NATURE

"To the solid ground
Of nature trusts the Mind that builds for aye."—Wordsworth

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NATURE

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MACHINERY OF GOVERNMENT
METHODS AND MEN

RECENT criticism of the Civil Service, so far as it is not superficial or biased, is largely an expression of a fundamental concern with the whole machinery of government in Great Britain. That concern has been fed from numerous sources : for example, the examination of our whole organization of production and supply for war purposes, and the related question of the general direction of our war effort ; the difficulties raised by the recommendations of the Scott and of the Uthwatt reports and in attempts to co-ordinate the planning of reconstruction. The statement on a national policy for industry issued by a group of industrialists, following on Mr. S. Courtauld's paper on "Government and Industry" in the *Economic Journal*, stimulates further thought on the mechanism by which the necessary control of industry is to be exercised, a field to which Prof. Cushman's admirable study of the Independent Regulatory Commissions has directed attention in the United States. The report of the President's Committee on Administrative Management is another stimulus to fundamental thinking about the functions and machinery of government which can fairly be compared with the Haldane Committee's report on the Machinery of Government in Great Britain.

The Planning group (P E P) has, of course, addressed itself to the problem, and the fundamental issues were well stated in the broadsheet issued in July 1941, though that was limited to the Civil Service itself. So far as the Civil Service is concerned, there are two fundamental aspects to be considered—methods and men. First, are the methods in use in the Civil Service to-day adapted to handle the new and wider range of problems with which it is called upon to deal in the service of a new and more positive conception of government ? Secondly, is its personnel, by recruitment, training and tradition, competent to handle those questions constructively, imaginatively and efficiently ? A committee of Ministers and an inter-departmental committee of permanent heads of departments is understood to be at work considering, *inter alia*, the machinery of government. The men who are in charge of departments, with all the prejudices and interests as well as the duties of their office, are so clearly the wrong men to conduct such a survey at the height of their war-time activity that far less value is likely to be attached to their findings than to those of the Sub-Committee on the Reform of the Civil Service appointed by the Industrial and Social Reconstruction Committee of the Liberal Party, or of the Sixteenth Report from the Select Committee on National Expenditure, which deals with the organization and control of the Civil Service.

The Sub-Committee presenting the former report had as its terms of reference : "to consider Civil Service Reform in relation particularly to the allegation that the Civil Service as at present constituted has proved wanting in the powers of rapid decision and action". It gives a glance at the question as to what machinery more suitable than the Civil Service can be found, where in the interests of the community

as a whole it is necessary to remove particular industries or undertakings from private profit-making to public ownership or control, but the major part of the report is concerned with the reforms required in the pre-war Civil Service to modernize it and bring it more into line with the modern art of administration. That is also the main theme of the Select Committee's report, which, however, passes over the question of administration of nationalized industry, but includes a survey of the functioning of the Central (Technical and Scientific) Register and the General Appointments Register of the Ministry of Labour and National Service and a review of professional and technical staffs in Government Departments.

The Sub-Committee of the Liberal Party opens its report with a review of the pre-war Civil Service and, as in other recent reviews of this matter, tribute is paid to the excellence of the Civil Service for the purpose for which it was originally designed. That much has never been in dispute. The difficulties arise from the fact that it was not contemplated when the Service was created that it would ever be called on to engage in trade directly, to control in detail the processes and operations of commerce, or be responsible for social services and direct contact with individual services. It was instituted to serve fundamentally a negative conception of Government, and the characteristic defects which it has tended to develop have to some extent rendered it inherently unfitted to serve the more positive conception of government to-day.

While this is true, it must also be remembered that its defects are minor compared with the virtues of its freedom from corruptibility and its devotion to the State, as opposed to party or personal interests, and they are also due not so much to the Service itself as to what public opinion insists upon in connexion with it. The policy of safety first is a direct result of insisting that every action of every Civil servant at every hour of the day shall be open to challenge. Furthermore, the Civil Service to-day is the product of Governments which in recent years have been characterized by an unparalleled timidity, vacillation and lack of vision. This inevitably accentuated the bias of the Service to expose the weaknesses, risks and disadvantages of new proposals, rather than to seize what was good in new ideas and embody them enthusiastically in speedy and decisive action.

The tendency to refer to higher authority by minute, and of higher authority to evade or postpone the issue or to consult other authorities before coming to a decision, is thus inherent in the system of Parliamentary questions. Accordingly, among its important recommendations to speed up and modernize the service, the Committee suggests in regard to this first point, while upholding the principle of Parliamentary questions, that reform might proceed through a recognition both in Parliament and in the Civil Service that modern government is too complex a subject for the simple device of the Parliamentary question to be equally applicable to all aspects of it.

Whether or not new mechanism is required to make ministerial responsibility effective without impairing the efficiency of the administrative machine, it is essential to maintain that responsibility. Some of the criticism of the system of public utility corporations has been on this very point of nebulous ministerial responsibility, although it is admitted that the system has to a large extent withdrawn the staffs from the constant stream of Parliamentary criticism. Until such fundamental issues are resolved, however, mere reforms in the method of recruitment of the Civil Service, in training and grading or in operating methods are unlikely to secure a keen and vital Service characterized not only by integrity and the capacity to take a wide view, but also by initiative and the readiness to accept responsibility.

In regard to recruitment, the Liberal Party's Sub-Committee recommends that the practice of grading entrants to the Service by their method of entry should cease and that there should be a system of post-entry training. Engineers and other professional specialists should no longer be regarded as inferior in status to administrative officers and should be remunerated on a scale sufficient to attract officers able to meet on an equal footing the leaders of their respective professions outside. They should be regarded as available for administrative posts. In the senior grades, there should be much more emphasis on systematic interviewing, and provision for an adequate inflow of officers from the lower grades.

With this insistence on a complete ladder from the bottom to the top, the Sub-Committee stresses the importance of post-entry training. The absence in it of a centrally prescribed scheme of training for officers after their entry is a fundamental weakness of the present Civil Service—though a like criticism might equally be advanced of much of the industrial organization of Great Britain. The Sub-Committee recommends the institution of such central courses of instruction by the Civil Service Commission, as well as of departmental courses, and it advocates strongly the establishment of a staff college for the Civil Service analogous to the staff college for the Army, through which those officers likely to be the future holders of the highest posts in the Service should pass. The Committee, moreover, is unanimous that if such a college for teaching, in effect, the art and science of administration were established for industry and commerce generally, it would be even better that the selected Civil Service officers should pass through it than through one established for the Civil Service only. This proposal should meet Sir Warren Fisher's objection that a staff college would accentuate the academic character of the Service. Contact in this way with the future leaders of commerce and industry should facilitate a better understanding of the needs and outlook of commerce and industry and check the narrow professional outlook sometimes attributed to the present Civil Service.

This proposal for a staff college, already advanced by P E P in its broadsheet, is reiterated by the Select Committee on National Expenditure, which makes the same point as to the importance of actual contact in this way of the Civil Servant with commerce and industry and with the work of local authorities, public utility companies, social services, etc., and in

particular with those levels of government activity at which Departments come into direct touch with the life of the community, such as the Inland Revenue and Public Assistance. The training thus provided should be of special value in helping to meet the increasing demand for promotion to the administrative grade of selected members of the executive and clerical grades. The Select Committee considers that, subject to tests of character, ability and merit, opportunities of graduating to positions of authority should be open to those who qualify from the school of experience in the Civil Service, equally with those whose qualifications are mainly academic. Moreover, it stresses the value of such a project in providing the training and opportunities needed by Civil Servants who wish to specialize in organization and methods of work.

Beyond this recommendation, the Liberal Party's Sub-Committee contemplates a complete reorganization of the Civil Service Commissioners and wide extension of their powers. It endorses emphatically the recommendation of the Planning broadsheet regarding the divorce from finance of the management and control of personnel. This is regarded as a central function, which cannot properly be discharged by any special department such as the Treasury, and it recommends that the present Civil Service Commissioner's Department should be made into a true central department by removing it from the control of the Treasury, and making it directly responsible to a Minister without Portfolio, who should be the Deputy Prime Minister. The present Establishment Branch of the Treasury would be transferred to the re-organized department, which would be staffed as soon as practicable with officers trained in the modern technique of management. Much importance is attached to method of selection and term of tenure of office of the permanent head of the re-organized Commission. This appointment should be made from within or without the Service by the Prime Minister on the advice of the Minister immediately responsible, and of an advisory committee independent of the Service, and tenure of the office should not exceed five years. As in the report of the Planning group, the importance of eliminating unsuitable officers at any stage in their career is emphasized, while caution is advised in regard to the introduction of outside blood in the more senior grades, on account of the dangers of political pressure and nepotism.

If the Liberal Party's Sub-Committee has relatively little to say about welfare work and office planning, though their importance is noted, the latter in particular is a main theme of the Select Committee's report, which is very largely a review of the whole work of the Organization and Methods Division and the re-organization of the Treasury in regard to the control of the Civil Service. It points out that, following the recommendations of the Haldane and Bradbury Committees, an Establishment Department was erected within the Treasury and establishment officers appointed in most Departments of State throughout the period 1919–39; nevertheless there was no overt sign that the Treasury or the departments accepted the proposition that the organization of administrative machinery was a subject requiring expert and specialized study, or that any lessons in the art of management could be learned from industry and commerce either in Great Britain or abroad. As a result of this twenty years of neglect, the outbreak of war found the Treasury insufficiently equipped to deal with the problems of administrative organization which were forced upon it. There was no core of expert knowledge which might have been built up if the systematic and periodical overhaul of the whole of the machinery of government had been undertaken. Such a body of knowledge might at least have supplied standards by which proposals concerning the staffing of new and expanding departments could have been examined and tested.

The Select Committee considers that control of establishment matters should continue to be exercised from the Treasury for three reasons. First, risk of duplication and waste through the interposition of a new authority between departments and the Treasury, because the Treasury's control on expenditure would still remain. Secondly, it is convinced that the advantages arising from the central position of the Treasury, with its unique knowledge of the general activities of Government, should be retained and utilized. Thirdly, it considers that the view that the association of the functions of finance and supply with those of establishment is bound to be detrimental to the interests of the latter is ill-founded. It bases its recommendations on a conception of economy which is identical with the promotion of efficiency. The ideal control of the Civil Service must be regarded as concerned with the systematic study of the means and methods by which the work of government may be carried out with the maximum efficiency and the minimum waste of time and money. Recommendations are accordingly made for improving the organization of the Treasury.

It is not necessary to accept without question the Select Committee's argument for the retention of Treasury control in order to appreciate the lucidity and precision with which the essentials of the problem are laid bare. The value of that analysis is unaffected whether the ultimate decision is to retain Treasury control or to establish a new central department, as suggested in the report of the Liberal Party's Sub-Committee and elsewhere. The Select Committee's own opinion, however, that, so far as the Treasury was concerned, the period from 1919 until 1939 was marked by an almost complete failure to foster the systematic study of organization as applied to Government departments is possibly the strongest argument against its own recommendation. The re-organization suggested cannot wisely be left in the hands of the same men or in those of similar outlook.

Fundamentally, the problem is one of men and not merely of methods. In any event, either plan of reform might prove equally effective, given men of the requisite imagination, personality and ability. The effectiveness of a staff college, for example, depends on the type of men who teach there, and the vital purpose by which it is informed, and there is no *a priori* reason why a Treasury Department, staffed by men of the right outlook and understanding,

should not prove brilliantly successful in securing that the machinery of government is maintained at the highest efficiency and adapted continuously to the purpose to be served. Sir Warren Fisher is unquestionably right in stressing the importance of the problem of the selection of men. As the Select Committee points out, however, expert knowledge of organization is not a monopoly of business men, and it does not regard the commercial world as even the principal source from which efficient organization officers should be recruited. There is a considerable field of recruitment among existing Civil Servants, many of whom possess the vigorous personality and the profound conviction that the study of organization and methods is worth while.

In the long run, however, the spirit and efficiency of the Civil Service are a reflection of the temper and interest of the community it serves. No matter what machinery we devise, we cannot expect a Civil Service of the highest ability and integrity, imbued with vision, initiative and enthusiasm, unless there is mutual understanding and respect between the Service and the community whose interests it serves and safeguards. The biased and irresponsible attacks on the Service by those seeking to promote their own selfish interests under the cloak of a return to the old intolerable muddle of *laisser-faire* do disservice to the State as well as to the Civil Service. It is a great merit of this sixteenth report of the Select Committee on National Expenditure—a report which may well take its place as a great State paper alongside the Haldane Report on the Machinery of Government for its creative analysis—that it provides not only a critical appreciation of the Service, for which Civil servants themselves should be grateful, but also an interpretation of the Service which should promote good understanding and closer and more fruitful co-operation between Whitehall and the public. Here is indeed trenchant criticism and the searching exposure of weaknesses. Here, too, is generous appreciation of good qualities, and an attempt to hold the balance and apportionate blame or responsibility fairly.

No one who attempts to think constructively and creatively about the exceedingly complex problems of modern government, the machinery to be called into being to serve the purposes of the War or of reconstruction in the new order to follow, can disregard this report and its elucidation of some of the fundamental issues upon which our machinery and our philosophy of government must be based. The wide interest in the larger questions of the general control and organization of the Service and the construction of further machinery to increase its efficiency displayed in the recent House of Lords debate, where Lord Hankey lent the weight of his authority to propositions substantially the same as the recommendations of the Select Committee, is one of the happiest indications that we are applying ourselves to a task which will tax the best ingenuity as well as the utmost intellectual resources of either British or American democracy, and in which each democracy may well contribute much towards the solution of the other's particular problems.

A GREAT ETHNOLOGIST

Haddon, the Head Hunter

A Short Sketch of the Life of A. C. Haddon. By A. Hingston Quiggin. Pp. xii + 169 + 7 plates. (Cambridge : At the University Press, 1942.) 7*s*. 6*d*. net.

BORN in 1855, A. C. Haddon died at the age of eighty-five in 1940. He richly deserves this exquisitely written life-history. For he achieved a great work and he was endowed with a unique personality. In the selection of her abundant material, Mrs. Quiggin is to be congratulated on her wise judgment. She knew Haddon intimately from the year 1904 when she began to help him, not only in secretarial work, but also in "the concocting of syllabuses and lecture notes, the abstracting of papers, the making of lantern slides and the writing of minor reviews".

Her sketch of his life is not overwhelmed, as so many biographies are, by excessively long extracts from correspondence. She throws much light on his ancestry and early life, which will be welcomed to-day by those who only knew him in middle-age and later. He was descended from three generations of John Haddons, all most ardent Nonconformists, the first a gentleman-farmer of Naseby, the second who founded in 1814 the printing firm of John Haddon & Co. in London, and the third who, failing to inherit the business abilities of his father, allowed the prosperity of the firm to suffer until he was supplanted in 1888 by an abler cousin. The thus dwindling fortune of A. C. Haddon's parents caused frequent family removals from suburb to suburb. It was his fate to be sent to "any school which happened to be in the neighbourhood", and he thus received but a scrappy and desultory formal education. When quite a child, he showed his first interest in acquiring skulls. By then he had already begun to collect minerals, plants, butterflies, eggs, etc., and soon he became busy with dissection and microscopy. At the age of fifteen, he entered the family printing office, where he served five years of "duty and drudgery", hating the work, until his father fortunately came to realize that it would be more economical to send his son to Cambridge, as he would never make a business man of him.

At Cambridge Haddon came under the influence of Michael Foster, McKenny Hughes, Alfred Newton and especially of Frank Balfour, "his beloved master and friend", as he styled him, in a subsequent dedication of his first book, an "Introduction to the Study of Embryology". From his childhood he had shown a fondness for sketching ; and while at Cambridge he attended the lectures on art of the Slade professor, Sidney Colvin. This early interest in design was to receive later development in an unexpected scientific direction. He met at Cambridge Holland Rose, a fellow undergraduate, later the distinguished Napoleonic historian, who married Haddon's younger sister. Haddon was appointed professor of zoology in the Royal College of Science, Dublin, in 1880 ; and a year later he married Rose's sister, whose devotion as mother and wife, self-sacrifice and courage throughout her husband's many hardships and disappointments made her a perfect helpmate.

At Dublin, Haddon felt himself soon "perishing for want of research". He became more and more dissatisfied at having to lecture on coral reefs and tropical fauna which he had never seen. So, in 1888,

on T. H. Huxley's advice (who had already visited this region in the voyage of the *Rattlesnake*), he spent a year in the Torres Straits. He went out as a zoologist; he returned as an ethnologist, destined to conduct, eleven years later, that second expedition to the Torres Straits, which earned him such well-deserved fame.

From 1893 he made his home at Cambridge, although retaining his zoological professorship in Dublin until 1901 in order to 'keep the wolf from the door'. His energy, both physical and mental, was throughout his life extraordinary. At Cambridge he at once began to teach physical anthropology, although he received no university stipend and held no university post. His first lectures and practical courses were offered to candidates for the second part of the Natural Sciences Tripos in human anatomy and physiology. I attended the first course in 1893–4, and well recall the care with which his lectures had been prepared and the wonderful skill and enthusiasm he displayed in teaching. Mrs. Quiggin is well justified in her observation: "It may be that his work as a teacher was even greater than his work as a scientist, for he had the gift of inspiring others, and his students have carried his ideals with them to the ends of the earth". The effect, at all events, upon me of my attendance at Haddon's first classes in anthropology at Cambridge was that I became immediately (before taking my degree) engaged on craniometric research, reporting on a collection of ancient British skulls recently acquired by the Anatomical Museum.

In my opinion, Haddon's most natural bent towards the science of ethnology lay in the direction of the study of native arts and crafts—technology. His fundamental contribution to this subject appeared in 1895 when he published "Evolution in Art", which became, as his biographer says, "an unexpected best-seller". He vainly hoped to issue it later in a revised form, embodying much of the immense material afterwards collected. His later works on the stone clubs of British New Guinea, the canoes of Oceania, the decorative art and fabrics of the Sea Dayaks, etc., arouse an intense, righteous anger, because one so eminently fitted to devote himself to this important aspect of ethnology should have felt compelled to spend his time unduly in writing newspaper articles and reviews, in acting as referee to various publishing firms, and in giving lectures throughout the country, in order to 'make ends meet' financially with his growing family of a son and two daughters. Whether or not they persisted sometimes needlessly as a habit, these activities certainly helped to arouse general interest in so young a subject; and anthropology would not have been what it was when Haddon left it had he not felt forced to give so much of his time to its popular nurture.

That he was a successful organizer is patent to anyone familiar with the success of his *chef-d'œuvre*, the Cambridge Anthropological Expedition to the Torres Straits and Sarawak, most of all to one who, like myself, was a member—now the last surviving member—of it. From start to finish of the Expedition and of its work, not a cross word escaped him; what he wanted was done because, under his inspiring and enthusiastic leadership, everyone realized the justice of it. From this expedition he returned in 1899 to find that a successor had been installed in his place, holding the £50 lectureship in physical anthropology which had been created for him in 1895. In the following year he received, in compensation, an appointment to an equally generous lectureship in ethnology at his old University, which only in 1909 raised it to a readership with a stipend of £200. By this time he had been elected to a fellowship at his old college, Christ's, and had been tempted to accept another distraction, the Martin White lectureship in ethnology in the University of London.

His tardy recognition at Cambridge may have been partly due to his unusual personality. "You must be a little mad," he once said, "to get anywhere. You can't advance without overbalancing." "He had no society manners, and his blunt, downright outspokenness was often disconcerting in conventional circles." He rather enjoyed shocking the 'unco' guid' and the prudish; "those whom he thought insincere or silly often thought him rude". Quite wrongly he was often regarded as being merely pagan or agnostic. But behind lay a strong inherited vein of religiousness, philanthropy and generosity. There was indeed some basis for the verdict of one of his (Christianized) Murray Islanders in the Torres Straits, who described him as being "close up alongside God". He had a wonderful love of humanity and a gift of sympathy with, and understanding of, less cultured people, which made him a unique ethnologist in the field.

C. S. MYERS.

COLLOID SCIENCE

Advances in Colloid Science

Edited by Dr. Elmer O. Kraemer, in collaboration with Prof. Floyd E. Bartell and Dr. S. S. Kistler. Vol. 1. Pp. xii+434. (New York: Interscience Publishers, Inc.; London: The Imperia Book Co. Ltd., 1942.) 33*s*.

COLLOID science nowadays covers a multitude of the branches of physical chemistry and even of technology. The diversity of subjects treated in the present volume is as wide as the all-embracing title might lead one to suppose. The editorial viewpoint is that the series shall present recent work in this subject by authors who have made significant contributions. If we may judge from the variety of topics dealt with in the first volume there will be no lack of subject matter for some time to come. One consequence of the editorial policy will be that the articles will often contain the individual opinions of the authors and that they will be more in the nature of progress reports than chapters in a text-book. But this fortunately leads to a more stimulating treatment, provided the reader has already some knowledge of the subject under review.

