in a progressive line, this need not represent the pedigree of this *bulla*. Nor is it necessarily referable to the same *Anlage*. Lastly, if, as many anatomists believe, the reptilian quadrate appears in the mammals as the *incus*, then all homology and homogeny of this *bullae* is excluded. In either case we stand before the problem of the formation of a *bulla* as such. The significant point is this, that although we dismiss the *bulla* of whale and reptile as obvious homoplasy, such resemblances, if they occur in two orders of reptiles, we take as indicative of relationship until positive evidence to the contrary is produced. That this is an unsound method is brought home to us by an ever-increasing number of cases which tend to throw suspicion on many of our reconstructions. Not a few zoologists look upon such cases as a nuisance and the underlying principle as a bugbear. So far from that being the case, such study promises much beyond the pruning of our standard trees—by relieving them of what reveal themselves as grafts instead of genuine growth—namely, the revelation of one or other of the many agencies in their growth and structure.

Since there are all sorts and conditions of resemblances, we require technical terms. Of these there is abundance, and it is with reluctance that I propose adding to them. I do so because unfortunately some terms are undefined, perhaps not definable; others have not "caught on," or they suffer from that mischievous law of priority in nomenclature.

The terms concerning morphological homologies date from Owen; Gegenbaur and Haeckel rearranged them slightly. Lankester, in 1870, introduced the terms homogenous, meaning alike born, and homoplastic, or alike moulded. Mivart rightly found fault with the detailed definition and the subdivisions of homoplasy, and very logically invented dozens of new terms, few of which, if any, have survived. It is not necessary to survey the ensuing literature. For expressing the same phenomenon we have now the choice between homoplasy, homomorphy, isomorphy, heterophyletic convergence, parallelism, &c. After various papers by Osborn, who has gone very fully into these questions, and Willey's "Parallelism," Abel, in his fascinating "Grundzüge der Palæobiologie," has striven to show by numerous examples that the resemblances or "adaptive formations" are cases of parallelism if they depend upon the same function of homologous organs, and convergences if brought about by the same function of non-homologous organs.

I suggest an elastic terminology for the various resemblances indicative of the degree of homology of the respective organs, the degree of affinity of their owners, and lastly the degree of the structural likeness attained.

Homogeny.—The structural feature is invented once and is transmitted, without a break, to the descendants, in which it remains unaltered, or it changes by mutation or divergence, neither of which changes can bring the ultimate results nearer to each other. Nor can their owners become more like each other, since the respective character made its first appearance either in one individual, or, more probably, in many of one and the same homogenous community.

Homoplasy.—The feature or character is invented more than once, and independently. This phenomenon excludes absolute identity; it implies some unlikeness due to some difference in the material, and there is further the chance of the two or more inventions, and therefore also of their owners, becoming more like each other than they were before

CATEGORIES OF HOMOPLASY.

Isotely.[1]—If the character, feature, or organ has been evolved out of homologous parts or material, as is most likely the case in closely related groups, and if the subsequent modifications proceed by similar stages and means, there is a fair probability or chance of very close resemblance. *Iso-tely*: the same mark has been hit.

Homoeotely.—Although the feature has been evolved

[1] *Cf.* "Isotely and Coralsnakes." By H. Gadow, Zoolog. Jahrbüther, Abt. f. Syst., xxxi., 1911.

from homologous parts or material, the respective modifications may proceed by different stages and means, and the ultimate resemblance will be less close and deficient in detail. Such cases are most likely to happen between groups of less close affinity, whether separated by distance or by time. *Homoeo-tely*: the same end has been fairly well attained. The target has been hit, but not the mark.

Parately.—The feature has been evolved from parts and material so different that there is scarcely any or no relationship. The resulting resemblance will at best be more or less superficial; sometimes a sham, although appealing to our fancy. *Para-tely*: the neighbouring target has been hit.

EXAMPLES.

Isotely: Bill of the Ardeidæ Balæniceps (Africa) and Cancroma (tropical America).

Zygodactyle foot of cuckoos, parrots, woodpeckers $\left(\frac{2\cdot3}{1\cdot4}\right)$.

Patterns and coloration of Elaps and other snakes.

Parachute of Petaurus (marsupial); Pteromys (rodent) and Galeopithecus.

Perissodactylism of Litopterna and Hippoids.

Bulla auris of Plioplatecarpus (Pythonomorphe) and certain whales; if tympanic=quadrate.

Grasping instruments or nippers in Arthropods: pedipalps of Phryne; chelæ of squill; first pair of mantis' legs.

General appearance of moles and Notoryctes, if both considered as mammals; of gulls and petrels, if considered as birds.

Homoeotely: Heterodactyle foot of Trogons $\left(\frac{3\cdot4}{2\cdot1}\right)$.

Jumping foot of Macropus, Dipus, Tarsius.

Intertarsal and cruro-tarsal joint.

Fusion and elongation of the three middle metarsals of Dipus and Rhea.

Paddles of Ichthyosaurs. Turtles, whales, penguins.

"Wings" of Pterosaurs and bats.

Long flexible bill of Apteryx and snipes.

Proteroglyph dentition of cobras and Solenoglyph dentition of vipers.

Loss of the shell of Limax and Aplysia.

Complex molar pattern of horse and cow.

Parately: Bivalve shell of Brachiopods and Lamellibranchs.

Stretcher-sesamoid bone of Pterodactyls (radial carpal); of flying squirrels (on pisiform); of Anomalurus (on olecranon).

Bulla auris of Pythonomorph (quadrate) and Wale (tympanic); if *incus*=quadrate.

"Wings" of Pterosaurs, or bats, and birds.

The distinction between these three categories must be vague because that between homology and analogy is also arbitrary, depending upon the standpoint of comparison. As lateral outgrowths of vertebræ all ribs are homogenes, but if there are at least hæmal and pleural ribs, then those organs are not homologous even within the class of fishes. If we trace a common origin far enough back we arrive near bedrock with the germinal layers. So there are specific, generic, ordinal, &c., homoplasies. The potentiality of resemblance increases with the kinship of the material.

Bateson, in his study of Homœosis, has rightly made the solemn quotation: "There is the flesh of fishes . . . birds . . . beasts, &c." Their flesh will not and cannot react in exactly the same way under otherwise precisely the same conditions, since each kind of flesh is already biased, encumbered by inheritances. If a certain resemblance between a reptile and mammal dates from Permian times, it may be homogenous, like the pentadactyle limb which as such has persisted; but if that resemblance has first appeared in the Cretaceous period it is Homoplastic, because it was brought about long after the class division. To cases within the same order we give the benefit of the doubt more readily than if the resemblance concerned members of two orders, and between the phyla we rightly seek no connection. However, so strongly is our mode of thinking influenced by the principle of descent that, if the same feature happen to crop up in more than two orders, we are biased against Homoplasy.

The readiness with which certain Homoplasies appear in related groups seems to be responsible for the confounding of the potentiality of convergent adaptation with a latent disposition, as if such cases of Homoplasy were a kind of temporarily deferred repetition, *i.e.* after all due to inheritance. This view instances certain recurring tooth patterns, which, developing in the embryonic teeth, are said not to be due to active adaptation or acquisition, but to selection of accomplished variations, because it is held inconceivable that use, food, &c., should act upon a finished tooth. It is not so very difficult to approach the solution of this apparently contradictory problem. Teeth, like feathers, can be influenced long before they are ready by the life experiences of their predecessors. A very potent factor in the evolution of Homoplasies is correlation, which is sympathy, just as inheritance is reminiscence. The introduction of a single new feature may affect the whole organism profoundly, and one serious case of Isotely may arouse unsuspected correlations and thus bring ever so many more homoplasies in its wake.

