NATURE

SATURDAY, SEPTEMBER 30, 1922

CONTENTS.

Editorial and Publishing Offices:
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.

Advertisements and business letters should be addressed to the Publishers.
Editorial communications to the Editor.

Telegraphic Address: PHUSIS, LONDON.
Telephone Number: GERRARD 8830.

The Protection of Inventions: An Empire Patent.

COMMON legislative action among the constituent parts of the British Empire would materially strengthen the bond which unites the peoples to one another and to the motherland. When, in addition, increased productiveness, lessening of cost, and simplification of procedure are its accompaniment, and when general expediency points to the special course prescribed by it, few voices could well be heard in opposition. For many years a dream of politicians and reformers, manufacturers and inventors, has been the granting of a single patent to an inventor which, effective throughout the British Dominions, would give adequate protection without the necessity of securing patents from each of the constituent countries of the Empire. To obtain this wide measure of protection, an inventor, at the present time, must make not less than forty-six separate applications at a cost in official fees of more than three hundred pounds. Further, if protection be desired for the full periods which the respective laws permit, an additional sum of twelve hundred pounds and more must be forthcoming; and to this sum there is to be added the cost of the highly skilled preparation of the necessary documents, a formidable item which alone may amount to as much as the official fees for the applications. Now, if it were genuinely believed by all classes that the stimulation of invention results in greatly increased production, and that trouble and outlay in that direction are amply repaid, expenditure by governing bodies would no longer be deemed speculative, but would be looked upon as a sure and certain investment to be welcomed on all hands.

Although there is much to be urged in favour of this belief, possibly to the point of conviction, many reasons may be adduced for its non-acceptance by the authorities. The reasons, however, need not be specified, for the fact remains that hitherto there has been no such consensus of opinion as to lead the separate law-making bodies to common action and, through simplification of procedure and great reduction in cost, to encourage the inventor to successful effort within the territories of the several legislatures. Yet until the year 1852 it was the practice in this country to issue a single patent which was co-extensive in its operation with the whole of the Colonies, and in the Patent Law Amendment Act of that year a similar power was reserved. Although this power was not employed, for, in fact, no extensions were made, the reservation in the Act secured a practical result. It set on foot a series of inquiries by the Government, and led India and the Colonies to pass various patent acts and ordinances. Simultaneously with the demand in the 'sixties of last century for the total abolition of patents, opinion was hardening upon the desirability for the extension of a patent to countries other than that in which it originated. In the Patents Act of 1883, which replaced the Act of 1852, no power was given for extending the territorial limit of a patent, nor in the Acts which now govern patents in this country is any such power present. In spite of much sporadic agitation, no practical steps were taken for a patent of the United Kingdom to become operative in India, the self-governing Dominions, the Colonies, and Protectorates. This invoked Sir Robert Hadfield to say that "It is a crying shame that in a great Empire like ours we do not have one Empire Patent to cover the whole of our Dominions."

Although many societies and various learned bodies had discussed the question and emphasised the need of an Empire Patent, and, from time to time, had made representations to Government, officialdom appears to have been deterred by inherent difficulties in the production of an acceptable scheme. It had not perceived the possibility of formulating a practical measure to satisfy the justifiable aspirations and fair demands of inventors. But steady pressure and persistent endeavour are meeting with reward, for there are now indications of Governments treating seriously the proposals for an Empire Patent. A notably important advance was made in 1921 at a conference of Prime Ministers and representatives of the United Kingdom, the Dominions, and India, when a memorandum, prepared in the Board of Trade, was discussed by a special committee. The conference agreed with the recommendation of its committee that representatives of the Patent Offices of His Majesty's Dominions should sit in London to consider the practicability of an Empire Patent. Accordingly sittings were held in June last, and a report of the conference has since been published.[1]

The report is not for popular reading; indeed in the main it is highly technical, and in its entirety can be understood only by those to whom the details of patent law and practice are of everyday concern. Further, its importance and significance are not to be measured simply by what it states expressly, since its implications and inferences must be gathered before its true import can be realised.

The discussion at the conference ranged round the present situation of affairs; the desirability for an Empire Patent; various schemes for obtaining the Patent and their practicability; and alternatively the possibility of rendering uniform the patent laws throughout the Empire. The conference, while emphasising the importance of the preservation of the autonomy of the self-governing Dominions and of India, and insisting upon the rights and facilities at present enjoyed by inventors, concluded that an Empire Patent is desirable. Five schemes of the many that had been brought to notice were selected for special examination, the conference taking for its basis a memorandum prepared by the Comptroller General of Patents in 1919. A few particulars of these schemes are set out in the report. Looking over these, it is apparent that for each much can be urged. In one, it may be, large expenditure is involved, although the advantages to be secured are great; in another, expenditure is comparatively small, with corresponding diminution in beneficial results. That difficulties will be encountered whatever scheme may ultimately be adopted is well known, but so far as can be judged, no such difficulty will be met as cannot be surmounted in the presence of a spirit of give-and-take, a spirit which must permeate the various legislatures and governing bodies before a uniform plan of action can be agreed upon.

According to one of the schemes, there is to be established a single central patent office for the issue of grants which should be operative throughout the Empire, local patent offices being abolished. This scheme was not approved, "having regard to practical difficulties," the chief of which were the distance apart of the units of the Empire and the loss of time which accordingly would be involved in transacting the necessary business. Another scheme contemplated the retention of local patent offices from which the usual territorial patents would issue, the issue taking place without examination into the novelty of the inventions to be protected. In addition, a central office would be established for the recording of the local patents and for their resultant extension to the Empire. The central office on being called upon by its patentees would also undertake a limited examination for novelty, and when the patent specification was suitably amended as a result of the examination, a note would appear that the examination had thus taken place. This scheme was not recommended, owing, it would seem, to the resulting abolition of the existing compulsory examination into novelty. The third scheme entailed the granting of Empire Patents in each self-governing Dominion and in India, each office being fully equipped with the registers and material necessary for the examination into novelty. In view of the expense and difficulty involved in setting up the offices and of the uncertainty as to the quality and value of the patent so granted, the conference found the scheme to be wholly impracticable. According to the "Preferred

[1] British Empire Patent Conference. Report of the Conference held at the Patent Office, London, from 12th June 1922 to the 23rd June 1922. 8vo. Pp. 28. (London: H.M. Stationery Office.) 1s. net.

Scheme," a scheme which the conference recommended for adoption in the future, local patent offices are to be retained, each performing its present functions. There is also to be a fully organised central office for the detailed examination of applications for patents, the examination to include an extended search for novelty, the office eventually issuing the Empire Patents. But to make a patent operative in any country, registration in that country is compulsory, the registration being open to opposition if the local law provides for opposition to the granting of a patent.

By a "Provisional Scheme," which is recommended for immediate adoption and for continuation until the "Preferred Scheme" can be introduced, the grant of a patent in the United Kingdom carries with it the right to registration in any desired country of the Empire, the act of registration extending the grant to that country. But here, again, before the registration is made, it is open to opposition, if opposition to local grants is permitted by the local law.

Manifestly, whatever scheme came to be adopted by the separate legislatures or law-making bodies, much mutual adjustment of substantive and adjective law would be required. Some of these necessary adjustments were discussed at the conference, and suggestions emanating therefrom appear in the report. None appears to be of such a character as to be outside the bounds of practicability. But to review those subjects which call for adjustment, and to discuss the opinions on these and other points expressed at the conference, would require for each a monograph. From the report it is clear that an extremely small portion of the necessary amendments which the respective authorities would be called upon to make could have been discussed, bearing in mind that the conference held ten meetings only, and that it refused to admit oral evidence from outside, deciding that "no useful purpose would be served by hearing such evidence." There was, therefore, excluded from consideration the oral evidence that could have been given, for example, by the Chartered Institute of Patent Agents, a body which is continually in touch with the needs of inventors and conversant with the working and details of the various patent laws. Of necessity must the conference be looked upon as merely preliminary to attacking at close quarters the problem which it set out to solve.

On the unanimous selection of a scheme by each of the governing authorities, the next step will be for each to submit for general consideration the law, rules, and regulations which must be formulated in order that the selected scheme may be successfully put into operation. Moreover, it will be necessary to distinguish between the law to be applied when the patent is granted and the procedure for obtaining the patent. It will also be found that, in endeavouring to secure a basis for action, the task will be the easier by reason of the large majority of the patent laws of the Dominions having copied the law of the United Kingdom, and of the ultimate Court of Appeal for the Empire being the Judicial Committee of the Privy Council.

In the preparation of a scheme for general adoption it is to be hoped that the authorities will not continue to ignore oral evidence from outside bodies; to do so will be to court failure. Procedure for obtaining a patent and the law and rules relating to patents are so intricate that none but those who are in daily contact with such matters and have learned in the hard school of experience the needs of inventors on one hand and the reasonable requirements of the public on the other, can be expected to produce a scheme which, satisfactory to all parties, can be put into operation without friction, much change in procedure, or extensive amendment of existing laws.

There is no reason to suppose that, if all parties are determined to produce an Empire Patent, the adjustment of conflicting opinions cannot be made nor suitable machinery devised. The result undoubtedly would be to the advantage of all inhabitants of the Homeland and of His Majesty's Dominions beyond the Seas, whether as inventors, manufacturers, or users. It remains, therefore, for the public to urge expedition upon the authorities, or it will be met with the charge of apathy, a plea which so often saves the situation where officials are concerned.

A word or two is to be said in respect of the charge for a copy of the report. In pre-war days, each copy of this small octavo would have been sold for 3*d*. or 4*d*., and the edition promptly exhausted with a consequent wide-spread dissemination of its information. For each copy of this edition of five hundred, however, one shilling is required, a charge which scarcely makes for extensive circulation. The wider the public that the report reaches, the greater chance of a definite outcome of its suggestions, while, at the same time, by the lowering of the price the probability of the recovery of the cost of the edition would not be appreciably lessened.

Industrial Physics.

A Dictionary of Applied Physics. Edited by Sir Richard Glazebrook. (In 5 volumes.) Vol. 1: Mechanics, Engineering, Heat. Pp. ix + 1067. (London: Macmillan and Co., Ltd., 1922.) 3*l*. 3*s*. net.

IN years to come the publication of this monumental work will rank as one of the milestones in British applied science. If argument were needed, none more convincing could be adduced in illustration of the necessity for a working co-operation between the physicist and the engineer. Sir Alfred Ewing recently defined engineering as "the turning to man's use and convenience of the things which it is the business of physics to understand." This Dictionary helps one to realise, as perhaps never previously, that in all branches of engineering the engineer, whether revealing or directing, whether inventing or designing, whether testing or measuring, whether systematising, co-ordinating, or clarifying, is continually turning physical principles to account.

Sir Richard Glazebrook, not content with the enduring monument to his fame in the shape of the National Physical Laboratory, has now laid physicists and engineers under perpetual obligation by undertaking the editorship of this "Dictionary of Applied Physics." No other British man of science, it is safe to say, could have brought the same wide experience, intimate knowledge, and critical judgment to bear upon the production of an encyclopædic work of this nature. For twenty years Sir Richard Glazebrook directed the policy of the N.P.L., and during that period, when the attitude of the nation towards scientific investigation was very different from what it is to-day, he toiled unceasingly to foster the applications of science to industry. To take one example alone, the fact that this country in 1914 led the world in aeronautical research is due in no small measure to his foresight and skilful guidance during the preceding eight years. Sir Richard's breadth of interests and his habit of establishing and preserving personal contact with original investigators are reflected in his choice of collaborators in the preparation of this Dictionary.

The work under review is the first of a series of five volumes, planned to cover the entire range of physics and, in particular, the applications of physics to industry. Volume I contains some fifty articles, covering mechanics, engineering, and heat.

Three main facts emerge from a survey of the work before us—first, the unexampled wealth of material; secondly, the authoritativeness, the maturity of judgment, the originality and inviting freshness of treatment which are exhibited by the majority of the writers; and, lastly, the presumption and futility of any single reviewer attempting to appraise such a diversity of articles by such a galaxy of experts. A glance at the names of contributors furnishes sufficient guarantee that the various subjects are dealt with by accepted authorities and experienced investigators; and probably the only useful service that a reviewer can hope to perform is to point out a few of the sins of omission which are inevitable in a treatise planned on such a comprehensive scale.

The first article in the volume is on air pumps, by the staff of the General Electric Co., and deals with the fundamental principles of the various types of pumps employed for evacuation and compression.

Calorimetric measurements are dealt with in a series of five articles by Dr. Ezer Griffiths. The subject is divided into sections dealing with bomb calorimetry, electrical methods of calorimetry, method of mixtures, methods based on change of state and the applications of the quantum theory to specific heat data. A glance through these articles shows how different are the methods employed by research workers from those described in text-books on this subject. As an indication of the highly developed state of technical calorimetry, it might be mentioned that with one of the bomb-calorimeter equipments described—that of the U.S. Bureau of Mines—a skilled operator can average thirty-five determinations per day of the calorific value of fuels. The purely scientific aspect of the subject is not neglected, for we find concise descriptions of the researches of White on specific heats at high temperatures and those of Dewar at low temperatures. Electrical methods of calorimetry naturally occupy a prominent place, for the ease with which electrical energy can be measured and controlled has placed a powerful tool in the hands of workers concerned with thermal measurements.

The principles of dynamical similarity are discussed in an article by Dr. H. Levy. The results of wind-channel and ship-tank experiments on models can be applied to full-scale machines by the use of the Principle of Similitude, which also finds application in numerous other branches of engineering. One is reminded of a famous article by the late Lord Rayleigh in NATURE, vol. 95, p. 66, 1915, in which the full generality and beauty of the Principle of Similitude are brought out. In the space of a column or two Rayleigh deduced a series of fundamental conclusions with the lucidity and brevity which distinguish all his writings.

Four articles are devoted to various aspects of steam engineering. Sir Alfred Ewing contributes one on the theory of the steam engine; Mr. A. Cruickshank another on the reciprocating steam engine, while the importance of the steam turbine fully merits the 38 pages devoted to the two articles on the physics of the steam turbine by Dr. Gerald Stoney and Mr. Telford Petrie, and the development of the steam turbine by Mr. R. Dowson of Messrs. Parsons.

These articles cover the ground pretty thoroughly, so far as present-day practice goes, but one would have liked to know something of the writers' views on the future trend of their subjects. For example, nothing is said of the possibilities of the gas turbine, should the practical difficulties connected with it be overcome, or of the advantages and disadvantages of the steam turbine for aircraft propulsion and on locomotives.

The internal combustion engine is dealt with in three articles: Mr. Aubrey Evans writes on the water-cooled petrol engine; Sir Dugald Clerk and Mr. G. A. Burls on the thermodynamics of internal combustion engines and also on some typical internal combustion engines. The standard work of these authors on the subject is familiar to most students.

On general engineering subjects we note, among many others, a brief monograph by Prof. W. E. Dalby on the balancing of engines and prime movers. In an article on the strength of structures by Mr. J. W. Landon, it is curious that no mention is made of airship and aeroplane structures, which are certainly of considerable interest at the present time.

Dr. T. E. Stanton's article on friction, supplemented by a very brief one by Mr. W. B. Hardy on boundary conditions in lubrication, form a complete and masterly résumé of this fascinating subject, in which there have been considerable developments during the past few years.

Elasticity has two articles devoted to it, one on the theory of elasticity by Mr. R. V. Southwell, and the other on elastic constants by Mr. R. G. Batson. Mr. Southwell's article of 11 pages is as brief as Mr. Batson's article of 125 pages is long. One would have liked to see included in the former a brief account of the mathematical researches which find practical application, such as the effect of keyways on the strength of a shaft, the vibration of rotating masses, such as turbine discs, the torsional vibration of propeller shafts, etc. Mr. Batson's article, which is lavishly illustrated, deals primarily with the testing of the materials of construction. We note that Fig. 120, p. 196, has evidently been transferred direct from a catalogue without the superfluous lettering being removed. In view of the thorough treatment of the subject of thermoelectric pyrometry in this volume, there was doubtful justification for including an elementary account of the principle of thermoelectric pyrometers in an article devoted to elasticity. Moreover, the sections on the permeability of concrete, together with those on attrition and abrasion tests, are somewhat uncomfortably housed in an article on elastic constants. The question of the seasoning and testing of timber merits a more exhaustive treatment than is accorded to it here.

Space does not permit of a review of the numerous short articles on various aspects of engineering, but some of the omissions may be pointed out for future rectification. In the brief article on gyroscopes by Dr. G. T. Bennett, no mention is made of important practical applications, such as gyro-compasses, stabilisers, and aeroplane-level indicators. The article on dynamometers, by Mr. J. H. Hyde, is confined mainly to the more familiar types. One would have liked, for example, to know something of those developed for testing aircraft engines during flight.

Mr. F. H. Schofield contributes articles on heat conduction and convection, the recent work of the Heat Department of the National Physical Laboratory on these subjects being well summarised. The classical researches on the mechanical equivalent of heat are ably reviewed by Dr. E. H. Griffiths. Reading his account of the difficulties encountered by early workers makes us realise how much they did indirectly to advance progress by following up the discrepancies between various temperature scales on one hand and the several electrical standards on the other. Sir Alfred Ewing contributes articles on thermodynamics, the liquefaction of gases and refrigeration, which are models of charm and clarity. The article on liquefaction might well have been amplified to include the advances of the last few years.

Temperature measurements are covered in a series of six articles. Messrs. Day and Sosman of the Geophysical Institute, U.S.A., are authors of an article on the realisation of the absolute scale of temperature. In this most readable contribution will be found a critical review of the numerous researches on the gas thermometer throughout the past century, which have helped to lay the basis of the standard scale of temperature in use at the present day.

Dr. Ezer Griffiths contributes noteworthy articles on resistance thermometers, thermocouples, total radiation pyrometry, and optical pyrometry. The resistance thermometer holds a unique position in practical pyrometry. Too fragile for works' use, as originally intended by Siemens, it has developed into a precision laboratory instrument. The practical scale of temperature over the range $-40°$ C. to $+1100°$ C. can be reproduced with extraordinary accuracy by the aid of a platinum resistance thermometer calibrated at the ice, steam, and sulphur points. Detailed descriptions of the methods to be employed in calibration and the precautions which must be observed will be found in the article.

As modern methods of measuring temperature have developed chiefly in the direction of electrical appliances, one naturally finds that prominence is given to a discussion of various types of potentiometers in the article on thermocouples. Considerable advance has been made in recent years in the design of thermoelectric potentiometers, and the student of purely electrical measurements might also with advantage study this section.

A notable feature of the article on optical pyrometers is the discussion of the theory underlying the use of red glass for obtaining approximately monochromatic light. This is a factor of fundamental importance when temperatures of the order of 3000° C. have to be measured by means of pyrometers calibrated on the basis of Wien's law to represent the distribution of energy in the spectrum of a "full radiator." The "disappearing filament" type of pyrometer has been greatly developed in recent years at the N.P.L. and elsewhere, and it would appear that, in time, it will supplant most of the other types now in use for high-temperature measurements.

Thermometry is covered by a comprehensive article written by Mr. W. F. Higgins. A detailed account is given of the N.P.L. equipment for thermometer testing, together with a complete discussion of the mercurial thermometer. No consideration is given to vapour-pressure thermometers. During the war many thousands per week were made for use on aircraft, and they are also being extensively fitted to motor-car radiators at the present time. Doubtless the new mercury-in-steel transmitting thermometers, which have been successfully developed and are coming into wide use, will receive a longer notice in a future edition.