An ever-recurrent problem in technology is the development of a rapid method of determining the state of subdivision of a powder. Usually all that is required is a measurement of the specific surface or perhaps a mean value for the radius of the constituent particles. Microscopic methods are too laborious, and sampling is difficult. P. H. Emmett gives a review of his own work in which the proper interpretation of the adsorption isotherm of selected gases or vapours provides the basis for computing the specific surfaces of the adsorbent. Provided the particles of adsorbent do not have a porous structure a measure of the mean diameter may thus be obtained. Another

method of measuring specific surface consists in determining the resistance to the flow of fluid through a plug of powder. Again the technique is not easy, but R. R. Sullivan and K. L. Hertel carefully point out the limitations of the method as compared with existing alternatives. These articles fortunately contain sufficient experimental detail to render them useful as working guides in the laboratory.

Differential adsorption has been brought to a high state of perfection in chromatographic analysis. But there is nothing in principle to prevent the method being more universally utilized, and A. Tiselius describes the modification of the technique for dealing with colourless solutions. The analysis, by refraction, of the concentration gradients of the emergent solution enables the several solutes to be separated and recognized. The method was specially developed for amino-acids and peptides ; its success here is proof of its sensitiveness and powers of discrimination.

The mechanism of detergent action, discussed by J. W. McBain, is of increasing importance in many technical processes. There is still much to be done to the theory because the search for new detergents is almost wholly empirical in character. The particular aspect of detergent action discussed is the increase in solubility of hydrophobic substances in water brought about by the addition of these agents.

High polymers rightly assume their proper place in colloid science and consequently in this volume. K. H. Meyer discusses in some detail the structure of starch and shows how purely chemical methods have thrown a flood of light on the way in which the glucose units make up the relatively complex molecule. At the other extreme R. E. Powell and H. Eyring survey the possible application of statistical methods to the physical behaviour of high polymers and their solutions. Owing to the complicated nature of the subject only broad generalizations may at present be formulated. Perhaps one of the more interesting is the conclusion that, in the flow of molecules in the molten polymer, segments of 20–25 carbon atoms move as a whole, which movement is independent of the chain-length of the polymer. Much can be learned of the shape of dissolved or dispersed particles by examining the streaming birefringence of their solutions. Again, enough is given of the technique and of the theory to make this article by J. T. Edsall a good starting-off point for those interested in studying the subject further.

A good indication of recent advances in colloid chemistry in the classical sense of the term is furnished by the elucidation of the structure of the gels of metallic hydroxides by following the process of their formation by examination of their X-ray diffraction patterns. H. B. Weiser and W. D. Milligan thereby add another chapter to the investigation of inorganic colloids. Some of the principles of the coagulation of colloidal solutions now find direct practical application to the concentration and precipitation of rubber from latex. G. E. van Gils and G. M. Kraay describe a systematic investigation of those factors which govern the preparation of concentrated and stable rubber latex which now has—or perhaps had—so many important applications in industry.

E. A. Hauser brings forward his pendent drop method for the measurement of surface tension and further discusses rather too briefly some of the anomalies of the surface tensions of solutions.

The removal of ions from natural water is of fundamental importance in the supply of suitable water to boilers, for the efficient utilization of detergents and indeed for most industrial processes (R. J. Myers). Cations are perhaps the most troublesome, and the base exchange zeolites—natural or artificial—provide one of the best methods of coping with this problem. Zeolites are not, however, unique in this respect, since certain phenol formaldehyde resins contain a sufficient percentage of hydroxy groups to react in a manner similar to that of the zeolites. Progressing a stage further, acid-exchange resins from aniline and formaldehyde allow of the removal of anions and their replacement by hydrogen ion. There is thus theoretically the possibility of removing both anions and cations from water by a two-stage process—in fact, it now is a commercial proposition for the preparation of 'ion-free' water.

It appears to be a far cry from colloid science to electron optics, but the fact is that the electron microscope bids fair to become a useful tool for the investigation of disperse matter lying in the range 0·01–10 μ. T. F. Anderson gives enough in his article to whet the appetite for more and to convince the colloid chemist that an electron microscope is even more useful than the ultramicroscope of classical colloid chemistry.

H. W. MELVILLE.

MUSEUM PRESENTATION OF GEOLOGY

Geology in the Museum

By Dr. F. J. North, C. F. Davidson and Lieut. W. E. Swinton. (Published for the Museums Association.) Pp. viii + 104 + 6 plates. (London : Oxford University Press, 1941.) 5*s*. net.

POST-WAR reconstruction promises to extend to museums, demanding from them not only rehabilitation after the neglect of the war years but also extended activities along both recreational and educational lines. Aims must be re-examined, collections overhauled or replaced, and exhibitions devised anew. Museum officials, amply supplied with textbooks on systematics, have hitherto been forced to delve laboriously in professional journals in search of papers on museum problems of preservation and presentation. For their especial needs, the Museums Association is publishing a series of handbooks, and that under notice surveys geology in the museum.

Dr. North deals with the general problems of the introduction of geology to a varied public ; Dr. Davidson contributes a section on mineralogy ; and Dr. Swinton completes the trilogy with one on palæontology. Notes on what to collect are followed by others on treatment and preservation, on registration and storage. The exhibition aspect of geology is prefixed by a discussion of aims, of what to show and how to show it, together with a consideration of layout and labelling, of diagrams, models and other adjuncts. Details of materials and instruments, recommended by past experience for future use, and the sources from which they can be obtained are given in text and footnote. Consideration is given to furniture and equipment, both for exhibition gallery and for staff laboratory. The bibliographies are carefully selected and up-to-date. While this little volume cannot make a curator a geologist, it will help to make a geologist a curator. D. A. A.

EVOLUTION IN ASTRONOMY*

By SIR JAMES JEANS, O.M., F.R.S.

ONE of the most important, and also one of the most fascinating, of the problems of astronomy is the tracing out of the steps by which the universe has evolved from primitive beginnings to its present complex form. But until recently it was like trying to piece together a jig-saw puzzle from which some of the more important pieces were missing. Happily the situation has changed rapidly of late; more pieces of the puzzle have come to light, and one in particular—a better knowledge of the possible sources of stellar energy—is found to fit very convincingly into a big vacant gap, with the result that the whole picture begins to assume a logical and satisfying shape.

Most cosmogonies have assumed that the universe began in a state of complete chaos. Newton saw that a mass of chaotic matter spread uniformly through space would form into condensations under its own gravitational forces, and that these would ultimately divide into separate detached masses. He here indicated the first broad lines of cosmic evolution; we are now able to fill in many of the details.

Astronomers have recently made two complementary discoveries which fit together very satisfactorily —that our galactic system of stars is smaller in size than used to be thought, and that the extra-galactic nebulæ are larger. Obscuring matter spread through space dims the brightness of the stars, making them appear more distant than they are; the recognition of this has brought the distant stars nearer and the galactic system has shrunk. Simultaneously, photometric studies of the sky have shown that the extra-galactic nebulæ extend much farther than appears on the photographs from which we used to estimate their dimensions. It is now clear that the galactic system and the extra-galactic nebulæ are all about the same size, their longest diameters perhaps averaging 100,000 light-years.

Their masses also are found to be not very dissimilar. The mass of the galactic system can be determined from the gravitational pull it exerts on the sun and the stars in its proximity; it proves to be rather more than 100,000 million times the mass of the sun. The masses of the extra-galactic nebulæ can be estimated from the gravitational pulls they exert on one another or on other moving objects; estimates of nebular masses range from 20,000 million to 200,000 million suns.

In this way the galactic system and the extra-galactic nebulæ prove to be similar objects, which we may conveniently describe as 'galaxies'. They are scattered fairly uniformly through space at an average distance apart of perhaps a million light-years. If we assume their average mass to be 100,000 million suns, the average density of matter in space is $2{\cdot}4 \times 10^{-28}$, which gives 200 atoms of hydrogen, or one of mercury, to the cubic metre. If the universe is really expanding in the way suggested by the spectra of the nebulæ, this density is continually decreasing, its value being halved every 450 million years. But the density of the primeval chaos must have been at least of the order just mentioned. With this density adjacent molecules are about a foot apart, while the free-path must be measured in light-years.

* Substance of a course of lectures delivered at the Royal Institution on November 3, 10 and 17.

If we know the density of a distribution of chaotic matter, and the average speed of the thermal motion of its units, we can calculate the average mass of the condensations which will form in it. Newton conjectured that these condensations would be of stellar mass; we now know they would be of galactic mass. Condensations having an average mass of 100,000 million suns would result from a density of $2{\cdot}4 \times 10^{-28}$ and a thermal velocity of 37 km. a second. The thermal velocity might easily have this high value if the chaos contained a good proportion of free electrons, since these have a speed of 111 km. a second at 0° C.

Thus the first step in the evolution of the universe was probably the breaking up of a primeval chaos into the separate masses which now form the galaxies. These are all of the shapes which would be assumed by compressible masses in rotation, and rotation can be observed spectroscopically in the nearer nebulæ. We do not know how it originated—possibly from currents and swirls in the primeval chaos. In any event, as the condensations contracted under their own gravitation, their speeds of rotation would increase and they would assume in turn the shapes appropriate to different rates of rotation. In the last stage of all, matter lies spread out in the equatorial plane of the rotating mass, where it again becomes liable to gravitational break up, and will form detached condensations. On inserting reasonable values for the density and thermal velocity of this matter, we find that the condensations will be of stellar mass. Thus, except for the intermediate step of the formation of galaxies, we can picture the stars as having been formed much as Newton imagined. As the average density of the parent nebula would scarcely be greater than 10^{-22}, the new-born stars will be of very low density; they will perhaps exist as distinct and detached masses while their densities are still as low as 10^{-20}.

They will of course begin by contracting rapidly under their own gravitation; a mathematical theorem of Poincaré helps us to follow their progress. It tells us that the total thermal energy imprisoned in a gaseous star at any time is just equal to the total energy which the star has lost, or would have lost, in contracting from a state of infinite diffusion. Incidentally, we notice that the more a gaseous star loses energy, the hotter it becomes—not the cooler, as we might be tempted to think.

Thus when the size and composition of a star is known, we can calculate its total thermal energy, and so deduce the temperature of its interior. It is found that the average temperature of the sun's interior must be about 20,000,000°, unless the sun contains a large amount of hydrogen, in which case it will be substantially lower. When other stars are treated in the same way, the surprising result emerges that for the largest class of known stars—the 'main-sequence' stars—the average internal temperature must be exactly or very nearly the same as for the sun.

The total energy supplied by gravitational contraction can, as is well known, only provide a small fraction of the total energy which the sun must have radiated even in geological times, and it has for some time been suspected that the sun—and of course the other main-sequence stars also—must draw energy from some source which comes into operation as soon as stellar matter attains a temperature of the order of 20,000,000°. The recent intensive study of nuclear physics has revealed just such a source of energy.

In a famous series of experiments, Rutherford

showed that the nuclei of the atoms of the light elements can be transmuted into nuclei which are chemically different through bombardment by α-particles. Now at the high temperatures of stellar interiors, α-particles, which are merely helium nuclei, are a normal constituent of stellar matter, the helium atoms being broken up into their constituent particles by the heat. The stars become alchemical laboratories, in which the chemical elements continually suffer transmutation as their atoms or nuclei are bombarded by α-particles and other swiftly moving projectiles—protons, neutrons, deuterons, and the like.

Reactions of this type are called thermonuclear. They are mostly very sensitive to changes of temperature, so that each reaction may be associated with a definite critical temperature; below this temperature the reaction occurs only in minute amounts, but above it in torrential amounts. This critical temperature depends very much on the complexity of the nuclei involved in the reaction, being approximately proportional to the square of the atomic numbers of these nuclei. It is consequently lowest—less than 1,000,000°—for the simple reaction of one proton with another. In this reaction a deuteron is formed, and as this leaves an excess of positive electricity, a positron is set free. The deuteron may afterwards capture two more protons and form a helium nucleus.

Next, at temperatures of from 3 to 7 million degrees, protons may react with the nuclei of the light elements lithium, beryllium and boron.

Then, at temperatures of the order of 20,000,000°, comes the reaction of a proton with a carbon nucleus of mass 12. The combination forms a nitrogen nucleus of mass 13, but this is only the first of a series of processes. The nitrogen nucleus may capture a second proton, becoming an ordinary nitrogen nucleus of mass 14, and then a third proton, becoming a nitrogen nucleus of mass 15. This may capture yet a fourth proton, but the result is not a nitrogen nucleus of mass 16; it is usually a carbon nucleus of mass 12, together with a helium nucleus, or α-particle, of mass 4. Actually this description has omitted subsidiary processes which do not affect the final result. The main events consist of the carbon nucleus swallowing four protons in succession, and thereby being pushed along the sequence of nitrogen isotopes until this road comes to an end. It then resumes the form of the carbon nucleus with which it started, the four protons it has swallowed being disgorged in the form of a helium nucleus. In this way four protons are bound together to form a helium nucleus, all the other nuclei emerging unaltered—the carbon has merely acted as a catalyst.

This transmutation may not appear to have any relation to the supply of energy for radiation, until we notice that the total mass of the matter concerned has experienced a diminution. The atomic weight of hydrogen (O = 16) is 1·008, whence the mass of four protons is 4·030, while the mass of the resulting helium nucleus is only 4·003. Thus there has been a loss of mass of 0·027 units, or one part in 150 of the total mass involved.

We know that all radiation has mass associated with it at the fixed rate of 1 gm. for every 9×10^{20} ergs of radiant energy. Thus the sun, radiating $3{\cdot}8 \times 10^{33}$ ergs a second, must lose $4{\cdot}2 \times 10^{12}$ gm. a second—250 million tons a minute. The core of the problem of the source of solar radiation is the finding of mass of this amount inside the sun which is capable of being set free in the form of radiation. Now each thermonuclear reaction in which mass is lost results in an equivalent emission of radiation in the form of γ- or X-rays; these are soon absorbed by the stellar matter and re-emitted as temperature radiation in equilibrium with the stellar matter. Thus thermonuclear processes are fully capable of explaining the sun's radiation qualitatively.

They are also adequate quantitatively. To emit its present stream of radiation for a period of 2,000 million years, the sun must lose one part in 7,500 of its mass; if it consisted wholly of hydrogen (apart from a small amount of carbon acting as a catalyst) it could transform one part in 150 of its mass into radiation by the process just considered. A sun in which only one fifth of one per cent was hydrogen could provide the present sun's radiation for 2,000 million years—and it is fairly certain that the sun contains more hydrogen than this. The evidence of astrophysics is that hydrogen is the most abundant element in most stars.

Other classes of stars present different problems, to which different answers must be given. The most luminous stars of all, apart from freaks, emit about 7,500 times as much radiation per gram of their mass as the sun. Neither thermonuclear reactions nor anything else could enable these stars to radiate at their present rates for 2,000 million years; to do this they would have to transform the whole of their mass into radiation. We must conclude that such stars cannot radiate as at present for another 2,000 million years, and probably have not done so in the past, unless they can draw on external sources of energy, as, for example, by an accretion of matter from outside. The red giants and Cepheid variables, which do not belong to the main sequence, have central temperatures well below the 20,000,000° which characterizes the main sequence stars. The carbon reaction cannot occur in these in appreciable amounts, but it seems likely that reactions with elements lighter than carbon may provide the energy for their radiation. In time, all these light elements will have been used up; the star will then contract, its internal temperature continually increasing, until it reaches 20,000,000°. The star has now joined the main sequence, and the carbon reaction comes into play to supply it with radiation.

Again, the smallest stars have central temperatures well above the critical 20,000,000°. These must have used up all their hydrogen, and then started contracting afresh. The energy they are emitting as radiation may be derived from their gravitational contraction—which could supply radiation for perhaps 100,000 million years—or possibly from some other thermonuclear processes, not yet identified, which occur at temperatures above 20,000,000°.

Certain minor complications, such as have already been mentioned, do not affect the occurrence of the processes, but they ensure the stability of the star. A process in which the generation of energy increases rapidly as the temperature increases is usually unstable. For any slight increase of temperature causes an excess generation of energy, which causes further heat, still more generation of energy, and so on indefinitely; the process becomes explosive. But when, to take a single instance, a carbon nucleus has swallowed its first proton and become a nitrogen nucleus of mass 13, it must emit a positron before it is ready to swallow a second proton. This is emitted by a sort of radioactive disintegration and, as an increase of temperature does not increase the rate of radioactive disintegration, the explosive sequence

of events just mentioned does not occur. An increase of temperature will now merely increase the pressure inside the star, so that the star expands and cools. By this thermostatic mechanism, the star continually adjusts itself so that just enough energy is generated to replace that lost by radiation. From its nature the adjustment cannot usually be instantaneous, so it is perhaps not surprising that the stars which are cooler than 'main sequence' stars are mostly variable stars in which regular and substantial fluctuations of light occur.

Thus we think of the matter of the primeval universe as having first condensed to form separate detached masses, one of which ultimately formed our galactic system. This process may well have taken tens of thousands of millions of years. These distinct masses in their turn broke up into separate stars, taking perhaps hundreds of millions of years to do so. These stars would at first be cool, of low density and of immense size. After contracting for a few million years, they attain a temperature at which the proton-proton reaction begins to occur. But at low temperatures this reaction occurs but rarely—too infrequently to make good all the energy lost by radiation. The stars accordingly continue contracting until they attain temperatures at which the protons react to an appreciable extent with the nuclei of light elements. This reaction may supply radiation for a few million years, after which the light elements are used up; then contraction begins afresh and continues until the temperature of 20,000,000° is reached. The carbon reaction now takes control and can supply radiation for thousands of millions of years if the star is not too massive and luminous. During this period, the proton-proton reaction still occurs, and may provide for an appreciable part of the star's radiation—perhaps for half in the sun, and for even more in less massive stars. Finally, the supply of protons gives out, and the star contracts once more—possibly for hundreds of thousands of millions of years.

At some point in this sequence of events the sun has given birth to planets; at some point other stars may do the same. Mathematical investigation shows that planets can be born out of a star by tidal action—through a second star approaching near to it and drawing out a long filament of gas, which then breaks up gravitationally and condenses into separate planets. If the two stars are of similar build, such an event requires an approach to within about three radii, whatever the sizes of the stars may be.

Approaches of the requisite closeness would clearly be far more frequent in the early period when the stars were big, than in the later period when they were compact. For our sun, the first period was short (less than 20 million years), while the latter period has been long (more than 2,000 million years). Nevertheless, calculation shows that an effective tidal encounter is far more likely to have occurred in the former short period than in the latter long period. It is not surprising, then, that the solar system is found to contain intrinsic evidence that its planets were born while the sun was still of immense size. It must have extended an appreciable fraction of the distance to the present orbit of Pluto: otherwise there would have been no mechanism for putting the outermost planets in their present orbits.

It follows from this that the age of the sun as a star is approximately equal to the age of the earth as a planet—probably between two and three thousands of millions of years. In this period, the sun can only have used up a small fraction of its protons, so that it probably can look forward to a life in its present state which will be incomparably longer than the life that lies behind it. When this is over, it will begin to shrink into a smaller and cooler star, and life on earth will become impossible.

Detailed calculations show that the chance that a star shall give birth to planets while it is of the compact dimensions of our sun is quite negligible. On the other hand, the chance of its having given birth to planets before attaining to this state is considerable—a fair proportion of the stars must, then, be accompanied by planets. Of these a substantial fraction are likely to be in a physical state not very different from that of our own earth, and so capable of maintaining life like our terrestrial life; it is possible that such life is far more abundant in space than we used to think.

PREVENTION AND TREATMENT OF ANTI-SOCIAL BEHAVIOUR

IN his Chadwick Lecture on "The Differentiation, Prevention and Treatment of Anti-Social Behaviour Disorders" delivered on December 8, Dr. Norwood East has made a succinct but systematic review of the main established facts regarding the causation of crime, and has presented a convincing argument for the view that crime is as much a scientific as a legal or a medical problem. Dr. East was for many years one of H.M. Commissioners of Prisons, and Medical Inspector of Prisons in England and Wales. He has recently completed a scientific study on an extensive scale of the medical, social and psychological aspects of crime, more particularly among adolescents (see NATURE, September 26, p. 361). He is therefore able to speak both with experience and authority; and much of his lecture is in fact concerned with the practical corollaries to be deduced from the inquiries that he has made.

Generally speaking, Dr. East regards behaviour disorders as manifesting in nearly every case a complex causation. They are "the result of stress, acting upon an inherited constitutional pattern, which may itself have been modified, in varying degrees, by environmental factors other than the stress itself". The inherited constitutional factors are themselves incapable of being greatly changed. It follows that, in general, the treatment of anti-social behaviour must be limited to efforts at changing the environmental factors, and particularly to relieving whatever stress may have precipitated the criminal action. In different cases, however, the relative importance of the constitutional factors, on one hand, and of the environmental factors, on the other, may differ widely. Thus, although individuals belonging to certain temperamental types may be more liable to yield to temptation than persons of average mental heredity, nevertheless, "the majority of persons, and perhaps all, are potential first offenders"; for criminal action, as a rule, results, not from one type of factor to the exclusion of the other, but from "a disturbance of the balance between the two".

According to Dr. East, therefore, the fundamental psychological premise from which the criminologist has to start is the fact that "no person corresponds exactly to his fellows; for even an arbitrarily selected normal person occasionally shows peculiarities of behaviour". Consequently, while anti-social behaviour

may be precipitated by almost any form of maladjustment between the individual and his environment, some individuals, by nature or by habit, will be more prone to disregard the requirements of the society in which they live, and so more easily led into actions which that society regards as criminal. This is especially true of those suffering from mental defect or mental disease. Much of his lecture is, therefore, devoted to the relation of crime to these particular pathological conditions.

