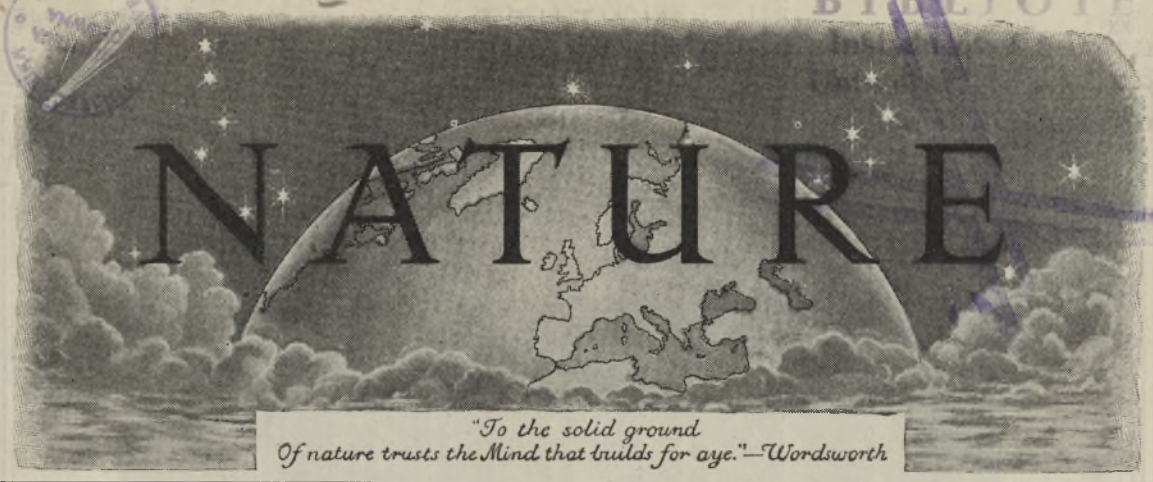

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SCIENCE AND NATIONAL DEFENCE*

IMPORTANT as it is that there should be worked out as speedily as possible an adequate national defence policy embodying all the lessons and experience of the last five years, no such policy can be formulated in isolation. It should be ensured of the support of all political parties in Britain, and it must also be related to the policies of other members of the British Commonwealth and of the United Nations. That much was clearly recognized in the debates in the House of Lords, in Lord Vansittart's plea for a permanent Inter-Allied Committee of Scientists to examine and control the use of any scientific discovery or invention considered dangerous to the safety of mankind, in Lord Strabolgi's proposal for pooling knowledge of scientific discoveries and inventions, in Lord Cherwell's reply, and in Lord Brabazon's plea for an international committee with full powers of investigation anywhere in the world. What is encouraging, however, is the evidence of the extent to which these problems are already occupying the minds of others of the United Nations, and notably in the United States.

The parallel in thought between the report of the Select Committee on National Expenditure and the address of the Hon. Robert P. Patterson, U.S. Under-Secretary for War, on "Science and Industry in National Security" (see *Nature*, **154**, 785 ; 1944) is unmistakable. A recommendation for the establishment within the National Academy of Sciences of a Research Board for National Security has already come from the Committee on Post-War Research, as was stated by the U.S. Secretaries of War and the Navy on February 12, 1945, in which these facts are recognized. Further, Dr. J. B. Conant has lent the weight of his authority to a proposal for the establishment of an international civilian technical inspectorate in which a tradition might be built up anchoring professional loyalties to an association of nations. Dr. Vannebar Bush in his recent report as president of the Carnegie Institution of Washington touches briefly on this same question of defence and its relation to scientific research, and the imperative necessity of continuing attention to the possible military applications of expanding science. Different aspects of the problem are also discussed in an able article, "Science and Foreign Policy", by the American expert, Mr. G. Fielding Elliot, in *Foreign Affairs* of April last, from which Lord Vansittart quoted, and in the study, "The Control of Germany and Japan", by H. G. Moulton and L. Marlio, which the Brookings Institution of Washington published last year.

Mr. Elliot raises the fundamental question whether the discoveries of science must not now become the common property of all for the use of all, and whether we can afford any longer to tolerate private research for military purposes, or commercial processes serving those purposes. The robot-bomb, the rocket and the jet-propelled plane demonstrated the dangers which must be guarded against, and no international organization for world security will be adequate

* *Continued from* p. 31.

which does not possess the ability to deal with such dangers at the source.