Function is always present in living matter; it is life. It is function which not only shapes, but creates the organ or suppresses it, being indeed at bottom a kind of reaction upon some stimulus, which stimuli are ultimately all fundamental, elementary forces, therefore few in number. That is a reason why nature seems to have but few resources for meeting given "requirements"—to use an everyday expression which really puts the cart before the horse. This paucity of resources shows itself in the repetition of the same organs in the most different phyla. The eye has been invented dozens of times. Light, a part of the environment, has been the first stimulus. The principle remains the same in the various eyes; where light found a suitably reacting material a particular evolution was set going, often round about, or topsy-turvy, implying amendments; still, the result was an eye. In advanced cases a scientifically constructed dark chamber with lens, screen, shutters, and other adjustments. The detail may be unimportant, since in the various eyes different contrivances are resorted to.

Provided the material is suitable, plastic, amenable to prevailing environmental or constitutional forces, it makes no difference what part of an organism is utilised to supply the requirements of function. You cannot make a silk purse out of a sow's ear, but you can make a purse, and that is the important point. The first and most obvious cause is function, which itself may arise as an incidental action due to the nature of the material. The oxydising of the blood is such a case, and respiratory organs have been made out of whatever parts invite osmotic contact of the blood with air or water. It does not matter whether respiration is carried on by ecto- or by endodermal epithelium. Thus are developed internal gills, or lungs, both of which may be considered as referable to pharyngeal pouches; but where the outer skin has become suitably osmotic, as in the naked Amphibia, it may evolve external gills. Nay, the whole surface of the body may become so osmotic that both lungs and gills are suppressed, and the creature breathes in a most pseudo-primitive fashion. This arrangement, more or less advanced, occurs in many Urodeles, both American and European, belonging to several sub-families, but not in every species of the various genera. It is therefore a case of apparently recent Isotely.

There is no prejudice in the making of a new organ except in so far that every organism is conservative, clinging to what it or its ancestors have learnt or acquired, which it therefore seeks to recapitulate. Thus in the vertebrata the customary place for respiratory organs is the pharyngeal region. Every organism, of course, has an enormous back history; it may have had to use every part in every conceivable way, and it may thereby have been trained to such an extent as to yield almost at once, like a bridle-wise horse to some new stimulus, and thus initiate an organ straight to the point.

Considering that organs put to the same use are so very often the result of analogous adaptation, homoplasts with or without affinity of descent, are we not justified in accusing morphology of having made rather too much of the organs as units, as if they were concrete instead of inducted abstract notions? An organ which changes its function may become a unit so different as to require a new definition. And two originally different organs may come to resemble each other so much in function and structure that they acquire the same definition as one new unit. To avoid this dilemma the morphologist has, of course, introduced the differential of descent, whether homologous or analogous, into his diagnoses of organs.

The same principles must apply to the classification of the animals. To group the various representative owners of cases of isotely together under one name, simply because they have lost those characters which distinguished their ancestors, would be subversive of phyletic research. It is of the utmost significance that such "convergences" (rather "mergers," to use an administrative term) do take place, but that is another question. If it could be shown that elephants in a restricted sense have been evolved independently from two stems of family rank, the convergent terminals must not be named Elephantinæ, nor can the representatives of successive stages or horizons of a monophyletic family be designated and lumped together as subfamilies. And yet something like this practice has been adopted from Cope by experienced zoologists with a complete disregard of history, which is an inalienable and important element in our science.

This procedure is no sounder than would be the sorting of our Cartwrights, Smiths, and Bakers of sorts into as many natural families. It would be subversive of classification, the aim of which is the sorting of a chaos into order. We must not upset the well-defined relative meaning of the classificatory terms which have become well established conceptions; but what such an assembly as the terminal elephants should be called is a new question, the urgency of which will soon become acute. It applies at least to assemblies of specific, generic, and family rank, for each of which grades a new term, implying the principle of convergence, will have to be invented. In some cases geographical terms may be an additional criterion. Such terms will be not only most convenient, but they will at once act as a warning not to use the component species for certain purposes. There is, for instance, the case of *Typhlops braminus*, mentioned at the beginning of this address. Another case is the dog species, called *Canis familiaris*, about which it is now the opinion of the best authorities that the American dogs of sorts are the descendants of the coyote, while some Indian dogs are descendants of a jackal, and others again are traceable to some wolf. The "dog," a definable conception, has been invented many times, and in different countries and out of different material. It is an association of converged heterogeneous units. We have but a smile for those who class whales with fishes, or the blind-worm with the snakes; not to confound the amphibian Cœcilians with reptilian Amphisbænas requires some training; but what are we to do with creatures who have lost or assimilated all those differential characters which we have got used to rely upon?

In a homogeneous crowd of people we are attracted by their little differences, taking their really important agreements for granted; in a compound crowd we at once sort the people according to their really unimportant resemblances. That is human nature.

The terms "convergence" and "parallelism" are convenient if taken with a generous pinch of salt. Some authors hold that these terms are but imperfect similes, because two originally different organs can never converge into one identical point, still less can their owners whose acquired resemblance depresses the balance of all their other characters. For instance, no lizard can become a snake, in spite of ever so many additional snake-like acquisitions, each of which finds a parallel, an analogy in the snakes. Some zoologists therefore prefer contrasting only parallelism and divergence. A few examples may illustrate the justification of the three terms. If out of ten very similar black-haired people only two become white by the usual process, whilst the others retain their colour, then these two diverge from the rest; but they do not, by the acquisition of the same new feature, become more alike each other than they were before. Only with reference to the rest do they seem to liken as they pass from black through grey to white, our mental process being biased by the more and more emphasised difference from the majority.

10 Ax Bx Cx D E F
9
8
7
6
5
4
3
2 Ax Bx
1 A B C D E F

Supposing A and B both acquire the character x and this continues through the next ten generations, while in the descendants of C the same character is invented in the tenth generation, and whilst the descendants of D, E, F still remain unaltered. Then we should be strongly inclined, not only to "key together $C\frac{x}{10}$ with $A\frac{x}{10}$ and $B\frac{x}{10}$, but tak ; this case for one of convergence, although it is really one of parallelism. If it did not sound so contradictory it might be called parallel divergence. The inventors diverge from the majority in the same direction: Isotely.

Third case.—Ten people, contemporaries, are alike but for the black or red hair. Black A turns white and red E turns white, not through exactly identical stages, since E will pass through a reddish-grey tinge. But the result is that A and E become actually more like each other than they were before. They *converge*, although they have gone in for exactly the same divergence with reference to the majority.

In all three cases the variations begin by divergence from the majority, but we can well imagine that all the members of a homogeneous lot change orthogenetically (this term has been translated into the far less expressive "rectigrade") in one direction, and if there be no lagging behind, they all reach precisely the same end. This would be a case of transmutation (true mutations in Waagen's and Scott's sense), producing new species without thereby increasing their number, whilst divergence always implies, at least potentially, increase of species, genera, families, &c.

If for argument's sake the mutations pass through the colours of the spectrum, and if each colour be deemed sufficient to designate a species, then, if all the tenth generations have changed from green to yellow and those of the twentieth generation from yellow to red, the final number of species would be the same. And even if some lagged behind, or remained stationary, these epistatic species (Eimer) are produced by a process which is not the same as that of divergence or variation in the usual sense.

The two primary factors of evolution are environment and heredity. Environment is absolutely inseparable from any existing organism, which therefore must react (adaptation) and at least some of these results gain enough momentum to be carried into the next generation (heredity).

The life of an organism, with all its experiments and doings, is its ontogeny, which may therefore be called the subject of evolution, but not a factor. Nor is selection a primary and necessary factor, since, being destructive, it invents nothing. It accounts, for instance, for the composition of the present fauna, but has not made its components. A subtle scholastic insinuation lurks in the plain statement that by ruthless elimination a black flock of pigeons can be produced, even that thereby the individuals have been made black. (But, of course, the breeder has thereby not invented the black pigment.)