Among inborn factors, the most important in his view are the inherited "drives", a term which he borrows from American psychologists to denote "the impulsive energy of any instinct". In guiding social behaviour, he holds, the acquisitive, sexual, gregarious and self-preservative instincts prove to be exceptionally powerful; and he argues that "much practical insight into normal and abnormal motivation is gained by regarding the various instincts and their accompanying emotions as the basic essentials of purposive action". But instinct is not all. Intelligence, as the psychologist defines the term, is equally an inborn factor. Differences in innate intelligence may limit the powers of self-control and of learning by experience. Hence individual intelligence has also to be taken into account in considering motive or lack of motive, and in proposing suitable treatment. In particular, as he points out, "it is characteristic of much anti-social behaviour that the desire of the moment, the proximate aim, is more importunate and decisive than a long-term ambition or desire".

Children and adolescents, owing to their immaturity, are largely under the sway of their innate impulses; and, particularly if brought up under adverse home conditions, may be slow in learning to control their conduct by intelligence or experience. Hence, during childhood and puberty, many forms of behaviour may arise as part of the normal development of the growing boy or girl which in an adult would be looked upon as criminal. In discussing the treatment of juvenile delinquents, Dr. East briefly notes the valuable part that may be played by child guidance clinics both in prevention and cure; and is apparently inclined to attribute much of the delinquency that is rife among children at the present day to ignorance of "even elementary standards of conduct". As to the means of combating this ignorance, he cites the view of the Middlesex Education Committee, which urged that "religious education was the surest means of acquiring these standards", and reported that teachers themselves were showing "considerable enthusiasm for this branch of education".

Since criminality is more apt to arise in persons of abnormal mentality, Dr. East, like most medical investigators, has paid special attention to the association of anti-social behaviour with insanity, with mental deficiency, with neuroses, and with psychopathic states; and quotes authoritative figures. "Although no particular crime is characteristic of insanity, the proportion of homicides in this country who are insane is much greater than the proportion of those who commit other offences"; but "criminal conduct associated with insanity may extend almost throughout the whole gamut of crime". The forms of major mental disorder chiefly associated with crime are schizophrenia, manic-depressive disease, and paranoid states; and since in each of these conditions inheritance appears to play an appreciable part, eugenic marriages, he argues, may tend in some degree to diminish the number of offspring liable to develop anti-social behaviour. However, as he goes on to point out, the frequency of definite insanity among criminals is exceedingly small: the number of persons received into prison who are either insane on reception or become insane during detention is barely 1 per cent of the admissions.

Mentally defective criminals are even fewer; they form only half of 1 per cent of the admissions. However, the higher grades of mental deficiency shade off imperceptibly into normality through a subnormal group, who may also display anti-social behaviour. The mentally deficient "commit various crimes including murder at one end of the scale and vagrancy at the other"; but "the majority of their offences are connected with the acquisitive instinct, namely, theft, embezzlement, false pretences and the like; next in frequency are various sexual offences; but, as with insanity, no particular kind of crime is characteristic of the condition". The defective offender, however, very easily forms a criminal habit; and the danger to the community from his misconduct is to be measured, not merely by a particular offence, but by his incorrigibility. Hence the importance in these cases of enforcing early institutional care. A large measure of prevention has already been secured by prompt ascertainment, followed by segregation or supervision; but, it is argued, if eugenic principles could be applied, still more anti-social behaviour would be prevented.

Since psychoneurosis is often precipitated by emotional maladjustment, it is not surprising to find that many criminals show neurotic symptoms. Here precise figures are harder to obtain. Hysteria, Dr. East believes, is far more frequently associated with major forms of anti-social behaviour than is sometimes supposed. Anxiety states, too, may often form the chief cause. On the other hand, contrary to notions prevalent among the general public, obsessive and compulsive states are not often related to serious misconduct; and, apart from the occasional effects of the accompanying hypersensitiveness and irritability, neurasthenia (in the proper sense of the term) is comparatively infrequent as a causative factor. In his investigation of 4,000 adolescent criminals, Dr. East found no more than 48 suffering from definite psychoneurosis—not much more than 1 per cent. In all such cases Dr. East once again stresses the importance of early recognition: the more promptly psychotherapeutic measures are applied, the less likely is anti-social conduct to ensue.

In criminological literature the phrase 'psychopathic personality' often becomes (as Dr. East acknowledges) a kind of waste-paper basket, into which anything that cannot be pigeon-holed under more definite headings may all too easily be bundled together. Nevertheless, he believes that there is a small but well-defined group, including schizoid, cycloid and paranoid personalities, as well as perverts, drug addicts, alcoholists and the mentally unstable generally, to whom the term may be usefully applied. The disabilities and social difficulties of the so-called psychopath seem largely due to innate factors; and the prevention of anti-social disorders among such persons consequently presents a serious practical difficulty. Treatment has often to be restricted to efforts designed merely to modify the particular impulse or activity which is leading the patient into conflict with the law.

On the whole, however, as Dr. East insists, "the majority of prisoners found guilty of criminal offences do not show abnormal characteristics (although, of

course, they exhibit individual variations among themselves, just as other groups of persons do). . . . The figures disprove the assertion of those who declare that crime is a disease." Coming from one who, in virtue of his work, his experience, and his writings, is among the foremost authorities on the subject in Great Britain, and is himself a medical man, this is a most significant pronouncement. Both in the medical and in the educational world there are still numerous writers and administrators who do not realize how opinion upon this point has changed. The trouble seems to be that laymen and Government officials are alike inclined to think that the qualified expert in mental science must be the medical man. Psychology, owing doubtless to the publicity given to its more sensational problems, is confused with psychoanalysis, and not yet regarded as a science in its own right. Many of the pioneers who have urged that the prime need of the adult criminal is treatment rather than punishment have done so on entirely misleading grounds, namely, that "crime is a pathological symptom, and therefore the criminal should be accorded the same medical care as any other mental sufferer". Similarly, when child guidance centres were established they were called 'clinics' (as though backward pupils as well as young delinquents were mentally diseased); and it has been the official policy of the Child Guidance Council itself that "since crime is a form of illness, the child guidance clinics at which such cases are examined should be under a medical director". No doubt, in a small proportion of the cases, moral delinquency, like educational backwardness, may be the outcome of physical or mental illness; and in every case the first step is unquestionably to investigate the possibility of such illness as a contributory factor. Recent investigations, however, like those of Dr. East, prove conclusively that it is, as a rule, only a minor factor, and a comparatively rare one at that. Hence, as recent experience has shown, there is considerable danger that exclusive or excessive emphasis on the need for a medical approach may lead to the neglect of other lines of study and treatment that are far more important—the social, the educational, or the psychological.

In all cases of delinquency or crime it is the psychological rather than the physical or pathological characteristics of the individual that call for first consideration. But in early years it is the social and educational environment—the home and the school—that are usually the deciding factors. "The home," says Dr. East, "should be the first training ground." The lad who comes from a broken home or from a family where discipline is unduly harsh, unduly lax, or so erratic as to be virtually non-existent, is not only more liable to drift into vice and crime, but also more resistive to subsequent efforts at reform. A wholesome training in the school is equally essential as a supplement to, and often as the only substitute for, the training in the home. "But its value is not to be measured by its success in teaching a lad how to acquire knowledge or even by its material usefulness in after life: . . . the formation of moral principles and habits is the most important part of education." "For this and other reasons," Dr. East observes, "the criminologist will welcome the proposal to raise the school-leaving age." As regards economic conditions, he finds that the relative amount of unemployment among offenders was not appreciably greater than that obtaining among the general population: but they seemed far more liable to commit their offences during spells of unemployment than at other times, In particular, he urges the importance of vocational guidance as a means of combating delinquency: among adolescents more especially, it would seem. "wrong placements tend to invite anti-social behaviour".

As to punishment, Dr. East notes that "the tradition that imprisonment is solely punitive still persists in certain quarters; but it cannot be too widely known that its modern purpose is treatment and training". This, as he points out, is the attitude taken in the Criminal Justice Bill of 1938, which was before Parliament before the outbreak of the War. That penal measures do not altogether fail is, in his view, borne out by after records: thus "of 17,918 males and 2,749 females who were over the age of 16 years in 1932, and were found guilty in that year of offences sufficiently serious to warrant the taking of finger-prints, and had no previous proved offences recorded against them, 90 per cent of the older males, and over 70 per cent of the younger, were free from any further charges during the subsequent five years: the figures for females were nearly 90 per cent".

Due attention to the psychological study of the criminal must be one of the items that should claim a foremost place in the programme for post-war reconstruction. Since at the moment the urgent need is knowledge, more detailed, more precise, and, in a word, more scientific, about the reactions of the individual mind, one of the first steps should be to establish "an institution where research into the problems of criminal behaviour, and the scientific treatment of offenders, can be carried out". "And the conclusion of the whole matter," says Dr. East, "seems to lie in the fact that a democratic State can no longer afford to ignore the effects of social hazards which are harmful and preventable; the treatment of delinquent and criminal behaviour are not merely matters that concern lawyers, administrators and scientists; they are matters that concern us all."

A PHYSIOLOGICAL THEORY OF COLOUR PERCEPTION

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IT is nowadays possible to record the discharge of the retinal elements directly by leading off to electrodes from more or less isolated fibres of the optic nerve. The electrical impulses following upon illumination are the physiological means of communication between the retina and the higher centres. They are amplified and led to an oscillograph for photographic recording and at the same time listened to in a loud-speaker. This is the technique for which the well-known work of Prof. E. D. Adrian and his collaborators originally laid a solid basis. For isolation of the fibres in the optic nerve a method of micro-dissection around the blind spot has been developed by Hartline[1] and a micro-electrode technique for picking up from the fibres inside the eye by Granit and Svaetichin[2]. The latter method is a great deal simpler and faster than the former, and for this reason it is the natural instrument for a rapid survey of the colour properties of a large number of single or grouped units in the response of the eye to illumination with spectral light of known energy

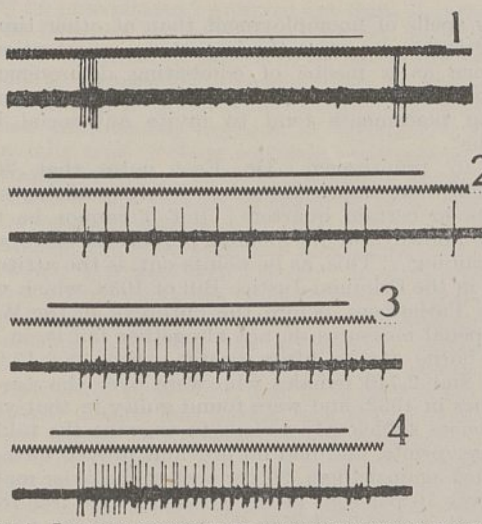

Fig. 1. IMPULSES PICKED UP BY A MICRO-ELECTRODE PLACED ON THE NERVE FIBRES INSIDE THE RETINA. ABOVE EACH OSCILLOGRAM IS THE TIME RECORD (50 PER SEC.) AND LIGHT SIGNAL.
1. "On-off"-element from photopic cat's retina responding to light of wave-length 0·660 μ. Somewhat above threshold.
2–4. "On"-element from scotopic retina of guinea pig responding to "white" light: 2, at strength 0·006 m.c.; 3, at 0·018 m.c.; and 4, at 0·061 m.c. Note increasing frequency and shortening latent period, as stimulus intensity increases.

content. Mammalian eyes can be studied with the micro-electrode as easily as eyes of the cold-blooded animals, to which the technique of micro-dissection is limited if it is to be used for analytical purposes. The animal is anæsthetized, cornea and lens removed, and the micro-electrode inserted with the aid of a micro-manipulator under suitable optical magnification.

Successful isolation, in mammals particularly easy to accomplish, leads to a discharge of spikes of impulses (Fig. 1). In different elements a response follows onset of illumination or both onset and cessation of illumination, as first noted by Hartline[1] with the frog's eye. In the latter and in some other eyes, there are also elements which merely respond to cessation of illumination. But these different types of responses are of less interest in this connexion because of the absence of any definite correlation between type of discharge and type of colour sensitivity, to judge by the work so far carried out.

In order to analyse the colour sensitivity of such discharges, we proceed to measure the amount of energy necessary for eliciting a threshold response in the different wave-lengths of the spectrum. If the element under the electrode has low sensitivity for light of a given wave-length, much energy is needed to elicit a discharge; if it has high sensitivity, little energy is required. Thus the inverse value of the energy necessary for a threshold response in each wave-length is the ordinate (per cent of the maximum) plotted in the curves of Figs. 2 and 3, illustrating the spectral properties of the retinal receptors. I shall briefly direct attention to some results of general interest from work published during 1940–42 (*Acta Physiologica Scandinavica*; preliminary review, *J. Amer. Opt. Soc.*, **31**, 570 (1941)). Since then the number of animals studied has been extended and principles have emerged which in my opinion suggest a relatively simple interpretation of some of the fundamental facts of colour vision, particularly of the differentiation of our sensations into the two categories of brightness (or luminosity) and colour. The principles discovered may also be of practical importance.

Analytically, the simpler structure is the dark-adapted eye with its rods fully charged with visual purple. We are familiar with the absorption curve of this substance. It was first accurately determined, with in every respect satisfactory and up-to-date technique, by the late R. J. Lythgoe[3], of University College, London. Our electro-physiological analysis of eyes of different animals in dark-adaptation has shown that a plot of the inverse value of the energy necessary for a threshold response reproduces the absorption curve for visual purple with perfect fidelity, provided that the curves are corrected for presentation in terms of quantum intensity, a necessity first pointed out by Dartnall and Goodeve[4] in NATURE. The maximum of this absorption curve is around 0·500 μ. Visual purple also determines the luminosity curve of the dark-adapted human eye (scotopic spectrum). After the latter has been light-adapted the maximum of our luminosity curve shifts to the region of 0·560 μ (Purkinje shift) and the new curve obtained determines the distribution of brightness in a spectrum strong enough to elicit sensations of colour (photopic spectrum). As is well known, the retina is then supposed to utilize cones as receptor elements.

In light-adapted eyes of animals the simple spectral sensitivity curves recorded with the micro-electrode technique are of two types: (i) broad absorption bands, here called *dominators*; and (ii) narrow bands, here called *modulators*. The most interesting fact about the photopic dominator, apart from the width of the curve, is the localization of its maximum to the region around 0·560 μ, as shown in Fig. 2 for frog and snake (Tropidonotus), the latter a pure cone eye which need not be light-adapted to give this curve. The same dominator has been found in the eye of the cat. The dominator is lacking in the eyes of guinea pigs and rats. The form and spectral locus of the dominator is practically identical with the average curve obtained from massed receptors in the light-adapted eyes of the same species. In this sense the dominator may be called the carrier of the Purkinje shift. This and its good correspondence with respect to form and locus with the luminosity curve of the light-adapted human eye necessitate the conclusion that the dominator is responsible for

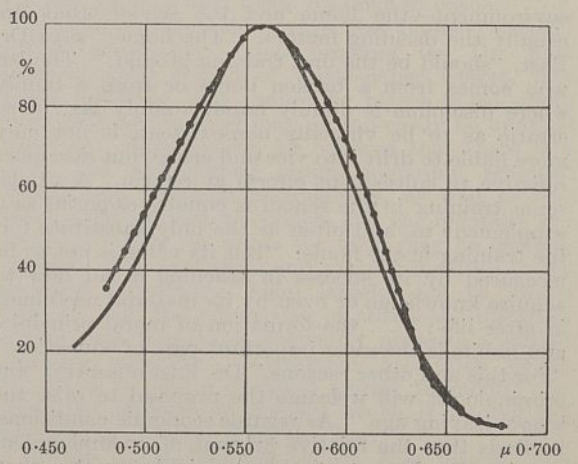

Fig. 2. DISTRIBUTION OF SENSITIVITY OF "DOMINATOR" ELEMENT IN THE RETINA OF FROG (UNINTERRUPTED LINE) AND SNAKE (LINE INTERRUPTED BY DOTS).

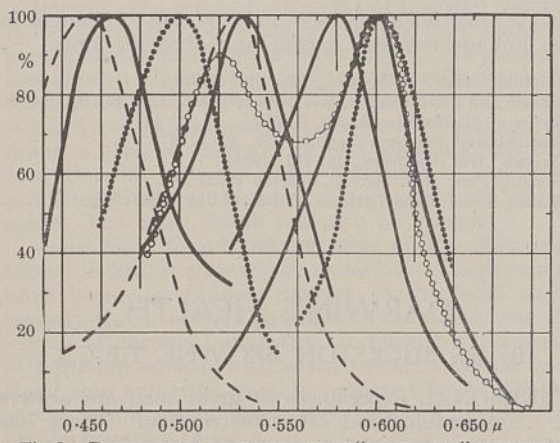

Fig. 3. DISTRIBUTION OF SENSITIVITY OF "MODULATOR" ELEMENTS FROM EYES OF RAT (DOTS), GUINEA PIG (BROKEN LINE), FROG (LINE IN FULL) AND SNAKE (LINE INTERRUPTED BY CIRCLES). NOTE THAT ALL CURVES ARE IN PERCENTAGE OF THE MAXIMUM AND THAT A NUMBER OF ORDINATES ON EITHER SIDE OF 0·560 μ ARE DRAWN DOWN TO INDICATE "DOMINATOR" VALUES. ALL SPECTRA OF EQUAL QUANTUM INTENSITY IN BOTH FIG. 2 AND FIG. 3.

the sensation of brightness, which thus is our dominant impression, coming, as it does, from the dominant receptor, dominant also in the sense that it is the most frequent one.

How then is colour vision possible? Modulation of the dominant impression of brightness to colour would seem to be the task of the much rarer modulators which occupy very narrow bands of sensitivity in three preferential regions around 0·580–0·600 μ, 0·520–0·540 μ and 0·450–0·470 μ. These are shown in Fig. 3. In addition, there is also in some eyes (rat, guinea pig) a narrow band in the region of 0·500 μ, which is the spectral locus of the maximum of the absorption curve for visual purple. The rat has 1 per cent cones, the guinea pig still less, if any. It is an interesting fact that in these eyes, which lack dominator and Purkinje shift, light-adaptation does not completely remove the absorption curve for visual purple but changes it to a very much narrower curve of modulator type, still placed in the same region. Light-adapted rods in this case serve as cones.

The most regularly recurring modulator in the different species studied has been the 'red' one with maximum at 0·600 μ. It has even been found in the eye of the rat, which lacks the dominator, but not in guinea pigs. In the cone eye of the snake the 'red' modulator was generally, though not always, connected to a 'green' hump at 0·520 μ, which sometimes was more, sometimes less, developed. Its narrowness (see Fig. 3) suggested a 'green' modulator which, however, was never obtained in the isolated state in this animal. But in guinea pigs and frogs 'green' modulators with maxima around 0·530 μ were seen. The 'blue' modulator was first found in the eye of the frog, then in the guinea pig. In both retinæ it is quite common in the shape of a hump on other curves, but it is difficult to isolate. The frog, of all the animals studied, has the most complete set of modulators (cf. Fig. 3). As rods and cones may converge towards a common retinal ganglion cell (Polyak[5]), and as many other factors antagonize isolation, it is clear that all attempts to interpret complex curves as well as to understand the nature of the sensory message as a whole must begin by emphasizing the positive character of the evidence for the existence of curves as simple as the modulators. Complex curves with several humps are, of course, common.

The experiments with the cone-eye of the snake suggested that the dominator itself is composed of modulators joined together in such a fashion—either photochemically or by connexions in the retinal synapses—as to operate as a *functional unit*. However, this assumption, though probable, is not essential to the theory based on the experiments. But it would explain why stimulation of all modulators together also causes an impression of white, and not of all colours confused. The modulators would in this case merely add to the effect of the dominator. Alternatively, the modulators could be coupled in antagonistic pairs which simultaneously neutralized each other at the retinal or some higher level. As a matter of fact, in eyes where both 'red' and 'green' modulators are present, they are very difficult to isolate from each other.

But let us now see what kind of theory of colour vision would be a direct consequence of the experimental subdivision of the receptors into a great number of almost identical dominators and a smaller number of narrow modulators varying somewhat in shape, locus, sensitivity and number within three preferential spectral regions. No further assumptions will be introduced beyond the original one, that the dominator stands for the dominant impression of brightness, and is modulated by the modulators so as to give the higher centres a cue for their integration of 'colour'.

(1) The greater the distance in the spectrum from the centre of the dominator the darker the colour. Colours towards the ends of the visible spectrum must be dark by comparison with those near the top of the dominator. This we know to be true.

(2) W. D. Wright[6] has shown that selective adaptation of the human eye to any colour causes chiefly a large general reduction of brightness and an insignificant selective effect on the fatiguing colour. This also is a direct consequence of a dominator for the perception of brightness. Classical theories would seem to require not only a much larger selective effect on the fatiguing colour but also a considerable shift of the luminosity curve.