Mr. Elliot urges that the foundation of successful partnership in international affairs, as elsewhere, is good faith and mutual confidence; and he suggests therefore that the first step to security is the exchange of full information regarding the armed forces. Already we have seen that modern warfare involves the mobilization of all national resources, and that science has introduced into warfare a succession of new weapons of steadily increasing range, speed and destructiveness. Nevertheless, Mr. Elliot believes—and the trend of Lord Cherwell's speech would seem to indicate his concurrence—that if the results of the labours of all scientific men in the peace-loving States were pooled, the chance of sudden surprise would be greatly reduced, since science in different countries generally advances on parallel lines.

Mr. Elliot does not ignore the difficulties that may have to be overcome in securing the complete and continuous interchange of information on the progress of scientific research among the United Nations. He puts a question mark against the attitude of the U.S.S.R., though here the appointment of Prof. Eric Ashby as scientific attaché at the Australian Legation in Moscow may mark the beginning of some closer contact between that country and the Western nations. The matter is so important that it is all the more unfortunate that the Government should have considered it necessary on any ground to refuse exit permits to British men of science who had accepted invitations to attend the two hundred and twentieth anniversary celebrations of the Soviet Academy of Sciences.

Mr. Elliot points out clearly all that is involved in such interchange—freedom of communication, travel, the Press, radio, and academic and scientific interchange—and if such a policy is the soundest from the point of view of national defence, it is the policy also which is most stimulating to creative thought and fundamental research. Such objectives are widely recognized as claiming the steady support of all scientific workers, but to attain them much more will be required than the maintenance of the machinery for Anglo-American collaboration and exchange of scientific and technical information set up during the War, or even the relaxation of the censorship. Much will depend on the readiness with which the U.S.S.R. abandons her 'Chinese wall', and clear thinking will be required to deal with the problems which arise out of the relation between scientific research prompted by commercial competition and military affairs, patent law and the like. Mr. Elliot notes that we must be prepared to find that the solution may involve much loss of individual freedom and some curtailment of the search for commercial or military advantage.

Only some of the problems that arise in the technical control of Germany and Japan are indicated very briefly by Mr. Elliot. Those problems are closely analysed in a recent book* by Dr. H. G. Moulton and Dr. L. Marlio, who, considering first the lessons of the Treaty of Versailles, suggest that measures for economic control must be based on two guiding principles: first, the economic devices must not be permitted to throttle the economic life of the country on which they are imposed; and secondly, the measures selected must be administratively feasible and relatively easy to enforce. On these grounds they regard, for example, the complete destruction of the chemical industry of Germany as impracticable; the only strategically key industry which holds sufficient possibilities of effective control to merit favourable consideration is the electric-power industry.

Drs. Moulton and Marlio reject the idea of permanent military occupation as well as of economic controls, and propose that reliance should be placed upon a system of detection and coercion by punitive measures if infringements are discovered. For this purpose they propose the creation of a Rearmament Detection and Prevention Board comprised chiefly of military officials, and in the nature of an extension of the war-time Combined Staff Organization. The Board would be the executive agency for the general policies and procedures regarding military controls determined by the governments at its establishment, but it should possess the power of independent action within the field so defined. It should be empowered to maintain within key industrial areas sufficient supervisors to detect evasions of the disarmament provisions, to direct the attention of the German or Japanese Government to any evasions discovered and to apply the necessary coercive measures if such warning is not promptly heeded.

There may be some grounds for doubt as to whether we can wisely rely on a system of detection and coercion alone; Drs. Moulton and Marlio are not altogether convincing in their demonstration of the impracticability of economic control, and their two principles can be stretched too far; but that some measure of inspection must be worked out and systematically applied is scarcely open to challenge. Any such system will almost certainly function more effectively when the free interchange of scientific and technical information and exchange of personnel is carefully fostered; and for this reason the development of the British Central Scientific Office in Washington, the American Scientific Office in London, the Anglo-Soviet Science Collaboration Committee and the Scientific Co-operation Office of the British Council in China into something of an international science co-operation service, as suggested by Dr. J. Needham (*Nature*, **154**, 657; 1944), may be a measure of the first importance from the point of view of defence.