There can be no evolution, progress, without response to stimulus, be this environmental or constitutional, *i.e.* depending upon the composition and the correlated working of the various parts within the organism. Natural selection has but to favour this plasticity, by cutting out the non-yielding material, and through inheritance the adaptive material will be brought to such a state of plasticity that it is ready to yield to the spur of the moment, and the foundation of the same new organs will thereby be laid, whenever the same necessity calls for them. Here is a dilemma. On one hand, the organism benefits from the ancestral experience; on the other, there applies to it de Rosa's law of the reduction of variability, which narrows the chances of change into fewer directions. But in these few the changes will proceed all the quicker and farther. Thus progress is assured, even hypertely, which may be rendered by "over-doing a good thing."

Progress really proceeds by mutations, spoken of before, orthogenesis, and it would take place without selection and without necessarily benefiting the organism. It would be mere presumption that the seven-gilled shark is worse off than its six- or five-gilled relations; or to imagine that the newt with double trunk-veins suffers from this arrangement, which morphologically is undoubtedly inferior to the unpaired, azygous, &c., modifications. The fact that newts exist is proof that they are efficient in their way. Such orthogenetic changes are as predictable in their results as the river which tends to shorten its course to the direct line from its head waters to the sea. That is the rivers Entelechy and no more due to purpose or design than is the series of improvements from the many gill-bearing partitions of a shark to the fewer, and more highly finished comb-shaped gills of a Teleostean fish.

The success of adaptation, as measured by the morphological grade of perfection reached by an organ, seems to depend upon the phyletic age of the animal when it was first subjected to these "temptations." The younger the group, the higher is likely to be the perfection of an organic system, organ, or detail. This is not a platitude. The perfection attained does not depend merely upon the length of time available for the evolution of an organ. A recent Teleostean has had an infinitely longer time as a fish than a reptile, and this had a longer time than a mammal, and yet the same problem is solved in a neater, we might say in a more scientifically correct, way by a mammal than by a reptile, and the reptile in turn shows an advance in every detail in comparison with an amphibian, and so forth.

A few examples will suffice:—

The claws of reptiles and those of mammals; there are none in the amphibians, although some seem to want them badly, like the African frog Gampsosteonyx, but its cat-like claws, instead of being horny sheaths, are made out of the sharpened phalangeal bones which perforate the skin.

The simple contrivance of the rhinocerotic horn, introduced in Oligocene times, compared with the antlers of Miocene Cervicornia and these with the response made by the latest of Ruminants, the hollow-horned antelopes and cattle. The heel-joint; unless still generalised, it tends to become intertarsal (attempted in some lizards, pronounced in some dinosaurs and in the birds) by fusion of the bones of the tarsus with those above and below, so that the tarsals act like epiphysial pads. Only in mammals epiphyses are universal. Tibia and fibula having their own, the pronounced joint is cruro-tarsal, and all the tarsals could be used for a very compact, yet non-rigid arrangement. The advantage of a cap, not merely the introduction of a separate pad, is well recognised in engineering.

Why is it that mammalian material can produce what is denied to the lower classes? In other words, why are there still lower and middle classes? Why have they not all by this time reached the same grade of perfection? Why not indeed, unless because every new group is less hampered by tradition, much of which must be discarded with the new departure; and some of its energy is set free to follow up this new course, straight, with ever-growing results, until in its turn this becomes an old rut out of which a new jolt leads once more into fresh fields.

SECTION E.

GEOGRAPHY.

Opening Address by Prof. H. N. Dickson, President of the Section.

Since the last meeting of this Section the tragic fate of Captain Scott's party, after its successful journey to the South Pole, has become known; and our hopes of welcoming a great leader, after great achievement, have been disappointed. There is no need to repeat here the narrative of events, or to dwell upon the lessons afforded by the skill, and resource, and heroic persistence, which endured to the end. All these have been, or will be, placed upon permanent record. But it is right that we should add our word of appreciation, and proffer our sympathy to those who have suffered loss. It is for us also to take note that this last of the great Antarctic expeditions has not merely reached the Pole, as another has done, but has added, to an extent that few successful exploratory undertakings have ever been able to do, to the sum of scientific geographical knowledge. As the materials secured are worked out it will, I believe, become more and more apparent that few of the physical and biological sciences have not received contributions, and important contributions, of new facts; and also that problems concerning the distribution of the different groups of phenomena and their action and reaction upon one another—the problems which are specially within the domain of the geographer—have not merely been extended in their scope but have been helped to their solution.

The reaching of the two poles of the earth brings to a close a long and brilliant chapter in the story of geographical exploration. There is still before us a vista of arduous research in geography, bewildering almost in its extent, in such a degree indeed that "the scope of geography" is in itself a subject of perennial interest. But the days of great pioneer discoveries in topography are definitely drawn to their close. We know the size and shape of the earth, at least to a first approximation, and as the map fills up we know that there can be no new continents and no new oceans to discover, although all are still, in a sense, to conquer. Looking back, we find that the qualities of human enterprise and endurance have shown no change; we need no list of names to prove that they were alike in the days of the earliest explorations, of the discovery of the New World or of the sea route to India, of the "Principall Navigations," or of this final attainment of the Poles. The love of adventure and the gifts of courage and endurance have remained the same: the order of discovery has been determined rather by the play of imagination upon accumulated knowledge, suggesting new methods and developing appropriate inventions. Men have dared to do risky things with inadequate appliances, and in doing so have shown how the appliances may be improved and how new enterprises may become possible as well as old ones easier and safer. As we come to the end of these "great explorations," and are restricted more and more to investigations of a less striking sort, it is well to remember that in geography, as in all other sciences, research continues to make as great demands as ever upon those same qualities, and that the same recognition is due to those who continue in patient labour.

When we look into the future of geographical study, it appears that for some time to come we shall still be largely dependent upon work similar to that of the pioneer type to which I have referred, the work of perfecting the geographer's principal weapon, the map. There are many parts of the world about which we can say little except that we know they exist; even the topographical map, or the material for making it, is wanting; and of only a few regions are there really adequate distributional maps of any kind. These matters have been brought before this Section and discussed very fully in recent years, so I need say no more about them, except perhaps to express the hope and belief that the production of topographical maps of difficult regions may soon be greatly facilitated and accelerated with the help of the new art of flying.

I wish to-day rather to ask your attention for a short time to a phase of pioneer exploration which has excited an increasing amount of interest in recent years. Civilised man is, or ought to be, beginning to realise that in reducing more and more of the available surface of the earth to what he considers a habitable condition he is making so much progress, and making it so rapidly, that the problem of finding suitable accommodation for his increasing numbers must become urgent in a few generations. We are getting into the position of the merchant whose trade is constantly expanding and who foresees that his premises will shortly be too small for him. In our case removal to more commodious premises elsewhere seems impossible—we are not likely to find a means of migrating to another planet—so we are driven to consider means of rebuilding on the old site, and so making the best of what we have, that our business may not suffer.

In the type of civilisation with which we are most familiar there are two fundamental elements—supplies of food energy, and supplies of mechanical energy. Since at present, partly because of geographical conditions, these do not necessarily (or even in general) occur together, there is a third essential factor, the line of transport. It may be of interest to glance, in the cursory manner which is possible upon such occasions, at some geographical points concerning each of these factors, and to hazard some speculations as to the probable course of events in the future.

In his presidential address to the British Association at its meeting at Bristol in 1898, Sir William Crookes gave some valuable estimates of the world's supply of wheat, which, as he pointed out, is "the most sustaining food-grain of the great Caucasian race." Founding upon these estimates, he made a forecast of the relations between the probable rates of increase of supply and demand, and concluded that "Should all the wheat-growing countries add to their (producing) area to the utmost capacity, on the most careful calculation the yield would give us only an addition of some 100,000,000 acres, supplying, at the average world-yield of 12·7 bushels to the acre, 1,270,000,000 bushels, just enough to supply the increase of population among bread-eaters till the year 1931." The president then added, "Thirty years is but a day in the life of a nation. Those present who may attend the meeting of the British Association thirty years hence will judge how far my forecasts are justified."