(3) As it is improbable that all receptors would be of exactly the same threshold, a diminution of intensity should, on classical theories, lead to perception of coloured spots. Instead we know that it leads to the spectrum becoming colourless, with the brightness distribution of the dominator, as required by the presence of this most common receptor.

(4) Similarly, a reduction of area of the visual object, which is known to lead to disappearance of its colour with maintained brightness distribution, must do so because the 'small' stimulus merely has a chance of hitting upon the common dominators.

(5) Colour-blindness need not, but *can* be possible without parallel change of the photopic luminosity curve. A colour-blindness of this type would be the common form of red-green blindness known as deuteranopia, to be interpreted as absence of the 'red' and 'green' modulators, with the remaining dominator alone giving the normal luminosity curve. Without a separate structure for the perception of brightness as distinct from colour, no theory can ever hope to explain colour-blindness unaccompanied by considerable 'luminosity blindness' to light from the 'blind' region of the spectrum.

Many of the animals studied represent different types of colour-blindness if considered from the point

of view of the complete colour sense of man. The guinea pig probably comes very near the totally colour-blind, the cat near the deuteranope. The cat has the typical dominator but no definite 'red' modulator. The guinea pig, however, has a number of different modulators in the short wave-lengths and hence may be able to discriminate colours in this region. But it lacks dominator and Purkinje shift. The totally colour-blind human has a photopic luminosity curve practically identical with the luminosity distribution of the normal dark-adapted eye dominated by visual purple. The guinea pig has the same scotopic *and* photopic sensitivity curve, slightly distorted by a hump in the blue in the photopic state.

With the three preferential regions for the modulators, it is clear that this theory can do what the trichromatic theory does and also that it demonstrates the essential correctness of Thomas Young's great generalization, although it is necessary to assume a greater or lesser number of somewhat different modulators within these regions. The main crux of the trichromatic theory and, indeed, of any classical theory, is the lack of precision in the concepts accounting for the perception of white as a separate entity which, nevertheless, somehow is intimately connected with the perception of colour. The trichromatic theory regards white as due to the summed effects of, chiefly, the 'red' and the 'green' sensitivity curves. This forces the theory to accept the consequence that removal of 'red' and/or 'green' should cause removal of the perception of luminosity in the same region of the spectrum. Hence there can be no colour-blindness without profound changes in the form and locus of the luminosity curve. It is an admission of failure to have to explain so important a phenomenon as deuteranopia by pushing it aside to be taken care of by the 'higher centres'.

Many of the phenomena to which the trichromatic theory has directed attention need not be discussed for the reason that my theory does not necessarily exclude the explanations already available. Thus, for example, the fineness of colour discrimination in different regions of the spectrum may be explained in the classical way, or else by the assumption that the number of slightly different modulators is particularly great in the regions where the maxima of colour discrimination are placed.

In its present form the theory gives no explanation of contrast colour, though certain alternatives seem reasonable in view of the fact that different elements are so often coupled together and that the retina contains a large number of coupling synapses. If a certain percentage of the 'red' and 'green' modulators are coupled together in such a manner that both are forced to discharge when either is stimulated, the natural result to expect from the asymmetry caused by fatiguing either of them is that the other one should predominate in the neighbouring region as well as in the off-effect. The experiments themselves have not yet dealt with situations calculated to bring forth contrast phenomena.

It is impossible in this brief review to deal with the available evidence concerning the nature of the colour-sensitive substances. The hypothesis I prefer is that visual purple—which may be called the dominator of the scotopic eye—is the mother substance for the photopic dominator and the modulators. Its molecule consists of a protein nucleus serving as carrier for about ten chromophoric groups (see Broda, Goodeve and Lythgoe[7]). The different colour sensitive substances may be due to changes in the linkage between carrier and chromophores.

[1] Hartline, *Amer. J. Physiol.*, **121**, 400 (1938).
[2] Granit and Svaetichin, *Upsala Läkaref. Förh.* N.F., **45**, 161 (1939).
[3] Lythgoe, *J. Physiol.*, **89**, 331 (1937).
[4] Dartnell and Goodeve, NATURE, **139**, 409 (1937).
[5] Polyak, *Arch. Ophthalm.*, **15**, 477 (1936).
[6] Wright, *Proc. Roy. Soc.*, B, **115**, 49 (1934).
[7] Broda, Goodeve and Lythgoe, *J. Physiol.*, **98**, 397 (1940).

DARWIN'S HEALTH

By SIR BUCKSTON BROWNE, F.R.C.S.

PERSONAL experiences of great men are always interesting, and often instructive. There has lately come to light a diary of his health by the immortal Charles Robert Darwin, from 1849 until 1854. It is now in the possession of the British Association for the Advancement of Science[1], and the Association's Secretary, Dr. O. J. R. Howarth, has permitted me to read it. It consists of thirty-four pages of unruled foolscap.

There is no doubt that the hardships of his five years voyage on board H.M.S. *Beagle* seriously affected Darwin's health. At first he tried to live in London, but found it impossible, and he sought a home in the country. He found it at Down House, Downe, Kent, sixteen miles from London, well away from any great road, quiet and secluded. He lived there for the rest of his life, forty years, dying in 1882, aged seventy-three. Down House is roomy, there are a large vegetable and fruit garden and considerable meadow land. It had no water or gas supply, and no bathroom. There was a cesspool—and a well. Cows and pigs were kept, the stables were large, and the dairy and coachman's house were separate buildings. There was a long path, called the "Sand-walk", along the northern side of the meadow land.

When Darwin began this daily account of his health, he had been married for ten years; he had a devoted wife, and a comfortable home, but the diary is a record of continual misery and suffering, although often the days are marked "good", and the good is sometimes underlined or even doubly underlined. His nights are disturbed by severe attacks of flatulence. In the daytime he suffers from attacks of sickness and vomiting. He has headaches and dizziness. He mentions lumbago and arthritis, and most painful of all, a succession of attacks of boils. They are allowed to burst of themselves and no antiseptics are used. One boil is described as "very large". He has pyorrhœa and sore gums and a tooth has to be extracted under chloroform. He complains that his writing has become very bad.

While the diary was kept, Darwin visited London, Eastbourne, and Great Malvern, where he tried the water-cure, and in a curtained corner of his study at Down House he kept a large shallow tin bath, and in the diary "douches" and "double douches" are mentioned. At the time a so-called electric belt was much advertised; it was tried and abandoned.

Darwin daily walked in his garden and up and down the "Sand-walk", and rode about the neighbourhood on a stout cob. After early manhood he smoked only occasionally. He became a regular snuff taker, but in order to keep the habit in abeyance kept his snuff jars in the hall, so that when desiring a pinch he had to rise and leave the room.

Darwin's last remaining son, Major Leonard Darwin, R.E., born in 1850, has given me the following particulars of his father's daily meals. He generally breakfasted alone; tea, with sugar, milk or cream, toast and a little bacon. He lunched with his family —joint, vegetables, and a simple sweet pudding. He drank a glass of sherry. He had afternoon tea with Mrs. Darwin. Dinner was a repetition of luncheon, and sherry was again taken. He never took ales or spirits, but often drank tea with his dinner.

Many have found the accounts of Darwin's continued ill-health somewhat mysterious. There cannot have been any organic disease, for he lived to be seventy-three, and all seems clear now—he was the victim of chronic indigestion, induced by five years of hardship at sea, with scant accommodation on a small ship and with roughly prepared food. All this would permanently upset the digestive organs of a highly sensitive man.

Indigestion results from : (1) imperfect mastication ; (2) too much food ; (3) improper foods. I think the cold baths must have done harm, and it is evident a good dentist should have been consulted, periodically. The stomach should have been called into action three, and not four, times daily. For many, afternoon tea is an insult to their luncheon and a menace to their dinner. I think his dietary was all wrong, but this is a professional matter not to be discussed in these pages. The sad thing is that there was so much suffering while "Malignant Fate sat by and smiled".

[1] NATURE, 150, 535 (1942).

SCIENTIFIC CENTENARIES IN 1943

By ENG.-CAPT. EDGAR C. SMITH, O.B.E., R.N.

FOUR hundred years ago, on May 24, 1543, the famous astronomer Nicolaus Copernicus died in the city of Frauenberg, situated on the Fritsches Hof, about midway between Dantzig and Königsberg. He was buried in the cathedral, the centre of the diocese which he had served faithfully through his knowledge of canon law. As he lay on his bed stricken with paralysis, the first copy of his book "De Revolutionibus orbium cœlestrum, Libri VI" was placed in his hands, but it was too late ; his memory had gone, his faculties were obscured. The book had lain completed for thirteen years, and it was only through the enthusiasm of the young German mathematician, Joachim Rheticus—whose attitude towards Copernicus was like that of Halley to Newton—that it was at last published. The expense of publishing was borne by Cardinal Schonberg, and to-day the first edition is exceedingly rare. A second edition appeared in 1566, and a third and last in 1617. Copernicus was just over seventy years of age, having been born at Thorn on January 19, 1473. Through his bishop-uncle he was able to study at Cracow, Bologna, Rome, Padua and Ferrara, at the last of which he took his doctor's degree in canon law. He returned north from Italy in 1505, lived at Heilsburg from 1507 until 1512, and from thence onward Frauenberg was his home. There is a statue of him at Thorn and another stands in the interior court of the library of the Jagellonian University, Cracow. A photograph of this was published in NATURE of March 2, 1922, to illustrate an article on "Science in Poland", and the question as to whether Copernicus was a Pole or a German was the subject of remarks in these columns so long ago as December 21, 1871 (p. 151).

A century after Copernicus died, John Bainbridge, the first Savilian professor of astronomy at Oxford, passed away "at his house opposite Merton College in this his 62d year, and his body was conveyed to the public school, where an oration having been pronounced in honour of him by Mr. William Strode, the University Orator, it was carried to Merton College Church and deposited on the left side of Mr. Henry Brigg's grave and an epitaph was inscribed upon his monument in Latin". Before his appointment to the Savilian chair, Bainbridge had taken degrees at Cambridge, kept a school, practised medicine and written on a comet. To what extent he had been influenced by the views of Copernicus we are not told, but his main interest was in Greek and Arabic scientific writings. A foreign mathematical contemporary of his was Habakkuk Guldinus (1577–1643), a Swiss Protestant who became a Jesuit and taught mathematics with success in the Jesuit colleges at Rome and Gratz.

Passing to the year 1743, we are faced with a long list of men of science, of greater or lesser fame, but all of interest. Of these the outstanding figure is Lavoisier, who was born in Paris on August 16, 1743, and fell beneath the guillotine on May 8, 1794. "The spring sends its green leaves and bright weather, bright May, brighter than ever : Death pauses not. Lavoisier, famed chemist shall die and not live : chemist Lavoisier was Farmer-General Lavoisier too, and all the Farmers-General are arrested ; all, and shall give an account of their moneys and incomings, and die for 'putting water in the tobacco' they sold." So wrote Carlyle. Twenty-eight Farmers-General and their three assistants were sentenced at one sitting of the Tribunal of the Terror ; and it was then that the terrible Coffinhal immortalized himself by replying to Lavoisier : "The Republic requires neither savants nor chemists ; the course of justice cannot be suspended". Condorcet (1743–94), author of works on the calculus, and of "The Progress of the Human Mind", perpetual secretary to the Royal Academy of Sciences, only escaped a similar fate by taking poison, but the unfortunate German astronomer, Johan Wilhelm Wallot (1743–94), who had been employed on the testing of Leroy's chronometers and had lectured and observed in Paris for many years, perished on the scaffold on July 27, the day before Robespierre fell and the prisons were thrown open. The 'father' of crystallography, René Just Haüy (1743–1822), born six months before Lavoisier, was at one time in danger, but friends came to his rescue. None took a more active part in the foundation of the metric system than Lavoisier, and in some of his measurements Haüy was associated with him. There is a statue of Condorcet near the French Institute, and statues of Lavoisier behind the Madeleine Church and at the Sorbonne. A reduced replica of the latter is in the National Gallery of Scotland.

The discoveries and theories of Lavoisier were embraced by some chemists and rejected by others, but the credit for their favourable reception in Germany was largely due to the tireless Martin Heinrich Klaproth, who was born on December 1, 1743, and died on January 1, 1817. Klaproth made a host of accurate analyses of minerals and discovered several elements. In 1792, when professor of chemistry in Berlin, he proposed to the Berlin Academy of Sciences to repeat the more important of Lavoisier's experiments. His offer was accepted, and from that

time most of the Berlin chemists declared in favour of the new theories. With F. B. Wolff, Klaproth published the first German chemical dictionary. Another French chemist of this time was Antoine-Alexis-François Cadet-de-Vaux, born in Paris on September 13, 1743, whose investigations dealt with matters of domestic economy, public health and agriculture.

In other fields of science occur the names of Antonio Cagnoli (1743–1816), the intimate of Lalande, who had observatories in the Rue Richelieu in Paris and at his birthplace, Verona; of Johan Ferber (1743–90), a learned Swedish mineralogist and traveller; of Colonel James Capper (1743–1825), of the East India Company, who in 1801 published his work on winds and monsoons, and of the two self-taught British mathematicians, John Mole (1743–1827), originally a farm labourer, and Henry Andrews (1743–1820), first a domestic servant and then a bookseller. For forty years Andrews calculated for the "Nautical Almanac", and as the compiler of "Moore's Almanac" raised its sale from 100,000 to 500,000, getting but £25 a year from the not too generous Stationers' Company. Among the other publications of the Stationers' Company was the "Ladies' Diary", begun by John Tipper in 1704. When Tipper died in 1713, Henry Beighton became its editor, and conducted it successfully until his own death in 1743. The "Ladies' Diary" filled a place in the mathematical life of Great Britain in the eighteenth century, and Beighton in his prefaces speaks of it as being "peculiarly adapted for the use and diversion of the fair sex", and of his own "gallant endeavours to introduce his readers to the study of the mathematical sciences". Beighton too has a place in the history of experimental science and of the steam engine.

To complete the review of the bicentenaries which fall this year, mention may be made of the ingenious Rev. Edmund Cartwright (1743–1823), the inventor of the power loom, over which, and other inventions, he lost a sum of £30,000; a Government grant in 1809 of £10,000 made the evening of his life comfortable, and he was afterwards remembered as "a portly dignified old gentleman, grave and polite, but full of humour and spirit".

If for no other reason, the centenaries of men of science who died in 1843 would be of interest inasmuch as they include that of the French astronomer, Jean Nicolas Nicollet (1786–1843), whose intelligence and spriteliness as a boy were maintained throughout his life and led him to have a share in the greatest scientific deception ever perpetrated—the so-called "Moon Hoax". Born to a life of poverty and drudgery, from these Nicollet was rescued by the local curé, and he ultimately gained an education which led him to the librarianship and secretaryship of the Paris Observatory. Grant refers to a "beautiful paper" of Nicollet's in the "Connaissance des Temps", 1822, and to observations he made with Bouvard on the moon's libration in longitude. But it is not for such things he will be remembered longest. Desiring to be rich, he speculated on the Stock Exchange, lost, got into debt and then fled to the United States. That was in 1831. In 1833, Sir John Herschel, with considerable public attention, sailed to the Cape to survey the southern heavens. An unforeseen result was the compilation of accounts of most extraordinary discoveries he had made in the moon. Sir John, of course, knew nothing of them. The ball was apparently set rolling by the Somerset-Cambridge man, Richard Adam Locke, as impecunious as he was versatile and unscrupulous. In 1832, at the age of thirty-two, he too went to the United States, where in 1833 the New York *Sun* made its first appearance. To the editor of the *Sun* Locke proposed an account of Herschel's discoveries in the moon, and so in issue after issue one could read about brown quadrupeds, temples, man bats and what not. The *Sun's* circulation soared and Edgar Allan Poe declared Locke's hoax to be "the greatest hit in the way of sensation . . . ever made by any similar fiction either in America or Europe". At any rate the story made people read, who had never read newspapers before. There is, however, another side to the matter. In Messrs. Sotheran's Catalogue, No. 826, p. 179, there is an entry: "The History of the Moon; or an account of . . . the Rocks, Trees, Flowers, Verdant Plains, Volcanoes, etc." (*c.* 1833), and the authorship of this is attributed by Messrs. Sotheran's to Nicollet, who "published the above account in the New York *Sun* partly to 'raise the wind' and partly to entrap M. Arago, his enemy, into believing it". Did Locke and Nicollet ever meet? Did they collaborate? What is the truth?

Of Alexis Bouvard (1767–1843), called by Miss Clerke "the indefatigable computating partner of Laplace", little seems to be known. He was perhaps the first to conceive the existence of a planet beyond Uranus. Another Frenchman of that time was Silvestre-François Lacroix (1765–1843), mathematical professor at the Collège de France and the Sorbonne. It was the translation by Herschel, Babbage and Peacock of his "Elementary Treatise on the Differential Calculus" which gave the first impulse to a mathematical revival in England. A Swiss mathematician of note who died in 1843 was Ferdinand Rudolph Hassler; Simon Newcomb married Hassler's grand-daughter. After taking part in the trigonometrical survey of Switzerland, Hassler went to the United States, in 1807 was made a professor at West Point Academy and in that same year put forward plans for a survey of the sea coast of the various States; thus he was the virtual founder of that great scientific service, the United States Coast Survey, of which he was the first director. He was born at Aarau in Switzerland in 1770.

Recrossing the Channel to recall some British men of science who died or were born in 1843, we come first to the well-known names of Macintosh, Hedley and Forsyth. Charles Macintosh (1766–1843), the industrial chemist, will always be remembered for his patent of 1823 for making waterproof fabrics by cementing two thicknesses together with india rubber dissolved in naphtha; William Hedley (1779–1843), one of the pioneers of the locomotive, will be remembered so long as his "Puffing Billy" stands in the Science Museum and his "Wylam Willy" stands in the halls of the Royal Scottish Museum, Edinburgh. The work of the Rev. Alexander John Forsyth (1769–1843) on the percussion lock for firearms is recorded on a memorial tablet erected on the walls of the Tower of London in 1930. To these names may be added that of Robert Bakewell (1768–1843), who when geology was first attracting widespread attention lectured up and down the country and wrote excellent text-books, the perusal of one of which awakened Lyell's interest in the subject.

When Herschel arrived at the Cape and set up his observatory at Feldhausen, the Royal Observatory near Cape Town had been nominally in existence since 1821, but no instruments were fixed until some years later. The Rev. Fearon Fallows was the first

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director and he was succeeded in turn by Thomas Henderson, Sir Thomas Maclear and Edward J. Stone, who in 1879 was followed by Sir David Gill. Gill was born at Aberdeen a century ago next June. Under Gill, who held the post of "Her Majesty's Astronomer" until 1906, the Observatory was completely transformed and it took a leading part in many of the principal projects of the day, including the great Astrographic Chart of the Heavens. Gill was also deeply interested in the measurement of an arc of meridian from the Cape northward through the entire African Continent. His retirement led to little lessening in his activities, and in 1913 he completed his "History and Description of the Cape Observatory". He died on January 24, 1914. Two other astronomers who laboured in the southern hemisphere in Gill's time were Henry Alfred Lenehan (1843–1908), the Government Astronomer of New South Wales and in 1905 president of the Royal Society of that colony, and John Macon Thome (1843–1908), who assisted and then succeeded Gould at the Argentine National Observatory at Cordoba.

Another eminent man of science holding, like Gill, a high official position and born in 1843 was Sir William Chandler Roberts-Austen (1843–1902), the successor of Thomas Graham at the Mint and the successor of Dr. Percy as professor of metallurgy at the Royal School of Mines, London. While assayer at the Mint, he was responsible for the standard fineness of about £190,000,000 of gold, silver and copper coin. He was the first secretary of the Physical Society, president of the Iron and Steel Institute and a Chevalier of the Legion of Honour. Some of his most valuable work was done for the Alloys Research Committee of the Institution of Mechanical Engineers.

To the foregoing may be added the names of Sir John Isaac Thornycroft, F.R.S. (1843–1928), the famous naval constructor and marine engineer; Ralph Hart Tweddell (1843–95), a pioneer of hydraulic tools for shipbuilding, bridge-building, etc.; George Frederick Deacon (1843–1909), a great water engineer who carried through the Vyrnwy Valley project in Montgomeryshire for the water supply of Liverpool; James Campbell Brown (1843–1910), for forty-three years associated with Liverpool as public analyst and as lecturer and professor of chemistry in the University; and finally the name of the eminent Belgian metallurgist, engineer and industrialist, Adolphe Greiner (1843–1915), director of the great Cockerill Works at Seraing, Bessemer medallist and president of the Iron and Steel Institute, who saw his medal and other valuables stolen during the "foul flood" which inundated Belgium a generation ago.

It will not have escaped notice that most of the men included in these notes were workers in the physical sciences. Readers who are more interested in the biological sciences can no doubt recall other workers of renown. One such distinguished man was the famous naturalist, Sir Joseph Banks, who, for forty-one years, was president of the Royal Society. Reference books differ as to the day and year of his birth, but Weld in his "History of the Royal Society" says he was born in Argyle Street, London, "on the 2nd of February, 1743 O.S.". Of the birth of the famous German bacteriologist, Robert Koch, who isolated the bacillus of tuberculosis, there is no such question. He was born at Klausthal in the Harz on December 11, 1843, and died in 1910; an obituary of him appeared in NATURE of June 2, 1910 (p. 402).