It is for men of science to stress the importance of this aspect of the matter at the present time. Mr. Lyttleton, in the House of Commons on June 13, admitted that the free flow of scientific information in an industry is absolutely necessary. The free flow of scientific and technical data in a nation and between nations is equally essential to world security, and to encourage, as Sir Arrol Moir suggested in the *Engineer* of June 2, the fullest possible inventiveness in time of peace.

Rapid progress in this matter, as Mr. Elliot observes, can scarcely be expected, but scientific

* The Control of Germany and Japan. By Harold G. Moulton and Louis Marlio. Pp. xi+116. (Washington, D.C.: Brookings Institution; London: Faber and Faber, Ltd., 1944.) 10*s*. net.

workers should miss no opportunity of educating both public opinion and Government as to its importance. A system of scientific attachés could do much to stimulate the free flow and interchange of information and of men and women, and to avoid incidents like that in connexion with the Soviet Academy of Sciences, which tend to jeopardize good relations. But while endeavouring to secure a wider understanding of the contribution of science to national defence and the conditions in which that contribution can be made most effectively, they should lend the full weight of their influence as citizens to secure urgent attention to the formulation of defence policy on lines above the turmoil of party politics, and to stimulate the clear thinking required. They could help in emphasizing certain principles which an adequate defence policy must embody : the retention of an adequate Combined Staffs Organization, not only of the different armed services but at least between Britain, the United States and the U.S.S.R. ; the determination of the peace strength of the armed forces in accordance with the possible rate of development of full war potential, the strength of the other principal Powers and our geographical strength, and in appropriate relation with our foreign policy, so that strength which can only be changed very slowly is in accord with policy, so far as that can be set by looking well ahead.

These are some of the principles emerging from the experience of the last twenty-five years ; and the Select Committee's recent report provides scientific workers with admirable material for their task of education. That there should be so much evidence on both sides of the Atlantic that the same conclusions are being reached provides ground for the hope that there will this time be thrashed out a national policy for defence which is in harmony with our commitments and our foreign policy, in which the various elements are in balance one with another and appropriate use is made of all the nation's resources of materials, man-power and intellect. No defence policy, no system for the control of Germany or Japan, will be effective which does not provide for attracting men of the highest ability into the armed services and the scientific and technical services of the United Nations, for the adequate prosecution of research and encouragement of inventive ability, and for the fullest and widest possible dissemination of scientific and technical information. Closer co-ordination is essential between the departments and other agencies or institutions within Great Britain and with such organizations as the National Academy of Sciences, the National Research Council, and the Office of Scientific Research and Development in the United States, possibly through a Central Scientific and Technical Board as suggested at the recent Conference of the Association of Scientific Workers. The free exchange of knowledge across national boundaries, upon which creative thought has always largely depended, and which now may well provide one of the strongest safeguards against those dangers of which the robot-plane and the long-range rocket have given so dire a warning, is still one of the fundamentals of a free society.

CHEMICAL ANALYSIS AND STRUCTURAL DIAGNOSIS BY INFRA-RED ABSORPTION

Infrared Spectroscopy

Industrial Applications and Bibliography. By R. Bowling Barnes, Robert C. Gore, Urner Liddel and Van Zandt Williams. Pp. vi+236. (New York : Reinhold Publishing Corporation, 1944.) 2.25 dollars.

THAT modern wars lead to scientific development is a commonplace more vividly borne out in the present War than in any other. Now that the silences may be broken, applications of physical techniques become evident which may be equally important in times of peace. Infra-red spectroscopy has been transformed during recent years from a delicate and exacting technique into a more easily controllable robust tool, which will be of great value in the future for both pure and applied science. Some indications of this have been shown by discussions such as that recently organized by the Faraday Society.

The limitations of secrecy imposed in different lands have varied, and still delay publication of many developments. Dr. Barnes and his colleagues, well known for their past work in the infra-red, and now members of the research laboratory of a leading industrial firm in America, have given us one of the first manuals for workers in this field, and particularly for those who will use infra-red absorption as an analytical technique. The first part of their book is a reprint of a lengthy paper published recently in *Industrial and Engineering Chemistry*, in which the theoretical and experimental principles of infra-red measurements were described, and a range of the spectrum of each of a very large number of molecules was shown graphically for purposes of reference. To this the authors have now added a detailed and excellent bibliography of the subject, which should be valuable to specialists and non-specialists alike.