Half the allotted span has now elapsed, and it may be useful to inquire how things are going. Fortunately this can be easily done, up to a certain point at any rate, by reference to a paper published recently by Dr. J. F. Unstead (*Geographical Journal*, August, 1913), in which comparisons are given for the decades 1881–90, 1891–1900, and 1901–10. Dr. Unstead shows that the total wheat harvest for the world may be estimated at 2258 million bushels for the first of these periods, 2575 million for the second, and 3233 million for the third, increases of 14 per cent. and 25 per cent. respectively. He points out that the increases were due "mainly to an increased acreage," the areas being 192, 211, and 242 million acres, but also "to some extent (about 8 per cent.) to an increased average yield per acre, for while in the first two periods this was 12 bushels, in the third period it rose to 13 bushels per acre."

If we take the period 1891–1900, as nearly corresponding to Sir William Crookes's initial date, we find that the succeeding period shows an increase of 658 million bushels, or about half the estimated increase required by 1931, and that attained chiefly by "increased acreage."

But signs are not wanting that increase in this way will not go on indefinitely. We note (also from Dr. Unstead's paper) that in the two later periods the percentage of total wheat produced which was exported from the United States fell from 32 to 19, the yield per acre showing an increase meanwhile to 14 bushels. In the Russian Empire the percentage fell from 26 to 23, and only in the youngest of the new countries—Canada, Australia, the Argentine—do we find large proportional increases. Again, it is significant that in the United Kingdom, which is, and always has been, the most sensitive of all wheat-producing countries to variations in the floating supply, the *rate* of falling-off of home production shows marked if irregular diminution.

Looking at it in another way, we find (still from Dr. Unstead's figures) that the total amount sent out by the great exporting countries averaged, in 1881–90, 295 million bushels, 1891–1900, 402 millions, 1901–10, 532 millions. These quantities represent respectively 13·0, 15·6, and 16·1 per cent. of the total production, and it would appear that the percentage available for export from these regions is, for the time at least, approaching its limit, *i.e.* that only about one-sixth of the wheat produced is available from surpluses in the regions of production for making good deficiencies elsewhere.

There is, on the other hand, abundant evidence that improved agriculture is beginning to raise the yield per acre over a large part of the producing area. Between the periods 1881–90 and 1901–10 the average in the United States rose from 12 to 14 bushels; in Russia from 8 to 10; in Australia from 8 to 10. It is likely that, in these last two cases at least, a part of the increase is due merely to more active occupation of fresh lands as well as to use of more suitable varieties of seed, and the effect of improvements in methods of cultivation alone is more apparent in the older countries. During the same period the average yield increased in the United Kingdom from 28 to 32 bushels, in France from 17 to 20, Holland 27 to 33, Belgium 30 to 35, and it is most marked in the German Empire, for which the figures are 19 and 29.

In another important paper (*Geographical Journal*, April and May, 1912) Dr. Unstead has shown that the production of wheat in North America may still, in all likelihood, be very largely increased by merely increasing the area under cultivation, and the reasoning by which he justifies this conclusion certainly holds good over large districts elsewhere. It is of course impossible, in the present crude state of our knowledge of our own planet, to form any accurate estimate of the area which may, by the use of suitable seeds or otherwise, become available for extensive cultivation. But I think it is clear that the available proportion of the total supply from "extensive" sources has reached, or almost reached, its maximum, and that we must depend more and more upon intensive farming, with its greater demands for labour.

The average total area under wheat is estimated by Dr. Unstead as 192 million acres for 1881–90, 211 million acres for 1891–1900, and 242 million acres for 1901–10. Making the guess, for we can make nothing better, that this area may be increased to 300 million acres, and that under ordinary agriculture the average yield may eventually be increased to 20 bushels over the whole, we get an average harvest of 6000 million bushels of wheat. The average wheat-eater consumes, according to Sir William Crookes's figures, about four and a half bushels per annum; but the amount tends to increase. It is as much (according to Dr. Unstead) as six bushels in the United Kingdom and eight bushels in France. Let us take the British figure, and it appears that on a liberal estimate the earth may in the end be able to feed permanently 1000 million wheat-eaters. If prophecies based on population statistics are trustworthy, the crisis will be upon us before the end of this century. After that we must either depend upon some substitute to reduce the consumption per head of the staple foodstuff, or we must take to intensive farming of the most strenuous sort, absorbing enormous quantities of labour and introducing, sooner or later, serious difficulties connected with plant-food. We leave the possibility of diminishing the rate of increase in the number of bread-eaters out of account for the moment.

We gather, then, that the estimates formed in 1898 are in the main correct, and the wheat problem must become one of urgency at no distant date, although actual shortage of food is a long way off. What is of more immediate significance to the geographer is the element of change, of return to earlier conditions, which is emerging even at the present time. If we admit, as I think we must do, that the days of increase of extensive farming on new land are drawing to a close, then we admit that the assignment of special areas for the production of the food-supply of other distant areas is also coming to its end. The opening up of such areas, in which a sparse population produces food in quantities largely in excess of its own needs, has been the characteristic of our time, but it must give place to a more uniform distribution of things, tending always to the condition of a moderately dense population, more uniformly distributed over large areas, capable of providing the increased labour necessary for the higher type of cultivation, and self-supporting in respect of grain-food at least. We observe in passing that the colonial system of our time only became possible on the large scale with the invention of the steam-locomotive, and that the introduction of railway systems in the appropriate regions, and the first tapping of nearly all such regions on the globe, has taken less than a century.

Concentration in special areas of settlement, formerly chiefly effected for military reasons, has in modern times been determined more and more by the distribution of supplies of energy. The position of the manufacturing district is primarily determined by the supply of coal. Other forms of energy are, no doubt, available, but, as Sir William Ramsay showed in his presidential address at the Portsmouth meeting in 1911, we must in all probability look to coal as being the chief permanent source.

In the early days of manufacturing industries the main difficulties arose from defective land transport. The first growth of the industrial system, therefore, took place where sea transport was relatively easy; raw material produced in a region near a coast was carried to a coalfield also near a coast, just as in times when military power was chiefly a matter of "natural defences," the centre of power and the food-producing colony had to be mutually accessible. Hence the Atlantic took the place of the Mediterranean, Great Britain eventually succeeded Rome, and eastern North America became the counterpart of northern Africa. It is to this, perhaps more than to anything else, that we owe our tremendous start amongst the industrial nations, and we observe that we used it to provide less favoured nations with the means of improving their system of land transport, as well as actually to manufacture imported raw material and redistribute the products.

But there is, of course, this difference between the supply of foodstuff (or even military power) and mechanical energy, that in the case of coal at least it is necessary to live entirely upon capital; the storing up of energy in new coalfields goes on so slowly in comparison with our rate of expenditure that it may be altogether neglected. Now in this country we began to use coal on a large scale a little more than a century ago. Our present yearly consumption is of the order of 300 millions of tons, and it is computed (General Report of the Royal Commission on Coal Supplies, 1906) that at the present rate of increase "the whole of our available supply will be exhausted in 170 years." With regard to the rest of the world we cannot, from lack of data, make even the broad assumptions that were possible in the case of wheat supply, and for that and other reasons it is therefore impossible even to guess at the time which must elapse before a universal dearth of coal becomes imminent; it is perhaps sufficient to observe that to the best of our knowledge and belief one of the world's largest groups of coalfields (our own) is not likely to last three centuries in all.