Mr. G. S. Baker writes on ship resistance, Prof. Horace Lamb contributes mathematical articles on Fourier's series, etc., Dr. A. W. Porter treats of thermal conductivity, and Mr. Jakeman deals with the measurement of pressure.

We regret that we have not space to notice the numerous short articles scattered throughout the volume, some of which are intended to supplement the longer articles.

There is an excellent name-index. The references are plentiful, and appear to have been carefully checked. The only slip which we have noticed is on page 1025, the Physical Society modestly confining itself to Proceedings, not Transactions, as implied by the writer. We notice that the names of Mr. Whetham (Phase Rule) and Miss Austin (Units of Measurement) have been omitted from the list of contributors on p. vii.

The printers have done their work well, and the publishers are to be congratulated on their enterprise and the general "turn-out" of the book. It was inevitable that a book of 1000 or more pages of this type should be expensive. The pity of it is that the price will put it out of the reach of so many students. It is true that they may have recourse to the nearest library, but the book is such that one would like to see every senior student of the subject with his own copy. Some of the articles will be a revelation to him, bearing as they do little resemblance in substance and treatment to the majority of the present-day text-books.

The division of the Dictionary into volumes on a subject-basis, and the fact that individual volumes are purchasable, are features greatly to be commended. Perhaps in the future it may prove possible to extend the system and divide the Dictionary into, say, double the number of smaller volumes, each confined to one main branch of the subject, and proportionately less costly. The volumes would be lighter to handle, and the formidable task of keeping so large a work abreast of modern science would be much facilitated.

G. W. C. KAYE.

Position of Agriculture in India.

Agricultural Progress in Western India. By G. Keatinge. Pp. xii+253. (London: Longmans, Green and Co., 1921.) 6*s*. net.

AGRICULTURAL conditions in India are such that any estimate of progress must be largely indirect. The bulk of the land is farmed in small holdings by peasants who keep no accounts, and sell their surplus products in local markets which render no statistical returns; again, the value of export crops, such as cotton, is subject to wide fluctuations owing to the erratic rainfall. But, by a consideration of other factors, such as the area under cultivation, changes in land values and rentals, irrigation schemes, and the standard of living, there is definite evidence of progress. Mr. Keatinge has spent thirty years in the midst of agricultural problems in the Bombay Presidency, and in this very interesting book he sets out his estimate of the progress that has been made, the obstacles to further advancement, and a proposed future policy.

With regard to the obstacles in the way of further advancement, the most serious one is the Hindu law of inheritance, by which each male member of a family is entitled to an equal share of the family property. This results, not only in the division of farms into uneconomic units, but in a further subdivision into scattered plots—a process reminiscent of the old three-field system in England. Another fundamental difficulty is that cattle cannot be bred and kept solely for profit, owing to their significance in the Hindu religion. They are of inefficient types, used of necessity in an uneconomic manner, and are more of a hindrance than a help to the struggling farmer. As an illustration of the difficulty of introducing improvements which do not clash seriously with the social and religious habits of the cultivators, the author considers the use of irrigation water. It appears that, financially, most irrigation canals are unsuccessful owing to the slow manner in which these facilities are taken up. This is due to the small number of men who have the necessary capital, skill, and energy to engage in the more intensive type of cultivation necessary on irrigated land.

In certain matters of technique, such as improvements in cultivation and rotations, the application of manures and the use of better seed, considerable advances have been effected. This is largely due to the investigations made at the experimental farms of the Agricultural Service.

In one of the appendices to the book the author outlines a draft bill to enable landowners to correct the excessive division of holdings, and he supports his case by full details of typical instances of subdivision, and by comparison with the remedial measures taken in other countries where the same conditions have arisen.

The book is essentially a plea for a specified course of legislative action, and therefore may be to some extent controversial, especially at the present time; but the facts are put forward in an eminently fair manner, and the author's treatment and discussion of them constitute an exceedingly interesting and useful account of agricultural conditions in an important region of India. B. A. KEEN.

Prehistory for the Schoolroom.

(1) *Everyday Life in the Old Stone Age.* Written and illustrated by M. and C. H. B. Quennell. (The Everyday Life Series, I.) Pp. x+109. (London: B. T. Batsford, Ltd., n.d.) 5*s.* net.

(2) *The World-Story of* 3,000,000,000 (*?*) *Years.* By J. Reeves. Pp. 16. (London: P. S. King and Son, Ltd., 1922.) 2*s.* 6*d.* net.

(1) THIS is a delightful book. It ought to be in every schoolroom; but the elders will want to borrow it and enjoy it in the evenings. The line drawings are masterpieces of well directed imagination. That on p. 48 shows a Mousterian family between the thin stems of the woodland and their cave; the big brother, just for fun, is frightening a little girl, who clings to her mother's back as she looks after the fire; an elder sister, sitting near him, checks him by a timely touch from her leg—her foot is just as ready as her hand. The 130 square cm. of the drawing—the authors justly use the metric scale—are full of life and incident; we should like to see the curtain rising on its realisation as the first scene of a folk-drama.

The clever guesses at the appearance in profile of successive types of man, from Pithecanthropus to the Magdalenian, should be supplemented by a few drawings of the actual skulls. There is no ugly suggestion nowadays about a skull, and readers would then see clearly on what the conclusions rest. The picture of a small valley-glacier producing a moraine-girdle is crude, and does little to explain the conditions found by earliest man in Europe. The absurdly small thickness assigned to Cainozoic strata in the table is sanctioned by British Museum guides, and is derived from the narrow cult of the London Basin by geologists in southern England. But we turn to the text and the living illustrations, to the proud dignity of *Cervus giganteus*, unconscious of his vulgar little enemy in the rear, and to the sleepy hippopotamus about to fall upon the stakes; then once more we cordially thank the authors.

(2) So much is problematic when we seek to summarise "the world-story" that we doubt the wisdom of drawing up charts which simulate those derived from written history. Mr. Reeves's book is, however, very useful to the teacher; but it necessarily contains much on which we await further information. By reserving the theromorphs, for example, for the Trias, the author is able to state that the Permian reptiles were not at first clearly differentiated from amphibians. The marvel, however, lies in the rapid rise in Permian times of a mammalo-reptilian type. The hypotheses of the earth's origin do not fit well with tables showing in detail the "periods" of man's occupation of the globe. We have the "solar planetary epoch," the Carboniferous "period," and later the La Tène "period." Unless the geological section is greatly extended, undue emphasis is thrown on the analysis by archæologists of the progress of early man in the European area. Prof. Sollas's estimates, made in 1909, are wisely taken as a basis for suggesting, by thickness of strata, the relative lengths of geological periods. The author's references to literature should aid the schoolmaster who attempts to deal with man as "a part of Nature." But how are other forms of teaching, in Kentucky, in Middlesex, and elsewhere, to be reconciled with this high ideal?

G. A. J. C.

Aesthetics.

(1) *Harmonism and Conscious Evolution.* By Sir Charles Walston (Waldstein). Pp. xvi+463. (London: J. Murray, 1922.) 21*s.* net.

(2) *The Poetic Mind.* By F. C. Prescott. Pp. xx+308. (New York: The Macmillan Co.; London: Macmillan and Co. Ltd., 1922.) 9*s.* net.

(1) HARMONISM, whatever its attraction as a theory, has chosen very unharmonious terms for its expression. Sir Charles Walston's theory is, in his own words, that conscious evolution in the

human being is due to harmoniotropism rising in its higher stages to aristotropism. "The new born infant," we are told, "emits a first sound or cry which is a spontaneous activity of its vocal chords. From this moment numerous somatocentric and centrobaric activities proceed which—unconsciously to the infant itself—establish its relationship to its own functioning body and to the outer world. But with the growth of sentience and nervous activity all the physiological activities of the child are somatocentric, and manifest geometrical or rhythmical regularity, establishing the harmoniotropic tendency and principle of activity."

The book contains a great amount of autobiography and many long extracts from the author's other writings. So far as æsthetics is concerned Sir Charles seems to come nearest to Groos's play theory. He makes no mention of the more recent æsthetic theories, that of Benedetto Croce for example. Art, we are told, is the product of an æsthetic instinct, and we seem to be expected to find the full explanation of it in this description. The purpose of the book is practical, however, rather than theoretical. The idea that inspires the whole scheme is the desire to find a way to reap the full benefit of the awful experience of war and direct to good purpose the agencies, such as the League of Nations, which aim at superseding the conditions which are making strife on the colossal scale a menace to civilisation.

(2) Mr. Prescott's book is a research work in connexion with, or at least undertaken at, Cornell University. It is a laborious attempt to prove a thesis by accumulating examples and illustrations. The thesis is that poetry is a product of the human mind which is to be correlated with dream consciousness. We are thinkers and dreamers. Most of us are both, but in a general way we may class people as one or the other according as imagination or reasoning is their predominant mental activity. It was therefore even more to M. Jourdain's credit than he supposed that he should have been speaking prose all his life. Mr. Prescott is a disciple of Freud and Jung and his thesis is that the dream interpretation of those psychologists is applicable, not merely in general, but in minute detail, to the interpretation of the imaginative content of poetry. It is a thesis which bears very hardly on the poets, and if it is right, they, being dreamers and not thinkers, will find it difficult to put in a defence. Our quarrel, however, is not with his psychology but with his inadequate conception of æsthetics. Poetry is indeed, as Vico was the first to hold, the primitive language, but surely when dreams find expression in poetry they cease to be dreams.

Both these volumes seem to illustrate the impossibility of treating æsthetic subjects without coming to a clear decision first as to what precisely the æsthetic function is, and second, as to what is the exact relation in which it stands to the logical function. It is no use short-circuiting the inquiry by dismissing æsthetic activity as an instinct, or by degrading it to descriptive psychology. Moreover, the work of Benedetto Croce in this field, open to criticism as it may be, has left research students with no excuse for ignoring the issue. Notwithstanding this defect, each of these books is, in its own way, fresh and original and distinctly stimulating to thought.

Our Bookshelf.

A Naturalist in the Great Lakes Region. By Elliot Rowland Downing. (The University of Chicago Nature-Study Series.) Pp. xxv+328. (Chicago, Ill.: University of Chicago Press, 1922.) 3.50 dollars.

THIS book has been written by a member of the School of Education at Chicago University as one of its nature-study series of handbooks, and it is designed for teachers of nature-study as a guide to the ecology of the country bordering Lake Michigan in the vicinity of Chicago. It is written on ecological lines, and shows abundant evidence of the influence of the American school of ecologists headed by Dr. C. G. Adams and Dr. V. E. Shelford. An account of the geology of the district is given first, followed by a résumé of the geological changes which have led to the present conformation of the country, with special reference to the glacial period and the formation of the basins of the Great Lakes. The animal and plant associations of the district are then dealt with in some detail under the headings: dune, forest, swamp, prairie, and the various aquatic types.

The book is abundantly illustrated by line drawings, which will serve at any rate for a preliminary identification of the animals and plants met with, and a very good series of photographs illustrating the various geological phenomena and biological associations which are described in the text. Many of the maps, however, are too small and so overloaded by unnecessary detail as to render obscure the point they are designed to illustrate. The book will serve admirably the purpose for which it is designed, and should be of the greatest use to teachers and students of Nature in the area with which it deals.

It is evident, however, that the author is not himself familiar with the scientific names of the animals and plants of which he writes. There are dozens of mistakes in the spelling of these names, and if a second edition is called for, the author would do well to enlist the services of a competent zoologist and botanist and submit his scientific names to them for correction. The index, too, shows evidence of hasty compilation. It is neither complete nor accurate. These defects are a serious blot on an otherwise useful book and should be remedied as soon as possible. Fig. 56, too, might usefully be replaced by a series of new and more accurate figures.

Department of Scientific and Industrial Research. Bulletin No. 6. *On the Electro-Deposition of Iron:* With an Appendix containing a bibliography of the subject. By W. E. Hughes. Pp. iv + 50. (London: H.M. Stationery Office, 1922.) 6*s*. 6*d*. net.

THE Department of Scientific and Industrial Research has rendered electrometallurgists signal service by the recent publication of this monograph, written by and containing the results of work by Mr. W. E. Hughes, formerly Chief Research Chemist to the Electrometallurgical Committee of the Ministry of Munitions, and already favourably known for his publications in this particular field. The present brochure contains, within the compass of fifty pages, a systematic study of the effect of current density, temperature, and mechanical movement on the nature of the cathodic deposit of iron formed from ferrous chloride solutions. The deposits were photomicrographed in every case, and the resulting numerous illustrations, excellently reproduced, are of considerable interest.

The view upheld by the author is that the effects of these different factors can all be satisfactorily explained if the formation of a crystalline cathodic metal deposit can be regarded as being governed by conditions similar to those which regulate the nature of a crystalline deposit formed from, say, a molten mass of metal, a fused rock magma, or an aqueous solution. It cannot be said that the view is quite novel. It has certainly been "in the air" for some little time. The striking work of von Weimarn, for example, if considered in connexion with the effect of colloidal additions to an electrolyte on the nature of the cathodic deposit, could not but suggest a close similarity between the nature of the phenomena of electrolytic deposition and precipitation from aqueous solutions. But to Mr. Hughes belongs the credit of stating the analogy in unequivocal language, and of bringing to it a very large measure of experimental support. The variations in crystal structure observed by him are correlated very satisfactorily with changes in the experimental conditions mentioned above, changes which bring about quite similar variations in the nature of crystallisation from other types of systems.

It should be added that an excellent bibliography of the subject is given in the form of an appendix.

Catalogue of the Fossil Bryozoa (Polyzoa) in the Department of Geology, British Museum (Natural History). The Cretaceous Bryozoa (Polyzoa). Vol. 4: *The Cribrimorphs.* Part 2. By Dr. W. D. Lang. Pp. 12 + 404 + 8 plates. (London: British Museum (Natural History), 1922.) 1*l*. 12*s*. 6*d*.

THOSE who use this volume will bear in mind the illuminating morphological introduction provided by the author in its predecessor (see NATURE, vol. 108, p. 39). The numerous lithographs are from the artistic drawings of Miss G. M. Woodward, and the author again furnishes vigorous text-illustrations showing the specific orthœcia (normal zoœcia) and the accompanying aviculœcia, which are the skeletons of the modified polypides that defend the colony. The variety of form, position, and number in the aviculœcia will surprise those who are not specialists. The general account of the genus Pelmatopora (pp. 241-253) is a good example of Dr. Lang's attractive method of dealing with Nature's species-making, here styled "evolutionary activity." In this case the whole of the thirty-eight species are derived from zones in the Senonian.

G. A. J. C.

Pope's Manual of Nursing Procedure. By Amy E. Pope. Pp. xi + 596. (New York and London: G. P. Putnam's Sons, 1919.) Price 15*s*.

THIS book has been prepared more especially to facilitate practical instruction in the work usually included in the probationer's first year of training. In each section a consideration of the principles underlying the various nursing procedures is followed by a description of demonstrations of the methods involved. In this way, and with frequent reference to physiology, the author associates theory with practice.

There are a few errors and omissions; in the description of Fowler's position, a right angle is represented diagrammatically and in the text as 100°; and in the list of prescription abbreviations and symbols no mention is made of the commonest in use, that for "thrice daily." The use of more illustrations would enable a reduction to be made in the length of descriptions of technique. The book is more suitable for the guidance of the instructor than as a manual for the probationer.

Précis d'Arithmétique. Par J. Poirée. Pp. x + 63. (Paris: Gauthier-Villars et Cie, 1921.) 7·50 francs.

M. POIRÉE has not written a book on arithmetic in the sense of a school text-book: it can be more accurately described as an introduction to the theory of arithmetic. Although the author sets out with care and precision the main ideas underlying arithmetical processes—"the why and the mechanism of each operation"—yet there is no attempt made to teach the subject. The book is very interesting—is there a French book on mathematics that does not make pleasant reading? A quarter of the space is devoted to the fundamental theorems of the theory of numbers, and in fact all through the book there is an evident suggestion that the author is aiming at the theory of numbers. Numerical illustrations of the processes are given, but there are no exercises for the student to work out himself.

S. B.

Practical Physics. By W. R. Bower and Prof. J. Satterly. Eighth impression (second edition). Pp. xi + 422. (London: University Tutorial Press, Ltd., 1922.) 7*s*.

A DISTINCTIVE feature of this text-book of practical physics is the inclusion of a considerable number of experiments which may be performed by the student at home, using very simple apparatus. In the second edition a supplement has been added containing a number of additional experiments. These are concerned with Fletcher's trolley apparatus, coefficients of friction, Mariotte's bottle, surface tension, expansion of solids, thermal conductivity, photometers, and critical angles. The importance of avoiding eye-strain has not been sufficiently considered in the mathematical tables at the end of the volume.

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.*]

Relativity and the Æther.

WHILE at Brighton recently I visited its excellent Public Library, and there found the three supplementary volumes of the "Ency. Brit." containing the remarkably lucid article on relativity by Dr. Jeans. Many have written and multitudes have read about this subject, but I venture to say that nowhere can be found a more compact and accurate presentation of the strict relativist position. There is nothing anæmic or half-hearted about it; and I imagine that while non-physicists will find the article readable, most physicists will find its crisp clearness instructive. Very little can a pragmatic or anti-philosophic relativist like myself find to disagree with in it, and where I do disagree it is just possible that both or neither may be right.

Still I do want to quote and criticise one clear and definite sentence; into which I insert only references to my comments which follow, so as not to spoil it.

On the electromagnetic theory of Faraday and Maxwell, waves of light "were simply waves in the æther and travelled with an absolute velocity c determined once and for all by the structure of the æther. (1) On this view it was quite certain (2) that an observer moving through the æther with a velocity u would measure the velocity of light travelling in the same direction as himself as $c-u$. Relativity teaches (3) that this velocity is always precisely c, and this in itself disposes (4) of the æther of Faraday and Maxwell."

On this pronouncement I comment thus:—

(1) That is certainly true.

(2) Not *quite* certain. It might have been thought certain; but the FitzGerald contraction is an indication of unexpected possibilities in the instruments of measure. Still, no first order loophole has been suggested, and the challenge is a legitimate one. Would that the experiment could be tried! I assume that every one will agree that it has not yet been tried, and that it is difficult to devise a sure and certain way.

(3) It certainly and very forcibly does so teach.

(4) But a hypothesis, even the foundation hypothesis of a developed theory, cannot logically be cited as if it were an experimentally ascertained and conclusive fact; nor can it be used to give a knock-out blow to another theory. Opposing theories still have to fight it out. Full-blown Relativity might equally well be said to dispose of Matter, by reducing it to the unevenness of a field, or to the tensor $-8\pi T_{\mu\nu}$, or to an algebraic expression like $G_{\mu\nu}-\frac{1}{2}g_{\mu\nu}G$, which apparently is conserved like matter, is obedient to our laws of motion, and vanishes in what we call empty space.

I do not think that even Dr. Jeans will claim that there is any ascertained fact to substantiate what I have marked as (3). It all depends upon ux/c^2 and differing estimates of time.

It may be said that conclusions of relativity have been verified, and that thus the theory is established. I should prefer to say that some mathematical deductions arrived at by the relativity method have been brilliantly verified, and hence that the method has pragmatically been proved to be sound. I should not say that its philosophic foundations were established; still less that they have rendered all other foundations rotten.