Infra-red absorption can be applied to the qualitative and quantitative analysis of mixtures of substances, but it can also be used for diagnostic purposes as well. The vibration frequencies of a molecule, which correspond with absorption bands in the near infra-red, are determined in magnitude by the masses of the atomic nuclei and the forces between them, that is, the strengths of the bonds. It follows that molecules with different nuclear configurations will have a different set of vibrational modes, and since all molecules other than a pair of optical enantiomorphs differ in nuclear configuration, the infra-red spectrum can be regarded as a fingerprint of the molecule. Indeed, it is probable that this vibrational spectrum is the most characteristic physical property of a molecule yet measured. In order to analyse a mixture of substances it will simply be necessary to know the spectra of the pure components present. Unless special interactions occur, the spectrum of the mixture is got by simply superposing those of the individual components with the appropriate intensities, and the key bands can therefore be used for either qualitative or quantitative estimation of the individual components.

In spite of this individualistic character of the infra-red spectrum, some linkages or small nuclear skeletons give rise to vibrational frequencies which are not much affected by the remainder of the molecule. In some cases the reason for this is obvious.

Thus, with bonds such as C—H, O—H, or N—H, the light hydrogen atom oscillates against a much heavier residue, the mass of which has little effect on the oscillation frequency. Each of these linkages therefore retains a roughly constant vibration frequency when present in different molecules. The same applies, even if to a less degree, to some other linkages such as the carbon-carbon double bond or the carbonyl group, and a measurement of how much these frequencies deviate from 'normal' values may give a clue to the nature of the rest of the molecule. In some cases, a roughly constant set of frequencies can be associated with a given set of atoms arranged in a definite manner. These are the bases of structural diagnosis.

The authors of this book have explained these principles clearly and in a way which will appeal to those who are wishing to apply a new method of which they have only fragmentary knowledge. They have described an instrument suitable for most industrial work, with the relevant accessories, and have discussed critically the various difficulties which have to be overcome in obtaining accurate results. They have given examples of analyses of different kinds in which either the standard absorption laws can be used, or in which empirical calibration charts have to be set up because of the breakdown of these absorption laws as a result of intermolecular interactions. By means of typical examples they have also considered carefully the magnitude of errors likely to arise in practice.

All these features make the book an admirable introduction to the subject. At the same time there are several points to which the attention of the inexperienced reader should be directed. For example, although the spectrometer described is a good one, marked recent improvements in both thermocouples and recording systems not referred to in this book should perhaps now be taken into account. One of the disadvantages of a single-beam automatic recorder is the fact that absorption bands usually have to be measured against the background energy of the emitter in air. This background of energy will in any event fall in moving towards longer wave-lengths, but in addition the absorption by atmospheric water vapour and carbon dioxide gives rise to a very irregular background over some spectral regions, and in these regions the quantitative measurement of the absorption by a substance is very difficult. The difficulty can be avoided by using vacuum spectrometers, or minimized by the copious use of drying agents, but neither procedure has proved very satisfactory. The most recent way of obviating the trouble is to use a spectrometer in which two equivalent beams of radiation traverse the instrument, one being used as a blank and the absorbing material being placed in the other. After emerging from the spectrometer, each of the beams is directed on to a sensitive thermocouple. The electromotive forces produced are then amplified separately by D.C. amplifiers and finally fed into a potentiometric recorder having a high speed of response, and so devised that a continuous record is obtained directly of the percentage absorption. Several other types of recording device have been tried recently and it may yet be early to decide which is the most serviceable for all purposes, but there seems little doubt that as regards spectrometers the double-beam system has established itself.

The spectral curves shown in this book suffer from the disadvantage that most of them do not extend to wave-lengths beyond 10 μ, or 1000 wave numbers, whereas it is outside this range, namely, between 1000–500 wave numbers, that many of the most useful key bands for analytical work are to be found. Also it might be inferred from the limited range shown of the spectra of some of the simpler hydrocarbons that suitable key bands for these compounds are hard to find, whereas a more extended study of their spectra leads to the reverse conclusion. In the same way experience has shown that a study of the range of lower frequencies leads to valuable structural correlations.

The authors have wisely directed attention to the fact that curves such as they have shown must not be used directly by other laboratories for quantitative work depending on intensities, since instrumental factors such as resolving power, or impure spectra due to scattering of radiation will lead to inapplicability. It is difficult at present to see how this general difficulty may be overcome, since it implies that each laboratory must have pure compounds for calibration work. In some cases high purity may not be essential, but in others it has been found that very small amounts of contaminants are easily detected in the infra-red spectrum. Indeed, some of the curves shown in this book appear to relate to compounds of doubtful purity; for example, the curve given for polyvinyl alcohol shows bands at about 1740 and 1260 wave numbers which are almost certainly due to a small amount of residual polyvinyl acetate from which the sample may have been obtained by hydrolysis.