NEWS and VIEWS

Wooden Aircraft for War Purposes

IT has been announced that a wooden construction aircraft, the Curtis C.76 known as the Caravan, has just been completed in the United States, being the first of its kind, in that country, to be designed especially for war transport purposes. It is a high-wing monoplane, powered with two 1,200 h.p. engines. It carries two pilots and a radio operator, and has a large cabin space suitable for the carriage of troops, guns, or other military equipment. The body is built specially low when standing on the ground, and the doors are arranged to facilitate the quick transfer of the contents. Outlets specially suitable for para-troops are also provided. An interesting feature of this development is that it represents, with several British contemporaries the most notable of which is the Mosquito day bomber, a return from metal to wooden construction that has taken place since the outbreak of war.

The immediate pre-war policy of the Air Forces of most countries was to use metal construction (1) because it allowed a rapid expansion of output along mass-production lines, (2) because of its relative immunity from fire due to enemy bombing of large concentrations in store. War experience has almost completely reversed these. In the case of (1), the need for constant progress in design makes real mass production prohibitively wasteful in labour and materials allotted to production machinery, tools, etc. It also neglects a large reservoir of wood-working labour and machinery that has not so great a use in any other sphere of war production. With (2), the large concentration of war material close behind the static lines preparatory to an attack is no longer needed, partly because warfare has proved to be more fluid; also the speed at which it has been proved that aircraft can be concentrated at any given point allows it to be dispersed in store over a wider area. Another field for wooden aircraft is that of pure transport, distinct from fighting or bombing. The rapid carriage of troops or material to points where needed for fighting operations can proceed far enough away from the enemy to be reasonably safe from interference on a large scale, and the high speeds of the aircraft allow it to take evasive action to avoid isolated attack from occasional enemy machines. Thus a machine designed to a transport specification rather than a war one becomes the ideal, and in this case wood construction has many advantages.

Short-Wave Broadcasting: Transmission

SIR NOEL ASHBRIDGE, controller of the Engineering Division of the B.B.C., gave an account of "Short-Wave Broadcasting: Ten Years Technical Progress", in the Overseas Service of the Corporation on December 17. Sir Noel said that it is about eleven years since the B.B.C., in spite of inconclusive reports on the existing service, decided that an attempt

should be made to build up a regular short-wave service to the countries of the British Empire, trusting to an improvement in both transmission and reception to make it justifiable. The bare principles on which the first station was designed did not differ in essentials from the much bigger stations which several countries are operating to-day. Wave-lengths in several groups within the limits of 13 to 50 metres are still used, except for the 100-metre transmissions to Canada, which are only used to overcome somewhat special conditions. Again, the principle of transmitting on directional beams, taking various parts of the world in turn, following the clock, still more or less applies to-day. No striking new invention has arisen to revolutionize the technique, but a great deal has been learned about the design of aerials, and how to construct them so that they radiate a beam of the right width and depth and as nearly as possible at the right angle to the earth, so that they will be reflected back to earth by the ionosphere, and arrive in that part of the world where they are intended to be received. The first experimental transmitter used only one wave-length, and the new station completed ten years ago used eight wave-lengths. We are now using no less than forty-four. The hours of transmission, too, are strikingly different ; the first station with its two transmitters sent out twenty-three transmitter hours per day ; but now the number of transmitter hours per day is more than three hundred and fifty-six. There was only one language used with the first station, as against nearly fifty at present.

Reception and Rediffusion

BIG developments have also taken place at the receiving end. At the beginning, short-wave receivers were looked upon almost as scientific instruments which were of little use to people with no particular interest in technical matters. Even super-heterodyne receivers were comparatively rare only ten years ago, and undoubtedly it was the development of this type of receiver, with efficient automatic volume control and simplified tuning, which has done a great deal to convert a highly speculative undertaking into what may now fairly be called a firmly established institution. Another important factor has been the growth in the rediffusion of programmes by wires connecting a number of houses to a central receiving station. Such a station can be an elaborate and costly affair embodying the very best technique in short-wave reception. Such undertakings exist in many parts of the Empire, for example, Malta, and notably in the West African colonies. Somewhat similar advantages are gained by rebroadcasting through a local broadcasting station. The Empire and North American Services transmit for a total of nearly 149 hours a week, and are rebroadcast by wireless stations for nearly 55 hours, and when we include wireless exchanges this figure rises to more than 130 hours. Two pioneers who were instrumental in establishing wireless exchanges in several of the Colonies were Sir Arnold Hodson, recently governor of the Gold Coast, and Mr. F. Byron, an engineer in the Colonial Service.

The Future

ALL this development, both on the transmitting and receiving side, has taken place well inside ten years, and is not solely due to the War. What will be the future of short-wave broadcasting ? Will people still go on listening and searching to see what they can find coming from distant countries ? There is not much doubt that for some time they will, since news must be foremost in everybody's mind for many years to come. The question remains what will happen when and if news becomes a matter of less pressing importance to the whole world ? Is short-wave broadcasting capable of further development, purely as a means of recreation and enjoyment ? Whether the results obtainable by this means will ever be equalled by an ordinary direct listener in his home would at first sight seem doubtful, but if the progress in the next ten years is anything like that in the last ten years, we may look forward to the day when reception from far-off countries is almost as good as from the local station, and a few years after that we may even see the addition of pictures.

Nottingham Open Forum

AN experiment successfully conducted in Nottingham during the last two months has aroused considerable local interest, and might well find favour in other towns and cities. The Nottingham Open Forum was sponsored by the British Council, in co-operation with University College, Nottingham, and the Ministry of Information, as an attempt to attain a better understanding and closer contact between local residents and visitors from overseas, both civilians and allied troops ; and to stimulate informative discussion on matters of general interest. A series of meetings on 'Brains Trust' lines, but on a broad international basis, was arranged, and organizations such as the International Centre, the British Empire Club, the Polish Troops' Club, the Rotarians, Y.M.C.A. and Y.W.C.A., etc., were invited to co-operate, as well as the general public. It was felt that the public to-day prefers to be stimulated to think for itself rather than to be 'lectured at' and told what to think. The promoters of the Nottingham Open Forum have no political bias and are therefore free in their choice of subjects and speakers, and the members of each panel can express their views without reserve however controversial they happen to be. This type of meeting naturally has a much wider appeal than the usual 'public meeting' which is seldom free from the taint of propaganda. The information-seeking public is surely entitled to be at least as well catered for as the amusement-seeking public, and the successful presentation of any open forum or 'Brains Trust' depends largely on the care with which it is organized.

In Nottingham, "International Relations" was chosen for the first Open Forum; the audience was then invited to submit suggestions for future topics. This resulted in a wide variety of subjects from which the committee selected those of most general interest, including "Local Government", "The British Commonwealth", "Science and Modern Life", "Books, Writers and Readers", "Social Democracy", "Education : for whom and for what ?", "Town and Country Planning", "National and International Law", etc. It is of obvious importance that the panel of speakers should be well-balanced and as representative as possible of the various aspects of each topic under discussion. For example, with "Local Government" as the subject, the panel consisted of a city councillor (Independent), the Deputy Town Clerk, an American city manager, a woman member of the City Council (Conservative), with a Labour M.P. (ex-chairman of

the L.C.C.) as guest speaker. Much depends upon the question master, who introduces the speakers, and generally 'controls' his team. Questions are invited from the public, and an average number of about thirty are sent in for each meeting. It has been found that a good panel can deal with about ten questions in an hour, so the Committee gives careful consideration to selecting those questions which cover the most ground and provide the greatest variety. The audience particularly appreciates an opportunity of submitting written supplementary questions. Stewards (provided with pencils and paper) collect these during the session, and the last twenty minutes are devoted to dealing with them in a brisk 'sharp-shooting' fashion. One important feature of the Nottingham Open Forum is that the members of the panel meet for a few minutes before the public proceedings begin, when they are given a list of the questions. This avoids any confusion as to who shall answer each question first, and provides an opportunity for the speakers to decide when they can best make their own special contributions, while in no way destroying the spontaneity of their answers. The Open Forum has attracted an audience of from three hundred to four hundred at each meeting, and the enthusiasm shown has been gratifying. Especial appreciation has been expressed by foreign nationals from the occupied countries who are much impressed by the 'free speech' permissible in Great Britain. Further information can be obtained from the Secretary of the Nottingham Open Forum, Mrs. R. B. Calder, 5 Western Terrace, The Park, Nottingham.

Charles L. Mayer Awards for Animal Cell Growth Research

DR. WILLIAM J. ROBBINS, chairman of the National Science Fund of the U.S. National Academy of Sciences, has announced the creation of two 2,000 dollars prizes to be known as the Charles L. Mayer Awards and to be presented in 1942 and 1943 for outstanding contributions to our knowledge of factors affecting the growth of animal cells with particular reference to human cancer. The awards are to be not only in recognition of past accomplishments but are also designed to increase the opportunities of those with exceptional abilities to carry on further research. To assist the National Science Fund in effective administration of the Mayer Awards, a special advisory committee has been appointed consisting of Dr. R. R. Williams, chemical director of the Bell Telephone Laboratories, Dr. Alan Gregg, director for the Medical Sciences of the Rockefeller Foundation, Dr. George H. Whipple, dean of the School of Medicine and Dentistry of the University of Rochester, and Dr. Elihu Root, jun., as the lay member. The donor of the Charles L. Mayer Awards, Dr. Robins said, had in mind the vast possibilities offered by research on the action of chemical agents and physical factors in stimulating or retarding cell growth, and the National Science Fund would consider studies of factors controlling the growth of protozoa, of animal tissue cultures or of entire organisms as eligible.

In announcing the establishment of these Awards, Dr. Robbins directed attention to significant work which has been done on the amino-acids and some of the more recent discoveries on the importance of the rarer mineral elements, for example, manganese and copper, as necessary for animal cell development. Recent advances in the identification and isolation of some of the vitamins and hormones have opened new vistas for the student concerned with the control of growth. Along with the increased knowledge of factors stimulating growth there have been significant contributions to our information about growth-inhibitors such as the sulpha drugs and the anti-vitamins. Dr. Robbins emphasized that the Committee is interested primarily in fundamental studies on the factors influencing growth of animal cells rather than applications to any particular aspect of normal or abnormal growth. Applications based on such studies may develop in the future but at present we need more knowledge of the essentials concerned. Reports of empirical success in treatment of human cancer will not be eligible for the awards. The Advisory Committee will welcome suggestions at once as to outstanding published contributions and manuscripts of 1942 on any phase of this subject, at the National Science Fund offices, 515 Madison Avenue, New York City.

National Coal Board

AT the first meeting of the National Coal Board held on December 21, Major the Right Hon. Gwilym Lloyd George, Minister of Fuel and Power, presided. He pointed out that the establishment of the Board completes the final stage in the Government's plan for the war-time reorganization of the industry in Great Britain. The Board would advise the Minister, in whose hands control of the industry is vested, and he appealed to members of the Board to approach the problems with which they would deal from a national point of view, and on the basis of national service. Sub-committees were appointed for dealing with the following matters : (1) The general planning of production, including the allocation of district and regional targets. The best means of securing the highest efficiency of the coal-mining industry and any improvements in machinery or methods of operation whereby output may be increased. (2) The provision of supplies, equipment and materials for the conduct of mining operations. (3) Matters relating to the maintenance of man-power and labour productivity, including the enrolment of new entrants and the instruction, training and advancement of boys and youths. (4) All matters affecting the welfare of mine-workers, including housing, transport and feeding facilities ; and questions of health and safety and, in particular, such occupational diseases as silicosis and nystagmus, with the view of providing all possible preventive measures, clinical treatment and rehabilitation.

The Turkish Earthquakes

EVER since the great Turkish earthquakes of December 27, 1939 (NATURE, **145**, 13 ; 1940), it has been noted that the earth-blocks in the affected district have never really attained their final position of rest. Aftershocks of the 1939 earthquake were frequent, of considerable amplitude and protracted. These followed the normal course, consisting of large shocks of gradually decreasing severity, interspersed with numerous minor shocks and tremors. After-shocks, however, normally finish some months after their 'parent' shock and subsequent earthquakes with adjacent epicentres must be regarded as discrete. As recently as December last (NATURE, **150**, 687 ; 1942) renewed seismic activity in Anatolia was noted.

Ciorum appeared to have been the most affected during the preceding month, though Balikesir was also damaged. During this time about 20 people were killed, 24 injured, 1,600 houses totally wrecked and some further 1,300 partly wrecked.

The most recent very strong earthquake took place on December 21, 1942, and the epicentre appears to have been slightly to the east and very close to Erba. This place is approximately a hundred miles to the east of Ciorum, and west-north-west of the epicentre of the very severe 1939 (Erzinjan) earthquake. On the recent occasion Erba was almost completely destroyed, partly by the earthquake and partly by the fires which followed it, and it is feared that more than a thousand people have perished. Niksar, east of Erba, also suffered severely, as did the intervening villages. Erba is the centre of a rich tobacco-growing region about eighty miles south-east of Samsun on the Turkish Black Sea coast, and about 280 miles east of Istanbul. The strong shocks were also felt severely in Ordu, Sivas, Kastamuni, Bakir-chai, Tokat, Fatza, Kaisarieh and Zara, though no major damage is reported from the last-named place.

North African Natural History

As suggested earlier in the War, the armies in North Africa have stimulated much useful war-time observation of fauna and flora in otherwise difficult regions, and the current issue of *Countryside* (12, No. 5) contains original papers by members serving abroad. These include notes on the birds of the British list wintering in West Africa by A. C. Allnutt, who noticed that while whinchats wintered in the coastal region for the whole of the six winter months, the willow-warblers arrived in waves of migration and remained only a few days. Blue-headed and grey-headed wagtails were there from December until February but no nuptial songs were heard. Their feeding habits were no different from those observed in Europe. Waders seen regularly included the marsh-sandpiper, ringed plover, greenshank, bar-tailed godwit, black-winged stilt; those seen mainly on passage were the sandpiper, curlew-sandpiper, grey plover, redshank, spotted redshank, little stint, turnstone and sanderling. Migrating sandwich terns remained for several weeks, and the arctic skua and black tern were noted. Previous numbers of this volume of *Countryside* have contained notes on the birds of Tobruk. In the current issue Col. W. R. Roberts has notes on the flora of the Egyptian wadis near Cairo.

Fruit Growing

ALLOTMENTS and gardens, though small units of horticultural production, are now so numerous that their aggregate contribution to the nation's nutrition is not small. The Ministry of Agriculture and Fisheries has recently issued "Growmore" Bulletin No. 7, "Fruit from the Garden" (H.M. Stationery Office, 3*d*. net, 1942) to assist the small grower to increase his production of fruit. Mr. J. M. S. Potter, of the Royal Horticultural Society, has written the text, which deals adequately with the planting and general management of stone fruits, apples and soft fruits. The bulletin's advice is eminently suited to the southern parts of Britain, but northern growers should not be advised to "avoid the strong growers like Bramley's Seedling and Newton Wonder". These varieties are often the most suitable for difficult climates. Many small apple orchards in the north are also unproductive because of the relative scarcity of other trees for pollination, and it is disappointing to find scant mention of suitable pollinating kinds for each variety. A useful spraying calendar is given, and sections on picking and storing, pruning, and the treatment of old trees also appear. Fruit culture is never so economically successful as when practised on a domestic scale, and it is good to see the Ministry's recognition of this important fact.

Planning of Science: in War and in Peace

THE Association of Scientific Workers is organizing a conference to be held on January 30 and 31, at the Caxton Hall, London, S.W.1, on the planning of science in war and in peace. Sir Robert Watson-Watt, president of the Association, will open the Conference. The first session will deal with the central direction of scientific research and development, and Sir Stafford Cripps has agreed to speak. It is also hoped to have statements on the organization of science in the U.S.A. and the U.S.S.R. The second session will be devoted to the local organization of scientific research and its application; among the speakers will be Mr. W. C. Devereux, managing director of High Duty Alloys, and Mr. Ben Smith, national organizer of the Association, who will speak on the relationship between managements and scientific staff as it affects production; detailed consideration will be given to the relations between scientific and other workers and to the work of joint production committees. The third session will discuss those changes in the organization of science brought about during the War which may have a continuing effect on the relations of science with society, and the re-orientation of science after the War. Prof. P. M. S. Blackett and Sir Lawrence Bragg will be the main speakers. The chair will be taken by Prof. J. D. Bernal. Tickets (2*s*. 6*d*. for whole conference or 1*s*. per session at the door) and full particulars can be obtained from the Conference Secretary, Association of Scientific Workers, 73 High Holborn, London, W.C.1.

Announcements

No. 3 of the War Background Studies issued by the Smithsonian Institution is by Dr. Aleš Hrdlička and is devoted to an account of the peoples of the Soviet Union. While there is nothing in these twenty-nine pages which purports to be new matter, the little publication gives a very convenient conspectus of the early history and make-up of the peoples of the U.S.S.R. It is compiled for the general public.

THE following appointments and promotions in the Colonial Service have recently been made: J. F. A. Sprent, veterinary research officer, Nigeria; I. H. Pattison, veterinary officer, Palestine; J. R. Curry (agricultural officer, Tanganyika Territory), director of agriculture, Bahamas; M. Greenwood (specialist (chemistry), Agricultural Department, Gold Coast), senior specialist, Agricultural Department, Gold Coast.

THE Institution of Naval Architects is offering two scholarships in naval architecture (Elgar Scholarship, £130 a year, and Denny Scholarship, £100 a year) and two in marine engineering (Parsons Scholarship, £150 a year, and Yarrow Scholarship, £100 a year) for competition in 1943. The age limit for the Denny Scholarship is nineteen, and that for the other scholarships twenty-three. Particulars can be obtained from the secretary of the Institution, 10 Upper Belgrave Street, London, S.W.1.

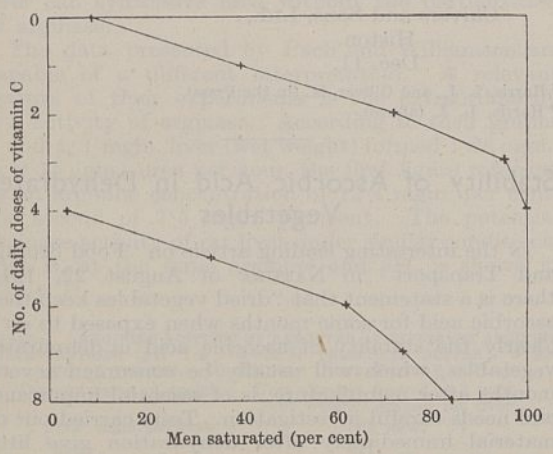
LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Vitamin C Saturation Test of Harris and Abbasy

DURING a year's service in the R.A.M.C., six months were occupied exclusively in carrying out and reporting upon this test[1] according to a scheme drawn up by the Directorate. Though the results concerning the 1,200 men examined cannot be given, some remarks on the method appear to be worth recording as based on experience gained in performing some thousands of titrations; also a couple of points accidentally discovered may be mentioned.

Much time is saved by having the fourth and fifth hours, after dosing with ¾ gm. of the vitamin, as the period of retention of urine and by making up the sample to ½ or one litre, instead of having the often inconveniently long three-hour period and measuring the volume of each sample. The 2 : 6 dichloro-phenol indophenol reagent is best adjusted so that 1·0 ml. corresponds to 0·1 mgm. of vitamin. By these small alterations several weeks of simple arithmetic were eliminated in the second tour.



The method was found to give consistent results capable of distinguishing between groups of 100 men living under slightly different conditions of vitamin C intake. These differences are clearly shown when one plots on the vertical axis the number of daily doses required to approach saturation, namely, an excretion of 35 mgm. of vitamin in a two-hour period, and on the horizontal the total percentage of men who have reacted before and on that day. The forms of the curves are shown in the accompanying figure, in which the upper relates to a population extremely well supplied with vitamin C and the lower to a badly fed one, in which those with the lowest reserves are approaching frank scurvy; cases of scurvy require about ten doses to become saturated, and no information is given about the 16 cases below the 8-dose limit. These curves do not represent conditions in the Army. Their importance lies in the fact that they show an appreciable personal variation existing in a population on a fairly uniform diet, and make it clear why some, and not all, of a ship's company become affected with scurvy. Severe muscular exercise is known to produce scurvy in those low in reserves of vitamin C, so possibly some men use up more than others, or minor differences in tastes or in cooking may be responsible.

There remains the question of the individual assimilation of the vitamin ingested. This may be very unequal. Information on this point was obtained through an accident. Two sections of men belonging to the same unit and feeding from the same cookhouse responded very differently to the doses, for one showed its peak of saturation about two days earlier than the other. The numbers, 22 and 21 respectively, appeared to rule out a chance aggregation. This remained a puzzle until on returning to the station four months later it was ascertained that a visiting unit was dosed after the first section, and that the second home section had breakfast before being dosed. Apparently the vitamin suffers less destruction when taken after food. A direct experiment should be made to test this accidental finding.