It would seem rather that more than one mode of expression is possible for even the simplest fact, and that a criterion of absolute and exclusive truth in any statement is increasingly difficult to find. A theory which renders it uncertain whether the Fire of London preceded or succeeded the outburst of Nova Persei, whether the sun revolves round the earth or *vice versa*, and whether a much-travelled man's death preceded his birth, should not be too positive when it leaves its own realm and enters the region of fact and reality, whatever those possibly question-begging terms may mean. Perhaps there is no absolute truth. More probably absolute truth exists, but is not easy to arrive at.

Meanwhile we may be grateful that, thanks to the new school, we are beginning to recognise the uncertainty and contingency inseparable from all forms of human statement. Let our geniuses not extinguish but supplement each other. There is room not only for Einstein and Weyl but also for Newton and Maxwell. The reconciliation may not be obvious, the connecting passage is difficult to find, but it would be wise to keep the door ajar.

OLIVER LODGE.

The Legal Equivalent of the Metre.

MAY I correct in NATURE an unfortunate error which occurs on p. 580 of the "Dictionary of Applied Physics"? It is there stated that the equivalent of the metre in inches is 39·37008, and the Order in Council of May 19, 1898, is referred to as giving the legalised value of this quantity. The information was taken, by permission, from the "Computer's Handbook," issued by the Meteorological Office in 1921, and the inference is that the above figure is the legalised value.

Dr. Stratton, of the United States Bureau of Standards, recently directed my attention to the error. The legalised value given in the Order of Council is 39·370113 inches.

The "Computer's Handbook" states that: "The most recent values for the metrical equivalent of the fundamental British Units are those contained in the Order of Council of 19th May 1898," and, after a reference to earlier editions of the "Handbook," continues: "Values in accordance with the Order in Council of 1898 have now been substituted."

I assumed this to mean that the actual legalised values had been used and printed the figures without further verification, but this is not the case.

The figure given—39·37008—is deduced from the relation 1 inch = 25·4 millimetres; the legalised value of the inch in millimetres is 25·399978. The difference, less than one part in a million, is negligible for nearly all purposes and there would be many advantages in accepting, as the legalised ratio, 1 inch = 25·4 millimetres, but this has not been done.

At present some confusion may easily arise; for in America the ratio 1 metre = 39·370000 inches has been adopted.

We thus have the equivalents given in the following table:

	Metre in Inches.	Inches in Millimetres.
America	39·370000	25·400051
"Computer's Handbook" .	39·37008	25·40000
British Legalised Value .	39·370113	25·399978

The matter is discussed in an article on metrology, by Mr. Sears, which will appear in the forthcoming volume of the "Dictionary of Applied Physics."

R. T. GLAZEBROOK.

Coton End, 63 Grange Road, Cambridge, September 9.

On the Reality of Nerve-Energy.

IF I have understood Prof. Fraser Harris's letter in NATURE of September 9, p. 342, it is a plea for the more widespread use of the term "nerve-energy" by physiologists and for the investigation of it as a special manifestation of energy like heat, light, or electricity. It is no doubt quite true that the term has a definite and useful meaning in psychology and psycho-pathology, though "mental energy" would probably do as well in most cases.

As a physiological concept, however, "nerve-energy" has little to recommend it. Some idea of the difficulties which are likely to attend its use may be seen even in Prof. Harris's letter; moreover, there is very little need to postulate a special kind of energy to explain the nervous impulse and its conduction, for of all the different activities of living cells that of conduction can be most readily described in terms of physics and chemistry.

The momentary change which makes the nervous impulse seems to consist in a depolarisation of the surface layers of the nerve fibre, a resulting increase in permeability, and an escape of ions from the interior of the fibre. The movement of ions brings about an increase of permeability in further sections of the fibre and a decrease in the sections previously active, so that the disturbance spreads but does not last for more than a brief time at any one point. The process is so simple in its essentials that Prof. Lillie has been able to construct model nerve fibres of iron wires coated with a film of passive iron and immersed in nitric acid. These models copy the behaviour of a nerve fibre with surprising fidelity.

For some time past, evidence has accumulated in favour of this explanation; it would be quite misleading to suggest that every detail of the conduction of the impulse is understood, but the broad outlines of the "membrane theory" have not been seriously challenged. The energetics of the process were worked out by Bernstein. The system loses free energy when the ions escape from regions of high to regions of low concentration, and ultimately this must be replaced by the metabolism of foodstuffs in the fibre. The splitting up of a large molecule into a number of smaller ones would suffice to restore the concentration differences upon which the movement of ions depends, and at various stages heat may be given out or absorbed from the surroundings. In no part of this scheme is there any need, or any opportunity, for the introduction of a special form of energy peculiar to nerves.

If the term "nerve-energy" is to be retained it might be used to mean the total potential energy in the neurone available for use in the transmission of impulses, but it is doubtful whether much would be gained by the measurement of this quantity. Prof. A. V. Hill has shown that the energy expended in the passage of a single impulse is extremely small, and the neurone is able to replenish its stores continually from the nutrient fluids which surround it. When failure of conduction occurs it seems to be due more often to a failure of the surface reaction than to an exhaustion of the store of potential energy in the fibre.

E. D. ADRIAN.

Trinity College, Cambridge.

Interspecific Sterility.

IN his letter on this subject (September 2, p. 312), Mr. Harrison states some interesting facts regarding the chromosome numbers in Salix. This appears to be the first case in plants where tetraploidy is accompanied by very little external change. Both tetraploid and hexaploid numbers in a genus have long been known, for example in Musa, but the point of my remark regarding interspecific sterility in crosses between diploid and tetraploid forms appears to have been missed. It is not that there is any difficulty in making such crosses in the first place. Usually they are easily made, but the result is a triploid form with an unstable chromosome content.

If such crosses between a diploid and a tetraploid species occur in Nature, they cannot lead to a permanent, stable form, except by apogamous reproduction. The hybrid may cross back with either parent, but this leads again to new and irregular chromosome numbers, with the result that, in the absence of apogamy, stability will be reached only when the extra chromosomes have been lost and the number has reverted to the diploid, or possibly in some cases to a balanced intermediate number. The two parental species, respectively diploid and tetraploid, will in the meantime each have carried on its own line of descent.

It follows that if a tetraploid form arises from a diploid species in Nature, it will continue to breed true, while its hybrids with the parent species will not give rise to a permanent line of descent unless there is apogamous reproduction. This is, for practical purposes, a condition of physiological isolation. *Spiranthes cernua* is a probable example of this sort, and there are many others. Once two such independent lines of descent are established, the divergence between them may go on increasing as fresh variations occur in each series.

R. RUGGLES GATES.

King's College, London.

Micro-Chemical Methods in the Practical Teaching of Chemistry.

IN view of the strenuous efforts now being made by education authorities in this country to economise on educational expenditure, considerable interest attaches to Prof. Egerton Grey's letter on the application of micro-chemical methods in the teaching of chemistry (NATURE, September 2, p. 309). During the War we conducted a course of practical instruction in chemistry in the Internment Camp for Civilian Prisoners of War in Ruhleben, and the difficulty of procuring large quantities of reagents led to the adoption of "Micro" methods wherever possible. Although we had at times forty students preparing for university examinations, the consumption of chemical reagents was extremely small in comparison with what would be required in the ordinary way. To give just one example, half a litre of nitric acid—a precious liquid in the camp—was found sufficient to supply the needs of these students for several months. One enterprising student fitted for himself a fully equipped "micro" laboratory in a tiny corner of his loft and undertook interesting research work.

A further advantage of the method is that the quantities involved are so small that the students can study the chemical properties of many of the rarer elements with great advantage to themselves and small expense to the laboratory. We are in hearty agreement with Prof. Grey as to the economic and educational advantages of the micro-chemical methods.

J. W. BLAGDEN.
A. WECHSLER.

The Progression of Life in the Sea.[1]

By E. J. ALLEN, D.Sc., F.R.S.

DIFFERENT views are still held as to where life in the world had its origin, but no one questions that it began in close connexion with water. That it began in the sea, where the necessary elements were present in appropriate concentrations and in an ionised state, is an idea which appeals to many with increasing force the more closely it is examined. This view has been developed recently by Church [2] in his memoir on "The Building of an Autotrophic Flagellate," in which he boldly attempts to trace the progression from the inorganic elements present in sea-water to the unicellular flagellate in the plankton phase, floating freely in the water. The autotrophic flagellate, manufacturing its own food, he regards as the starting-point from which all other organisms, both plants and animals, have sprung. To understand the first step in this progression, the passage from the dead inorganic to the living organic remains, is as it has always been, one of the great goals of science, not of biological science alone, but of all science. Recent research has, I think, thrown much light on the fundamental problems involved. In a paper published last year, Baly, Heilbron, and Barker,[3] extending and correcting previous work by Benjamin Moore and Webster,[4] have shown that light of very short wave-length ($\lambda = 200\ \mu\mu$), obtained from a mercury-vapour lamp, acting upon water and carbon dioxide alone, is capable of producing formaldehyde, with liberation of free oxygen. Light of a somewhat longer wave-length ($\lambda = 290\ \mu\mu$) causes the molecules of formaldehyde to unite or polymerise to form simple sugars, six molecules of formaldehyde, for example, uniting to form hexose. The arresting fact brought out in these researches is that the reactions take place, under the influence of light of appropriate wave-lengths, without the help of any catalyst, either organic or inorganic. Where a source of light is used which furnishes rays of many wave-lengths, the simple reaction of the formation of formaldehyde is masked by the immediate condensation of the formaldehyde to sugar, but this can be prevented by adding to the solution a substance which absorbs the longer wave-lengths, so that only the short ones which produce formaldehyde are able to act.

When the formation of sugars is postulated, the introduction of nitrogen into the organic molecule offers little theoretical difficulty; for not only has Moore [5] shown that nitrates are converted into the more chemically active nitrites under the influence of light of short wave-length, but he maintains that marine algæ, as well as other green plants, can, under the same influence, assimilate free nitrogen from the air. Baly [6] also has succeeded in bringing about the union of nitrites with active formaldehyde in ordinary test-tubes by subjecting the mixture to the light of a quartz-mercury lamp.

If these results of the pure chemist are justified, they go far towards bridging the gap which has separated the inorganic from the organic, and make it not too presumptuous to hazard the old guess that even to-day it is possible that organic matter may be produced in the sea and other natural waters without the intervention of living organisms. We may note here, too, that if we take account of only the most accurate and adequately careful work, the actual experimental evidence at the present time requires the presence of a certain amount of organic matter in the culture medium or environment before the healthy growth of even the simplest vegetable organism can take place.

Let us then assume that we are allowed to postulate in primitive sea-water or other natural water organic compounds formed by the energy of light vibrations from ions present in the water, and see how we may proceed to picture the building up of elementary organisms. Without doubt the evolutionary step is a long and elaborate one, for even the simplest living organism is already highly complex both in structure and function. As the molecules grew more complex by the progressive linkage of the carbon atoms of newly formed carbohydrate and nitrogenous groups, we must suppose that the organic substance, for purely physical reasons, assumed the colloidal state, and at the same time its surface-tension became somewhat different from that of the surrounding water. With the assumption of the colloidal state, the electric charges on the colloidal particles would produce the effect of adsorption and fresh ions would be attracted from the surrounding medium, producing a kind of growth entirely physical in character. We thus arrive at the conception of a mass of colloidal plasma differing in surface-tension from the water and increasing in size by two processes, one chemical, due to linkage of carbon atoms; the other physical, brought about by the adsorption of ions by the colloidal particles.

The difference of surface-tension would tend to make the surface a minimum and the shape of the mass spherical. On the other hand, maximum growth would demand maximum exchange with the surrounding medium, and hence maximum surface. From the antagonism of these two factors, surface-tension and growth, there would follow, first, the breaking up of the mass into minute particles upon the slightest agitation, and, secondly, changes of form wherever growth involved local alterations of surface-tension; the latter would represent the first indication of the property of contractility.

So far we have considered only the process of the building up of the elementary plasmic particles, the anabolic process. Church, whose memoir already referred to I am now closely following, points out that these anabolic operations must from the beginning have been subject to the alternations of day and night, for during the night the supply of external energy is removed. "If during the night," he asks, "the machine runs down, to what extent may it be possible so to delay the onset of molecular finality that some reaction may continue, at a lower rate, until the succeeding day?" And his answer is: "The suc-

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[1] From the presidential address delivered to Section D (Zoology) of the British Association at Hull on Sept. 8.

[2] "Biological Memoirs," I. Oxford, 1919.

[3] Journ. Chem. Soc., London, vols. 119 and 120, 1921, p. 1025. NATURE, vol. 109, 1922, p. 344.

[4] Proc. Roy. Soc. B., vol. 87, p. 163 (1913), p. 556 (1914); vol. 90, p. 168 (1918).

[5] Proc. Roy. Soc. B., vol. 90, p. 158 (1918); vol. 92, p. 51 (1921).

[6] Baly, Heilbron and Hudson, Journ. Chem. Soc., London, vols. 121 and 122, 1922, p. 1078.

cessful solution of this problem is defined physiologically by the introduction of the conception 'katabolism,' as implying that energy derived from the 'breaking down' of the plasma itself . . . may be regarded as a 'secondary engine,' functional in the absence of light, and evolved as a last resort in failing plasma." Katabolism persists as the ultimate mechanism in the physiology of animal as contrasted with plant life, but if the suggestion just quoted is sound it originated, as the first "adaptation" of the organism, to meet the factor of recurring night and day. That the problem was successfully solved we know, but as to the mechanism of its solution we have no key. It is at this point, again to use Church's words, that the "plasma, previously within the connotation of chemical proteid matter, becomes an autotrophic, increasingly self-regulated, and so far individualised entity, to which the term 'life' is applied."

The elementary plasma is thus now fairly launched as an individual living organism, and the great fundamental problems of biology—memory, heredity, variation, adaptation—face us at each step of our further progress. We see in broad outline the conditions the advancing organism had to meet, we see the means by which those conditions were in fact met, we know that only those individuals survived which were able to meet them. Further than this we, the biologists of to-day, have not advanced. The younger generation will pursue the quest, and, with patient effort, much that now lies hidden will grow clear.

The differentiation of the growing particles of plasma into definite layers, which followed, seems natural; first the external layer, in molecular contact with the surrounding water, from which it receives substances from outside in the form of ions, and to which it itself gives off ions; beneath this the autotrophic layer to which light penetrates, and in which, under the influence of the light, new organic substance is built up; in the centre a layer to which light no longer penetrates. This central region, the nucleus, depends entirely on the peripheral layers for its own nutrition, and becomes itself concerned only with katabolic processes, those processes of the organism which depend upon the breaking down, and not the building up, of organic substance.

At an early stage in the development of the individual organism the spherical shape, which the organic plasma was compelled to assume under the influence of surface-tension, underwent an important modification, the effect of which has impressed itself upon all later developments. A spherical organism floating in the water and growing under the direct influence of light would obviously grow more rapidly on the upper side, where the light first strikes it, than it would on the lower side away from the light. There followed, therefore, an elongation of the sphere in the vertical direction, and the definite establishment of an anterior end, the upper end which lay towards the light and at which the most vigorous growth took place. In this way there was established a definite polarity, which has persisted in all higher organisms, a distinction between an anterior and a posterior end. With the concentration of organic substance which took the form of nucleus and reserve food supply, the specific gravity of the plasma would become greater than that of the surrounding water and the organism would tend to sink. The necessity, therefore, arose for some means of keeping it near the surface, that it might continue to grow under the influence of light. The response to this need, however it was attained, came in the development of an anterior flagellum. This we may regard as an elongation in the direction of the light of a contractile portion of the external layer, moving rhythmically, which by its movement counteracted the action of gravity, and acting as a tractor drew the primitive flagellate upwards towards the surface layers, into a position where further growth was possible. With the establishment of the flagellum an organ is produced which shows remarkable persistence in both the animal and vegetable kingdoms, and from the existence of the flagellated spermatozoon in the higher vertebrates, in accordance with Haeckel's biogenetic law that the individual in its development repeats or recapitulates the history of the race, we conclude that they also in their earliest history passed through a plankton flagellate phase.

Exactly at what stage in the history of the autotrophic flagellate the first formation of chlorophyll and its allied pigments took place we have no means of determining, but it may have been before even the flagellum itself had begun. This advance and the subsequent concentration of the pigments into definite chromatophores or chloroplasts doubtless increased immensely the efficiency of the organism in producing the food which was necessary to it. The recent work of Baly and his collaborators becomes here again of the first importance, and though the subject of the part played by chlorophyll in photosynthesis belongs rather to botany and chemistry than to zoology, I may perhaps, for the sake of completeness, be allowed to refer to it very briefly. I have already said that Baly brought about the synthesis of formaldehyde from carbon dioxide and water under the influence of rays of very short wave-length ($\lambda = 200\mu\mu$) from a mercury-vapour lamp. He was also able to show that when certain coloured substances were added to the solution of carbon dioxide in water the same reaction took place under the influence of ordinary visible light. His explanation of this process is that the coloured substance known as the photocatalyst absorbs the light rays and then itself radiates, at a lower infrared frequency corresponding to its own molecular frequency, the energy it has absorbed. At this lower frequency the energy thus radiated is able to activate the carbonic acid, so that the reaction leading to the formation of formaldehyde can and does take place. In the living plant this synthesised formaldehyde probably polymerises at once to form sugars.

Malachite green and methyl orange, as well as other organic compounds, were found to act as photocatalysts capable of synthesising formaldehyde, and Moore and Webster's work had previously shown that inorganic substances, such as colloidal uranium oxide and colloidal ferric oxide, can do the same. Chlorophyll in living plants may with some confidence be assumed to operate in a similar way, though no doubt the series of events is more complex, since the green pigment itself is not a single pigment, and others, such as carotin and xanthophyll, are also concerned.

We have tried to picture the gradual building up from elements occurring in sea-water of a chlorophyll-bearing flagellate, capable of manufacturing its own nourishment and able to multiply indefinitely by the simple process of dividing in two. If we assume only one division during each night as a result of the day's work in accumulating food material, such an organism would be able in a comparatively short space of time to occupy all the natural waters of the world. But here we are met by a difficulty which is not easily overcome. Chlorophyll, the photocatalyst, the most essential factor in the building up of the new organic matter, is itself a highly complex organic substance, and in any satisfactory theory its original formation and its constant increase in quantity must be accounted for. Lankester[7] has maintained that chlorophyll must have originated at a somewhat late stage in the development of organic life, and has suggested that earlier organisms may have nourished themselves like animals on organic matter already existing in a non-living state. An alternative hypothesis, which in view of the recent work seems more attractive, is to suppose that the earlier organisms were either activated by some simpler photocatalyst, or that they received the necessary energy at suitable frequency directly from some outside source.

It must not be forgotten, also, that at the time these developments were taking place the conditions of the environment would in many ways have been different from those now existing in the sea. One suggestion of special interest that has been made[8] is that the concentration of carbon dioxide in the atmosphere, and hence also in natural waters, was very much greater than it is to-day. Free oxygen, indeed, may have been entirely absent, and all the free oxygen now present in the air may owe its existence to the subsequent splitting up of carbon dioxide by the action of plant life. With such possibilities of differences in the conditions in this and in so many other directions, may we not be well satisfied if, for the time, we can say that the formation of carbohydrates and proteids has been brought within the category of ordinary chemical operations, which can occur without the previous existence of living substance?