These shortcomings do not, however, destroy the great value of this book as a convenient working manual, and it will certainly become widely known and used, together with others which may soon be published, by all those concerned with experimental work in this field. H. W. THOMPSON.

SYMPOSIUM ON INDIA

Essays in Anthropology

Presented to Rai Bahadur Sarat Chandra Roy. Edited by J. P. Mills, B. S. Guha, K. P. Chattopadhayay, D. N. Majumdar and A. Aiyappan. (Published for the S. C. Roy Commemoration Committee of the Indian Science Congress Association.) Pp. viii+268. (Lucknow: Maxwell Co., n.d.) 12 rupees.

"ESSAYS in Anthropology Presented to Rai Bahadur Sarat Chandra Roy" was published in India in 1942, but one of the limitations imposed by war conditions has been the unconscionable delay and irregularity with which books from India have reached Great Britain, if at all. In this case, Roy's *Festschrift* did leave the press in time for him to read it shortly before he died in April of that year, and it must have given him much gratification, for he must have appreciated the general high level which these essays as a whole maintain, and to which his own work indirectly had done much to contribute.

There are twenty-one essays in all; of these, about a third of them by Europeans, the remainder by Roy's fellow countrymen. Both the physical and sociological sides of anthropology are represented, but the latter greatly predominate, physical anthropology being limited to three papers: Dr. Eileen Macfarlane, writing on "The New Systematics and Anthropology", sums up the present position in regard to the classification of human racial units—a very lucid and useful exposition. Drs. R. Krishna

Rau and A. Ananthanarayana Ayer contribute a study at length of South Indian brains, and G. M. Kurulkar studies briefly "The Abdominal Bulge in Health (Males)".

Turning to the non-physical contributions we find a useful essay on "Basic Concepts in Anthropology" by Mandelbaum which has been evoked in part by correspondence resulting from the broadcasting of lectures in anthropology direct from a Minnesota classroom. Clearly the study of anthropology is more popular, or better boosted, in the United States than in Great Britain. Aiyappan writes well on "Theories of Culture Change and Culture Contact", as does Prof. Chattopadhyay on "Conflict and Social Behaviour", though the latter's psychological explanation of why the inhabitants of Bengal accepted Islam more readily than those of the Agra and Oudh only really amounts to the fact that the latter had been Hinduized for a longer time.

One of the best essays in the volume is Mrs. Karve's "Some Studies in the making of a Culture Pattern". She examines the conflict between patrilineal and patrilocal institutions on one hand and matrilocal institutions on the other, and discusses the cross-cousin marriage in Maharastra, and the maternal uncle-niece marriage found farther south. She comes to the conclusion that patriliny is an indigenous institution derived from a primitive hunting-gathering complex; and although one may find difficulty in accepting the theory that it was not an Indogermanic import, one cannot but endorse wholeheartedly her criticism of "the unsoundness of a policy which would impose the same code on the whole of India completely disregarding the cultural and historical antecedents of different provinces and different castes".

All the essays, of course, are not of the same high level. Radhakumud Mookerjee's attempt to show that the Rig-Veda is not later in time than the Indus civilization of 3000 B.C. fails to convince. He argues that the Hittite deities with names analogous to those of India, Mitra and Varuna, must have been carried to Mesopotamia from India, ignoring the more likely hypothesis of a distribution from some common centre in Iran or near the Caspian. He seems to think, moreover, that the Sumerians and "Dravidians" belonged to a common physical type; but whereas the Sumerians, so far as our evidence goes, seem to have been brachycephalic, Dravidian-speaking India is on the whole emphatically dolichocephalic, and his statement that the Rig-Veda "is the earliest text not merely of India but of the world" does not help one to accept his conclusions without reserve.