Additional evidence was obtained that this vitamin, unlike vitamin D, is not stored in quantity for long. For it was found that those dosed at one station in May included about 40 per cent dosed four months previously. When three lists were prepared (*a*) those saturated in January, (*b*) all those previously dosed, (*c*) those not dosed before, three curves were obtained, roughly parallel, with *a* uppermost, then *b* and *c*, but only about ¾ of a dose separated *a* from *c*. Thus there were men in class *c* with much higher reserves than in *a*, though after *a* had been saturated all lived on the same diet.

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Dec. 13.

[1] Harris, *et al.*, *Lancet*, 1, 71 (1935); 2, 1429 (1937); 1, 642 (1942).

Vitamin C Saturation Test: Standardization Measurements at Graded Levels of Intake

DR. ATKINS'S valuable account of his experiences with the saturation test prompts me to send a brief summary of my own unpublished observations bearing on two of the points to which he alludes: first, the degree of 'scatter' in the responses seen in different subjects kept on the same or similar intakes; secondly, the choice of criteria to be used.

In my own tests, groups of boys (12–36 in each group) at a residential home were kept on a basal diet of known vitamin C content and given in addition various graded supplements of vitamin C, natural and synthetic, over periods of 3–4 months or longer, so that each boy in a group received identically the same intake. About twice a year (an interval found to be sufficiently long to allow the effect upon their 'reserves' of any previous saturation test to have become negligible), the boys were tested by the standardized procedure previously described[1], 700 mgm. per 10 stone being given daily and the number of days counted until the approach of saturation (taken as an excretion of 50 mgm. or more per 10 stone in the 2½-hour specimen collected in the fourth and fifth hours after each test dose).

Results were found to be graded, as follows: daily intakes of 75, 60, 50 and 45 mgm. gave first-day responses of decreasing magnitude; 40 mgm., first to

second-day responses ; 25 mgm., second to third-day responses, the 'scatter' in the responses of subjects kept on the same level of intake being small (see table). In earlier tests, children on still lower intakes had third-day to fifth-day responses. Similar graded results have been recorded with adults on varied intakes, patients with scurvy taking 7–10 days to saturate.

Date	Daily intake of vitamin C (mgm.)	Total number of boys in group tested	No. of boys approaching saturation			
			1st day	2nd day	3rd day	4th day
Autumn 1941	75	12	12	0	0	0
	60	10	10	0	0	0
	45	10	9	1	0	0
Spring 1942	50	12	12	0	0	0
	40	11	5	6	0	0
	25	12	0	5	7	0

As a standard of reference in assessing results of surveys, it is noted that an intake corresponding with the League of Nations requirement (30 mgm.), or an amount not greatly in excess of it, suffices in nearly all subjects to give responses on the first or second day of dosing. The number of days beyond the second may be taken as an index of the relative deficit in the past intake. For high and low base lines respectively, it is observed that with intakes of the order of 50–75 mgm. per day (the optimal standard recommended by some American authorities), saturation is attained on the first day of dosing, whereas with intakes appreciably below the League of Nations standard three days and upward are needed, reaching a limit of seven to ten days for cases of developed scurvy. These criteria agree with those previously suggested[1].

It is hoped to publish the extended data elsewhere.

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Medical Research Council.
Dec. 11.

[1] Harris, L. J., *Lancet*, 1, 642 (1942).

Vitamin C Intakes at a Residential Home

SINCE July 1941 we have been making a study[1] of the vitamin C in the diet at a residential institution (home for waifs and strays at Cambridge), in order to obtain information about the day-to-day intakes, the influence of seasonal fluctuations in the supply of available sources, the effect of the War, etc. Chemical analyses were made on representative specimens of the various cooked and raw foods served and the results used to calculate each day's total intake. From time to time complete meals were analysed as a further check on the calculated values, and the agreement was good (average 'predicted' result was 110 per cent of average 'determined' result).

The average daily intakes (in mgm.) were as follows : 1941 : July, 23 ; August, 35 ; September, 55 ; . . . 1942 : January, 24 ; February, 27 ; March, 19 ; April, 19 ; May, 23 ; June, 24 ; July, 42 ; August, 53 ; September, 53 ; October, 38 ; November, 35. The pronounced difference between the intakes in summer and winter was reflected in the results of saturation tests (first-day response in all instances after summer, as compared with second to third-day response in all instances after winter).

The change from old to new potatoes in late July (1942) or late August (1941) made an addition of about 30 mgm. per day. The other notable cause of the higher values in the summer was the increased use of garden produce, for example, cabbage, cauliflower, spinach and some fruits.

Apart from potatoes, important because of their regular use and the relatively large amounts consumed, the principal source of vitamin C throughout the year was provided by the green vegetables, such as cabbages and sprouts. Cooked vegetables had an advantage over raw in that much larger quantities could be eaten and assimilated. The water in which the vegetables had been cooked was utilized for preparing gravies, etc., and also furnished an important supply of vitamin C.

In this institution dietary practice was particularly good, with the result that the vitamin C intakes and levels of nutrition, as determined by saturation tests[2], were considerably higher than average working-class values.

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Histon.
Dec. 11.

[1] Harris, L. J., and Olliver, M. (in the Press).
[2] Harris, L. J. (above).

Stability of Ascorbic Acid in Dehydrated Vegetables

IN the interesting leading article on "Food Storage and Transport" in NATURE of August 22, 1942, there is a statement that "dried vegetables keep their ascorbic acid for some months when exposed to air". Clearly the stability of ascorbic acid in dehydrated vegetables, which will usually be consumed several months after manufacture, is of essential importance and needs careful investigation. Tests carried out on material immediately after dehydration give little indication of its antiscorbutic value under war conditions.

In recent experiments carried out in my laboratory, commercially dehydrated (steam-blanched) vegetables were kept for several months in an incubator at 37° C. in sealed (not exhausted) tins. The tins, containing samples from a consignment of each of the vegetables processed on one particular day, were opened at intervals for testing. It was found that dehydrated cabbage, cauliflower, and knol-khol lost 50 per cent of the ascorbic acid originally present in the dehydrated material in 12 weeks. The samples were stored at 37° C. to simulate tropical conditions. In other samples of these vegetables stored in closed but not sealed tins at Coonoor room temperature (say 18°–23° C.), the loss was 70–75 per cent in 6 weeks.

These samples took up some moisture, which may have accelerated destruction of ascorbic acid ; the vitamin appears to be more stable in material which remains *crisp*. In a sample of dehydrated potato stored at room temperature in an unsealed closed tin the loss was only 10 per cent in 12 weeks. The stability of vitamin C in dehydrated vegetables in

relation to conditions of packing and storage, the method of 'scalding', time of dehydration, etc., obviously requires further investigation.

Even in dehydrated amla fruit (*Phyllanthus emblica*), powdered, in tablets, and vacuum-packed, steady though slow loss of ascorbic acid occurs on storage. Amla, unlike common vegetables and fruits, contains tannins which have a protective effect on ascorbic acid. The loss in amla is slower than in the case of common vegetables, but the fact that loss does occur under such conditions suggests that ascorbic acid is unlikely to be very stable in other dehydrated vegetables and fruits not packed in containers from which oxygen has been excluded.

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Oct. 30.

Urea Synthesis in Mammalian Liver

BACH and Williamson[1] claim to have shown that rat liver forms urea from ammonium lactate even when the activity of arginase is inhibited by high concentrations of ornithine[2]. They conclude that liver can synthesize urea without the participation of arginase.

The data presented by Bach and Williamson are capable of a different interpretation. A relevant feature of their experiments is the extraordinarily low activity of arginase. According to their graphs 3 and 4, 1 mgm. liver (wet weight) formed 1·26 μgm., or 0·75 μgm., urea per hour, the first figure referring to an arginine concentration of 12·4 mgm. per cent, the second of 7·5 mgm. per cent. The potential arginase activity of rat liver under similar conditions, that is, at the same arginine and *p*H, is shown in Table 1[3].

TABLE 1. ARGININE ACTIVITY OF RAT LIVER AT DIFFERENT ARGININE CONCENTRATIONS (*p*H 7·4; 0·025 *M* PHOSPHATE BUFFER; 4 ML. TOTAL VOLUME; 40 MINUTES INCUBATION AT 40°).

Concentration of arginine	Urea nitrogen formed by 1 mgm. (wet weight) ground rat liver
1112 mgm. per cent	369 μgm.
556 ,,	371 ,,
278 ,,	347 ,,
139 ,,	265 ,,
69·5 ,,	180 ,,
34·8 ,,	117 ,,
17·4 ,,	75 ,,
8·7 ,,	43 ,,

TABLE 2. ARGINASE ACTIVITY IN THE EXPERIMENTS OF BACH AND WILLIAMSON COMPARED WITH POTENTIAL ARGINASE ACTIVITY.

Arginine concentration	Arginase activity (μgm. urea nitrogen formed per mgm. wet liver per hour)	
	Potential activity	Bach and Williamson
12·4 mgm. per cent	88	1·3
7·5 ,,	63	0·8

The comparison of the arginase activity observed by Bach and Williamson with the potential activity obtained by graphical interpolation from Table 1 shows that no more than a minute fraction—about 1·3 per cent of the total arginase—was active in the experiments of Bach and Williamson (Table 2); presumably it was only the arginase from the surface layer of the slices or from disintegrated cells which reacted. The inhibition by ornithine refers to this fraction only. The bulk of the tissue arginase—more than 98 per cent—did not come into play in the inhibition experiments of Bach and Williamson. These, therefore, do not show that the arginase in their liver slices was inhibited, and it is thus unnecessary to conclude that there is a urea formation without arginase.

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Nov. 25.

[1] Bach, S. J., and Williamson, S., NATURE, **150**, 575 (1942).

[2] This inhibition was first observed by R. E. Gross (*Z. physiol. Chem.*, **112**, 236; 1920). L. Hellerman and C. C. Stock (*J. Biol. Chem.*, **125**, 771; 1938) suggest that it may be due to the formation of metallic complexes of ornithine.

[3] The activities vary somewhat with sex, age and other factors, but are always of the same order of magnitude (see E. Baldwin, *Biol. Rev.*, **11**, 247; 1936; H. D. Lightbody, *J. Biol. Chem.*, **124**, 169; 1938).

IT seems scarcely possible to compare the activity of arginase observed with intact cell material suspended in bicarbonate buffer with that of ground tissue in phosphate buffer. There is also no linear proportionality between arginase activity and weight of slices[1].

If part of the arginase activity in the experiments with slices was caused as Krebs suggests by 'disintegrated cells', this criticism could surely be more justifiably applied to his experiments with ground tissue.

Krebs's criticism leads to the assumption that the 'tissue arginase' is incapable of decomposing added arginine but is active in the formation of urea from added ammonium lactate (via arginine). No explanation is given for this hypothetical difference.

Details of our work will be given elsewhere in due course.

S. J. BACH.
S. WILLIAMSON.

Biochemical Laboratory,
Cambridge.
Dec. 8.

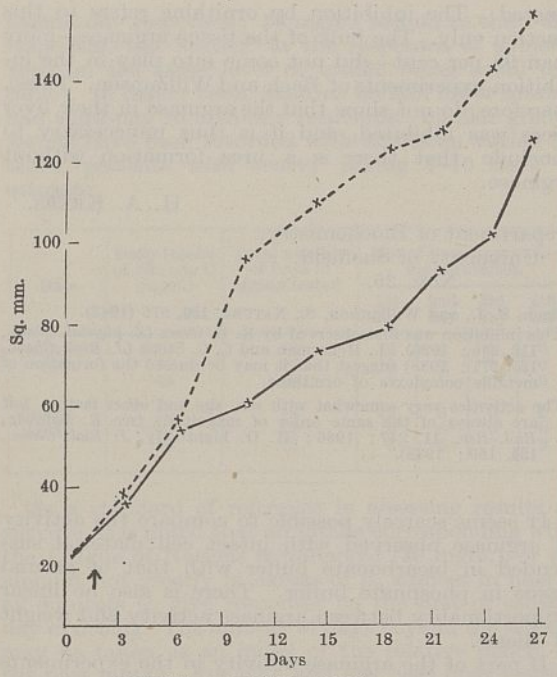
[1] Leuthardt, F., and Koller, F., *Helv. chim. Acta*, **17**, 1030 (1934).

Growth Stimulators in Urinary Extracts

IN a recent communication by Werner and Doljanski, the growth-promoting effects of certain tissue extracts upon tissue cultures are described[1]. The methods of extraction indicate that the active extracts may contain protein or protein-associated groups.

It may be of interest to note that in the fractionation of the growth-inhibiting extract of urine, H. 11 Extract[2], which is now being used in the treatment of cancer, certain fractions have been obtained which are stimulatory to the growth of transplanted tumours. Such fractions are protein-free and can contain only substances of relatively low molecular weight. It therefore seems likely that non-protein growth-promoting substances are present in the tissues.

An example of such a stimulatory solution is that obtained when neutral H. 11 Extract is fractionated by precipitation with copper salts. Extraction of this precipitate with dilute hydrochloric acid yields an insoluble tarry substance which is partially soluble



- - - - - - - - Treated (average of 7 tumours).
———— Untreated (average of 10 tumours).

Extract given in doses of 0·5 c.c. b.d. intraperitoneally. First injection 11 days after inoculation.

Tumour size evaluated as product of two diameters.

in sodium hydroxide. The alkali-soluble part is found to be growth acceleratory, as indicated by the accompanying graph.

As these results were only incidental to the main research on substances inhibitory to cancerous growths, no further investigations were made. It is felt desirable, however, to record them for the use of other research workers in this field.

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R. FORBES JONES.

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Dec. 7.

[1] NATURE, **150**, 660 (1942).
[2] *Medical Press and Circular*, **205**, 334 (1941).

The 'Age' of Terrestrial Matter and the Geochemical Uranium/Lead Ratio

IN 1937 Stefan Meyer[1], of the Radium Institute in Vienna, using the data then available, obtained a value for the 'age' of the sun, or rather of terrestrial matter (assumed to be of solar origin). Assuming matter to have taken on its present elementary composition when radioactive disintegration was also started, Meyer calculated the length of time required for producing all the uranium- and actinium-lead in existence through disintegration of uranium I and of actino-uranium respectively. In his calculation Meyer made use of the figures for the isotope ratios of uranium and lead determined by the mass spectrograph, and also of the geochemical uranium/lead ratio worked out by Goldschmidt. Finally, he assumed the activity ratio between the uranium and the actino-uranium series to be as 25 : 1. The result gave $(4{\cdot}6 \pm 0{\cdot}4) \times 10^9$ years as the age of the sun and, incidentally, the half-period of actino-uranium was found to be $(7{\cdot}0 \pm 0{\cdot}5) \times 10^8$ years.

Thanks to recent very accurate measurements by J. O. Nier[2], it is now possible to revise these calculations. Also the half-period of U^{235} has been found by independent methods ($7{\cdot}1 \times 10^8$ years). Using the latter value, the calculation can be carried out without using the hypothetical value of the geochemical uranium/lead ratio, which can be determined instead through the calculation. From Nier's determination the following constants are used: Isotope ratio of lead $Pb^{204} : Pb^{206} : Pb^{207} = 1{\cdot}5 : 22{\cdot}6 : 22{\cdot}6$; Decay constant of actino-uranium, $\lambda_{acu} = 9{\cdot}72 \times 10^{-10} a^{-1}$; Isotope ratio of uranium, $\frac{U^{238}}{U^{235}} = \beta = 139 : 1$.

From the law of radioactive decay it follows that:

$$\lambda_U t_a = \ln U_a/U_0. \quad . \quad . \quad . \quad . \quad (1)$$

If U_a was the number of uranium atoms t_a years ago and U_0 their present number, we find

$$U_a = U_0 + \alpha_u \Sigma Pb. \quad . \quad . \quad . \quad (2)$$

From equations (1) and (2):

$$t_a = (1/\lambda_u)\ln(1+\alpha_u \Sigma Pb/U_0). \quad . \quad . \quad . \quad (3a)$$

For the actinium we find a similar equation

$$t_a = (1/\lambda_{acu})\ln(1+\alpha_{acu}.\beta.\Sigma Pb/U_0), \quad . \quad . \quad (3b)$$

where λ_u is the decay constant of uranium ($1{\cdot}535 \times 10^{-10} a^{-1}$), α_u the ratio $Pb^{206}/\Sigma Pb = 0{\cdot}226$ and α_{acu} the ratio $Pb^{207}/\Sigma Pb$ is 0·226.

By a graphical method we find from the preceding equations $t_a = 5{\cdot}33 \times 10^9$ years, whereas the geochemical lead/uranium ratio is found to be 5·6. It should be observed that the latter figure is derived directly from the radioactive constants. It agrees fairly well with Goldschmidt's assumption that per 100 atoms of silicon there are 0·0008 atoms of lead and 0·00016 atoms uranium present, giving a lead/uranium ratio of 5 : 1. We further find the present-day lead/actino-uranium ratio to be 750 : 1, whereas the uranium/urano-actinium ratio at the starting point, 5·33 billions of years ago, should have been as 1·78 : 1.

The age of matter thus found is seen to agree with the short-time scale now generally adopted in cosmic physics. It is of the same order of magnitude although numerically less than the new maximum age for iron meteorites given by Paneth[3] at $7{\cdot}8 \times 10^9$ years.

The figure here found for the age of terrestrial matter obviously represents a *maximum*, since any non-radioactive genesis of the lead isotopes Pb^{206} and Pb^{207} would mean a corresponding reduction in the time required for their production through disintegration. On the other hand, the age as stated only applies to the uranium isotopes, leaving the possibility open that when they were evolved the other elements may have existed for an indefinite time.

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Göteborg.
Oct. 29.

[1] Meyer, S., *Mitt. Inst. Radiumforschung*, No. 393, No. 407.
[2] Nier, J. O., *Phys. Rev.*, **55**, 150, 153 (1939); **60**, 112–116 (1941).
[3] Arrol, W. J., Jacobi, R. B., and Paneth, F. A., NATURE, **149**, 235 (1942).

Effect of Air Currents, Light, Humidity and Temperature on Slugs

IN view of the communication by Kalmus[1], it is of interest to record a brief summary of results obtained during an attempt to determine the causes of activity in slugs. The results will be considered under four headings, namely, responses to (1) air currents, (2) light, (3) humidity, and (4) temperature.

(1) *Air Currents*. A gentle draught of air (just perceptible to the observer's cheek) was played across the path of slugs (*Agriolimax reticulatus* and *Limax maximus*) just in front of the animals. The slugs turned away, going through the following movements. The tentacles were withdrawn, the head moved to right or left and the tentacles extended again. This process was repeated until the tentacles eventually remained extended and the animal moved away from the draught, presumably because the tentacles were no longer stimulated. Air played on the tail or body of the slug increased the speed of locomotion or, if the animal was at rest, induced activity. The same result was obtained using saturated air, showing that the effect was not due to the temperature drop (see below) caused by the evaporation of water which occurs when dry air is used. Air currents thus have a dual effect: (*a*) stimulation of the tentacles affecting the direction of locomotion, and (*b*) stimulation of the body or tail affecting the occurrence or speed of locomotion.

The above effects were readily demonstrated on a specimen of *Limax maximus* moving over a glass plate. Observation of the sole showed that stimulation of the tentacles by air currents involved immediate inhibition of the locomotory waves, while stimulation of the body or tail initiated waves or increased their speed. This inhibition of the locomotory waves by anterior stimulation is in accord with experiments in which a posterior half of a slug, completely severed from the head end, produced locomotory waves without ceasing for two hours after isolation.

(2) *Light*. In some instances slugs (*A. reticulatus*) kept at constant temperature in the dark showed increased activity when illuminated by electric light, though the increase was never as marked as in the temperature responses described below. The effect was short-lived, adaptation occurring quickly. In the final experiments using 72 animals at a time and noting activity at 15-minute intervals (instead of 5-minute as in previous experiments) no effect was obtained, possibly because adaptation occurred within 15 minutes. (In considering these experiments it is necessary to remember that a light was used for taking the readings in the dark, and the animals were thus illuminated for occasional short periods (1–2 minutes). The animals showed a typical avoiding reaction at the boundaries of well-defined regions of bright light. The boundary was, however, traversed if this was the only way in which the slug could avoid facing into a draught (see above).

(3) *Humidity*. At room temperature (16–18° C.) slugs (*A. reticulatus*) were found to be no more active at high than at low humidities. No orthokinesis comparable with that described by Gunn[2] in the woodlouse or by Pielou and Gunn[3] in the mealworm was observed. Slightly greater activity was obtained at low humidity. This may be explained as a response to the fall in temperature (see below) which occurs when a damp object is introduced into a dry atmosphere.

Humidity might affect the animals indirectly by altering their water content. Experiments on *A. reticulatus* and *L. maximus* showed that when loss of water by evaporation and mucus production exceeded a certain minimum value, the distance moved after the animal was transferred to an arena was reduced. The nature of the normal habitat of slugs makes it unlikely that such a reduction in water content would occur owing to evaporation alone, particularly as slugs can be shown to absorb water readily from damp objects with which they are in contact. Loss of water by mucus production may affect the occurrence of activity, and since mucus is produced during locomotion, may also limit its duration. Howes and Wells[4] observed weight fluctuations due to water content in *Arion ater* living under laboratory conditions but made no correlation with activity.