To return once more, however, to the free-swimming, autotrophic flagellate. In the early stages of its history the loss caused by sinking, and so getting below the influence of light and the possibility of further growth, must have been enormous. We may conceive a constant rain of dead and dying organisms falling into the darker regions of the sea, and thus a new field would be offered for the development of any slight advantages which particular individuals might possess. Under such conditions we may suppose that the holozoic or animal mode of nutrition first began in the absorption of one individual by another one, with which it had chanced to come into contact. If the one individual were more vigorous and the other moribund we should designate the process "feeding," and the additional energy obtained from the food might well cause the individual to survive. If the two individuals which coalesced were both sinking from loss of vigour, the combined energy of the two might make possible a return to the upper water layers, where, under the influence of light, growth and multiplication would proceed, and we should, I suppose, designate the coalescence "conjugation," or sexual fusion.

Other individuals, again, sinking in shallow water, would stick to solid objects on the sea-floor, while the flagellum continued to vibrate. The current produced by the flagellum under these conditions would draw towards the organism dead and disintegrating remains of its fellows, and again we should have ingestion and animal nutrition. At this stage we witness the definite passage from plant to animal life. A further stage is seen when a cup-like depression to receive the incoming particles of food is formed at the base of the flagellum, to be followed still later by a definite mouth.

The transformation from the plant to the animal mode of feeding can be seen in action by studying actual organisms which exist to-day. In the course of my work on the culture of plankton organisms there has flourished in the flasks, on several occasions, a small flagellate belonging to the group of chrysomonads, which was first described by Wysotzky under the name of *Pedinella hexacostata*, and to which I directed the attention of Section D at the Cardiff Meeting in 1920. The general form of Pedinella resembles that of the common Vorticella, but its size is much smaller. The body, which is only about 5μ in diameter, is shaped like the bowl of a wine-glass, and from the base of the bowl, which is the posterior end, a short, stiff stalk extends. From the centre of the anterior surface there arises a single long flagellum, surrounded at a little distance by a circle of short, stiff, protoplasmic hairs. Arranged in an equatorial ring just inside the body are six or eight brownish-green chromatophores or chloroplasts. In a healthy culture Pedinella swims about freely by means of a spiral movement of the flagellum, which functions as a tractor, the stalk trailing behind. The chromatophores are large, brightly coloured, and well developed, and the organism is obviously nourishing itself after the manner of a plant, like any other chrysomonad. But from time to time a Pedinella will suddenly fix itself by the point of the trailing stalk. The immediate effect of this fixing is that a current of water, produced by the still vibrating flagellum, streams towards the anterior surface of the body, and small particles in the water, such as bacteria, become caught up on the anterior surface, the ring of fine stiff hairs surrounding the base of the flagellum being doubtless of great assistance in the capture of this food. One can clearly see bacteria and small fragments of similar size engulfed by the protoplasm of the anterior face of the Pedinella and taken into the body. The organism is now feeding as an animal. In some of the cultures in which bacteria were very plentiful nearly all the Pedinella remained fixed and fed in the animal way, and when this was so the chromatophores had almost disappeared, though they could still be seen as minute dark dots. We can, as it were, in this one organism, see the transition from plant to animal brought about by the simple process of the freely swimming form becoming fixed.

In the group of dinoflagellates, also—the group to which the naked and armoured peridinians belong—

[7] "Treatise on Zoology," Part I., Introduction. London, 1909.

[8] Carl Snyder, "Life without Oxygen," *Science Progress*, vol. vi., 1912, p. 107.

the same transition from plant to animal nutrition can be well followed by studying different members of the group. In heavily armoured forms, with a rich supply of chromatophores, nutrition is chiefly plant-like or holophytic. In those with fewer chromatophores there is, on the other hand, often distinct evidence of the ingestion of other organisms, and nutrition becomes partly animal-like. Among the naked dinoflagellates such holozoic nutrition is very much developed, and in many species has superseded entirely the earlier method of carbonic acid assimilation.

It is surprising how many structural features found in higher groups of animals make their first appearance in these naked dinoflagellates in conjunction with this change of nutrition, and we seem to be led directly to the metazoa, especially to the cœlenterata. In Polykrikos there are well-developed stinging cells or nematocysts, as elaborately formed as those of Hydra or the anemones. In Pouchetia and Erythropsis well-developed ocelli are found, consisting of a refractive, hyaline, sometimes spherical lens, surrounded by an inner core of red pigment and an outer layer of black; the whole structure is comparable to the ocelli around the bell of a medusa. In Noctiluca and in the allied genus Pavillardia a mobile tentacle, which is doubtless used for the capture of food, is developed. Division of the nucleus, with the formation of large, distinct chromosomes, has also been described in several of these dinoflagellates. With the tendency of the cells in certain species to hold together after division and form definite chains we seem to approach still nearer to the metazoa, until, finally, in Polykrikos we reach an organism which may well have given rise to a simple, pelagic cœlenterate. It is difficult to resist the suggestion put forward by Kofoid[9] in his recent monograph, that if to Polykrikos, with its continuous longitudinal groove which serves it as a mouth, its multicellular and multinucleate body and its nematocysts, we could add the tentacle of Noctiluca, and perhaps also the ocellus of Erythropsis, "we should have an organism whose structure would appear prophetic of the cœlenterata and one whose affinities to that phylum and to the dinoflagellata would be patent." Or it may be that the older view is the correct one here, and that the first cœlenterate came from a spherical colony of simple holozoic flagellates, arranged something on the plan of Volvox, in which the posterior cells of the swimming colony, in the wake of which food particles would collect, had become more specialised for nutrition than the rest.

As a purely plankton organism, swimming freely in the water, the progress of the cœlenterate was not great, and reached, so far as we know, no further than the modern ctenophore. The ctenophore seems to represent the culminating point of the primary progression of pelagic animals, which derived directly from the autotrophic flagellate. Further evolution was associated with an abandonment of the pelagic habit by a cœlenterate-like animal, and the establishment of a connexion with the sea-bottom, either by fixing to it, by burrowing in it, or by creeping or running over it. At a later stage many of the animals which had become adapted to these modes of life developed new powers of swimming, and thus gave rise to the varied pelagic life which we find in the sea to-day; but this must be regarded as secondary, the primary pelagic life, so far as adult animals were concerned, having ended with the evolution of the ctenophore.[10] Such is the teaching of embryology, the history of the race being conjectured from the development of the individual. In group after group of the animal kingdom, when the details of its embryology become known, the indications are the same—first the active spermatozoon, reminiscent of the plankton flagellate, then the pelagic larval stage, recalling the cœlenterate, and then a bottom-living phase.

It is in a ctenophore-like ancestor that we find the line of development to higher animal groups, and this ancestor must have been at one time widely distributed in the seas. Its immediate descendants are familiar to every zoological student in the well-known series of pelagic larval forms. Müller's larva, taking to the bottom, and in its hunt for food gliding over hard surfaces with its cilia, led to the flatworms; the Pilidium, developing a thread-like body and creeping into cracks and crevices to transfix its prey, gave rise to the nemertines. A trochophore, burrowing in soft mud and sand, developed a segmented body which gave it later the power of running on these soft surfaces, and became an annelid worm. Another trochophore, developing a broad, muscular foot, crept on the sand, and afterwards buried itself beneath it as a lamellibranchiate mollusc, or migrated on to harder surfaces as the gastropod and its allies. Pluteus, Bipinnaria, Auricularia, first fixing, as the crinoids still do, and developing a radial symmetry, afterwards broke free and wandered on the bottom as sea-urchin, star-fish, and cucumarian. Tornaria developed into Balanoglossus, the structure of which hints to us that the ascidians and vertebrates came from a similar stock. All the phyla thus represented derive directly from the free-swimming ctenophore-like ancestor, and only one considerable group, the arthropods, remains unaccounted for. The evolutionary history of an arthropod is, however, not in doubt. Its marine representatives, the trilobites and Crustacea, came directly from annelids, which, after their desertion of a pelagic life to burrow in the sea-floor and run along its surface, again took to swimming, and not only stocked the whole mass of the water with a rich and varied life of copepods, Cladocera, and schizopods, but gave rise to amphipods, isopods, and decapods, groups equally at home when roaming on the bottom or swimming above it.

Another important addition to the pelagic fauna we should also notice here. From the molluscs, creeping on solid surfaces, sprang a group of swimmers, the cephalopods, which have grown to sizes almost unequalled amongst the animals of the sea.

All these invertebrate phyla had become established and most of them had reached a high degree of development in the seas of Cambrian times. Among animals then living there are many which have survived with little change of form until to-day. One is almost tempted to suggest that the life which the sea itself

[9] Kofoid and Swezy, "The Free-living Unarmoured Dinoflagellata." Mem. Univ. California, 1921.

[10] There is perhaps a possibility that further knowledge of the embryology of Sagitta and its allies might make it necessary to modify this suggestion.

could produce was then reaching its summit and becoming stabilised. Since Cambrian times geologists tell us some thirty million years[11] have passed, a stretch of time which it is really difficult for our imaginations to picture. During that time a change of immense moment has happened to the life of the sea; but if we read the signs aright, that change had its origin rather in an invasion from without than in an evolution from within. From whence came that tribe of fishes which now dominates the fauna of the sea? It would be rash to say that we can give any but a speculative reply to the question, but the probable answer seems to be that fishes were first evolved not to meet conditions found in the sea, but to battle with the swift currents of rivers, where fishes almost alone of moving animals can to this day maintain themselves and avoid being swept helplessly away.[12] It was in response to these conditions that elongate, soft-bodied creatures, which had penetrated to the river mouth, developed the slender, stream-lined shape, the rigid yet flexible muscular body, the special provision for the supply of oxygen to the blood to maintain an abundant stock of energy, and all those minute perfections for effective swimming that a fish's body shows. The fact that many sea fishes still return to the rivers, especially for spawning, supports this view, and it is in accordance with Traquair's classical discoveries of the early fishes of the Scottish Old Red Sandstone, which were for the most part fresh- and brackish-water kinds.

Having developed, under the fierce conditions of the river, their speed and strength as swimmers, the fishes returned to the sea, where their new-found powers enabled them to roam over wide areas in search of food, and gave them such an advantage in attack and defence that they became the predominant inhabitants of all the coastal waters, and as such they remain to-day.

The other great migration of the fishes, also, the migration from the water to the land, giving rise to amphibians, reptiles, birds and mammals, must not be left out of account. The whales, seals, and sea-birds which, after developing on land, returned again to the waters and became readapted for life in them, are features which cannot be neglected.

And so we are brought to the picture of life in the sea as we find it to-day. The primary production of organic substance by the utilisation of the energy of sunlight in the bodies of minute unicellular plants, floating freely in the water, remains, as it was in the earliest times, the feature of fundamental importance. The conditions which control this production are now, many of them, known. Those of chief importance are (1) the amount of light which enters the water, an amount which varies with the length of the day, the altitude of the sun, and the clearness of the air and of the water; (2) the presence in adequate quantity of mineral food substances, especially nitrates and phosphates; and (3) a temperature favourable to the growth of the species which are present in the water at the time. Experiments with cultures of diatoms have shown clearly that if the food-salts required are present, and the conditions as to light and temperature are satisfactory, other factors, such as the salinity of the water and the proportions of its constituent salts, can be varied within very wide limits without checking growth. The increased abundance of plankton, especially of diatom and peridinian plankton, in coastal waters and in shallow seas largely surrounded by land, such as the North Sea, is due to the supply of nutrient salts washed directly from the land by rain or brought down by rivers. An exceptional abundance of plankton in particular localities, which produces an exceptional abundance of all animal life, is also often found where there is an upwelling of water from the bottom layers of the sea. These conditions are met with where a strong current strikes a submerged bank, or where two currents meet. Food-salts which had accumulated in the depths, where they could not be used owing to lack of light, are brought by the upwelling water to the surface and become available for plant growth. The remarkable richness of fish life in such places as the banks of Newfoundland and the Agulhas Banks off the South African coast, each of which is the meeting-place of two great currents, is to be explained in this way.

Attention has already been directed to the suggestion that fishes developed their remarkable swimming powers in rivers in response to a need to overcome the currents, and that they returned afterwards to the sea, where they preyed upon a well-developed and highly complex invertebrate fauna already fully established there. Their speed enabled them to conquer their more sluggish predecessors, while they themselves were little open to attack. With the exception of the larger cephalopods, which are of comparatively recent origin, and were probably evolved after the arrival of the fishes, there are few, if any, invertebrates which capture adult fishes as part of their normal food. Destructive enemies appeared later in the form of whales and seals and sea-birds, which had developed on the land and in the air.

And now in these last days a new attack is made on the fishes of the sea, for man has entered into the struggle. He came first with a spear in his hand; then, sitting on a rock, he dangled a baited hook, a hook perhaps made from a twig of thorn bush, such as is used to this day in villages on our own east coast. Afterwards, greatly daring, he sat astride a log, with his legs paddled further from the shore, and got more fish. He made nets and surrounded the shoals. Were there time we might trace step by step the evolution of the art of fishing and of the art of seamanship, for the two were bound up together, till the day when the trawlers and drifters kept the seas for the battle fleet.

There can be little doubt that in European seas the attack on the fishes in the narrow strip of coastal water where they congregate has become serious. A considerable proportion of the fish population is removed each year, and human activity contributes little or nothing to compensate the loss. We have not, however, to fear the practical extinction of any species of fish, the kind of extinction that has taken place with seals and whales. Fishing is subject to many natural limitations, and when fishing is suspended recovery will be rapid. There is evidence that such recovery took place in the North Sea when fishing was restricted by the war, though the increase which was noted is perhaps not certainly outside the range of natural

[11] Osborn, "Origin and Evolution of Life," 1918, p. 153.
[12] Chamberlin, quoted in Lull, "Organic Evolution," New York, 1917, p. 462.

fluctuations. Until the natural fluctuations in fish population are adequately understood, their limits determined, and the causes which give rise to them discovered, a trustworthy verdict as to the effect of fishing is difficult to obtain.

If such problems as these are to be solved the investigation of the sea must proceed on broadly conceived lines, and a comprehensive knowledge must be built up, not only of the natural history of the fishes, but also of the many and varied conditions which influence their lives. The life of the sea must be studied as a whole.

The Efficiency of Man and the Factors which influence it.[1]

By Prof. E. P. CATHCART, M.D., D.Sc., F.R.S.

THE subject of my address—the efficiency of the human organism and the factors which influence this efficiency—is, in my opinion, one of the most important problems of the present day. It is a problem which cannot, however, be considered only from its physiological aspect if it is to receive adequate consideration; its implications are much wider, reaching right down to the very basis of our daily lives. As I am no expert in industry or economics, I shall confine my attention so far as possible to the problem from the physiological side, and leave to others the sociological application.

The term "efficiency" has become a mere catchword, bandied about by people who have not the faintest idea of what the word connotes. Practically it has come to mean, to the average man in the street, the mythical improvement which is to be anticipated from some change in workshop or office organisation—a bigger and better result at a smaller cost. The word has a very definite meaning in engineering science, and this meaning has been transferred from the inanimate machine to the living organism. In the case of the engine, the problem is relatively simple, as the number of interfering factors is not great, but the solution of the problem in the case of the organism is beset with many difficulties, as the interfering factors are numerous and varied. Two types of efficiency are spoken of in connexion with the animal body. One type is the mechanical efficiency in the engineering sense, *i.e.* the ratio which exists between the heat equivalent of the external muscle work done and the energy output of the subject during the performance of the work in question. This is a problem which has attracted many workers, and there seems to be a general consensus of opinion that the efficiency of man in the performance of external work is about 20 per cent. gross and 25 per cent. net. The other type of efficiency is that which is called industrial or productive efficiency, where the capacity of the individual to perform effective work is dealt with, judging the capacity of the individual by, for example, his output in unit time. So far as the worker himself is concerned, the whole object in industrial efficiency is undoubtedly to get the greatest output with the minimum of effort. The determination of the mechanical efficiency is fairly readily carried out, but it is very difficult to get an accurate gauge of the industrial efficiency. At bottom they are closely related, and both are physiological problems.

The leaders of industry have not been slow to accept and utilise the gains of science in the realm of inanimate things, but they have been slow to recognise the fact that there is a science of physiology which deals with the man who controls the productive machinery. New inventions may completely revolutionise shop equipment, good machines may be replaced by better, and better by still better, but man remains almost as immutable as the ages. Physiological evolution is infinitely slow, and man has not yet become "an affectionate machine-tickling aphid."

It is but a little more than a hundred years since this country was industrialised, and we are still reaping the aftermath of the terrible conditions which then reigned, when the great centres of industry were swamped with country dwellers who poured into the towns in the race for wealth. Few realise the hopelessly unphysiological conditions which developed in the methods of work, the hours and conditions of work, the housing. The following citation from Robert Owen gives a good idea of the conditions ruling in the early years of last century in one of our staple industries: "In the manufacturing districts it is common for parents to send their children of both sexes at seven or eight years of age, in winter as well as summer, at six o'clock in the morning, sometimes, of course, in the dark, and occasionally amidst frost and snow, to enter the manufactories which are often heated to a high temperature, and contain an atmosphere far from being the most favourable to human life, and in which all those employed in them very frequently continue until twelve o'clock at noon, when an hour is allowed for dinner, after which they return to remain, in a majority of cases, till eight o'clock at night." Six till eight, with a break of one hour: a fourteen hours' day, and fifteen was not unknown. Owen, in the article from which I have quoted, was petitioning Parliament, asking what? That a twelve hours' day be instituted, to include one and a half hours for meals, and that no child should be employed until the age of ten was reached. He pointed out in the course of the article that the results from the manufacturers' point of view would be better with a twelve hours' day (*i.e.* that the industrial efficiency, in modern words, would be improved).

Yet we wonder that the offspring of stock descended from workers under these conditions, which certainly improved as the century advanced, but were far from ideal, gave the high yield of C3 lads recorded in the National Service Report. We might have been prepared for the disclosure, as the pre-war records of countries with conscription showed that the number of rejections for the Army of town and factory workers was far in excess of those for men drawn from country districts. But evidence of the state of the national

[1] From the presidential address delivered to Section I (Physiology) of the British Association at Hull on Sept. 8.

physique is not confined to these war figures. Sir George Newman, in his valuable and interesting Report on Preventive Medicine, has directed attention to the enormous amount of time which is annually lost through sickness. The minimum average amounted to 14,295,724 weeks (or a period upwards of 270,000 years) of sickness per annum, and this figure did not include absence from work due to maternity benefit, sanatorium treatment, or absence for less than four days per patient. This is the evidence of the National Health Insurance.

The design of the organism which has to stand the strain is not at fault. It is an organism which, in the language of the engineer, is abundantly supplied with factors of safety, and has an over-all high factor of safety. The body is not designed merely to perform the minimum amount of work or to stand the minimum strain; there is always a reserve. The perfect co-ordination of the different parts of the organism is required, because the human being is capable of intense muscular exertion for short periods. The intensity of the work is, as a general rule, inversely proportional to the length of time during which it must be carried out.

If, in the human organism, we were concerned merely with the co-ordinated action of a series of effectors, with the capacity of a certain group of muscles to perform a given amount of work, the solution of the problem would be relatively simple. But we are dealing with a living organism, capable not only of doing work, but of repairing the worn-out parts, as and when required. Further, we are dealing with an organism which varies not only in its capacity to perform work, but in its "will to work." We are dealing with a subtle organism which has a whole series of protective mechanisms at its command, an organism which can be fatigued and rendered useless, as a working unit, by an amount of work on a particular day which on another day it can perform with the utmost ease and without apparent fatigue.