W. J. Culshaw writes of "The 'Folk Consciousness' of the Santals", and W. G. Archer of "The Women's Hunt", a periodic phenomenon of Oraon culture which impresses itself on neighbouring tribes as a sort of "cross between a pantomime and a carnival". J. P. Mills deals with "Some Recent Contact Problems in the Khasi Hills", making the problems clear enough but not offering a solution; C. Fürer von Haimendorf writes of "Religion and Ethics among the Konyak Nagas and other Indian Tribes" and in doing so qualifies the conclusions he came to in "Custom is King"; and Elwin writes, informatively again, on "Primitive Ideas of Menstruation and the Climacteric in the East Central Provinces of India". P. G. Shah in "Non-Hindu Elements in the Culture of the Bhils of Gujarat" makes a useful and important contribution to the study of that tribe, the documentation of which has been neglected to an extent out of all proportion to its importance.

The remaining essays—though one seeks in vain, alas, for one by Dr. B. S. Guha—include one on "Bongaism" by D. N. Majumdar, a joint editor who contributes also an introduction giving an account of Sarat Chandra Roy, whose portrait serves as a frontispiece, but is not well reproduced. The volume has an index and is commendably free from misprints. "Essays in Anthropology" is probably the first anthropological *Festschrift* to appear in India. If subsequent ones keep up to the standard set by it they will do well enough. J. H. HUTTON.

FUNCTIONS OF A COMPLEX VARIABLE

Vorlesungen über allgemeine Funktionentheorie und elliptische Funktionen

Von Prof. Adolf Hurwitz. Herausgegeben und ergänzt durch einen Abschnitt über Geometrische Funktionen, von Prof. R. Courant. Dritte, vermehrte und verbesserte Auflage. (Published and distributed in the Public Interest with the consent of the Alien Property Custodian.) Photo-lithoprint Reproduction, 1929. Pp. xii+534. (New York: Interscience Publishers, Inc., 1944.) 7.50 dollars.

PERHAPS one of the most regrettable consequences of the War, from a purely academic point of view, has been the inevitable loss of touch with current developments in Europe and the accompanying inaccessibility of standard Continental literature. The appearance of a photo-lithoprint reproduction, from the United States, of one of the classical treatises on function theory, which in pre-war years was rightly regarded as an indispensable possession of the pure mathematician, is thus an event of paramount interest and importance.

This volume, in German, containing among its pages all the fundamental theorems and the results of the classical theory of functions of a complex variable, is so well written as to be almost impervious to any sort of criticism, however fastidious.

It is a third and enlarged edition of the original produced by the authors in 1922 and is divided into three principal sections, of which the first two are mainly ascribable to Hurwitz and the last to Courant.

The first section consists of a development from 'first principles' of the Weierstrassian treatment of the theory, the fundamental idea being the complex power-series and its analytic continuations, from which Cauchy's theorem and its corollaries are ultimately derived. A certain amount of special function theory is also included, with particular reference to integral and meromorphic functions.

The second section, on elliptic functions, gives an account of the elementary properties of doubly-periodic functions, proceeding by way of the Weierstrassian functions and theta functions to those of Jacobi and the elliptic modular function and finally to a discussion of elliptic integrals and their transformations.

The last half of the book, comprising the third section, is entitled "Geometrical Function Theory" and deals very comprehensively with a large variety of topics, including Riemann surfaces, Picard's theorem, conformal representation, Dirichlet's principle, Green's functions and the fundamental theorem of Riemann.

J. H. PEARCE.

ELECTRON SHADOW-MICROGRAPHS OF HÆMOCYANIN MOLECULES

By Prof. ROBLEY C. WILLIAMS
AND
Dr. RALPH W. G. WYCKOFF
Department of Physics and the Virus Laboratory, Department of Epidemiology, School of Public Heath, University of Michigan

ELECTRON micrographs of bacteria[1] and of virus particles[2] covered with an obliquely deposited metallic film have a three-dimensional appearance that brings out clearly the shapes of these objects. The visibility of small objects appearing in these preparations has been so greatly enhanced by the shadowing technique[3] that we have been led to apply it to the photography of the elementary particles, or molecules, of a number of proteins and high polymeric substances. The present communication describes such experiments carried out on a hæmocyanin.

Purified hæmocyanin was prepared by quantity ultracentrifugation from the 'blood' of the horse-shoe crab, *Limulus polyphemus*, which has already been photographed with the electron microscope[4]. This 'blood' was first cleared by centrifugation for an hour in a field of *c.* 5,000 times gravity, all sedimented material being discarded. The resulting clear blue solution was then ultracentrifuged for four hours in a field of slightly more than 100,000 times gravity to sediment much of its hæmocyanin. This produced pellets consisting of a very firm colourless core overlaid by a blue transparent jelly which dispersed readily in distilled water and was taken as crude hæmocyanin. The solution of the jelly, after a second hour of clearing at low speed, was ultracentrifuged again at 100,000 times gravity to yield homogeneous bluish pellets. Their dispersion in distilled water provided the purified hæmocyanin used for electron microscopy.