Here again the present interest lies rather in the phases of change which are actually with us. During the first stages of the manufacturing period energy in any form was exceedingly difficult to transport, and this led to intense concentration. Coal was taken from the most accessible coalfield and used, as far as possible, on the spot. It was chiefly converted into mechanical energy by means of the steam-engine, an extremely wasteful apparatus in small units, and hence still further concentration; thus the steam-engine is responsible in part for the factory system in its worst aspect. The less accessible coalfields were neglected. Also, the only other really available source of energy—water-power—remained unused, because the difficulties in the way of utilising movements of large quantities of water through small vertical distances (as in tidal movements) are enormous; the only easily applied source occurs where comparatively small quantities of water fall through considerable vertical distances, as in the case of waterfalls. But, arising from the geographical conditions, waterfalls (with rare exceptions such as Niagara) occur in the "torrential" part of the typical river-course, perhaps far from the sea, almost certainly in a region too broken in surface to allow of easy communication or even of industrial settlement of any kind.

However accessible a coalfield may be to begin with, it sooner or later becomes inaccessible in another way, as the coal near the surface is exhausted and the workings get deeper. No doubt the evil day is postponed for a time by improvements in methods of mining—a sort of intensive cultivation—but as we can put nothing back the end must be the same, and successful competition with more remote but more superficial deposits becomes impossible. And every improvement in land transport favours the geographically less accessible coalfield.

From this point of view it is impossible to overestimate the importance of what is to all intents and purposes a new departure of the same order of magnitude as the discovery of the art of smelting iron with coal, or the invention of the steam-engine, or of the steam-locomotive. I mean the conversion of energy into electricity, and its transmission in that form (at small cost and with small loss) through great distances. First we have the immediately increased availability of the great sources of cheap power in waterfalls. The energy may be transmitted through comparatively small distances and converted into heat in the electric furnace, making it possible to smelt economically the most refractory ores, as those of aluminium, and converting such unlikely places as the coast of Norway or the West Highlands of Scotland into manufacturing districts. Or it may be transmitted through greater distances to regions producing quantities of raw materials, distributed there widespread to manufacturing centres, and reconverted into mechanical energy. The Plain of Lombardy produces raw materials in abundance, but Italy has no coal supply. The waterfalls of the Alps yield much energy, and this transmitted in the form of electricity, in some cases for great distances, is converting northern Italy into one of the world's great industrial regions. Chisholm gives an estimate of a possible supply of power amounting to 3,000,000 horse-power, and says that of this about one-tenth was already being utilised in the year 1900.

But assuming again, with Sir William Ramsay, that coal must continue to be the chief source of energy, it is clear that the question of accessibility now wears an entirely different aspect. It is not altogether beyond reason to imagine that the necessity for mining, as such, might entirely disappear, the coal being burnt *in situ* and energy converted directly into electricity. In this way some coalfields might conceivably be exhausted to their last pound without serious increase in the cost of getting. But for the present it is enough to note that, however inaccessible any coalfield may be from supplies of raw material, it is only necessary to establish generating stations at the pit's mouth and transport the energy to where it can be used. One may imagine, for example, vast manufactures carried on in what are now the immense agricultural regions of China, worked by power supplied from the great coal deposits of Shan-si.

There is, however, another peculiarity of electrical power which will exercise increasing influence upon the geographical distribution of industries. The small electric motor is a much more efficient apparatus than the small steam-engine. We are, accordingly, already becoming familiar with the great factory in which, instead of all tools being huddled together to save loss through shafting and belting, and all kept running all the time, whether busy or not (because the main engine must be run), each tool stands by itself and is worked by its own motor, and that only when it is wanted. Another of the causes of concentration of manufacturing industry is therefore reduced in importance. We may expect to see the effects of this becoming more and more marked as time goes on, and other forces working towards uniform distribution make themselves more felt.

The points to be emphasised so far, then, are, first, that the time when the available areas whence food supply as represented by wheat is derived are likely to be taxed to their full capacity within a period of about the same length as that during which the modern colonial system has been developing in the past; secondly, that cheap supplies of energy may continue for a longer time, although eventually they must greatly diminish; and, thirdly, there must begin in the near future a great equalisation in the distribution of population. This equalisation must arise from a number of causes. More intensive cultivation will increase the amount of labour required in agriculture, and there will be less difference in the cost of production and yield due to differences of soil and climate. Manufacturing industries will be more uniformly distributed, because energy, obtained from a larger number of sources in the less accessible places, will be distributed over an increased number of centres. The distinction between agricultural and industrial regions will tend to become less and less clearly marked, and will eventually almost disappear in many parts of the world.

The effect of this upon the third element is of first-rate importance. It is clear that as the process of equalisation goes on the relative amount of long-distance transport will diminish, for each district will tend more and more to produce its own supply of staple food and carry on its own principal manufactures. This result will naturally be most marked in what we may call the "east-and-west" transport, for as climatic controls primarily follow the parallels of latitude, the great *quantitative* trade, the flow of foodstuffs and manufactured articles to and fro between peoples of like habits and modes of life, runs primarily east and west. Thus the transcontinental functions of the great North American and Eurasian railways, the east-and-west systems of the inland waterways of the two continents, and the connecting links furnished by the great ocean ferries, must become of relatively less importance.

The various stages may be represented, perhaps, in some such manner as this. If **I** is the cost of producing a thing locally at a place A by intensive cultivation or what corresponds to it, if **E** is the cost of producing the same thing at a distant place B, and **T** the cost of transporting it to A, then at A we may at some point of time have a more or less close approximation to

$$\mathbf{I} = \mathbf{E} + \mathbf{T}.$$

We have seen that in this country, for example, **I** has been greater than **E+T** for wheat ever since, say, the introduction of railways in North America, that the excess tends steadily to diminish, and that however much it may be possible to reduce **T** either by devising cheaper modes of transport or by shortening the distance through which wheat is transported, **E+T** must become greater than **I**, and it will pay us to grow all or most of our own wheat. Conversely, in the 'seventies of last century **I** was greater than **E+T** in North America and Germany for such things as steel rails and rolling-stock, which we in this country were cultivating "extensively" at the time on more accessible coalfields, with more skilled labour and better organisation than could be found elsewhere. In many cases the positions are now, as we know, reversed, but geographically **I** must win all round in the long run.

In the case of transport between points in different latitudes the conditions are, of course, altogether dissimilar, for in this case commodities consist of foodstuffs, or raw materials, or manufactured articles, which may be termed luxuries, in the sense that their use is scarcely known until cheap transport makes them easily accessible, when they rapidly become "necessaries of life." Of these the most familiar examples are tea, coffee, cocoa and bananas, india-rubber and manufactured cotton goods. There is here, of course, always the possibility that wheat as a staple might be replaced by a foodstuff produced in the tropics, and it would be extremely interesting to study the geographical consequences of such an event as one-half of the surface of the earth suddenly coming to help in feeding the two quarters on either side; but for many reasons, which I need not go into here, such a consummation is exceedingly unlikely. What seems more probable is that the trade between different latitudes will continue to be characterised specially by its variety, the variety doubtless increasing, and the quantity increasing in still larger measure. The chief modification in the future may perhaps be looked for in the occasional transference of manufactures of raw materials produced in the tropics to places within the tropics, especially when the manufactured article is itself largely consumed near regions of production. The necessary condition here is a region, such as (*e.g.*) the monsoon region, in which there is sufficient variation in the seasons to make the native population laborious; for then, and apparently only then, is it possible to secure sufficient industry and skill by training, and therefore to be able to yield to the ever-growing pressure in more temperate latitudes due to increased cost of labour. The best examples of this to-day are probably the familiar ones of cotton and jute manufacture in India. With certain limitations, manufacturing trade of this kind is, however, likely to continue between temperate and strictly tropical regions, where the climate is so uniform throughout the year that the native has no incentive to work. There the collection of the raw material is as much as, or even more than can be looked for—as in the case of mahogany or wild rubber. Where raw material has to be cultivated—as cotton, cultivated rubber, &c.—the raw material has to be produced in regions more of the monsoon type, but it will probably—perhaps as much for economic as geographical reasons—be manufactured at some centre in the temperate zones, and the finished product transported thence, when necessary, to the point of consumption in the tropics.