The efficiency of a man is not merely dependent on the amount of work which can be performed by his muscles; the circulatory, respiratory, and nervous systems are of equal importance, and all are intimately related. In spite of the many and varied stresses and strains to which the organism is subjected in the course of life, as the result of the many factors of safety, unless the overloading is excessive, too frequent or too long continued, the organism, so long as it remains physiological, is practically unaffected by ordinary hard work.

If we turn now to the consideration of the factors which influence the efficiency, both in the mechanical and the industrial sense, we find that the main controlling factor is undoubtedly the condition known as fatigue. Fatigue is a word just as frequently used as efficiency, and yet it is almost impossible to give an accurate definition of the term. Generally speaking, it is to be regarded as the antithesis of efficiency.

The study of the metabolism has given little or no clue so far to the real nature of fatigue. Benedict and I carried out a certain amount of experimental work on this phase of the question. Our results show that the subject may be on the very verge of absolute collapse, and yet, so far as the metabolic determination goes, there is no very marked evidence of diminished efficiency in a mechanical sense. In an experiment with M. A. M., who, in the post-absorptive state, rode on a bicycle ergometer for nearly four and a half hours until on the verge of collapse, doing 208,000 kilogrammetres of external work during the time, the metabolism was determined six times during the riding period with the following result:

TABLE I.

Time.	Oxygen Consumption per min. in c.c.	Rate of Work, revs. per min.	Net Efficiency in per cent.
8.30 A.M. (start)			
9.00 ,, . .	1967	91·3	23·1
9.45 ,, . .	1946	91·4	23·3
10.30 ,, . .	1969	91·7	23·2
11.15 ,, . .	1948	90·3	23·2
12.00 noon . .	2003	89·0	21·7
12.45 P.M. . .	1899	78·2	21·3

It will be noted, as might be expected, that there is some slowing of the rate at which the work is done, but the diminution in the net efficiency, in spite of the fact that the subject admitted he was completely done at the conclusion of the last determination, is not striking.

Obviously, then, the capacity to carry on is limited by the genesis of fatigue. But it is equally obvious in practice that a man may be engaged in strenuous labour for many hours without acute signs of impending exhaustion. How is this condition attained? There are at least four factors which, to my mind, play predominant rôles in the attainment of maximum efficiency, namely, the rate of the performance of work, the amount of rest offered or taken by the subject, the rhythm with which the work is performed, and the work habits developed by the worker. Although I shall attempt to examine each of these factors separately, it is not to be inferred that they can really be considered as independent phenomena. As a matter of fact, they are all intimately related, and usually merge into one another.

Of these four factors probably most attention has been devoted to the rate or speed at which work is carried out. Benedict and I found, for example, working with a carefully calibrated bicycle ergometer, that there was a very close connexion between the speed at which work was done and the mechanical efficiency. There was a very definite falling off with increased speed, as the following table shows. Unfortunately it was impossible to get our subject to pedal slower than 70 revolutions per minute.

TABLE II.

Revolutions per min.	Gross Efficiency.	Revolutions per min.	Gross Efficiency.
70	20·6	110	17·6
80	20·0	120	16·9
90	19·2	130	16·1
100	18·4	..	..

We found further that if the amount of effective muscular work done was kept constant, that the efficiency fell with an increase of speed. Thus with effective work equivalent to 1·95 calories performed at the rate of 90 and 124 revolutions per minute respectively, with the lower speed the net efficiency was 22·6 per cent., whereas with the higher speed it fell to 15·7 per cent. Or again, with effective work of 1·58 calories at 71 and 108 revolutions per minute, the efficiency was 24·5 per cent. and 15·6 per cent. respectively; and finally, with effective work of 1·35 calories at speeds of 71, 94, and 105, the efficiencies were 23·1, 20·4, and 17·0 per cent.

A. V. Hill has also recently dealt with this problem in a most interesting piece of work, where the activity was strictly confined to the biceps and the brachialis anticus. He demonstrated very clearly that, in spite of the fact that the slower the contraction the greater was the amount of work done, all the advantage thus gained was rapidly neutralised and dissipated as the result of the slow contraction necessarily causing an increased degradation of energy in the way of physiological changes resulting from the maintenance of contraction. It thus followed that a slow contraction, powerful though it might be, was not necessarily one of high efficiency. Hill found that the maximum efficiency was very rapidly attained, the optimum for the muscles investigated being apparently just less than one second, but the fall which followed, as the duration of the contraction increased, was a comparatively slow one. On account, therefore, of the blunt nature of the curve, the efficiency remained more or less constant over a wide range of speeds.

The load has obviously a direct connexion with the speed at which work is done, but it has also a relation to efficiency. Benedict and I found, for example, that both the gross and net efficiencies within the limits of our experiments increased with the load. The probable explanation of this result is that when light work is carried out, maintenance or physiological requirements which have to be covered form a large proportion of the total energy output, a balance which is steadily altered as the amount of external effective work done increases.

On the other hand, when the loads become excessive there is a definite falling off, both in gross and net efficiencies. Laulanié, who also investigated this question, found that at voluntarily selected speeds, with steadily increasing load, the external work done rose with decreasing speed until the load became excessive. He maintained that there were two optima, (*a*) an economic optimum at 4 kilo. load with high efficiency and a low oxygen consumption per kilogrammetre, and (*b*) a mechanical optimum between 8 and 12 kilo. load when the output in unit time was highest. The following table from Laulanié makes his point clear:

Table III.

Resistance in kilos.	1	2	3	4	5	6	8	10	12	15
Speed adopted, metres per sec..	1·49	1·07	0·80	0·61	0·54	0·44	0·37	0·29	0·24	0·13
Work done, kilogrammetres per 5 min.	448	642	726	778	812	853	896	905	906	570
Oxygen intake in c.c. per kgm.	3·5	2·44	2·17	2·14	2·23	2·25	2·43	2·53	3·12	5·31
Efficiency per cent.	14·1	[20·4	22·9	23·3	22·3	22·1	20·4	19·7	17·0	9·4

It will be noted that when the load becomes excessive the efficiency rapidly falls away. This means that, although the effort may be continued as strenuously as before, and although the physiological cost of the effort remains at a very high level, the amount of external work done is reduced to a very low figure. The static element in the muscular effort has become dominant, and static expenditure is parasitic on dynamic work. The more static the work becomes the greater is the fall in the efficiency. Personally I am of the opinion that the severity of muscular work, *qua* the organism as a whole, is a function of the static component of the effort made. Fatigue, *i.e.* inability to carry on, is more readily induced by static work than by either positive or negative work. The following figures, from experiments which I have carried out with Miss Bedale and G. McCallum, show clearly this diminution in efficiency as the static element in the work is increased:

Table IV.

Pulls per min.	Kgm. per min.	Cost in grm. cals. per kgm. p. sq. m.	Net Efficiency per cent.
32	40	16	8·0
12	15	17	7·5
6	7·5	20	6·0
4	5·0	31	3·0+
3	3·75	38	3·0
2	2·5	68	2·0−
1	1·25	146	1·0

Very closely allied with the rate of working is the rhythm with which the work is performed. Although they are not identical phenomena, they are so closely related that the habit of work may be considered along with rhythm. Every one is well aware that once a rhythm, or the proper co-ordination in the play of a set of muscles in the performance of some definite act, is mastered, not only is the energy expenditure reduced by the exclusion of numerous extraneous muscular activities, but there is an actual enhancement of the ease with which we perform the specified act. It is not a mere question of rate. In a series of experiments which I carried out with Burnett, the subject, working on a specially geared ergometer, was allowed to select his own rate of working, the load being varied from nothing to 4 kilos. At each change of load the subject was directed either to work rapidly or very slowly, and after a period of such work was told to adopt the rate he liked best. As the following table (Table V.)

Table V.

Load in kilos.	Rate of Work per min. voluntarily selected.			
	Exp. I.	Exp. II.	Exp. III.	Exp. IV. (Immediately after 1 hour's work at rate of 45 per min.)
0	78	80	83	..
1	80	79	79	71
2	81	80	81	..
3	80	78	83	73
4	82	77	78	..

shows, the rhythm of work was practically identical for all loads. This occurred under all conditions, provided the working spells were not of too long duration. If the work were continued over a long period, the rhythm tended to alter, to increase in speed, and if the subject became really tired, periods of rapid movement alternated with periods of slow movement.

The rhythm adopted, although it may suit the worker, is not of necessity the series of muscle movements which lead to the least expenditure of energy.

Most probably the rhythm selected is only in small part due to the worker's physical configuration; in greater part it is evolved in imitation of some more experienced or older worker. The average workman is not so much concerned with the diminution of the physiological cost in the performance of a given act as in the reduction of conscious effort. It is not, of course, suggested that the methods adopted by workers independently are the perfect methods, and that proper investigation will not discover better and easier methods of performing certain given operations. If newer and more economical methods are to be developed and brought into operation, the only real chance will be to segregate the newer young workers.

There is good evidence, that of Muscio, for example, that both resting and working, in addition to the individual muscle rhythm, there is a definite variation in the course of the day in the capacity to carry out work; that, in other words, a diurnal rhythm exists. There is a certain amount of evidence also in favour of the view that a seasonal rhythm exists. Further, when efficiency is measured in terms of output, it is found that there is a definite rhythm in output during the course of the working day and of the working week. This type of curve is not peculiar to any one industry. The total weekly output curve with the low Monday effect and the sharp fall on Saturday resembles in general shape the daily output curve. The main point about these curves is that they seem to demonstrate the absence of progressive fatigue from overwork, which would have been deduced had there been a sharp rise at the commencement of the week, followed by a steady fall.

The third of the potent factors in the control of fatigue is rest. If work is done, rest is ultimately imperative. Rest not merely relaxes the muscle, allowing a more thorough and complete removal of the waste products and a more abundant supply of oxygen, but it removes the strain of attention. Rest is best obtained, not by simple quiescence, but by change of posture; slow movement of another type to that which produced the fatigue will, unless the organism is tired practically to complete exhaustion, give the most beneficial results.

So far, little attention has been paid to the duration of the rest period in relation to the work done. As a general rule, it may be said that, in the majority of occupations, although the hours of labour are continuous, the actual spells of hard manual work are discontinuous, either due to the fact that certain operations are intermittent in their severity, that supplies of material are not constant, or that, if these more or less natural conditions do not operate, rests at irregular intervals are deliberately taken by the operative. So far as I am aware there is only one type of hard work where a definite rest period is laid down as part of the exercise, namely, in Army route marching.

So much, then, for the ordinary effector factors. There are many other factors directly concerned with the efficient action of the organism, some directly influencing the internal economy of the body, others acting more indirectly on the organism from the environment.

One of these factors is the state of the nutrition. It may be definitely stated that an insufficient intake of food or the consumption of poor or inadequate food is one of the chief sources of general inefficiency. The capacity of the body to store reserve food material which will meet the daily demands for energy and leave a surplus is another of the vital factors of safety. The much more important problem is unfortunately only too common, the influence of chronic undernutrition, a condition which lowers efficiency, not merely in the actual performance of muscular work, but by inducing an increased susceptibility to disease. This is a question which has never received the attention which its importance demands, largely on account of the immense difficulties of carrying out the investigation in a practical manner. As the direct result of the war, we have the records of at least two sets of observers. Benedict and his co-workers investigated the problem, using a group of twelve men, comparing them with a similar group drawn from the same class. In the experimental group the food intake was reduced, so that there was a loss of 12 per cent. of the body weight. Although the experiment was carried on for more than four months, the diminution in muscle power, so far as laboratory tests were concerned, was not great. The subjective impression, however, of the subjects was that they felt weaker and less capable.

The other recorded experiment is that of the condition in Germany during the war years. A general statement of the effects of the blockade is contained in a long document prepared by the German Government (dated December 1918). Admittedly the document was prepared for a specific purpose; but, after making all allowances, the record of the far-reaching effects of chronic underfeeding is valuable. Apart from the increased death rate, the increased liability to disease, and the slow recovery from the attacks of disease, the document definitely states that the working capacity of the people was reduced by at least one-third. Evidence would also indicate that it is not only the quantity but the quality of the food consumed which plays a part in the fitness of the individual to perform hard muscular work.

Another factor which plays an enormous rôle in the general efficiency is the response of the organism to the multiple psychic imponderabilia which compose such a large part of the average environment. When we are dealing with the efficiency of the human organism, male and female, we are dealing with individuals whose performance is neither uniform throughout the year nor from week to week, nor even from hour to hour. We have to deal with an organism, as I have already mentioned, which is not only under physical control, but is very responsive to psychic influences. Man is, in the main, a psychic chameleon.

In this connexion monotony of work must be considered. Although there may be a close relationship between monotony and fatigue, as generally recognised, they are not identical. The temperament of the operative plays an enormous part in determining whether or no any particular operation is a monotonous one. As Munsterberg has shown, it is extremely difficult, if not impossible, for an outsider to determine what is a monotonous operation.

There are many other factors which play a definite and important rôle in the maintenance of efficiency, such as lighting, heating, ventilation, the mode of life led by the worker outside his definite hours of labour, his housing, etc. Many of these factors have been partially examined. Thus Leonard Hill has carried out a great deal of valuable work on the influence of the cooling power of the air. Vernon has collected much interesting evidence, which shows that there is a very definite relation between the efficiency, as measured by output, and the temperature of the working place. The output in the hottest weather was about 30 per cent. below that when the weather was coldest. He also observed an apparent connexion between the relative humidity of the air and the efficiency of the worker. The efficiency, as might have been expected, was apparently greatest when the relative humidity was low. Elton has reported on the influence of lighting in silk weaving. He found that the output was lowest when artificial light was used. He stated that even when electric light of sufficient intensity was used, the output was about 10 per cent. lower than the daylight value. The actual equipment of the factories, the provision of seats of suitable size, height, etc., the design of the machines, and so on, all play their part, as is shown by the many records, particularly from the United States.

In other words, the real over-all industrial efficiency of the worker cannot be causally related to any single factor. It is not the mere capacity of the individual to perform so many kilogram-metres of work in a given time with the smallest expenditure of energy. The quest of efficiency calls for the closest and most intimate co-operation between the scientific investigator, the employer, and the employee, and it can only be satisfactorily attacked when mutual distrust of motives, capacities, and methods is stilled.

The Total Solar Eclipse of September 21.

By Dr. A. C. D. Crommelin.

THE failure of the Christmas Island eclipse expedition is a great astronomical disappointment. Messrs. Jones and Melotte have devoted ten months or more to it, and hoped to secure useful photometric results for connecting the northern and southern stellar magnitude scales in addition to the eclipse work. The climate, however, proved unexpectedly unfavourable, and practically nothing could be done.

On the other hand, the conditions appear to have been ideal right across Australia, and enthusiastic reports have come from Wollal (West Coast), Cordillo Downs (centre), and Goondiwindi and Stanthorpe (Queensland). The Einstein problem was studied at Wollal by the Lick Observatory party under Prof. Campbell, and that from Toronto under Prof. Chant. Mr. Evershed also finally selected this station in preference to the Maldives, and is believed to have undertaken the same investigation, in addition, doubtless, to spectroscopic work. Prof. Dodwell, the Government Astronomer at Adelaide, had the use at Cordillo Downs of a tower telescope lent by the Lick Observatory for the Einstein problem; the New South Wales astronomers were in Queensland and did some spectroscopic work; they intended also to make Einstein investigations, but the telegrams do not allude to these.

It is well to point out that the test of the Einstein theory does not depend wholly on the results of this eclipse. The plates secured in the 1919 eclipse at Principe and Sobral settled definitely that at least the half-shift was present, while the two cameras with the best definition gave values very close to the Einstein value. Further, the star-field in that eclipse was the best along the whole extent of the ecliptic, the stars in the present eclipse being much fainter. There are, however, two circumstances that should add weight to this eclipse: (1) that some of the observers were pointing directly on the stars, avoiding the use of a cœlostat or other mirror; (2) that the plan was being tried of photographing another star-field *during totality*, thus obtaining an independent scale-value for the plates, which gives a much larger coefficient to the Einstein displacement in the equations of condition.

Probably weeks or months must elapse before the Einstein results are to hand.

The corona is said to have had four long streamers, one extending to three solar diameters, which is more than the average, though by no means a record.

Prof. Chant reports that the shadow bands were photographed. Prof. Kerr Grant, of Adelaide University, made measures at Cordillo by the photo-electric cell of the relative brightness of the sun and the corona. The results, with this very sensitive instrument, should be more trustworthy than previous determinations.

The next two total eclipses (1923, September, and 1925, January) are visible in the United States; 1926, January, in Sumatra, etc., and 1927 in England and Norway.

Obituary.

Prof. Alexander Smith.

ALEXANDER SMITH, emeritus professor of chemistry in Columbia University, New York, died in Edinburgh on September 8, aged fifty-seven. Smith was born in Edinburgh, and entered the University there in 1882, where he studied mathematics under Chrystal, natural philosophy under Tait, and chemistry under Crum Brown, graduating as B.Sc. in 1886. During the following three years he attended the University of Munich, working in Baeyer's laboratory, chiefly under the direction of Claisen, and obtained the degree of Ph.D. in 1889.

After a year spent as assistant in the chemistry department of the University of Edinburgh, Smith was offered the chair of chemistry and mineralogy in Wabash College, Indiana, a post which he held for four years. In 1894 he became assistant professor of chemistry in the University of Chicago, and rose through intermediate grades to that of professor and director of general and physical chemistry in 1903. Here his extraordinary gifts as organiser and teacher found ample scope. His "Laboratory Outline of General Chemistry" was published in 1899, since when at short intervals new text-books or new editions flowed from his pen. Each book had in view the requirements of students of a definite stage of development, and all were characterised by an orderliness of method, combined with an originality of thought, which have made them popular not only throughout the English-speaking world but also as translations in almost every country where science is studied. An even wider field was offered to him in the principal chair of chemistry in Columbia University in the City of New York, where he became director of the department of chemistry. Here he may be said to have revolutionised the methods of teaching and the organisation for chemical research.

Smith at the outset of his career was an organic chemist, and until 1902 his published papers are all concerned with organic topics, chiefly the chemistry of diketones, the benzoin reaction, and, generally, the action of potassium cyanide as a condensing agent. After 1902 his work is inorganic and physico-chemical, the physical character of his investigations becoming more and more marked with the lapse of years. An admirable series of papers on the liquid and amorphous modifications of sulphur formed the first-fruits of his cultivation of this new field. Chiefly in conjunction with A. W. C. Menzies, now professor of chemistry at Princeton, Smith published a long series of papers on vapour pressures, many new devices for their exact measurement and for the measurement of boiling-points under standard conditions being described. Among the valuable data obtained may be noted the exact determinations of the vapour pressure of mercury from 250° to 435° C. The vapour pressures of dissociating substances such as ammonium chloride, calomel, and phosphorus pentachloride were also measured and discussed, particularly in connexion with the unexpected values obtained when the substances were perfectly dry. His scientific merit was recognised by his election to membership of the National Academy of Sciences, and to the Presidency of the American Chemical Society. In 1919 the honorary degree of LL.D. was conferred upon him by the University of Edinburgh.

Smith was a most genial personality, a pleasant companion, and a delightfully amusing talker. He was filled to overflowing with energy, which in the end proved his undoing. A breakdown owing to overwork, complicated by a serious operation, forced him after a year's leave to relinquish his chair, and his death at a comparatively early age deprives his science of a great teacher whose name will not soon be forgotten.