In a first series of experiments, serial dilutions of this hæmocyanin in distilled water were placed, as micro-drops, on the surface of collodion-covered metal screens prepared in the usual fashion for examination in the electron microscope. After standing for a minute on the screens, as much as possible of each droplet was withdrawn and the rest allowed to dry. These dried preparations were placed in a vacuum chamber designed for the evaporation of metallic films, and covered with an obliquely deposited film of metallic chromium having a computed thickness of *c.* 70 A. The angle of deposition used in studying hæmocyanin was always such as to make the lengths of shadows ten times the heights of the objects casting them.

Fig. 1 was obtained by photography with an RCA type EMB microscope of an appropriately dilute solution of hæmocyanin prepared in this way. The film of hæmocyanin, which was continuous at greater concentrations, here has begun to break up into its spherical components and to leave empty spaces or holes such as that near the centre of the figure. As the shadows within this hole indicate, metal was evaporated downwards from the top of the picture. At still greater dilutions such areas of unoccupied collodion, which can be recognized by their characteristic pebbly structure of very fine grain and by

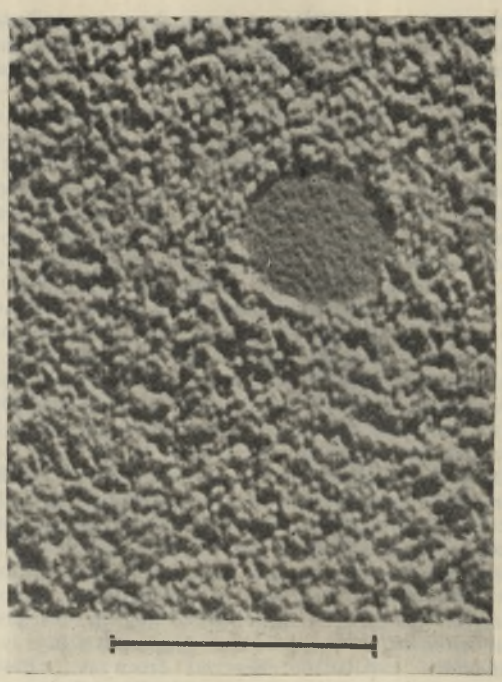

Fig. 1. An electron micrograph of a dilute solution of *Limulus* hæmocyanin shadowed by the oblique deposition of *c.* 70 A. of metallic chromium.

the shadows cast on them by the surrounding hæmocyanin, increase in size and number, and the hæmocyanin film itself becomes more fragmented, breaks up into islands and ultimately separates into its component particles distributed singly and in small aggregates.

(Figs. 1, 2 and 3 are negatives; hence regions which appear dark are relatively transparent to electrons. They have each been prepared from the original plates by making an intermediate contact positive on medium lantern-slide emulsion and printing from this on to # 3 Bromide paper. The line at the bottom of each figure represents one micron on the photograph.)

The particles of hæmocyanin are so small that their shapes and dimensions as recorded in such pictures as Fig. 1 must of necessity be considerably altered by the thickness of chromium deposited on their 'illuminated' sides when the angle of shadowing is as great as 10 : 1. In order to give them a truer representation, we have carried out a second set of experiments using gold rather than chromium as the shadowing metal. Gold will deposit as a continuous film when very thin, and because of its great scattering power for electrons will cast adequate shadows in a calculated thickness of only 5–10 A. Fig. 2 is a photograph of a dilute hæmocyanin solution after shadowing with *c.* 8 A. of gold. The hæmocyanin molecules, singly and in small clusters, are clearly evident upon their collodion support.

Though there is no danger of confusing these hæmocyanin molecules with the details of the pebbly collodion background, it is evident that with other smaller macromolecules such a confusion will occur long before one reaches the lower limit of particle size that can be photographed in shadowed preparations. Polished glass has a surface that appears much smoother than collodion, and we have shown[5] that a replica technique can be used to reproduce for

electron micrography both the texture of the glass surface and the size and shape of tobacco mosaic virus protein fibrils deposited on it. A third series of experiments has been made to see whether or not particles as small as the hæmocyanin molecules could be investigated successfully with the help of such replicas.