We are here, however, specially liable to grave disturbances of distribution arising from invention of new machinery or new chemical methods; one need only mention the production of sugar or indigo. Another aspect of this which is not without importance may perhaps be referred to here, although it means the transference of certain industries to more accessible regions merely, rather than a definite change of such an element as latitude. I have in mind the sudden conversion of an industry in which much labour is expended on a small amount of raw material into one where much raw material is consumed, and by the application of power-driven machinery the labour required is greatly diminished. One remembers when a fifty-shilling Swiss watch, although then still by tradition regarded as sufficiently valuable to deserve enclosure in a case constructed of a precious metal, was considered a marvel of cheapness. American machine-made watches, produced by the ton, are now encased in the baser metals and sold at some five shillings each, and the watch-making industry has ceased to be specially suited to mountainous districts.

In considering the differences which seem likely to arise in what we may call the regional pressures of one kind and another, pressures which are relieved or adjusted by and along certain lines of transport, I have made a primary distinction between "east-and-west" and "north-and-south" types, because both in matters of food supply and in the modes of life which control the nature of the demand for manufactured articles climate is eventually the dominant factor; and, as I have said, climate varies primarily with latitude. This is true specially of atmospheric temperature; but temperature varies also with altitude, or height above the level of the sea. To a less extent rainfall, the other great element of climate, varies with latitude, but the variation is much more irregular. More important in this case is the influence of the distribution of land and sea, and more especially the configuration of the land surface, the tendency here being sometimes to strengthen the latitude effect where a continuous ridge is interposed, as in Asia, practically cutting off "north-and-south" communication altogether along a certain line, emphasising the parallel-strip arrangement running east and west to the north of the line, and inducing the quite special conditions of the monsoon region to the south of it. We may contrast this with the effect of a "north-and-south" structure, which (in temperate latitudes especially) tends to swing what we may call the regional lines round till they cross the parallels of latitude obliquely. This is typically illustrated in North America, where the angle is locally sometimes nearly a right angle. It follows, therefore, that the contrast of "east-and-west" and "north-and-south" lines, which I have here used for purposes of illustration, is necessarily extremely crude, and one of the most pressing duties of geographers at the present moment is to elaborate a more satisfactory method of classification. I am very glad that we are to have a discussion on "Natural Regions" at one of our sederunts. Perhaps I may be permitted to express the hope that we shall concern ourselves with the types of region we want, their structure or "grain," and their relative positions, rather than with the precise delimitation of their boundaries, to which I think we have sometimes been inclined, for educational purposes, to give a little too much attention.

Before leaving this I should like to add, speaking still in terms of "east-and-west" and "north-and-south," one word more about the essential east-and-west structure of the Old World. I have already referred to the great central axis of Asia. This axis is prolonged westward through Europe, but it is cut through and broken to such an extent that we may include the Mediterranean region with the area lying further north, to which indeed it geographically belongs in any discussion of this sort. But the Mediterranean region is bounded on the other side by the Sahara, and none of our modern inventions facilitating transport has made any impression upon the dry desert; nor does it seem likely that such a desert will ever become a less formidable barrier than a great mountain mass or range. We may conclude, then, that in so far as the Old World is concerned, the "north-and-south" transport can never be carried on as freely as it may in the New, but only through certain weak points, or "round the ends," *i.e.* by sea. It may be further pointed out that the land areas in the southern hemisphere are so narrow that they will scarcely enter into the "east-and-west" category at all—the transcontinental railway as understood in the northern hemisphere cannot exist; it is scarcely a pioneer system, but rather comes into existence as a later by-product of local east-and-west lines, as in Africa.

These geographical facts must exercise a profound influence upon the future of the British Isles. Trade south of the great dividing line must always be to a large extent of the "north-and-south" type, and the British Isles stand practically at the western end of the great natural barrier. From their position the British Isles will always be a centre of immense importance in *entrepôt* trade, importing commodities from "south" and distributing "east and west," and similarly in the reverse direction. This movement will be permanent, and will increase in volume long after the present type of purely "east-and-west" trade has become relatively less important than it is now, and long after the British Isles have ceased to have any of the special advantages for manufacturing industries which are due to their own resources either in the way of energy or of raw material. We can well imagine, however, that this permanent advantage of position will react favourably, if indirectly, upon certain types of our manufactures, at least for a very long time to come.

Reverting briefly to the equalisation of the distribution of population in the wheat-producing areas and the causes which are now at work in this direction, it is interesting to inquire how geographical conditions are likely to influence this on the smaller scale. We may suppose that the production of staple foodstuffs must always be more uniformly distributed than the manufacture of raw materials, or the production of the raw materials themselves, for the most important raw materials of vegetable origin (as cotton, rubber, &c.) demand special climatic conditions, and, apart from the distribution of energy, manufacturing industries are strongly influenced by the distribution of mineral deposits, providing metals for machinery, and so on. It may, however, be remarked that the useful metals, such as iron, are widely distributed in or near regions which are not as a rule unfavourable to agriculture. Nevertheless, the fact remains that while a more uniform distribution is necessary and inevitable in the case of agriculture, many of the conditions of industrial and social life are in favour of concentration; the electrical transmission of energy removes, in whole or in part, only one or two of the centripetal forces. The general result might be an approximation to the conditions occurring in many parts of the monsoon areas—a number of fairly large towns pretty evenly distributed over a given agricultural area, and each drawing its main food supplies from the region surrounding it. The positions of such towns would be determined much more by industrial conditions, and less by military conditions, than in the past (military power being in these days mobile, and not fixed); but the result would on a larger scale be of the same type as was developed in the central counties of England, which, as Mackinder has pointed out, are of almost equal size and take the name of the county town. Concentration within the towns would, of course, be less severe than in the early days of manufacturing industry. Each town would require a very elaborate and highly organised system of local transport, touching all points of its agricultural area, in addition to lines of communication with other towns and with the great "north-and-south" lines of world-wide commerce, but these outside lines would be relatively of less importance than they are now. We note that the more perfect the system of local transport, the less the need for points of intermediate exchange. The village and the local market-town will be "sleepy" or decadent as they are now, but for a different reason; the symptoms are at present visible mainly because the country round about such local centres is overwhelmed by the great lines of transport which pass through them; they will survive for a time through inertia and the ease of foreign investment of capital. The effect of this influence is already apparent since the advent of the "commercial motor," but up to the present it has been more in the direction of distributing from the towns than collecting to them, producing a kind of "suburbanisation" which throws things still further out of balance. The importance of the road motor in relation to the future development of the food-producing area is incalculable. It has long been clear that the railway of the type required for the great through lines of fast transport is ill-adapted for the detailed work of a small district, and the "light" railway solves little and introduces many complications. The problem of determining the direction and capacity of a system of roads adequate to any particular region is at this stage one of extraordinary difficulty; experiments are exceedingly costly, and we have as yet little experience of a satisfactory kind to guide us. The geographer, if he will, can here be of considerable service to the engineer.

In the same connection, the development of the agricultural area supplying an industrial centre offers many difficult problems in relation to what may be called accessory products, more especially those of a perishable nature, such as meat and milk. In the case of meat the present position is that much land which may eventually become available for grain crops is used for grazing, or cattle are fed on some grain, like maize, which is difficult to transport or is not satisfactory for bread-making The meat is then temporarily deprived of its perishable property by refrigeration, and does not suffer in transport. Modern refrigerating machinery is elaborate and complicated, and more suited to use on board ship than on any kind of land transport. Hence the most convenient regions for producing meat for export are those near the sea-coast, such as occur in the Argentine or the Canterbury plains of New Zealand. The case is similar to that of the "accessible" coalfield. Possibly the preserving processes may be simplified and cheapened, making overland transport easier, but the fact that it usually takes a good deal of land to produce a comparatively small quantity of meat will make the difficulty greater as land becomes more valuable. Cow's milk, which in modern times has become a "necessary of life" in most parts of the civilised world, is in much the same category as meat, except that difficulties of preservation, and therefore of transport, are even greater. That the problem has not become acute is largely due to the growth of the long-transport system available for wheat, which has enabled land round the great centres of population to be devoted to dairy produce. If we are right in supposing that this state of things cannot be permanent, the difficulty of milk supply must increase, although relieved somewhat by the less intense concentration in the towns; unless, as seems not unlikely, a wholly successful method of permanent preservation is devised.