J. W.

DR. SOPHIE BRYANT.

BY the death of Dr. Sophie Bryant in the Alps last month the educational world has lost a great personality. As mathematician, philosopher, Irish patriot, suffragist, and, above all, as a teacher and pioneer in education, she had gained distinction in so many fields that it is difficult to give any adequate account of her in a few paragraphs.

Mrs. Bryant in her own person gave the lie to the old conception of the unwomanly "bluestocking." Her greatness of intellect was shot through with a warmth of genial humanity and an endearing charm that those who knew her can never forget. She came of a scholarly stock: her father, Dr. Willock, a clergyman of the Church of Ireland in Co. Fermanagh, worked in the cause of education there. After his death the family moved to London, and his brilliant daughter distinguished herself by obtaining, at the age of sixteen, first-class honours in the Senior Cambridge Local Examination, with distinction in mathematics, and an Arnott scholarship at Bedford College. It was only after her marriage and early widowhood that she became acquainted with Miss Buss, and, having joined the staff of the North London Collegiate School in 1875, was one of the first to take advantage of the opening of London University degrees to women. After matriculating in honours in 1879 (with the distinction of being placed second on the list), in two years she had obtained the B.Sc. with honours in mathematics and moral science, and three years later was the first woman to gain the doctor's degree of London University, her subject being mental and moral science. She used to relate an amusing story about this:—one of the two examiners wrote to his colleague, "There's a very good man in;" the other, who knew Mrs. Bryant, replied, "Your man's a woman!"

Ten years later, in 1894, Mrs. Bryant was appointed to sit on the Royal Commission for Secondary Education, of which Lord Bryce was chairman. In 1900 she became a member of the Consultative Committee of the Board of Education, and in the same year took her seat on the Senate of London University. From 1908 to 1914 she was a member of the London Education Committee.

During all this time she was, in a very real sense, a "guide, philosopher, and friend" to her pupils at the North London Collegiate School; the writer of this article is one of many whose debt to her in this respect is beyond all reckoning. When in 1895 Mrs. Bryant succeeded Miss Buss as head-mistress, her mathematical teaching perforce devolved to a large extent on her colleagues, but she remained the guiding moral force in the school, *ex*plicitly through her Scripture lessons and weekly addresses, but *im*plicitly in all that she did. She was a pioneer in the revitalising of Scripture teaching, bringing to bear on religious instruction the same psychological insight and width of outlook by which she and her fellow-reformers brought life into the dry bones of the educational curriculum. Of this work she has left a permanent memorial in her books: "The Teaching of Morality in the Family and the School," "The Teaching of Christ in Life and Conduct," "How to read the Bible in the Twentieth Century," "Moral and Religious Education."

Mrs. Bryant was a devoted Irishwoman, and perhaps no honour pleased her more than the degree of doctor of literature, *honoris causa*, bestowed upon her by Trinity College, Dublin, when first it opened its degrees to women. Her love of Ireland also found expression in her writings: "Celtic Ireland," "The Genius of the

Gael," and the book on the Brehon laws, barely completed before she left England for the last time, which is to be published shortly under the title "Liberty, Order, and Law under Native Irish Rule," dedicated to "the Rebuilders of Ireland United and Free."

Like Plato's philosopher "the spectator of all time and all existence," Mrs. Bryant by her clearness of vision and width of outlook made it impossible to think of anything mean or ungenerous in association with her. She was a great teacher, a great personality, and a splendid friend, a perpetual source of inspiration and joy to those who knew her. Her spirit lives, not only in the school she helped to build (advancing it alike in science and the humanities till it stood first among a band of sister-schools), but in all those who owe to her a grasp of the ideal, an understanding of the meaning and value of life. M. H. W.

WE much regret to announce the death on September 21, at the age of fifty-eight years, of Prof. F. T. Trouton, F.R.S., emeritus professor of physics in the University of London.

THE secretary of the Institution of Electrical Engineers informs us of the death of Mr. Louis Heathcote Walter, a member of the Institution staff, who had been editor of *Science Abstracts* since 1903.

Current Topics and Events.

IT was no mean occasion that the members of the Yorkshire Philosophical Society met together on Wednesday, September 20, to celebrate. To have held aloft the lamp of learning for a hundred years, and to have conserved and preserved, amid all the changing scenes and conditions of a century, the ancient ruins of St. Leonard's Hospital, the Roman Wall and the Multangular Tower, the ruins of St. Mary's Abbey, and built up a museum second to none in the provinces in the richness of its collections, is indeed a record of which the society might feel justly proud. Moreover, during this period the society has been instrumental in founding two most powerful and wide-reaching institutions, for the Yorkshire Museum was the birthplace and cradle of the British Association and the younger Museums Association. It was therefore very fitting that the society should celebrate the occasion of its hundredth birthday and receive the congratulations of its honoured patron His Majesty the King, and various universities and learned societies. Mr. W. H. St. Quintin, the president, occupied the chair, and was supported by the vice-presidents and council, the hon. treasurer (Mr. Edwin Gray), the hon. secretary (Mr. C. E. Elmhirst), the keeper of the museums (Dr. Walter E. Collinge), and the Rt. Hon. the Lord Mayor, the City Sheriff, Aldermen, and Council. After briefly tracing the history of the society, the work it has done, and recounting its benefactors, Mr. St. Quintin pointed out that a considerable sum of money will be necessary if the society is to continue its good work for the advancement of science, and he asked that in this, its centenary year, a substantial amount should be forthcoming. Addresses were read or presented from a number of leading scientific societies and other national institutions. His Highness the Maharaj Rana of Jhalawar offered congratulations on behalf of the Indian Empire, and congratulatory messages were received from other distinguished people. At the close of the meeting a highly picturesque procession was formed to the Cathedral, where a special evensong was held, the Lord Bishop of Beverley officiating. The delegates and visitors were later entertained to dinner in the De Grey Rooms, after which a conversazione was held in the Yorkshire Museum and the Tempest Anderson Hall.

ACCORDING to the September issue of the *Decimal Educator*, the official organ of the Decimal Association, the metric system has been or is soon to be adopted in Greece, Poland, Haiti, and Japan, while the Russian government is rapidly introducing it into its administrative departments. The British Chamber of Commerce in the Argentine and the Consul for Bolivia again warn British exporters of the futility of quoting in pounds, shillings, and pence for amounts specified in Imperial weights and measures. Mr. W. A. Appleton, secretary of the General Federation of Trade Unions, states that "these weights and measures of ours cheat the home buyer and arouse the suspicion of the foreigner," and asks how many buyers know the difference in weight of a peck of potatoes and a peck of peas. The Lancashire cotton market has ceased to quote cotton in sixty-fourths of a penny and now gives the price in hundredths, but we still appear likely to fulfil the prediction of Augustus de Morgan and "adopt the metric system when every other country has done so." Sir Richard Gregory, president of the association, recommends in an introductory article that the metric system should be made the sole legal system in all departments of State, and the nation thus prepared for its general introduction, which is bound to come in its time, as it is foolish to expect the world to adopt the Imperial as an international system.

A REPORT has been received that the ruins of an ancient city of great extent have been discovered in Colombia by the South American Archæological Expedition from Chicago. As yet the information is scanty, but Dr. J. A. Mason, the leader of the expedition, states that the ruins are situated in the Province of Magdalena, twenty miles south of Santa Marta: "There must have been a tremendous population here at one time, as the country is covered with house sites. The country is very mountainous, and the houses, which were of wood, were built on terraces made with retaining walls." It is not certain that these terraces may not be those used in terraced cultivation, but Colombia has been little explored, and a detailed report of the excavations must be awaited before the value of the discovery can be estimated.

AFTER having been lost for centuries the remains of the ancient monastery of Nendrum, on Mahee

Island, Strangford Lough, have been brought to light by the agency of the archæological section of the Belfast Natural History and Philosophical Society. Founded about A.D. 450 it is mentioned in connexion with St. Patrick, and it held for centuries an important position in the Celtic Church. The discovery of the site is due to Bishop Reeves. The most remarkable part of the ruins is a long stone causeway which was probably the monks' walk. Near the north door of the Church a fragment of an important old Norse inscription has been discovered. Words meaning "Prime Abbot" and "Church of Christ" have been interpreted by Prof. Macalister of Dublin. Every effort to preserve the ruins is now being made by the Belfast Society.

ON September 16, Sir Humphrey Rolleston, president of the Royal College of Physicians of London, opened the John Elliott Memorial Pathological and Bacteriological Laboratory at the Chester Royal Infirmary, which has been equipped by public subscription in memory of Dr. John Elliott, honorary physician of the infirmary from 1895 to 1921. Dr. Elliott had a well-furnished laboratory of his own, which he used for the elucidation of his cases, and, in addition to his consulting work, was much interested in radiology and in the treatment of venereal disease. The provision of such laboratories in hospitals in recent years has done much to promote the progress of medicine by bringing together the clinician and the worker in pure science; and the pathological laboratory is now recognised as a necessary part of an efficient hospital.

THE Faraday Society and the British Cold Storage and Ice Association will hold a joint meeting at the Institution of Electrical Engineers on Monday, October 16, to discuss the present position of the generation and utilisation of cold. It will be divided into three sessions, at the first of which laboratory methods of liquefaction and methods of measuring low temperatures will be discussed. The opening address will be delivered by Prof. H. Kamerlingh Onnes, and Dr. Crommelin will give a description of the equipment of the cryogenic laboratory at Leyden. The second and third sessions will be devoted to industrial methods of liquefaction and practical applications of low temperatures. A general introduction will be given by Mr. K. S. Murray of the British Oxygen Company (Limited). M. Claude will deal with the industrial manufacture of hydrogen by the partial liquefaction of water gas, and Mr. E. A. Griffiths with the subject as it touches aeronautical work. Invitations have been extended to members of the London Section of the Society of Chemical Industry and to the Physical Society of London. Others desirous of attending should communicate with the Secretary of the Faraday Society, 10 Essex Street, London, W.C.2.

A PROVISIONAL programme of lectures on meteorology in connexion with the Imperial College of Science and Technology, South Kensington, for the ensuing session is given in the *Meteorological Magazine* for September. There are twenty-one lectures by Capt. D. Brunt on advanced meteorology, dynamical and physical, on Mondays at 3.30 P.M. during the winter and spring terms, beginning on Monday, October 9; seven lectures by Sir Napier Shaw on meteorological conditions of the air-routes of the world, at 3 P.M. on Fridays, commencing on October 13, and continued each week until November 24; three lectures by Mr. R. A. Watson-Watt on wireless telegraphy and weather, at 3 P.M. on Fridays in each of the first three weeks of December; ten lectures on forecasting weather by Sir Napier Shaw on Fridays, at 3 P.M., during the spring term, beginning on Friday, January 19. Discussions on the incidents of the weather charts of the previous week are arranged for on Saturdays at 10 A.M. throughout the year during term-time, beginning on Saturday, October 14.

WE learn from the September number of the *Museums Journal* that Dr. W. Rushton Parker has offered to set aside 100*l.* a year for several years to induce any men excavating in any part of the United Kingdom to look out for fossil remains of any kind, to extract them as completely as possible, and to preserve them until some expert can value them, with the view of presenting them to the National Museums. This is an offer that should be made known to the scientific societies as well as to the museums in various parts of the country.

DR. R. C. FARMER has been invited to take up the position of deputy director of explosives research at the War Office Research Department, and will commence duty in October. Dr. Farmer was formerly chemical adviser to the Explosives Department under Lord Moulton, and was a member of the nitrogen products committee and the chemical committee of the Munitions Inventions Department. Since the armistice he has been a director of Messrs. W. J. Bush and Company, Ltd., chemical manufacturers, of Hackney, London, which position he is now resigning.

A COMMITTEE has been appointed by the Secretary for Mines to undertake research, under the general direction of the Safety in Mines Research Board, into the causes of, and the means of preventing, the ignition of firedamp and coal dust by the firing of permitted explosives. The Committee has been constituted as follows: Sir F. L. Nathan, Mr. W. Rintoul, Dr. G. Rotter, Mr. H. Walker, and Prof. R. V. Wheeler. A grant has been made by the Miners' Welfare Committee out of the Miners' Welfare Fund to meet the cost of initiating the research.

ON account of continued poor health, Dr. George Ellery Hale, director of the Mount Wilson Observatory, has resigned from the Committee on Intellectual Co-operation of the League of Nations. Dr. Robert A. Millikan, director of the Norman Bridge Physical Laboratory of the California Institute of Technology, Pasadena, has been appointed by the council of the league to succeed Dr. Hale.

THE Faraday Medal of the Institution of Electrical Engineers, the first award of which was made by the council in the early part of the year to Mr. Oliver

Heaviside, was personally presented to him by Mr. J. S. Highfield, president of the institution, at Torquay, on September 9.

THE Secretary for Scotland has appointed Dr. James Ritchie to be an additional member of the committee appointed to advise him on matters connected with the administration of the Wild Birds Protection Acts.

SIR LAWRENCE WEAVER will shortly relinquish the post of second secretary and director-general of land settlement at the Ministry of Agriculture in order to take up the appointment of director of the Art section and of the Agriculture section of the British Empire Exhibition.

THE Model Abattoir Society, the objects of which are the improvement of methods and conditions in slaughter-houses, has organised an annual Benjamin Ward Richardson lecture in memory of its founder. The memorial lecture, on the sanitarian and humanitarian aspects of Sir Benjamin Ward Richardson's work, will be delivered by Sir William Collins on October 12. Admission is free, and invitations may be obtained from the Rev. George Martin, St. John's Vicarage, Kilburn.

MR. W. K. FORD writes to inform us that an unusually large specimen of the common viper, *Viper berus*, was caught recently in Epping Forest. The snake, which was a female, is stated to be 29·5 in. in length, the tail measuring 3·12 in. The largest specimen in the British Museum is only a little more than 27 in. in length, though on account of the difficulty of measuring a snake's skin without stretching it—it can be stretched to one and a half times its real length—larger specimens have been recorded. Mr. Ford's specimen appears to be unusually large, but the skin should be submitted for examination to the Zoological Society, Regent's Park, or similar authority, before it can be accepted as a record.

A "WIRELESS WEATHER MANUAL" has been published by the Meteorological Office of the Air Ministry. It is a guide to the reception and interpretation of weather reports and forecasts distributed by wireless telegraphy in Great Britain. A table is given showing the information issued by wireless, revised to June 1, and the instructions are clear and concise for persons who possess wireless receiving sets. It is not only possible to pick up the messages distributed, to aid which the codes used are interpreted, but a "general inference" is given by the Meteorological Office in plain language twice daily, which with a very little intuition can be understood by those little versed in meteorology. A study of the manual will aid in the general understanding of the subject and will render the charting of the information received quite simple. A short list of elementary text-books is given, a study of which will simplify the interpretation of the charts. A weather chart is given daily in many of the newspapers, but the wireless information gives the details much earlier, for it is possible to draw a weather map within about an hour of the observations being made. In the introduction to the manual, it is stated that those wishing to know can find out "what the weather will be in the next twenty-four hours (sometimes longer)."

THE Automatic and Electric Furnaces, Ltd., informs us that the increasing demand for Wild-Barfield electric hardening furnaces has made necessary the removal of the firm to larger works and offices. The address now is: Automatic and Electric Furnaces, Ltd., Elecfurn Works, 173-175 Farringdon Road, London, E.C.1. Demonstration rooms with furnaces in operation will be provided, and suitable arrangements made for hardening large and small parts for firms which desire to compare both the results and costs with those obtained by gas or solid fuel furnaces. Laboratory and industrial electric muffles will also be available for trial purposes.

Our Astronomical Column.

THE ORBIT OF SIRIUS.—This orbit is of peculiar interest from the conspicuous brightness of the primary, from the irregularity in the proper motion having led to a prediction of its duplicity, and from the subsequent verification by the discovery of the companion in 1862. It now presents one of the not very numerous cases in which a complete revolution has been observed. The various determinations of the elements that have recently been published give an index of the degree of accuracy that is attainable. A new determination by Mr. C. P. Howard is given in *Pop. Ast.* (Aug.-Sept. 1922), and that by Mr. R. Jonckheere (Mon. Not. R.A.S., June 1918) is printed for comparison. Both were made by graphical methods, using every refinement possible:

	Howard.	Jonckheere.
Periastron passage	1894·25	1894·10
Period in years	50·17	50·00
Eccentricity	0·5938	0·60
Semi-axis major	7″·482	7″·55
Inclination	42°·01	43°·4
Node	44°·56	42°·7
Arc from node to periastron	148°·38	145°·6

AN INTERESTING ALGOL VARIABLE.—Mr. A. H. Joy gives a discussion of the Algol Variable, RS Canum Venaticûm, in Publ. Ast. Soc. Pacific, August 1922. It is possible to study the spectra of both components, since the faint star is the larger, and totally eclipses the bright star at principal minimum, when the magnitude is 9·0. The two stars are of equal mass, each 1·3 times the sun; they differ greatly, however, in spectral type, the brighter being F3, the fainter K0. This wide difference is difficult to explain in view of their equal mass. The period is 4·8 days, and the radius of the orbit of each component 5,700,000 miles. The absolute magnitude of the brighter star, deduced from its spectrum, is 2·8, giving a parallax of 0″·008. Three spectrograms have been obtained of the faint star by Mr. Adams; the star is too faint to give satisfactory spectrograms, but it is stated that, taken by themselves, they would indicate a dwarf star. However, from its large size, indicated by the duration of totality being two or three hours, and consequent low density, there can be little doubt that it is really a giant; its absolute magnitude, about 4·2, is very low for a K giant. Altogether the star is rather a puzzling one, and merits careful study.

Research Items.

The Oldest-dated Seal Cylinders.—M. Leon Legrain, in the March issue of the *Museum Journal*, claims for the University Museum, Philadelphia, the possession of the oldest-dated cylinder seal, brought from Baghdad in 1890, which belonged to Basha-Enzu, probably the first king of the IVth Kish dynasty, about 2990 B.C. It therefore antedates the famous buffalo seal of Sargani of Akkad, and pushes back toward the third millenium B.C. a standard of art formerly known as the Gudea style. The engraving is of special interest from the point of view of Babylonian ritual. The museum also prides itself on possessing the oldest Cassite royal seal cylinder so far known, bearing the earliest contemporary record of the war god Shugamuna. It is inscribed with the name of the son of King Karaindash, and may be dated about 1540 B.C.

Honey that drove Men Mad.—In the September issue of *Discovery*, Prof. W. R. Halliday, with the help of his colleague, Prof. McLean Thompson, has cleared up a difficulty unsolved by editors of Xenophon's "Anabasis." The historian describes how the retreating Greeks, when they arrived near Trebizond, ate some honey, with effects ranging from intoxication to insensibility. Some authorities have denied that poisonous honey was found in Pontus, but the writers now point out that there is no evidence to show that the breed of bees in Pontus, or the general climatic condition, was responsible for this poisonous honey. When honey is produced in excess, and the floral parts fail to develop, there results an accumulation of by-products in which toxins abound. When the competition for nectar pollen is intense many insects develop a biting habit, piercing the tissues of plants in search of short-cuts to food supply, and this habit results in the formation of poisoned honey. The observation of Pliny that honey was poisonous in some seasons and not in others is thus proved to be accurate, and can be explained on scientific grounds.