(4) *Temperature*. Slugs (*A. reticulatus*) respond readily to temperature changes. No correlation was observed between degree of activity and temperature when the latter was kept constant. Activity was, however, invariably stimulated by rising temperature above a critical value of about 20° C. Below this value the effect was reversed and activity stimulated by falling temperature. (In both cases the rate of rise or fall was about 1° C. in 10 minutes.) If the temperature was kept constant at any value, the activity fell to a low level. Some evidence has been obtained that temperature changes towards the critical value of 20° C., that is, in the reverse direction to those above, reduce activity below the level observed at constant temperature.

The results of these and related experiments will be published in detail elsewhere.

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Dec. 8.

[1] Kalmus, NATURE, **150**, 524 (1942).
[2] Gunn, *J. Exper. Biol.*, **14**, 178 (1937).
[3] Pielou and Gunn, *J. Exper. Biol.*, **17**, 307 (1940).
[4] Howes and Wells, *J. Exper. Biol.*, **11**, 326 (1934).

Discoveries by Accident

IT is not derogatory of a discoverer to say that his discovery arose from an accident; for the power to use accidents, events the occurrence of which was not intended, is the mark of one form of scientific genius. Probably all experimenters are presented with about the same number of accidents which, if they had had the wit, would have led them to important discoveries; but most of us fail to appreciate their significance until the discovery has been made by somebody else; we may then fail to remember them or forget them to save our self-respect. I know that I had at least three such accidents that would certainly have led Röntgen to discoveries, if not as important as X-rays, at least of considerable technical and scientific interest. Two of them I missed entirely, and the third I used very imperfectly.

Doubtless there is another form of scientific genius that proceeds from triumph to triumph according to an ordered plan; but it is seldom certain that the progress was really as orderly as it appears when the results are presented. Even if this form must be reckoned the higher, science would never have reached its present position without the other.

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Dec. 18.

RESEARCH ITEMS

South African Bored Stones

A. J. H. GOODWIN, of the University of Cape Town, has given an account of the bored stones of South Africa in No. 1 of the new series of Communications from the School of South African Studies published by the University of Cape Town. Bored stones are of various kinds—as described in the article—but, generally, may be visualized as balls of stone so pierced that they can be hafted on to sticks, which are then used for digging or other purposes, the weight of the stone materially assisting the operation. The age of these bored stones varies considerably, some being quite modern and some of unknown antiquity, and culturally speaking they have been used by Bantus, Bushmen and prehistoric peoples. They are figured in some of the so-called Bushmen paintings. The present article analyses a large amount of material and will be very useful for reference purposes to students of South African Stone Age archæology.

New Palæolithic Industry from East Anglia

AN interesting paper on a new palæolithic industry from the Norfolk coast appears in the *Geological Magazine* (79, July–August 1942) under the names of D. F. W. Baden-Powell and J. Reid Moir. The problem of the number and relationships of the various glacial deposits in Norfolk has evoked much literature, but this short article may well be preferred to some of the longer treatises. For the first time, the Corton sands at Corton are properly taken into account and correlations made between the deposits there and at Hoxne. A very interesting flint industry found in the "Corton" sands at Runton and hence named *Runtonian* is also described. The artefacts are apparently usually small and include neatly trimmed round scrapers, points, etc. The whole industry might perhaps be assigned to an early Clactonian culture since it certainly belongs to the flake-tool culture group, and plain, unfaceted striking platforms are the rule. It is to be hoped that Baden-Powell and Reid Moir will not rest content with this small article; it should be treated as a synopsis to a more comprehensive work on the prehistory of these parts of East Anglia.

Biology of the Brown Trout

THE results of the research by A. E. J. Went and Winifred E. Frost form the fifth of the series of the survey of the River Liffey begun by the late Rowland Southern and continued after his death in 1935 by Miss Frost (River Liffey Survey, V. Growth of Brown Trout (*Salmo trutta* L.) in Alkaline and Acid Waters. *Proc. Roy. Irish Acad.*, 48, B, No. 4; 1942). Variation in the size of brown trout from different localities has given rise to much discussion. In general, in waters of low *p*H values the trout were small and slow-growing, whereas in limestone waters they were of the large quick-growing type. The present work is based on sets of scales together with other data relating to length, weight, sex, date of capture, etc., most of which have been collected by Miss Frost from brown trout taken by angling in the River Liffey and its tributaries. The main part of the material was obtained from Straffan (alkaline water, mean *p*H 7·9) where the trout were of relatively large size, and from Ballysmuttan (acid water, mean *p*H 5·5) where they are seldom more than four ounces in weight. It is suggested that the difference in growth-rate in the two localities is mainly due, not, as it is often considered, to the age of sexual maturity, which is found to differ little, but to a longer period of rapid (summer) growth and more active growth during the period of slow (winter) growth at Straffan than at Ballysmuttan.

Subantarctic and Antarctic Algal Communities

C. SKOTTSBERG describes the communities of marine algæ in subantarctic and antarctic waters (Kungl. Svenska Vetenskapsakademiens Handlingar. Tredje Serien. 19, No. 4; 1941). The work is based on his personal observations during the Swedish Antarctic Expedition (1901–1903) and the Swedish Magellanic Expedition (1907–1909). The algal communities were practically unknown in the regions visited except that the 'kelp belt', the association of *Macrocystis pyrifera*, had attracted attention for centuries. This, the most famous of all southern communities, ranges from the Peruvian coast to Cape Horn and is circumpolar in the antarctic, forming a belt outside the breakers but approaching close to the shore in smooth waters. It was a great misfortune that the major part of the antarctic collection was lost with the ship in the pack-ice of Paulet Island. A large amount of work, however, has still been possible. The four districts concerned—South America from Chiloë to Fuego, the Falkland Islands, South Georgia and West Antarctica ("Graham Land")—are treated separately and there are distinct differences in the algæ of these regions. There are some interesting deep water communities. The red algæ dominate in deep water, whereas the littoral species often show a brownish violet tinge. The author believes that, judging from his own material, in the antarctic at least a small number of red algæ are able to exist at a depth greater than 40 m., especially as the Desmarestia association extends to almost this depth, but that there are no special deep-water species justifying the recognition of a separate elittoral algal region, and that records from below 50 m. need corroboration.

Genetics of the Potato

SEVERAL viruses of the potato cause a lethal necrosis of some varieties when these are grafted on to infected stocks. This necrosis only occurs on those varieties which are intolerant of the virus, and which rarely, if ever, carry the infection in the field. C. H. Cadman (*J. Genetics*, 44, 33–52; 1942) has shown that the products of top-necrosis due to virus *X* after grafting occur in those varieties which carry a dominant gene *Nx*. This gene segregates in an autotetraploid manner; the occurrence of equational exceptions and the statistical examination of the segregation ratios show that *Nx* is situated far from the centromere. It should be possible to raise varieties which are intolerant, that is, practically immune from virus *X*.

Great Iron Boulder from Ovifak

H. Löfquist and C. Benedicks give a detailed account of the core from the great iron boulder brought by Nordenskiöld from Ovifak to Stockholm ("Det Stors Nordenskiöldska Järnblocket fran Ovifak: Microstructur och Bildningssätt." Kungl. Svenska Vetenskapsakademiens Handlingar. Tredje Serien. 19, No. 3; 1941). This huge mass of 25 tons belongs to the Mineralogical Department of the State Museum of Natural History (Riksmuseet) and was successfully

drilled out in 1938. The core obtained was divided into five specimens and a complete metallographic investigation was made. Chemical analyses of samples taken close to these specimens show that the iron boulder consists of nickel-bearing, sulphur-rich massive iron with a high carbon content, making a natural raw iron. The microstructure, on the whole, agrees well with the analytical results, and minute investigations were made on all the constituents. The general conclusion is that there are strong reasons for the view that the iron boulder has been formed from iron sulphide to which carbon has been added. The genesis of the Ovifak boulder may be explained as the result of the following contact-metamorphosis: "One of the boulders of the nickeliferous pyrrhotite of the neighbourhood has happened to be enclosed in a crack in which molten basalt has risen, after having absorbed carbon from the coal beds broken through. . . . Under the combined action of the high temperature of the magma and its carbon, the sulphides of the pyrrhotite have been dissociated, giving carbon-rich iron, i.e., a natural crude iron containing nickel, being Ovifak iron." This work is in Swedish with an English summary.

Crystal Structure of Phosphorus Pentachloride

THERE is proof from electron diffraction experiments that the molecules of some phosphorus pentahalides have the configuration of a trigonal bipyramid, and the same configuration is found for a number of other molecules of similar formula. The appreciable electrical conductivity of solutions of phosphorus pentachloride and other observations suggest that it may be able to exist in an ionized form. The physical properties of the solid lend support to this idea, and a comparison of the Raman spectra in various states shows that the bipyramidal molecules do not persist in the solid. An examination of the X-ray spectrum by D. Clark, H. M. Powell and (independently) A. F. Wells (*J. Chem. Soc.*, 642; 1942) has now given the very interesting result that in the crystal the substance exists in ionic form. The unit cell is tetragonal and contains tetrahedral PCl_4^+ and octahedral PCl_6^- groups. These are arranged in a structure essentially of the cæsium chloride type, but distorted, since the ions are not spherical. The structure bears some resemblance to that of tetramethylammonium iodide but belongs to a lower symmetry class of the tetragonal system. The phosphorus to chlorine distance varies from 2·06 A. in PCl_6^- to 1·98 A. in PCl_4^- and is interpreted as related to change of effective nuclear charge. The P to Cl distance in PCl_4^+ is short by about 0·08 A. of the length calculated from the sum of the normal tetrahedral covalent radii derived from methyl compounds, with a correction for charge. Similar shortenings have been observed for many halogen compounds.

Estimation of Added Calcium Carbonate in National Flour

AT a meeting of the Society of Public Analysts and Other Analytical Chemists held on November 4, E. N. Greer, J. D. Mounfield and W. J. S. Pringle described "The Estimation of Added Calcium Carbonate (Creta Praeparata) in National Flour". Three methods have been studied and are described: (*a*) The sample is incinerated and calcium is determined in the ash by precipitation as oxalate and titration with permanganate; a blank estimation should be made on a sample of the same flour without added Creta. (*b*) The sample is treated with excess of standard hydrochloric acid and the excess titrated back with alkali; with this method also a blank estimation is necessary. (*c*) The carbon dioxide liberated by excess of hydrochloric acid is absorbed and weighed. If a control sample of the unfortified flour is available, the oxalate method is the most accurate; without a control sample the error may be as much as 20 per cent. Method (*b*) also requires a control sample and when the amount of Creta is about 7 oz. per sack the method is accurate to 3–4 per cent. Method (*c*) is accurate to within about 3 per cent even in absence of a control, and this method is therefore the most useful of the three.

Crystal Structure of Graphite

A FURTHER discussion of the faint extra lines found on X-ray powder photographs of well-crystallized graphite by Taylor and Laidler (NATURE, 146, 130; 1940) is given by H. Lipson and A. R. Stokes (*Proc. Roy. Soc.*, A, **181**, 101; 1942). A new structure is proposed having hexagonal layers similar to those of graphite, but arranged in a different sequence. About 14 per cent of the new structure is present in the samples examined, ranging from natural graphite from Ceylon, Bavaria and Travancore to graphite extracted from the 'kish' occurring in the casting of carbon-rich steels as well as in graphite crystallized by arcing.

Obscured Regions in the Greenwich Astrographic Zone

IN a paper on this subject (*Mon. Not. Roy. Astro. Soc.*, **102**, 5) E. G. Martin gives the results of the separate counts for the Greenwich region (Dec. +64° to +87°, galactic latitude +4° to +51°), originally published in vol. 4 of the *Astrographic Catalogue*. A comparison of the average log N_m at different latitudes and longitudes with the figures by van Rhijn provides some very interesting results. The frequency curve shows that there is a considerable amount of asymmetry, negative residuals being in excess. On the assumption that the scatter is due to accidental error, the probable error in log N_m of a single count for regions at latitudes exceeding 25° is $\pm 0{\cdot}102$, and for those less than latitude 25° it is $\pm 0{\cdot}122$. There are twenty-nine regions in which the negative residuals are larger than three times the probable error, the largest residual being eight times the probable error, and it is considered that this is due to a real absorption effect. Nineteen of the outstanding regions are spaced in latitudes 4° to 20°, and only ten lie between latitudes 20° and 50°; this confirms the hypothesis that absorption increases towards the galactic equator. Among the five strips selected in galactic longitude to derive the separate mean values of log N_m, it was found that there is a tendency for the central strips to contain more outstanding regions than the outer strips, indicating a higher absorption around longitude 90°–100° and confirming a secondary maximum. It is very difficult to determine how much the absorption for each individual count amounts to in magnitude and also to find at what distance the absorption is effective, owing to the fact that actual counts are available only from magnitudes 10 to 13. An attempt was made to analyse the mean results of the counts for latitude 7°, and, while the result showed a density near the sun similar to that given by van Rhijn up to 1,000 parsecs, at 10,000 parsecs the density rapidly increased to a much larger value than that of van Rhijn.

TRACE ELEMENTS IN RELATION TO HEALTH

THE eighth scientific meeting of the recently formed Nutrition Society, or fifth of the English group, took the form of a whole-day conference at the London School of Hygiene and Tropical Medicine, on "Trace Elements in Relation to Health".

Dr. J. Russell Greig occupied the chair at the morning session, opening the proceedings with a brief reference to his own interest in 'pining' of sheep in Scotland. Prof. C. Harington took the chair at the afternoon session and finally summed up the day's discussion as a whole. Ten papers provided by fourteen contributors were included on the agenda paper, all of which will be published in due course in the *Proceedings of the Nutrition Society*.

(1) *Significance of Trace Elements in Relation to Diseases of Plants and Animals.* In this paper Dr. H. H. Green, of the Veterinary Laboratory of the Ministry of Agriculture at Weybridge, offered a 'bird's-eye view' over the whole field of trace elements of known economic importance in both plant and animal life, intended to serve as an introduction to the more specialized papers to follow. Commencing with a definition of 'trace element' as any element regularly occurring in minute amounts in living tissues whether it exercises any specific physiological function or not, metals such as aluminium and nickel were cited as apparently inert and merely present because incidentally taken up by the action of plant roots; elements such as copper and manganese cited as essential for both plants and animals, boron as essential for the plant but not known to be essential for the animal, cobalt as essential for cattle and sheep but not yet known to be essential for non-ruminants or for plants, selenium and molybdenum as probably unessential for both plants and animals but sometimes taken up by healthy plants in amounts which cause disease in the consuming animal.

Omitting elements such as lead and arsenic which, though known to be toxic, are not absorbed by plants in amounts dangerous to animals, and passing over the essential element iodine as "trace but no longer novel", the elements copper, cobalt, manganese, zinc and boron, were dealt with in some detail as involved in deficiency diseases, and fluorine, selenium and molybdenum as causing toxicoses.

The occurrence of relevant plant and animal ailments in various parts of the world was summarized, local names, prominent symptoms and methods of control being mentioned. Control varies from fertilizing apple trees with borax in Tasmania for control of 'internal cork', or pine trees in Australia for 'needle fusion', top-dressing pastures with copper sulphate for control of 'Urbarmachungskrankeit' in crops and 'Lecksucht' in animals in Schleswig-Holstein, or for control of 'falling disease' of ruminants in Australia, providing copperized salt licks to breeding sheep for protection against 'sway-back' of lambs in England or 'enzootic ataxia' in other parts of the world, supplying cobalt to prevent 'wasting disease' of cattle and sheep in Australia, 'Grand Traverse disease' in Michigan, and 'pining' in Scotland, to controlling the 'alkali disease' of Dakota or the 'blind staggers' of Wyoming by eradicating plants which take up excessive quantities of selenium from seleniferous shales and act as 'selenium converters' by finally returning that toxic element to the soil in a form more available for other plants.

The quantities of essential trace elements in plants are, however, no necessary indication of the quantities required by consuming animals, and animals may waste away when grazing on luxuriant herbage or complete the cycle of their being on plants showing obvious symptoms of vegetative failure.

(2) *Distribution of Trace Elements in Soils and Grasses.* Dr. R. L. Mitchell, of the Macauley Institute, near Aberdeen, pointed out that a very large number of elements is present in soils, each in traces of fractional parts per million upwards, but that the amount of any one of them may vary a thousand-fold from soil to soil. The variations correspond to the parent material from which the soil is derived, in the last resort from igneous rocks and the magmas from which they have crystallized; but certain geochemical rules prevail, and if any particular trace element occurs in a rock there must be present in it a mineral at least one of the constituents of which can be replaced by an atom of the element in question. For this reason elements such as cobalt, nickel and chromium would be expected in higher quantities in ultrabasic rocks than in acidic rocks, where elements such as barium would be more prevalent. If the origin of a soil can be directly traced to an igneous formation, it is possible to forecast the probable occurrence of its trace elements, but in practice the problem is complicated by weathering and metamorphosis and if, as often the case in north-east Scotland, the surface is derived by glacial drift from sedimentary rocks, the problem becomes individual for each soil considered. These points were illustrated by discussing the range of trace elements found by spectrographic analysis of Scottish soils, in respect of silver, barium, cobalt, chromium, cæsium, copper, gallium, germanium, lanthanum, lithium, manganese, molybdenum, nickel, lead, rubidium, tin, strontium, thorium, titanium, vanadium, yttrium and zirconium.

The occurrence of a given trace element in a soil, however, is not necessarily a guide to its occurrence in plants, and although there exists a general correlation between soil quantities soluble in dilute acetic acid and quantities found in the covering vegetation, trace-element deficiency diseases are sometimes found in plants growing on soils containing abundance. The natural *p*H of the soil is an important factor, as evidenced by the lime-induced 'chlorosis' of plants found in parts of England.

In general, trace-element deficiencies of plants and grazing animals can be rectified by incorporating small amounts in fertilizers, as little as 2 lb. per acre of a cobalt salt being su ficient to prevent the 'sheep pining' of certain pastures in Ross-shire. Among plant diseases in Scotland associated with trace elements were mentioned boron deficiency of turnips and sugar beet in the west and manganese deficiency leading to 'oat sickness' in the north.

(3) *Copper, Zinc and Other Trace Elements in Relation to Physiological Function and Enzyme Systems.* Dr. H. Mann, in this paper with Prof. D. Keilin, pointed out that, of the numerous trace metals detectable in tissues, definite physiological functions have so far only been assigned to iron, copper and zinc. To these, several distinct purposes can be assigned, of analogous character in all three cases. They either form oxygen carriers or catalyse reactions involving oxidation, reduction, or acid-base equilibrium. In each case the metal has definite physiological properties only when stoichiometrically bound with highly specific protein molecules which, although themselves inactive, determine the pro-

perties of the metallo-protein compounds and can be limiting factors in their formation. It is the specific protein which determines whether the trace element is to function as carrier of molecular oxygen in the circulating fluid or as catalyst promoting intracellular oxidation in the tissues, or perform any other function.

In dealing with iron, Dr. Mann discussed the rare iron-protein hæmerythrin, the commoner iron-porphyrin-protein oxygen-carrier h emoglobins and myoglobins, the green h emoglobin chlorocruorin of certain molluscs, and the oxidizing catalysts cytochrome, peroxidase and catalase. Among the copper-protein compounds are the blue oxygen-carrier hæmocyanins of some arthropods and molluscs, the oxidizing catalysts such as the phenolic oxidases which account for the rapid darkening of fruits and vegetables on bruising, and of insect cuticle after emergence from the pup e. The function of the hæmocuprein of red blood cells is not yet known, although copper is recognized as essential for hæmoglobin formation. In the case of zinc, only one enzyme is yet recognized, the carbonic anhydrase of blood corpuscles, gastric mucosa, pancreas and other tissues. Its function is to catalyse the reversible dissociation of carbonic acid into carbon dioxide and water, and so facilitate the removal of oxidation products and the maintenance of acid-base equilibrium in the body. The fact, however, that the distribution of zinc is not strictly coincident with that of carbonic anhydrase suggests other zinc-protein compounds with other functions.

Of special interest is the enormously high activity of the trace metals in the form of their specific protein compounds. The enzymes are active when present as parts per thousand million, a level at which neither the metal itself nor the protein itself can be detected by any known chemical means.

(4) *Enzootic Ataxia or 'Swayback' of Lambs in England in Relation to Copper Feeding of Ewes During Pregnancy.* This contribution took the form of a cinematographic film illustrating the Derbyshire investigations of a group of workers under the general co-ordination of Prof. T. Dalling, recently translated from the chair of animal pathology at Cambridge to the directorship of the Veterinary Laboratory of the Ministry of Agriculture at Weybridge, into a disease of lambs termed 'swayback' in Britain and 'enzootic ataxia' in Australasia and other parts of the world. The disease can be controlled by supplying copperized salt during pregnancy to outwardly healthy ewes, the lambs of which otherwise develop the disease during fœtal growth and suffer high mortality incidence in the first week of life. Although the precise role of copper is not yet clear, the quantities of that element in the blood of affected lambs and their mothers is below that of unaffected controls. Unlike certain Australasian pastures, however, affected Derbyshire pastures cannot be incriminated as grossly deficient in copper.