In determining the positions of the main centres, or rather, in subdividing the larger areas for the distribution of towns with their supporting and dependent districts, water supply must be one of the chief factors in the future, as it has been in the past; and in the case of industrial centres the quality as well as the quantity of water has to be considered. A fundamental division here would probably be into districts having a natural local supply, probably of hard water, and districts in which the supply must be obtained from a distance. In the latter case engineering works of great magnitude must often be involved, and the question of total resources available in one district for the supply of another must be much more fully investigated than it has been. In many cases, as in this country, the protection of such resources pending investigation is already much needed. It is worth noting that the question may often be closely related to the development and transmission of electrical energy from waterfalls, and the two problems might in such cases be dealt with together. Much may be learned about the relation of water supply to distribution of population from a study of history, and a more active prosecution of combined historical and geographical research would, I believe, furnish useful material in this connection, besides throwing interesting light on many historical questions.

Continued exchange of the "north-and-south" type and at least a part of that described as "east-and-west" gives permanence to a certain number of points where, so far as can be seen, there must always be a change in the mode of transport. It is not likely that we shall have heavy freight-carrying monsters in the air for a long time to come, and until we have the aërial "tramp" transport must be effected on the surfaces of land and sea. However much we may improve and cheapen land transport, it cannot in the nature of things become as cheap as transport by sea. For on land the essential idea is always that of a prepared road of some kind, and, as Chisholm has pointed out, no road can carry more than a certain amount; traffic beyond a certain quantity constantly requires the construction of new roads. It follows, then, that no device is likely to provide transport indifferently over land and sea, and the seaport has in consequence inherent elements of permanence. Improved and cheapened land transport increases the economy arising from the employment of large ships rather than small ones, for not only does transport inland become relatively more important, but distribution along a coast from one large seaport becomes as easy as from a number of small coastal towns. Hence the conditions are in favour of the growth of a comparatively small number of immense seaport cities like London and New York, in which there must be great concentration not merely of work directly connected with shipping, but of commercial and financial interests of all sorts. The seaport is, in fact, the type of great city which seems likely to increase continually in size, and provision for its needs cannot in general be made from the region immediately surrounding it, as in the case of towns of other kinds. In special cases there is also, no doubt, permanent need of large inland centres of the type of the "railway creation," but under severe geographic control these must depend very much on the nature and efficiency of the systems of land transport. It is not too much to say (for we possess some evidence of it already) that the number of distinct geographical causes which give rise to the establishment and maintenance of individual great cities is steadily diminishing, but that the large seaport is a permanent and increasing necessity. It follows that aggregations of the type of London and Liverpool, Glasgow and Belfast will always be amongst the chief things to be reckoned with in these islands, irrespective of local coal supply or accessory manufacturing industries, which may decay through exhaustion.

I have attempted in what precedes to direct attention once more to certain matters for which it seems strangely difficult to get a hearing. What it amounts to is this, that as far as our information goes the development of the steamship and the railway, and the universal introduction of machinery which has arisen from it, have so increased the demand made by man upon the earth's resources that in less than a century they will have become fully taxed. When colonisation and settlement in a new country proceeded slowly and laboriously, extending centrifugally from one or two favourable spots on the coast, it took a matter of four centuries to open up a region the size of England. Now we do as much for a continent like North America in about as many decades. In the first case it was not worth troubling about the exhaustion of resources, for they were scarcely more than touched, and even if they were exhausted there were other whole continents to conquer. But now, so far as our information goes, we are already making serious inroads upon the resources of the whole earth. One has no desire to sound an unduly alarmist note, or to suggest that we are in imminent danger of starvation, but surely it would be well, even on the suspicion, to see if our information is adequate and trustworthy and if our conclusions are correct; and not merely to drift in a manner which was justifiable enough in Saxon times, but which, at the rate things are going now, may land us unexpectedly in difficulties of appalling magnitude.

What is wanted is that we should seriously address ourselves to a stocktaking of our resources. A beginning has been made with a great map on the scale of one to a million, but that is not sufficient; we should vigorously proceed with the collection and discussion of geographical data of all kinds, so that the major natural distributions shall be adequately known, and not merely those parts which commend themselves, for one reason or another, to special national or private enterprises. The method of Government survey, employed in most civilised countries for the construction of maps, the examination of geological structure or the observation of weather and climate, is satisfactory as far as it goes, but it should go further, and be made to include such things as vegetation, water supply, supplies of energy of all kinds, and, what is quite as important, the bearings of one element upon others under different conditions. Much, if not most, of the work of collecting data would naturally be done as it is now by experts in the special branches of knowledge, but it is essential that there should be a definite plan of a *geographical* survey as a whole, in order that the regional or distributional aspect should never be lost sight of. I may venture to suggest that a committee formed jointly by the great national geographical societies, or by the International Geographical Congress, might be entrusted with the work of formulating some such uniform plan and suggesting practicable methods of carrying it out. It should not be impossible to secure international cooperation, for there is no need to investigate too closely the secrets of anyone's particular private vineyard—it is merely a question of doing thoroughly and systematically what is already done in some regions, sometimes thoroughly, but not systematically. We should thus arrive eventually at uniform methods of stock-taking, and the actual operations could be carried on as opportunity offered and indifference or opposition was overcome by the increasing need for information. Eventually we shall find that "country-planning" will become as important as town-planning, but it will be a more complex business, and it will not be possible to get the facts together in a hurry. And in the meanwhile increased geographical knowledge will yield scientific results of much significance about such matters as distribution of populations and industries, and the degree of adjustment to new conditions which occurs or is possible in different regions and amongst different peoples. Primary surveys on the large scale are specially important in new regions, but the best methods of developing such areas and of adjusting distributions in old areas to new economic conditions are to be discovered by extending the detailed surveys of small districts. An example of how this may be done has been given by Dr. Mill in his "Fragment of the Geography of Sussex." Dr. Mill's methods have been successfully applied by individual investigators to other districts, but a definitely organised system, marked out on a carefully matured uniform plan, is necessary if the results are to be fully comparable. The schools of geography in this country have already done a good deal of local geography of this type, and could give much valuable assistance if the work were organised beforehand on an adequate scale.

But in whatever way and on whatever scale the work is done, it must be clearly understood that no partial study from the physical, or biological, or historical, or economic point of view will ever suffice. The urgent matters are questions of distribution upon the surface of the earth, and their elucidation is not the special business of the physicist, or the biologist, or the historian, or the economist, but of the geographer.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

LEEDS.—In connection with the work on animal nutrition which is being conducted under a grant from the Development Commissioners, Dr. H. W. Dudley, of the Herter Research Laboratory, New York, has been appointed lecturer in biochemistry. The experimental station in flax growing, which is also supported by the Development Commissioners, has been placed under the direction of Mr. F. K. Jackson, formerly of the agricultural departments of the Universities of Leeds and Cambridge.

LONDON.—The following courses of advanced science lectures are announced:—"The Cytology and Affinities of the Higher Fungi," by Dr. Gwynne-Vaughan, at University College, beginning on October 23; "The Physiological Significance of Acidosis," by Drs. Kennaway and Poulton, at Guy's Hospital, beginning on October 9; "The Cerebro-spinal Fluid," by Profs. Halliburton and Dixon, at King's College, beginning on November 3; "Mechanism and Teleology," by Prof. Hans Driesch, at King's College, beginning on October 21; "The Theory of Heat in Relation to Atmospheric Changes," by Dr. W. N. Shaw, F.R.S., at the Meteorological Office, beginning on January 23. All the lectures are free.