The Rocks of Mount Everest.—In the *Geographical Journal* for September, Dr. A. M. Heron has a note on a small collection of rock specimens made at heights between 23,000 ft. and 27,000 ft. by the climbers on the recent expedition. These specimens show Mount Everest to be a pile of altered sedimentary rocks—shales and limestones—converted into banded hornfels, finely foliated calc-silicate schists, and crystalline limestones. They confirm the views reached by Dr. Heron last year by examination of moraine material from the northern spurs, and by inspection of the mountain by telescope from the Rongbuk valley. From 21,000 ft. to 27,000 ft., Mount Everest appears to be built of these dark hornfels and schists, with occasional bands of white limestone and veins of quartz and muscovite granite. From 27,000 to 27,500 ft. extends an almost horizontal belt of schorl muscovite granite, above which are black schists. Dr. Heron thinks that the age of the rocks may perhaps be assumed, for the present, to be Jurassic or Trias.

Wind-speed from Sea and Land.—The Meteorological Office has issued, as Professional Notes No. 28, a comparison of the anemometer records for Shoeburyness and the Maplin lighthouse, by Messrs. N. K. Johnson and S. N. Sen. The wind-speed in each case is recorded by a Dines pressure tube anemometer. For wind direction Shoeburyness has been used throughout, the Maplin direction recorder being out of order. The wind-speed observations are only available for about ten months in 1919, no observations being to hand from Maplin for the comparison from June 12 to September 1. Maplin lighthouse is five miles from the coast, and is situated twelve miles east-north-east of Shoeburyness. The head of the anemometer at Shoeburyness is carried above the top of a steel girder tower to a height of sixty feet above the surrounding buildings and ninety feet above ground, but there is an avenue of trees about seventy feet high running parallel to the coast at a distance of 150 yards on the landward side of the anemometer. At Maplin the head of the anemometer is about five feet above the apex of the roof of the lighthouse, on the western side, being fifty feet above sea-level. Shoeburyness is said to have a slight predominance of light winds, and at Maplin lighthouse strong winds are decidedly more frequent; the latter is explained by the suggestion that the increased friction over land as compared with the sea causes the air to pile up over the land. This difference of pressure, it is said, must tend to reduce the speed of the surface wind as it approaches the shore-line. There is good evidence of the land and sea-breeze. The height of the head of the anemometer at Maplin seems scarcely sufficient to insure that it is clear from an upward rush of air caused by the obstruction of the lighthouse.

Metallurgical Research.—Volume 16 of the Collected Researches of the National Physical Laboratory has recently been published. It is predominantly of a metallurgical character, although certain papers dealing with engineering subjects are contained therein. The twenty-one papers which it contains are all reprints of papers published by members of the staff in various scientific and technological journals during the years 1919 and 1920. Fourteen of the papers are definitely metallurgical, and a considerable number of these relate to aluminium and its alloys, which have been intensively studied during the last few years, under the general superintendence of Dr. Rosenhain, the head of the department. These investigations are of a very valuable nature, and have contributed in no small degree to the continually extending use of aluminium alloys, not only in aviation, but also in general engineering. Of the papers dealing with iron, attention may be directed to that published by Dr. and Mrs. Hanson on the constitution of nickel iron alloys. The investigations of these authors on this series of alloys have finally enabled the general nature of the equilibrium diagram to be settled once and for all, although they are careful to point out that no very high degree of accuracy can well be claimed. It is interesting to notice that the general result of their researches is to establish firmly the late M. Osmond's hypothesis of the constitution of these alloys, particularly in the range from 0-30 per cent. of nickel. The importance of keeping down the impurities to a minimum is clearly seen in this work, otherwise a true equilibrium is not established. Attention may also be directed to the paper by Dr. Haughton on the study of thermal E.M.F. as an aid in the investigation of the constitution of alloy systems and on the measurement of the electrical conductivity of metals and alloys at high temperatures. The volume contains a paper of the first importance by Dr. Stanton, D. Marshall, and C. N. Bryant on the conditions at the boundary of a fluid in turbulent motion, and two papers by Mr. Baker, the superintendent of the William Froude National Tank. The high character of the series is well maintained in the present volume.

The Inheritance of Size.[1]

THE study of size-inheritance is beset with difficulties which do not attend the study of qualitative differences involving colour and form. Students of genetics have stated size-inheritance in various plants and animals in terms of multiple size factors segregating independently in the Mendelian fashion; but the universal presence of fluctuations which obscure the quantitative effects of separate factors, as well as other difficulties, have prevented the study of size factors being in the same satisfactory condition as that of the factors which control sharply marked qualitative characters.

Stature in man has been investigated from the time of Quetelet and Galton to the recent paper of Davenport,[2] but investigators are not yet agreed even concerning the nature of the Mendelian units, if such they be, which affect and control this feature of bodily measurement. Are there only general growth factors, or are there also separate factors influencing the length of individual segments of the body, such as the legs, trunk, and neck? Davenport concludes that both types of factors are present, and that some races and families have different relative lengths of these segments because of the independent inheritance of such local factors controlling the length of individual bones or segments. Moreover, Davenport believes that crossing between races leads to various bodily disharmonies, such as large teeth in small jaws or a small heart in a large body.

Castle, in a recent study of size-inheritance in rabbits,[3] criticises Davenport's view of local size factors as essentially preformationist, and shows with considerable success that, so far as the rabbits of his breeding experiments are concerned, general inherited growth factors appear to control the size reached by all parts. In crosses between the large Flemish rabbit and small varieties such as the Polish and Himalayan, Castle concludes, as Punnett and Bailey[4] had concluded from earlier experiments on *weight* in rabbits, that several size factors are involved, as indicated by the greater range of variation in F_2 and later generations than in F_1. This substantiates other results of these authors[5] with poultry. They crossed Gold-pencilled Hamburghs and Silver Seabright Bantams and obtained in F_2 and F_3 both larger and smaller birds than the original parental types. That several independent factors are concerned in the determination of size or weight in birds and mammals seems then well established.

But another difficulty comes in to obscure such quantitative results, and that is the fact of hybrid vigour or heterosis, which occurs largely or entirely in the F_1 generation, producing a general increase in the size of the F_1 offspring. For example, in the rabbit crosses, the F_1 is nearer the size of the larger parent owing to this effect, but the effect disappears in the F_2 and later generations. This of course shifts the curve of size temporarily towards the right.

Castle made a careful study of the growth-curves of his rabbits, weighing them at intervals throughout their development to maturity, but he appears not to have studied the variation of his races before crossing. He concludes that the adult Flemish rabbit is larger because it is larger at birth and grows more rapidly and for a longer period than the small Polish rabbit. This is contrary to the views of Punnett and Bailey that age of maturity is not necessarily closely correlated with size. Castle applies his results to man, and reasons that natives of the south of Italy are short of stature and short-limbed because they cease to grow at a relatively early age, while Swedes and Scotch are tall and long-limbed because they mature later.

In the hybrid rabbits, series of measurements were made of weight, ear-length, skull dimensions, and certain leg bones. From these data the correlation-coefficients between the various measurements were determined and were found to be uniformly high. Thus the correlation between ear-length and weight in F_1 and F_2 rabbits was 0·836, and between lengths of femur and skull 0·871. This furnishes strong support for the conclusion that the size of all parts is determined by general growth factors affecting the whole body, and not by independently segregating factors affecting the size of particular organs. Davenport points out that certain races of man have long legs and relatively short trunks, while others have short legs and longer trunks, but Castle holds that the former races are absolutely taller, and regards them as a later growth stage than the short races. Whether this explanation will apply to all races of man remains to be seen. The most urgent requirement at the present time is a mass of accurate anthropometric measurements of all parts of the body in various races.

Many genetic factors are known to affect chiefly one organ of the body, such as the eye or the wing in flies, and since that is the case there seems no *a priori* reason why some size factors should not also affect chiefly certain organs. To demonstrate such an effect, however, a considerable mass of biometric data is required. So far as plants are concerned, the results of Gates[6] show that size factors in hybrids are in some cases local in their effects. In crossing species of Œnothera having large and small flowers respectively, he obtained in F_2 and later generations frequently a wide range of flower-size on the same plant, and in many cases even the four petals of the same flower differed widely in length. Thus it is clear that local size factors occur in plants. Whether they also occur in animals and man remains to be determined.

That an increase in the range of variation of the F_2 as compared with the F_1 is not in itself sufficient to prove the presence of several inherited size-factors, is indicated by a recent paper of Sumner and Huestis.[7] In connexion with extensive breeding investigations of the California deer-mouse, *Peromyscus maniculatus*, they have compared the length or weight of corresponding right and left bones such as the mandible and femur. In this way they obtained sinistro-dextral ratios for these bones and showed statistically that there is no inheritance of such a ratio from one generation to the next, *e.g.* if the parents had a slightly longer left femur there is no tendency for the same condition to be repeated in the offspring. Nevertheless, they found that in crosses between different sub-species these ratios showed greater variability in F_2 than in F_1. This fact will need to be taken into account in future studies of size-variation.

[1] "Genetic Studies of Rabbits and Rats." By W. E. Castle. (Publication No. 320.) Pp. 55. (Washington: Carnegie Institution, 1922.) 1 dollar.
[2] Davenport, C. B., 1917, "Inheritance of Stature," *Genetics*, 2, pp. 313-389.
[3] Castle, W. E., 1922, "Genetic Studies of Rabbits," etc.
[4] Punnett, R. C., and Bailey, P. G., 1918, "Genetic Studies in Rabbits: I. On the Inheritance of Weight," *Journ. Genetics*, 8, 1-25.
[5] Punnett, R. C., and Bailey, P. G., 1914, "On Inheritance of Weight in Poultry," *Journ. Genetics*, 4, pp. 23-39.
[6] Gates, R. R., 1917, "Vegetative Segregation in a Hybrid Race," *Journ. Genetics*, 6, pp. 237-253.
[7] Sumner, F. B., and Huestis, R. R., 1921, "Bilateral Symmetry in its Relation to certain Problems of Genetics," *Genetics*, 6, pp. 445-485.

An Optical Sonometer.

ONE form of an optical sonometer recently made by Messrs. Adam Hilger, Ltd. (of 75A Camden Road, N.W.1), is shown diagrammatically in Fig. 1. The

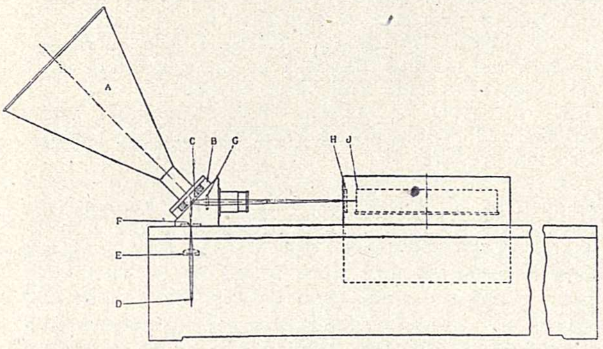

FIG. 1.

apparatus is designed to record the pressure variation caused by sound waves. It consists of a diaphragm box B, to which is attached a horn for receiving sound waves. In box B is a diaphragm with a platinised, silvered, or gilt inner face; this is the actual receiver. Recording the vibrations produced in the disc is accomplished by means of a beam of light directed from the source D (a Pointolite Lamp of 30 or 100 candle-power) by a condenser E through the slit F and brought to a focus on the diaphragm C. Thence by means of lenses G and H an image of the slit is formed on the photographic paper or film on the drum J. The lens H being cylindrical with its axis parallel to the drum, the beam of light is brought to an intense point image on the drum, and as the latter rotates a record of the deflection of the diaphragm is obtained. The spot of light can be focussed on the drum at any distance from 4 to 20 inches according to the amplitude of vibration under investigation and the degree of magnification consequently required.

Some of the models constructed are fitted with a camera into which the film is loaded through a small aperture at the back, while an arrangement for visual observation of the sound wave is also included. The revolving drum, on which the record of the vibrations is made, is enclosed in a specially designed camera with an automatic shutter; by this means any fraction of the drum, from one-sixth to one complete revolution, can be exposed according to the type of record which it is desired to make.

Records of various sounds have been made with the apparatus, *e.g.* for whistling at a frequency of about 1300 per second, singing at about 200 per second, and

FIG. 2.

of the sound produced by a leather-covered mallet on wood. This last is shown in Fig. 2, the frequency being about 250 per second.

The Rowett Research Institute, Aberdeen.

THE Rowett Institute, which was formally opened by Her Majesty the Queen on September 12, had its origin in the scheme of research in agriculture adopted by the Development Commission in 1911. Under that scheme provision was made for the establishment of one or more Institutes to carry out research in each of the branches of agricultural science. It was decided to establish two Institutes for the study of Animal Nutrition, one at Cambridge and one in Scotland. In 1913 a Joint Committee representing the University of Aberdeen and the North of Scotland College of Agriculture was constituted to act as a governing body for the Scottish Institute. Preliminary work was begun in 1914, but was stopped by the war. In 1920 the scheme for the development of the Institute was approved by the Board of Agriculture for Scotland and the Development Commission, and the erection of the buildings began early in 1921. The buildings are now practically completed, except for the fitting up of one or two of the laboratories.

In determining the nature of the Institute to be established it was recognised that the basis of practical experimental work is the researches of the purely scientific worker. Provision was therefore made for work in those branches of science that constitute animal nutrition. The Institute was planned to consist of the following departments: physiology, biochemistry, bacteriology, and pathology, which are housed in the one main building, and animal husbandry, which consists of an experimental stock farm with buildings adapted for conducting feeding experiments. To facilitate the collaboration of those engaged in laboratory researches and those carrying out feeding experiments, the main building containing the laboratories has been erected on the experimental farm. This enables the workers to be in daily contact with each other, and to be conversant with the different aspects of the problem or group of problems on which the Institute is engaged.

The experimental farm is situated on the outskirts of Aberdeen, within easy access of tramway and train. The building containing the laboratories is built of granite and is 156 feet long by 45 feet deep in the central block and 39 feet deep in the wings. It consists of two floors and a basement. The biochemical department, the calorimetry room, the aseptic room, and certain other rooms occupy the ground floor. The physiology and the bacteriology and pathology departments are on the first floor. In the west wing of this floor is the administrative department, rooms for filing records and statistics, and the library. About 30 yards west of this building are the experimental farm buildings which have a floor area of about 1500 square yards. The part nearest to the building containing the laboratories is occupied by two rooms, where animals under metabolic experiment can be kept in cages. The rest of the building consists of food stores, food preparation rooms, and stalls and pens for the accommodation of farm animals under feeding experiments.

The capital outlay, which was estimated in 1920 at 40,000*l.* to 50,000*l.*, will amount to about 46,000*l.* Of this sum the Treasury, on the recommendation of the Development Commission, provided 20,000*l.* Mr. John Quiller Rowett, LL.D., generously contributed 10,000*l.*, and in addition supplied sufficient funds to purchase the experimental farm. Various smaller sums have been received from other contributors; but the whole of the necessary funds have not yet been raised.

The Queen, at the opening ceremony, visited all the departments and talked with the senior workers, asking questions that showed a deep interest in the research work in progress. She was especially interested in the work on indirect calorimetry, and asked to be shown all the apparatus and to have the method explained. In the experimental farm she was chiefly attracted by the dairy cows. These are Ayrshires, a breed kept at the Balmoral Estate. She asked questions about the breed and also about milk production in general, which showed an interest in and an appreciation of the importance of the dairy industry.

After the visit to the different departments the Queen proceeded to the library, where there was a company of about 120, including the Duchess of Atholl, the Duke of Richmond and Gordon, the Marquis and Marchioness of Aberdeen, the Marquis and Marchioness of Huntly, and representatives of public bodies. Here she was presented with a gold key by Dr. Rowett, and formally declared the Institute open. She signed the visitors' book, and before leaving planted a tree in the grounds of the Institute to commemorate the visit.

The Sun's Activity, 1890–1920.

THE sun, as is well known, is a variable star having a period of approximately eleven years, but, unlike other stars, its variability can be determined from several different visible phenomena and not solely from the total integrated light emitted. As classed among stars, it is not considered, however, as a regular variable, because the approximate period of eleven years is itself made variable through other minor periods of various lengths.

Though the sun has a dominating action on many terrestrial phenomena, authorities differ as to the exact relation between the pulsations of the two bodies. It is important, therefore, always to keep in mind, so far as possible, the actual state of solar activity at the moment, *i.e.* whether the sun is in a quiescent state through lack of spots and prominences, or whether it is in a very turbulent condition caused by their abundance.

The data for determining the state of the activity of the sun are published separately year by year in various volumes from different sources, and are only brought together, probably with some difficulty, by research workers who wish to use them for particular inquiries.

Dr. W. J. S. Lockyer has recently coordinated the solar data regarding the sunspotted area, the latitudes of the activity zones of sunspots and prominences, together with the variations in the form of the corona for the period 1920 *to as near the present as possible*. The accompanying diagram (Fig. 1) illustrates the solar changes in graphic form. The following paragraphs deal briefly with each set of curves individually, including the sources of the data:

MEAN DAILY AREAS OF SUNSPOTS.—Each of the points in the curve represents the mean of the daily areas of sunspots corrected for foreshortening for each year. The values are published by the Astronomer Royal yearly in the Monthly Notices of the Royal Astronomical Society, the last value published being that for 1918 (vol. 82, p. 485). The three later years marked with crosses are only provisional values.

It will be seen that the maximum spot activity occurred in the years 1893, 1905, and 1917, while the years of minimum were 1901 and 1913. The next minimum will probably fall in 1924 or 1925.

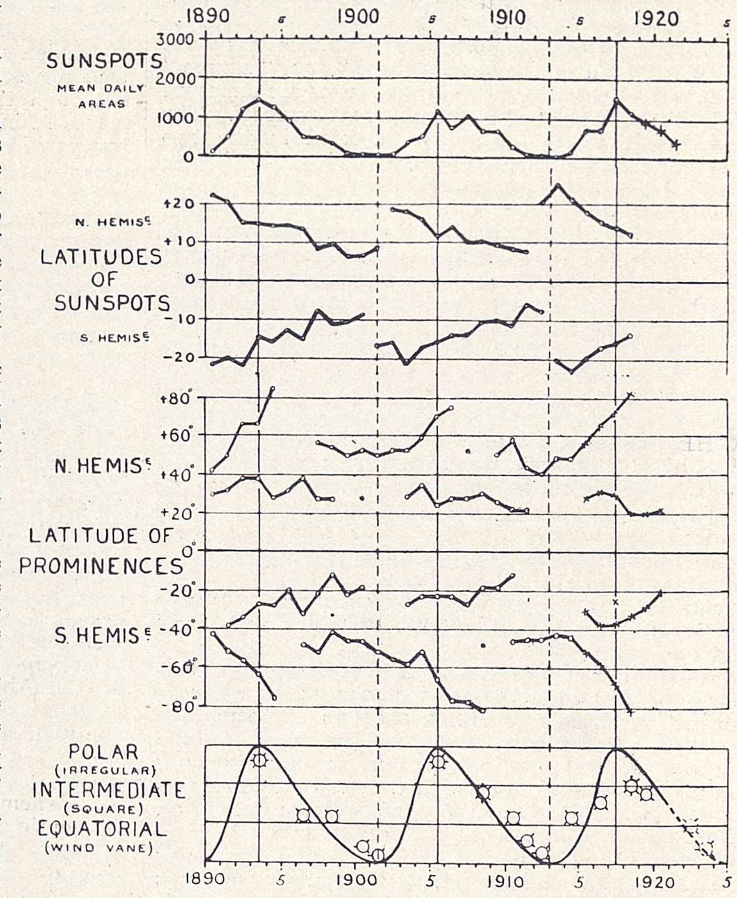

FIG. 1.