The film illustrated the characteristic spastic paralysis of limbs with resultant inco-ordination during life, and the pathological lesions found at post-mortem. The latter comprised symmetrical demyelination of the cerebrum and secondary degeneration of the motor tracts of the cord.

(5) *Cobalt and Other Trace Elements in Relation to Disease in Australasia.* This paper, read by Dr. H. Chick on behalf of Sir Charles Martin, who had personal experience of animal diseases in Australia during his sojourn there about a decade ago, placed in historical perspective the classical researches carried out over the last fifteen years in that continent into diseases of cattle and sheep caused by deficiency of cobalt, of copper, or of both combined.

Along the coast of South and West Australia, areas occur in patches long known by farmers to be unsuitable for rearing ruminants, although they enjoy a rainfall of 20–40 in. and produce abundant herbage throughout the growing period. Animals could be fattened on them but not reared, since if confined to them for more than a few months cattle and sheep began to weaken, without characteristic lesions to suggest a cause, finally dying of starvation in the midst of apparent plenty. In South Australia the soil of these unsound areas consists of unconsolidated wind-blown sand and shells; in West Australia of loamy granitic gravel about five miles from the coast at an altitude of 500 ft. In the latter area the disease was termed 'enzootic marasmus' by Filmer, who found that, like the 'bush sickness' of New Zealand formerly attributed by Aston to iron deficiency, it can be prevented and cured by mineral licks containing the iron ore limonite. Very poor response, however, was given by therapeutic treatment with pharmaceutical iron salts, and in following up this observation Filmer subjected the limonite to chemical fractionation. Extracts freed from iron but containing zinc, nickel and cobalt were as active as the original material and trials of these elements separately led to the discovery that enzootic marasmus is a cobalt-deficiency disease preventable by administration of so little as 0·1 mgm. daily for sheep and 0·5 mgm. for cattle.

Parallel researches by Marston and others in West Australia were complicated by differences in symptomatology. In addition to the progressive weakness of enzootic marasmus, ataxia proceeding to complete inco-ordination of limb movements was observed, particularly in lambs and young sheep, and shown by Bull to be associated with demyelination of spinal tracts. After much exhaustive testing of possible causes, from poisonous plants to gross mineral imbalance, a trace element factor was suspected and Jansen's salt mixture, containing zinc, nickel, cobalt, manganese, aluminium, boron, arsenic, molybdenum and copper, along with the usual major elements, was tried. This gave excellent results, and by a process of elimination it was finally ascertained that the required combination was copper and cobalt. Unless both were included the experimental controls succumbed within a year.

Further investigation showed the occurrence of copper deficiencies alone, notably the enzootic ataxia of lambs in West Australia, while the bush-sickness of New Zealand was then found to be due to deficiency of cobalt and not iron. Arising from the Australasian investigations, similar diseases were then identified in many other parts of the world, including the long known 'renguerra' of Peru and the 'swayback' in restricted areas of England.

(6) *Sheep 'Pining' in Britain.* Mr. W. Lyle Stewart, veterinary investigational officer at Newcastle, dealt mainly with the occurrence of 'pine' in Northumberland, a wasting disease of sheep associated with anæmia. This is treated as the result of interaction between malnutrition and helminth infestation. Neither factor alone is su ficient to account for death. In fairly large-scale experiments a small ration of mineralized cake containing a variety of trace elements, including copper and cobalt, reduced incidence of the disease, and periodic dosing with anthelmintics achieved the same effect, but much

the best results were obtained by combining both treatments. In another series of experiments equally good results were obtained by combining fortnightly dosing with mixed trace elements in solution and monthly dosing with phenothiazine as anthelmintic. Live-weight gains of lambs over a short experimental period were 27 lb. for the controls, 31 lb. for trace element dosing, 36 lb. for anthelmintic treatment, but 41 lb. for the combined treatments.

(7) *Fluorine in Human Nutrition.* Biochemical aspects were dealt with by Dr. M. M. Murray, a clinical account of fluorine distribution was provided by Dr. D. C. Wilson, and radiological investigations were reported upon by Mr. F. H. Kemp.

Dr. Murray dealt briefly with sources of fluorine in drinking water, the main cause of chronic endemic fluorosis manifested most clearly as 'mottling' of teeth; and with compounds such as fluorspar and cryolite causing industrial fluorosis characterized by osteosclerosis. It was pointed out that fluorine occupies a curious position nutritionally in that very small traces appear to be beneficial, whereas larger traces seriously interfere with bone metabolism. More fluorine was found by American workers in sound teeth than in carious teeth, and 'mottled enamel', occurring where fluorine in drinking water reaches about 1 p.p.m. during the period of development of teeth, is more resistant to caries. Fluorine affects the bones at all ages; adult workers exposed to industrial risk develop osteosclerosis but not mottled teeth. Little is known about the precise action of fluorine, but the low concentration at which it inhibits osteogenesis suggests a catalytic effect. Traces of fluorine can pass the placental barrier, and disorganization of calcification occurs in the fœtuses of experimental rats on high fluorine intake.

Mr. Kemp showed lantern slides illustrating cases of human skeletal fluorosis, including 'round back' of children and adults in areas of Great Britain in which mottled teeth are prevalent. It was not claimed that high fluorine intake is alone responsible for interference with spinal ossification in children, but merely that high fluorine in drinking water may influence development of such defects.

Dr. Wilson discussed the relationship between fluorosis and nutritional status, stating that although mottling and staining of teeth are proportional to the amount of fluorine in drinking water, the state of nutrition of the individual determines the character of the enamel and regularity of dentition. Nutritional status also influences the skeletal lesions in chronic endemic fluorosis, and dietary surveys in India have shown much more severe lesions in poor villages than in prosperous neighbouring communities. For early treatment of 'round back' associated with dental fluorosis of children in Oxfordshire, good results can be expected by combining school meals with attention to posture in physical training.

(8) *Industrial Fluorosis of Animals in England.* Under this title Mr. F. Blakemore, veterinary investigational officer at Cambridge, described an outbreak of industrial fluorosis in farm animals extending for about a mile in the direction of the prevailing winds from a high concentration of kilns in a brick-making district of England. Analysis of pasture grass and other plants showed surface contamination with fluorine compounds and this was traced to the flue gases drifting down from the chimneys, and thence to the high fluorine content of the clay used in brick-burning. Cattle are most severely affected and typical cases show lameness and enlarged atrophic bones with fluorine content up to 16,000 p.p.m.; mottling of the permanent incisors occurs in most cattle within the affected belt. Urinary fluorine is high even in animals without pronounced clinical symptoms, and its estimation in catheter samples has proved an excellent method of mapping affected farms. On removal of clinically affected animals from the district, urinary elimination of fluorine continues above normal, with rapid clinical improvement. The content of fluorine in surgically removed bone fragments fell rapidly over the first three months, but over the following five months showed little change from the residual high level.

A few parallel observations in the Manchester smoke belt showed no evidence of fluorosis at all.

(9) *'Teart' of Somerset: a Molybdenosis of Farm Animals.* Mr. W. S. Ferguson, one of the three Jealott's Hill investigators who established the etiology of this disease a few years ago, described the condition as one only affecting ruminants, chiefly dairy cows, and characterized by scouring and progressive cachexia. The dung becomes watery, foul and greenish yellow; hair covering of Red Devon cattle turns dirty yellow, and that of black beasts a rusty colour. Affected areas comprise about 20,000 acres in central Somerset associated with the Lower Lias geological formation, and smaller regions in north Somerset, Gloucester and Warwick. Spectrographic examination of affected pastures reveals abnormally high molybdenum, up to 100 p.p.m. on the dry matter as compared with 5 p.p.m. for healthy pastures, and the degree of 'teartness' is directly related to the water-soluble molybdenum content, which is highest in lush young grass and lowest in old herbage. The analytical conclusions were supported by reproducing the disease experimentally, by dosing with calculated amounts of sodium molybdate and by top-dressing sound pasture to raise the molybdenum content to that of affected pastures.

In searching for an antidote, it was found that oral ingestion of 2 gm. copper sulphate per cow per day prevents scouring and permits grazing of teart pastures throughout the season. Explanation of the mode of operation of the copper, and of the limitation of the molybdenum effects to ruminants, awaits further investigation.

(10) *Absorption and Excretion of Trace Elements.* Miss E. M. Widdowson, reading a joint paper with Dr. R. A. McCance, pointed out that there are no special characteristics in regard to absorption and elimination of trace elements except in so far as these can be deduced from their known chemical properties. Both absorption and excretion of silver as a trace element are limited by the insolubility of its chloride; in the case of barium by the insolubility of its sulphate. If divalent and capable of forming insoluble phytates and phosphates, as in the case of zinc and manganese, they tend to behave like the physiologically abundant calcium. If monovalent and characterized by solubility of their salts, they behave like the alkali metals or the halogens. The soluble milligram or so of lithium in daily human food behaves exactly like the concomitant 5,000 mgm. of sodium. Elements which cannot be excreted by the kidney in virtue of attachment to serum proteins will react alike, and zinc or manganese will tend to behave in the same way as iron.

The difficulties inherent in determining absorption and excretion of any element while the cycle of ingestion, intestinal absorption and partial return to

the intestine by bile and digestive juices is in progress were stressed, and further parallels drawn between relatively abundant elements such as calcium and magnesium and trace elements such as strontium, tin, cobalt and nickel.

In his final summary of the day's discussion, Prof. C. Harington reviewed a number of the salient features in the light of his own experience of the history of development of the physiology of iodine, stressing the point that although much information on the importance of various trace elements may accumulate, final conviction concerning the significance of any particular one does not really penetrate the scientific consciousness of the community until precise physiological function becomes clear and the actual operative mechanism is biochemically demonstrated.

T. DALLING.
H. H. GREEN.

STAR MAGNITUDES AND IMAGE DIAMETERS IN PHOTOGRAPHIC PHOTOMETRY

FORMULÆ hitherto employed to determine the relationship between star magnitudes and image diameters on photographic plates have been empirical, and fail in certain circumstances. It is impossible to apply them in the case of bright stars which give diameters larger than a certain limiting value (and this value varies with different formulæ) and, in addition, the formulæ take no account of the effect of star colours. D. L. Edwards has described a new method of investigation which gives very satisfactory results (*Mon. Not. Roy. Astro. Soc.*, **102**, 5). The work was carried out at the Norman Lockyer Observatory, Sidmouth. Three different Zeiss triplet lenses were used: (*a*) aperture 14 cm., focal-length 70 cm., (*b*) aperture 10·4 cm., focal-length 50 cm., (*c*) similar to (*b*) but stopped down to 2 cm. aperture. The plates used were the Barnet Super Press (blue sensitive emulsion), and Ilford Hypersensitive Panchromatic, which gives a good scale of photovisual magnitudes without a filter. When the panchromatic plates were considered and measured diameters were plotted against H.D. visual magnitudes (only stars of type *A*0 being used to determine the form of the relation for one colour only) the empirical formula $m=a-b(D-kD^2)$ gave the best fit. In this formula m is the magnitude, D the diameter, and a, b, k are constants.

Measures made on Barnet Super Press plates were treated in the same way, except that photographic instead of photovisual magnitudes were used, and it was found that the above relation held as for the photovisual plates. In addition, the same values of k were also applicable, in spite of the different magnitude scales and of the different types of emulsion used. Good values of k were given by $k=10^{-5}(140-13C)$, where C is the colour index.

The advantage of the first formula given above is that it has a greater range of application to bright stars than earlier formulæ, and it also allows for colour effect.

Edwards has applied this formula to γ Cassiopeiæ. The series of photographs extended over the period June 1, 1940, until March 24, 1942. During 1940 the magnitude variations were more pronounced, but by the end of the year and also throughout 1941 they tended to become steadier. Considerable changes in the spectrum accompanied the more pronounced fluctuations. At, and just preceding, the minima of June 29, 1940, photovisual magnitude 2·76 and photographic magnitude 2·64, and also of September 21, photovisual and photographic magnitude each 2·53, the *H* lines showed well-separated double emission components with strong central absorption and rather faint 'dish-shaped' absorption fringes. The He I absorption lines at 4471, 4026, 3964 were strong and sharp, and O II absorption rather faint. During the rise to maxima at August 24 and October 7, the magnitudes on these dates being $m_{pv}=2\cdot20$, $m_p=2\cdot06$, $m_{pv}=2\cdot05$, $m_p=2\cdot06$ respectively, the *H* central absorption became fainter and the 'dish-shaped' absorption stronger. The He I lines became fainter and more diffuse, OII became a little stronger, and λ 3888 (He I) very strong.

It was found that the colour index changes were subject to considerable uncertainty and did not show such pronounced correlation with spectrum changes as the magnitude variations. The mean colour index over the whole period was −0·12, and corresponds to the average colour index of *B*6 stars. As γ Cassiopeiæ is a *B*2 star, the average colour index of which is −0·30, its average colour index suggests considerable reddening.

ULTRA-SHORT RADIO WAVE PROPAGATION

AT a meeting of the Wireless Section of the Institution of Electrical Engineers on November 4, Dr. R. L. Smith-Rose and Miss A. C. Stickland read a paper describing the results of an analysis of field intensity measurements obtained during the years 1937–39, over the Post Office radio-telephone link between Guernsey and Chaldon, England, on wave-lengths of 5 and 8 m. (frequencies 60 and 37·5 mc./s.). The path between the radio stations was almost entirely over sea and about 85 miles in length, of which some 36 miles were outside the optical range. The material analysed was in the form of continuous, twenty-four hours a day, records of the field intensity received at Chaldon from the transmitters at Guernsey.

A quantitative study of the records confirmed the similarity of the type of signal fading on the two wave-lengths, and the lack of both diurnal and true annual variation; on the other hand, the results suggested a long-term secular variation in which the amount of fading on 5 m. tended to increase to a maximum over the period of observations while that on 8 m. decreased. The period of two years over which the observations were taken was not sufficient, however, to allow of any conclusions being formed as to an explanation of this trend.

Comparison with meteorological data showed a marked correlation between periods of very little fading and the presence of low-pressure systems, while periods of slow fading recurred at times of anticyclonic conditions. This, together with the fact that fading, while always less in winter than in summer, showed no regular seasonal variation, led to the conclusion that the winter decrease was due to the greater prevalence of low-pressure systems during this season.

A simple theoretical treatment of the propagation of waves through the lower atmosphere shows that account must be taken of the various paths by which rays can pass from transmitter to receiver, these rays being subject to diffraction, refraction or reflection on the way. The received signal is the resultant of the various rays received, and it is clear that interference effects may result from the arrival of two rays simultaneously by different paths. Sudden changes in the temperature and water vapour content in the atmosphere produce corresponding changes in refractive index and so cause marked bending of the rays transmitted. In regions of temperature inversion these conditions may be specially marked, resulting in the ray being completely bent over and returned to earth in a manner analogous to reflexion from a discontinuity.

An explanation of the lack of fading in bad weather and of the pronounced fading in good weather is sought in the fact that, in anticyclonic conditions, temperature inversions and associated sudden changes in relative humidity are usually present at heights of 1–2 miles, whereas in cyclonic or depression conditions these are absent. While the existence and diurnal variations of temperature inversions may be different over land and over sea, the general structure of the atmosphere in an anticyclone is probably the same in the two cases; in particular, changes in water vapour content may obtain over sea, which give rise to refraction in the lowest layers, and thus cause sufficient bending of the direct rays to account for the received signal and its variations. As mentioned above, rapid fading occurred mainly on the wave-length of 5 m. and was usually superposed on flat or steady records and was present only in winter. It is thought that this is probably a shimmering effect due to turbulence in the atmosphere during bad weather. A similar effect had previously been noted by Ross Hull in the United States and was attributed to the same cause.

A more detailed study of the radio phenomena on the above lines has not been possible on account of the limitations imposed by the nature of the meteorological information available at the place and for the period of the wireless observations. In future investigations, this limitation may be at least partly removed, by improved meteorological technique for studying conditions in the lower atmosphere, and by making arrangements for special and close co-operation between those responsible for the wireless and meteorological observations.

FORTHCOMING EVENTS

Monday, January 4—Wednesday, January 6

AGRICULTURAL EDUCATION ASSOCIATION (at the Midland Agricultural College, Sutton Bonington, Loughborough). Conference.

Monday, January 4

SOCIETY OF CHEMICAL INDUSTRY (FOOD GROUP, PLASTICS GROUP AND LONDON SECTION) (in the Royal Institution, Albemarle Street, London, W.1), at 2.30 p.m.—Prof. E. K. Rideal, F.R.S.: "Catalytic Hydrogenation" (Jubilee Memorial Lecture).

Friday, January 8

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. C. C. Pounder: "Some Types of Propelling Machinery available to Shipowners" (Thomas Lowe Gray Lecture).

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Newcastle-upon-Tyne), at 6 p.m.—Mr. C. Le Maistre: "War-Time Standardization".

Saturday, January 9

ASSOCIATION OF SCIENTIFIC WORKERS (in the Lecture Theatre of the London School of Hygiene, Keppel Street, London, W.C.1), at 2.15 p.m.—Conference on Problems connected with the Organisation, Application and Personnel of the Medical Sciences. (Chairman: Dr. D. McClean.)

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN MECHANICAL ENGINEERING—The Principal, Heriot-Watt College, Edinburgh (January 7).

ASSISTANT TO THE ADVISORY OFFICER IN ANIMAL HUSBANDRY—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow (January 8).

WOMAN PSYCHOLOGIST for service at the Child Guidance Clinic—The Chief Education Officer, Education Office, Council House, Margaret Street, Birmingham 3 (January 9).

REGIUS PROFESSOR OF GEOLOGY at Edinburgh University—The Private Secretary, Scottish Office, Fielden House, 10 Great College Street, London, S.W.1 (January 11).

SCIENCE GRADUATE (BOTANY), with experience in abstracting and knowledge of languages desirable—The Deputy Director, Imperial Bureau of Plant Breeding and Genetics, Cambridge (January 16).

RUSSIAN TRANSLATOR to work on literature in Agricultural Botany—The Deputy Director, Imperial Bureau of Plant Breeding and Genetics, Cambridge (January 16).

HONOURS GRADUATE TO TEACH BIOLOGY in the Bede Collegiate Girls' School—The Director of Education, 15 John Street, Sunderland (January 18).

LABORATORY STEWARD for the Veterinary Laboratory—The Veterinary Investigation Officer, University College of North Wales, Bangor (January 18).

THREE JUNIOR ELECTRICAL INSPECTORS OF MINES—The Ministry of Labour and National Service, Central (Technical and Scientific) Register (Section D.521), Sardinia Street, Kingsway, London, W.C.2.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Why India? By Reginald Reynolds. Pp. 28. (London: War Resisters' International.) 6*d*. [2112

Gas Research Board. Communication GRB7a: 33rd Report of the Refractory Materials Joint Committee. Abridged edition. Pp. 8. (London: Gas Research Board.) [2112

Institution of Gas Engineers. Communication No. 249: Report of the Committee of Enquiry on Gas Quality. Pp. 10. Communication No. 250: Report of the Committee of Enquiry on Sulphur Removal. Pp. 10. Communication No. 251: Report of the Committee of Enquiry on Standardization of Appliances, Part 1: Domestic Gas Cookers. Pp. 16. Communication No. 252: Report of the Committee of Enquiry on Coke Quality, Part 1: Sizing of Coke. Pp. 8. Communication No. 253: 3rd Report of the Chairmen's Technical Committee, 1941–42. Pp. 18. Communication No. 254: 19th Report of the Gas Education Committee, 1941–42. Pp. 24. (London: Institution of Gas Engineers.) [2112

Other Countries

U.S. Department of Agriculture. Technical Bulletin No. 828: Further Studies on the Removal of Spray Residues from Eastern-Grown Apples. By M. H. Haller, C. C. Cassil, Edwin Gould and A. L. Schraeder. Pp. 32. (Washington, D.C.: Government Printing Office.) [2112

British Honduras. Abridged Report of the Forest Department for the Year ended 31st December 1941. Pp. 4. (Belize: Forest Department.) [2112

Forest Research Institute, Dehra Dun. Indian Forest Leaflet No. 22: Possible War-Time Sources of Vegetable Rubber in India. By T. V. Dent. Pp. iv+16. 4 annas; 6d. Indian Forest Leaflet No. 26: Rectangular Plywood Containers. Pp. ii+2+1 plate. 4 annas; 6*d*. Indian Forest Leaflet No. 27: Notes on some Aspects of Erosion Control. By Jagdamba Prasad. Pp. v+18. 4 annas; 6*d*. (Dehra Dun: Forest Research Institute.) [2212

University of Bombay: Department of Chemical Technology. Annual Report, 1941–42. Pp. iv+28. (Bombay: The University.) [2212

Smithsonian Miscellaneous Collections. Vol. 103, No. 5: New Upper Cambrian Trilobites. By Charles E. Resser. (Publication 3693.) Pp. iii+136. (Washington, D.C.: Smithsonian Institution.) [2412

Annual Report of the Agricultural Department, Dominica, 1941 Pp. 4. (Roseau: Agricultural Department.) [2412

Catalogues

A Catalogue of Books and Periodicals on Entomology, together with a Selection of Recently Acquired Books on General Natural History. (No. 606.) Pp. 24. (London: Bernard Quaritch, Ltd.)

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