THE Maharaja Scindia of Gwalior has contributed 25,000 rupees to the Yunani Vedic Medical College at Delhi.

DR. T. FRANKLIN SIBLY, lecturer in geology at King's College, London, has been appointed professor of geology in the University College of South Wales and Monmouthshire, Cardiff.

THE report by cable that Mr. W. Robbie, a pioneer gold-digger, who died at Ballarat a short time ago, had left a large bequest to the University of Aberdeen, has been confirmed by mail. The estimated amount of the bequest, however, is 23,000*l.*—not 30,000*l.* as at first reported—and it is to be applied for scholarships in mathematics, natural philosophy, and chemistry.

SOCIETIES AND ACADEMIES.

NEW SOUTH WALES.

Linnean Society, July 30.—Mr. W. S. Dun, president, in the chair.—T. G. **Sloane**: Revisional notes on Australian Carabidæ. Part iv., The genus Notonomus. The number of species recognised is eighty-nine, of which fifteen are proposed as new.—J. J. **Fletcher**: A case of natural hybridism in the genus Grevillea (N.O. Proteaceæ. *Grevillea laurifolia,* Sieb., and *G. acanthifolia,* A. Cunn., are two common and characteristic members of the flora of the higher portion of the Blue Mountain area. Certain other rare forms are sometimes associated with one or both of them, some of which have been described under the name of *G. gaudichaudii,* R. Br. The object of this paper is to justify the contention, that the rare plants to which the name *G. gaudichaudii,* R. Br., has been applied, or is applicable, form one group only of a series of transitional forms between *G. laurifolia and G. acanthifolia,* of which another, equally remarkable, group has escaped notice; that the entire series is one series of naturally related forms; and that the explanation of their real relationship is, that they are hybrids between the two species mentioned. Seven recognisably different types are described. The two parent-species are markedly contrasted in most of their morphological characters, in their habit of growth, and in being members of two different plant-associations and consequently in their habitats; but cross-pollination is possible, because the racemes of both are of the same pattern (elongated and secund). As the two species belong to different plant-associations, the conditions favouring cross-pollination arise only at or close to the boundary between them, while circumstances prevent the hybrids from spreading laterally.

BOOKS RECEIVED.

Papers and Proceedings. Seventh Annual Meeting, American Sociological Society held at Boston, Mass., December 28, 30, 31, 1912. Vol. vii. Pp. vi+223. (Chicago, Ill.: University of Chicago Press; Cambridge, England: University Press.) 6*s.* net.

Moths of the Limberlost. By Gene S. Porter. Pp. xiv+370. (London: Hodder and Stoughton.) 10*s.* 6*d.* net.

Pedagogical Anthropology. By M. Montessori. Translated from the Italian by F. T. Cooper. Pp. xi+508. (London: William Heinemann.) 14*s.* net.

Proceedings of the Aristotelian Society. New series. Vol. xiii. Containing the Papers read before the

Society during the Thirty-fourth Session, 1912–13. Pp. 375. (London: Williams and Norgate.) 10s. 6d. net.

The Golden Bough: a Study in Magic and Religion. By Prof. J. G. Frazer. Third edition. Part vi. The Scapegoat. Pp. xiv+453. (London: Macmillan and Co., Ltd.) 10s. net.

Contributions from the Jefferson Physical Laboratory of Harvard University for the Year 1912. Vol. x. (Cambridge, Mass.; U.S.A.)

Preliminary Statistics of Nebulae and Clusters. By C. V. L. Charlier. Pp. 35+11 plates. (Upsala and Stockholm: Almqoist and Wiksell; London: Wesley and Son.)

Armstrong College, Newcastle-upon-Tyne. Calendar. Session 1913–14. Pp. 514. (Newcastle-upon-Tyne.) 1s.

Forty-Third Annual Report of the Entomological Society of Ontario, 1912. Pp. 143. (Toronto: Department of Agriculture.)

Fire Tests with Doors, by Chubb and Sons' Lock and Safe Co., Ltd., London. The Committee's Report. Pp. 20. ("Red Books" of the British Fire Prevention Committee, No. 183.) (London: The British Fire Prevention Committee.) 2s. 6d.

Organic Chemistry for Students of Medicine. By Prof. J. Walker, F.R.S. Pp. xi+328. (London: Gurney and Jackson; Edinburgh: Oliver and Boyd.) 6s. net.

University of Bristol. Calendar, 1913–14. Pp. 304. (Bristol.)

La Catalyse en Chimie Organique. By P. Sabatier. Pp. xiv+255. (Paris and Liege: Libraire Ch. Beranger.) 12.50 francs.

The New Encyclopædia. Edited by H. C. O'Neill. Pp. vii+1626. (London and Edinburgh: T. C. and E. C. Jack.) 7s. 6d. net.

A Leisurely Tour in England. By J. J. Hissey. Pp. xviii+396+plates. (London: Macmillan and Co., Ltd.) 10s. net.

The National University of Ireland. Calendar for the Year 1913. Pp. 480. (Dublin; London: Longmans, Green and Co.)

Eighth Annual Report of the Meteorological Committee to the Lords Commissioners of H.M. Treasury. For the year ended March 31, 1913. Pp. 68. (London: H.M. Stationery Office; Wyman and Sons, Ltd.) 1s.

The Realm of Nature: an Outline of Physiography. By Dr. H. R. Mill. Second edition. Pp. xii+404+maps. (London: J. Murray.) 5s.

Materials and Methods in High School Agriculture. By Prof. W. G. Hummel and Bertha R. Hummel. Pp. xi+385+plates. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd.) 5s. 6d. net.

Handwörterbuch der Naturwissenschaften. Edited by E. Korschelt and others. Liefs 56–59. (Jena: G. Fischer.) 2.50 marks each part.

A History of University Reform from 1800 A.D. to the Present Time. With Suggestions towards a Complete Scheme for the University of Cambridge. By A. I. Tillyard. Pp. xv+392. (Cambridge: W. Heffer and Sons, Ltd.) 10s. net.

Proceedings of the Prehistoric Society of East Anglia for 1912–13. Vol. i. Part iii. Pp. 245–382+plates lix–cxvii. (London: H. K. Lewis.) 3s. 6d. net.

Modern Problems in Psychiatry. By Prof. E. Lugaro. Translated by Dr. D. Orr and Dr. R. G. Rows. Second edition. Pp. vii+305. (Manchester: University Press; London: Sherratt and Hughes.) 7s. 6d. net.

Wireless Telegraphy and Telephony without Wires. By C. R. Gibson. Pp. 156. (London: Seeley, Service and Co., Ltd.) 2s. net.

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E. Merck's Annual Report of Recent Advances in Pharmaceutical Chemistry and Therapeutics, 1912. Vol. xxvi. Pp. 524+xix. (Darmstadt and London: E. Merck.) 1s. 6d.

Metallography. By Dr. C. H. Desch. Second edition. Pp. xi+431+xiv plates. (London: Longmans, Green and Co.) 9s.

New South Wales. Department of Mines. Mineral Resources, No. 7. Mercury or "Quicksilver' in New South Wales. Second edition. Pp. 53+maps. (Sydney, N.S.W.) 2s. 6d.

The University of Leeds. Calendar, 1913–14. Pp. 666. (Leeds.)

DIARY OF SOCIETIES.

FRIDAY, OCTOBER 3.

JUNIOR INSTITUTION OF ENGINEERS, at 8.—The Testing of Gas Engines: W. A. Tookey.

MONDAY, OCTOBER 6.

SOCIETY OF ENGINEERS, at 7.30.—Highways: C. H. Cooper.

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MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.

Advertisements and business letters to be addressed to the Publishers.

Editorial Communications to the Editor.
Telegraphic Address: PHUSIS, LONDON.
Telephone Number: GERRARD 8830.