LATITUDES OF SUNSPOTS.—Under this heading there are two sets of curves—one for the northern and the other for the southern hemisphere of the sun. Each point represents the mean heliographic latitude of all spots for each hemisphere throughout the whole year. The data are taken from the same sources as mentioned above. It will be noticed that a new sunspot cycle is always heralded by outbursts of spots in zones of high latitudes (about 22°), while the zone of spots nearer the equator is dying out.

LATITUDES OF PROMINENCES.—Here also there are two sets of curves, one for each hemisphere; where in the case of the spots there was only one zone for each hemisphere, for prominences there are two zones. Each point in the curves represents the mean latitude of each zone throughout the year. It will be noticed that in each hemisphere the zone in lower latitudes gradually approaches the equator, dying out just before or at sunspot minimum, while the zone further away from the equator increases its latitude rapidly and dies out at or a little after sunspot maximum. The data up to 1914 are published in the Memoirs of the Kodaikanal Observatory (vol. 1, part ii.) by Mr. John Evershed, and the remainder have been extracted from that Observatory's Bulletins published half-yearly, from which the mean yearly latitudes of the zones have been provisionally determined by Dr. Lockyer.

THE FORMS OF THE CORONA.—The last curve shows the condition of activity of the sun as indicated by the form which the corona takes when seen at total eclipses.

When the corona (polar form) exhibits streamers all around the solar disc, *i.e.* in all solar latitudes, this indicates a very turbulent state of the solar atmosphere and a time therefore of maximum activity. At this time the prominences reach their highest latitudes. When the streamers are confined to the equatorial regions and the poles are quite clear and void of streamers, the corona takes an "equatorial" or "wind-vane" form, and the solar activity is at a minimum. Intermediate stages are indicated by the corona taking an "intermediate" or "square" shape. The various forms of the corona are indicated clearly in the curve by three different symbols. The curve also shows the forms expected in the two approaching eclipses, namely, of this and of next year. The form for the present year will be of the "intermediate" type, while that for 1923 should be typical of the "equatorial" type. The data for the various forms of the corona have to be obtained from the individual reports of eclipse expeditions, but those to which reference has here been made have been collected by Dr. Lockyer and published in the Monthly Notices of the Royal Astronomical Society (vol. 82, p. 326).

All the solar phenomena described above thus indicate clearly that the activity of the sun is decidedly on the wane, and that the epoch of minimum disturbance in the solar atmosphere is approaching and will be reached in the year 1924 or 1925.

University and Educational Intelligence.

BRISTOL.—The degree of Ph.D. has been awarded to Mr. Joseph Lineham for his dissertation on "The Concept of Activity."

LONDON.—The list of courses of University Extension Lectures for the session 1922–23 has recently been issued, containing particulars of some 90 courses and lectures which will be given in the University and locally. Of this number, 14 only are on scientific topics. Dr. W. B. Brierley is giving a course of 24 lectures at Gresham College on inter-racial problems of man, and a similar course at Morley College on the principles of evolutionary biology; F. Womack is giving 2 lectures on wireless telephony at Hatch End and at Hounslow, and 5 lectures on pioneers of science at Wood Green; and F. J. Chittenden, 3 lectures on horticulture at Hatch End. The remaining science lectures are related to psychology: Miss V. H. Hazlitt, 10 lectures on the psychology of character and conduct, at Croydon; Mr. Cyril Burt, 5 lectures on psychoanalysis, at Twickenham; S. E. Hooper, 24 lectures on psychology, at Wimbledon and also at Wood Green; and E. O. Lewis, 24 lectures on psychology, at the Working Men's College, Crowndale Road, N.W. There are also four psychology courses, at Croydon, at the Mary Ward Settlement at Tavistock Place, W.C., at Wandsworth, and at Wood Green, for which lecturers' names are not yet given. Further particulars of the lectures can be obtained from the local secretaries whose addresses are given in the lecture list, application for which should be made to the Registrar, University Extension Board, University of London, South Kensington, S.W.7.

THE *Chemiker Zeitung* of August 29 reports that Dr. H. Lecher, of the University of Munich, has been appointed professor of organic chemistry at the University of Freiburg.

A SPECIAL committee of the World's Student Christian Federation has been appointed to co-operate with the Universities' Library for Central Europe in its work of securing British books, journals, and scientific papers for the universities of Central Europe. Donations of books, periodicals, and money should be forwarded to Mr. B. M. Headicar, Universities' Library and Student Relief for Europe, London School of Economics, Houghton Street, W.C.2.

ON several occasions recently the *Chemiker Zeitung* has reported the gifts of large sums granted by industrial concerns to universities and to associations of students, for the assistance of these bodies in teaching scientific subjects, particularly chemistry. Although the amounts, which run into millions of marks in individual grants, may seem modest when translated into English currency, they represent important contributions in Germany, and the attention of British manufacturers might well be invited to the matter. It is evident that Germany realises, as she did in former years after defeat, that the hope of the future lies in education, and one cannot help feeling that the victors in the recent war would do well to consider whether their future also does not lie in the same direction, and do a little more of a practical character in the furthering of the work of our educational institutions. The reduced grants made to the universities will be reflected in reduced facilities, and if the industries which have reaped so much benefit from research in pure science made in the universities, often associated with individual hardship on the part of the students, were to make some return, it would be repaid to them a hundred-fold.

THE draft Regulations for Secondary Schools recently issued by the Board of Education remedy the anomalous position which hitherto geography has occupied in advanced courses. As a school subject, geography has steadily gained ground, and in 1921 was offered by no less than 78 per cent. of the candidates taking the School Leaving Examination. Furthermore, Sir Richard Gregory, in his presidential address to the Education Section of the British Association this year at Hull, pointed out the still greater part this subject could, and should, play in economy of time-table and efficiency of teaching. At the other end of the scale, the Universities have steadily increased the facilities for graduation in geography. There remained, however, the hiatus of the advanced courses which cut off, in large measure, the supply of students of geography. The 1922 Regulations provide for a new group of studies, E, which is defined as "Geography, combined with two other subjects approved by the Board, of which one must be History or a Science." The way is now clear for a complete revision of the syllabuses in geography for the Higher School Certificate and for the provision of university scholarships in this subject.

Calendar of Industrial Pioneers.

October 1, 1838. Charles Tennant died.—The founder in 1797 of famous chemical works at St. Rollox, Glasgow, Tennant while manager of a bleaching field near Paisley discovered a method of controlling chlorine gas by the admixture of lime. He introduced the manufacture of chloride of lime in a solid state, to which he gave the name bleaching powder. His production of bleaching powder in 1799–1800 was 52 tons, the price being 140*l*. per ton. By 1835 the St. Rollox works had become the most important chemical works in the world.

October 2, 1804. Nicolas Joseph Cugnot died.—A military engineer and the author in 1766 of "Éléments de l'art militaire ancien et moderne," Cugnot in 1769 made the first steam-propelled road carriage, and two years later built a steam tractor for the French Government for hauling artillery. This vehicle was to carry a load of 4½ tons at 2¼ miles per hour. Though never used, this carriage is preserved in the Conservatoire des Arts et Métiers.

October 3, 1867. Elias Howe died.—One of the chief pioneers of the sewing machine, Howe was the son of a farmer of Spencer, Massachusetts, and was born in 1819. He began work on the sewing machine in 1841, took out a patent in 1846, and was one of the first inventors to place the eye of the needle towards the point.

October 4, 1821. John Rennie died.—Acknowledged as the greatest civil engineer of his day, Rennie was the builder of the London Docks, the East India Docks, the Plymouth Breakwater, Waterloo and Southwark Bridges, and he prepared designs for London Bridge. He was born at Phantassie, East Lothian, in 1761, gained practical experience under Andrew Meikle, attended the lectures of Robison and Black, and in 1789 erected the Albion Mills for Boulton & Watt, in London, the site of which was afterwards occupied by Rennie's workshops. He is buried in St. Paul's Cathedral.

October 5, 1892. Alexander Carnegie Kirk died.—The author of many improvements in marine engineering, Kirk, after gaining experience at Maudslay's and at Elder's, became a partner in 1877 in the firm of Napier. He was especially known for his advocacy of high steam pressure and the triple-expansion engine, the advantages of which were demonstrated in the s.s. *Aberdeen* built by him in 1882, which on a voyage to Australia showed a saving of 500 tons of coal.

October 6, 1905. Charles Brown died.—Brown has been called the founder of mechanical industry in Switzerland. Brought up in London, in 1851 at the age of 24 he entered the service of Sulzer Brothers, a firm of mechanical engineers at Winterthur. He established afterwards the Swiss locomotive works at Winterthur and also played a prominent part in the creation of the Swiss electrical industry.

October 7, 1908. Jean Baptiste Gustave Adolphe Canet died.—A distinguished armament engineer, Canet was trained at the École Centrale des Arts et Manufactures, fought in the Franco-German War, and for a time engaged in railway engineering. From 1872 to 1881 he was associated with Vavasseur at the London Ordnance Works, and in 1876 brought forward his theory of hydraulic brakes for checking the recoil of guns. Returning to France he became the head of armament works at Havre and after the amalgamation of these works with those of Schneider at Creusot became manager.

E. C. S.

Societies and Academies.

SWANSEA.

Institute of Metals, September 20.—G. D. **Bengough** and J. M. **Stuart**: The nature of corrosive action, and the function of colloids in corrosion (Sixth Report to the Corrosion Research Committee of the Institute).—Sir Henry **Fowler**: The effect of superheated steam on non-ferrous metals used in locomotives. Superheated steam as used on locomotives generally leaves the superheater at a temperature of 340° C. On the Midland Railway, piston tail rod bushes were made of M.R. A.1 alloy (copper, 87; tin, 9; zinc, 2; lead, 2). A phosphor bronze (copper, 88; tin, 11; phosphorus, 1) has been found satisfactory. For piston rod packing, McNamee rings (copper, 75·5; tin, 8·5; zinc, 0·33; phosphorus, trace; nickel, 0·5; lead, 15·0) are used satisfactorily. These rings prevent the steam coming into contact with the white metal (lead, 70; antimony, 30) packing rings. With the temperature rising to 425° C. the packing rings may fuse. Piston valve fittings and cylinder relief valves are made of alloy M.R. A.1. For by-pass valves which are subjected to shock, a nickel-brass gave good service, but was replaced for economy by malleable iron or steel castings.—A. H. **Mundey**, C. C. **Bissett**, and J. **Cartland**: White metals. The manufacture and use of white metal for industrial purposes is described, and constitution and microstructure are dealt with only so far as the uses and manufacture are concerned. Antifriction or bearing metal, printing alloys, die-casting alloys, metals for chemical works castings, solders, are discussed.—J. H. **Andrew** and R. **Higgins**: Grain-size and diffusion. Diffusion at high temperatures may take place simultaneously with grain-growth, while at low temperatures it promotes a breakdown in the grain-size. These results have been applied to the annealing treatment of castings. It has been assumed that in the interior of the crystalline grains the system of closest packing holds, while at the boundaries the atoms in the separate grains touch only at one part of the circumference. This explains the decrease in specific gravity with an increase in the number of grains, for in such an arrangement free spaces occur. Plastic deformation, by shifting some of the atoms from their positions of equilibrium, will cause them to rearrange themselves when heated to a sufficiently high temperature. This rearrangement will be such that the stressed atoms will fall in, row for row, with the unstrained atoms of the adjacent crystal. This effects a gradual migration of the grain boundary which, proceeding from every side of a crystalline unit, may result in one grain being divided up and absorbed by others. The final bounding surface will result when the boundary configuration is reached.

PARIS.

Academy of Sciences, August 28.—M. L. Maquenne in the chair.—L. **Mangin** and N. **Patouillard**: The destruction of the woodwork at the château of Versailles by *Phellinus cryptarum*. A detailed examination of the oak beams showed a varied fauna and flora, but *Phellinus cryptarum* is mainly responsible for the damage. This fungus has not hitherto been regarded as destructive to wood.—Jacques **Chokhate**: The development of the integral $\int_a^2 \frac{p(v)}{x-y} . dy$ as a continued fraction.—Ch. N. **Moore**: The equivalence of the methods of summation of Cesàro and of Holder for multiple limits.—Nilos **Sakellariou**: Polar systems.—Amédée **Béjot**: Placing in reciprocal perspective, figures of the same species.—M. **Gignoux** and P. **Fallot**: The marine quaternary on the Mediterranean coasts of Spain.—Raoul **Combes** and Denise **Kohler**: The rôle of respiration in the diminution of the carbohydrates in leaves during the autumnal yellowing. It has been commonly held that during the change of colour of leaves in the autumn, the carbohydrates are withdrawn from the leaf and stored in the plant as reserves. It has been proved by Michel Durand that some of the carbohydrates are removed by rain, and in the present communication proof is given that part is used up by respiration and leaves as carbon dioxide—L. **Carrere**: The sphincter of the iris in the selacians. This muscle in the selacians, especially in species possessing a pupil-shaped opening, is more developed at the nasal and temporal extremities of the pupil: it is less important, and may even disappear, in the ventral and dorsal sectors.—Paul **Wintrebert**: The mechanical polarity of the germ of selacians (*Scylliorhinus canicula*) at the time of gastrulation.

September 4.—M. L. Guignard in the chair.—Théodore **Varopoulos**: A theorem of M. Rémoundos.—Alf. **Guldberg**: The theorem of M. Tchebycheff.—Victor **Henri** and Pierre **Steiner**: Absorption of the ultraviolet rays by naphthalene. From a quantitative study of the absorption of solutions in hexane, ether, alcohol, and water, seventeen bands have been found between wave lengths 3207Å and 2563Å. These results are compared with those previously obtained for benzene by a similar method.—Erik **Hulthén** and Ernst **Bengtsson**: Researches on the band spectra of cadmium.—G. **Murgoci**: The classification of the blue amphiboles and of certain hornblendes.—Marcel **Mirande**: The formation of anthocyanin under the influence of light on the scales of the bulbs of certain lilies.—Raphaël **Dubois**: The destruction of mosquitos by eels. Goldfish have been suggested for destruction of mosquitos as they eat the larva, but they have the disadvantages of being costly and requiring a pure and well-aerated water. Young eels in the spring are equally voracious and devour the larvæ readily. They are more readily procurable than goldfish, and live equally well in fresh and salt water, and even in water containing sewage effluent.

SYDNEY.

Royal Society of New South Wales, August 2.—Mr. C. A. Sussmilch, president, in the chair.—C. E. **Fawsitt** and C. H. **Fischer**: The miscibility test for eucalyptus oils. Instead of testing the solubility by measuring the volume of aqueous alcohol required to obtain complete solution of a measured volume of oil, the critical solution temperatures with definite mixtures of alcohol and water are taken after the manner of testing fixed oils. This method is more sensitive for the indication of small changes in composition of the oil. The critical solution temperature in some cases varies markedly with time and as the oil is kept.—R. T. **Baker** and H. G. **Smith**: The Melaleucas and their essential oils, Pt. VI. Two species are discussed, *Melaleuca ericifolia*, Sm., and *M. Deanei*, Fr. M. Oil was first distilled from *M. ericifolia* by Mr. J. Bosisto in 1862, and Dr. J. H. Gladstone in 1864 determined its physical constants. The chief oxygenated constituent was thought to correspond with that in ordinary oil of "cajuput." The yield of oil obtained by the present authors was 0·8 per cent., and the chief oxygenated constituent found to be dextrorotatory terpineol, while less than 10 per cent. of cineol was present. Pinene, limonene, and a sesquiterpene were also detected. The yield of oil from young material of *M. Deanei* was also 0·8 per cent., and consisted almost entirely of pinene with about 15 per cent. of cineol. Old leaves of this species contain very little oil.—A. R. **Penfold**: The essential oil from *Backhousia myrtifolia*, Pt. I. This small tree inhabits gullies containing running water in the coast and coast mountain districts of New South Wales. Material collected at Lane Cove near Sydney, and at Currowan of the southern district, yielded 0·3-0·75 per cent. of a brown-yellow oil, varying with the time of year and locality. The oil possesses a pleasant odour and is heavier than water. Its principal constituent is elemicin (80 per cent.), a somewhat rarely occurring phenol ether. The remainder of the oil consists of α-pinene, unidentified alcoholic bodies and phenols, sesquiterpene, and a paraffin of melting-point 62°-63° C.

CAPE TOWN.

Royal Society of South Africa, August 16.—Dr. J. D. F. Gilchrist, president, in the chair.—W. A. **Jolly**: The rhythm of discharge of the spinal centres in the frog. The rate of discharge of the cord in Xenopus at different temperatures, as indicated by galvanometric records from the gastrocnemius muscle reflexly excited, was discussed.—J. P. **Dalton**: On the mathematics of the homogeneous balanced action. It has been shown by the author that the integrated velocity equations of chemical reactions can be written in terms of a certain function. The same function may be employed in the treatment of the homogeneous balanced action.

Official Publications Received.

Western Australia. Annual Progress Report of the Geological Survey for the Year 1921. Pp. 61. (Perth.)

Northampton Polytechnic Institute, St. John Street, London, E.C. Announcements, Educational and Social, for the Session 1922–1923. Pp. 248. (London: Northampton Polytechnic Institute.)

New Zealand. Department of Mines: Geological Survey Branch. Palæontological Bulletin No. 9: The Upper Cretaceous Gastropods of New Zealand. By Dr. Otto Wilckens. Translated into English by the Author. Pp. iv+42+5 plates. (Wellington, N.Z.)

Prospectus of the Royal College of Art, S. Kensington, London. Session 1922–1923. Pp. iv+29. (London: H.M. Stationery Office.) 9*d*. net.

London School of Tropical Medicine, Department of Helminthology. Collected Papers, 1922 (Part 2), Nos. 16-25. Pp. 3+4+11+7+9+75+3+7+11+5. (London: 23 Endsleigh Gardens.)

Diary of Societies.

MONDAY, OCTOBER 2.

SOCIETY OF ENGINEERS (at Geological Society), at 5.30.—C. H. J. Clayton: The Economics of Arterial Land Drainage.

THURSDAY, OCTOBER 5.

ROYAL AERONAUTICAL SOCIETY (at Royal United Service Institution), at 5.30.—Prof. L. Bairstow: The Work of S. P. Langley.

CHILD-STUDY SOCIETY (at Royal Sanitary Institute), at 6.—Dr. C. W. Kimmins: Visual Humour.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—R. H. Lawton: The Use and Misuse of Short Focus Lenses.

CHEMICAL SOCIETY, at 8.—H. Bassett and R. G. Durrant: Cupric Tetrammine Nitrite and the Corrosion of Copper by Aqueous Solutions of Ammonia and of Ammonium Nitrate.—C. K. Ingold and H. A. Piggott: The Additive Formation of Four Membered Rings. Pt. I. The Synthesis and Resolution of some Derivatives of Tetrahydro-1:3-Diazine.

FRIDAY, OCTOBER 6.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—W. A. Tookey: Engineering in Bacon Factories.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—F. Lambert: The Beginnings of London.

PUBLIC LECTURE.

THURSDAY, OCTOBER 5.

KING'S COLLEGE, at 5.30.—Prof. H. Wildon Carr: The New Method of Descartes and the Problems to which it gave rise (1). Succeeding Lectures on Oct. 6, 12, 13, 19, 20, 26, 27, Nov. 2, 3.