To make these replicas, small drops of dilute hæmocyanin solutions were allowed to dry directly on the cleaned surface of a microscope slide, which was then placed in the vacuum chamber and covered with 6–8 A. of obliquely deposited gold. The areas for study were coated immediately after removal from the chamber with a thin layer (*c.* 500 A.) of collodion. As soon as dry, this collodion and its adhering gold were stripped from the glass and prepared for electron microscopy according to the usual procedures[6] developed for handling metallographic replicas. Because of the great scattering power of the gold compared with organic materials, the replica shows the presence of very small particles regardless of whether or not they are removed from the glass along with the stripped metallic film.

A photograph of such a replica is reproduced as Fig. 3. Comparison between it and Fig. 2 demonstrates that the replica is as successful in showing particles the size of the hæmocyanin molecules as it has been in delineating the tobacco mosaic fibrils. The hæmocyanin molecules appearing in the two figures do not have measurably different sizes and shapes. The background of the replica is more uniform because of the smoothness of the glass surface, and because the fine structure of the unshadowed collodion cannot be seen. Such results suggest that particles much smaller than the molecules of hæmocyanin can be recorded through the use of this replica technique.

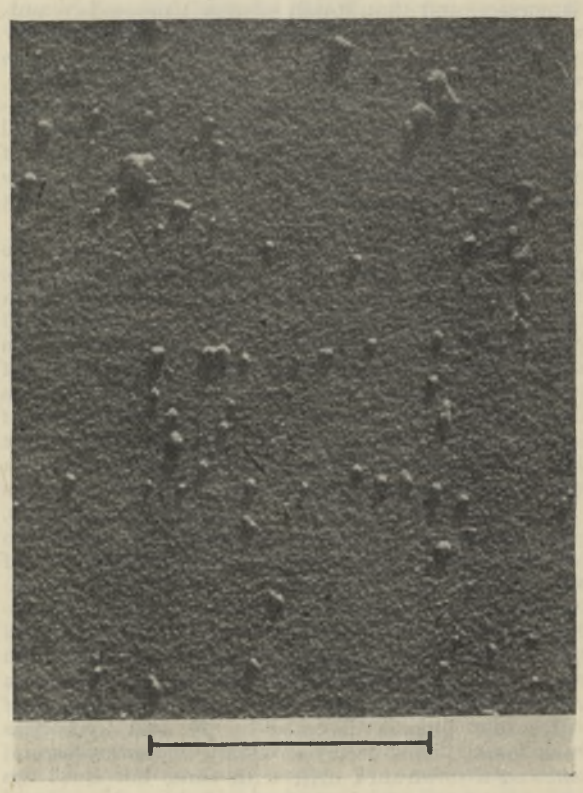

Fig. 2. A MICROGRAPH OF A MORE DILUTE HÆMOCYANIN SOLUTION SHADOWED BY THE OBLIQUE DEPOSITION OF 6–8 A. OF GOLD. RELATIVELY FEW HÆMOCYANIN PARTICLES, MOSTLY IN SMALL CLUSTERS, ARE DISTRIBUTED OVER THE PEBBLY COLLODION SUBSTRATE.

Fig. 3. A MICROGRAPH OF A GOLD REPLICA OF HÆMOCYANIN PARTICLES ON A POLISHED GLASS SUBSTRATE. A PORTION OF A LARGE HÆMOCYANIN CLUMP CAN BE SEEN AT THE TOP RIGHT-HAND CORNER. THE PARTICLES, AS WELL DEFINED AS IN FIG. 2, STAND OUT MORE CLEARLY ON THE SMOOTHER BACKGROUND.

The sizes of the individual particles of Figs. 2 and 3 have been compared with estimates of molecular size derived from rates of sedimentation in the analytical ultracentrifuge. The hæmocyanin from *Limulus* is not so satisfactory for this purpose as some other hæmocyanins would have been, had they been available, because its sedimentation diagram[7] shows evidence of four different particle sizes with sedimentation constants of 57, 35, 16 and 6 *s* units. Spherical molecules of proteins sedimenting at these rates may be expected to have diameters between something less than 100 A. and about 20 A. Diameters have been determined on four hundred particles in one photograph, care being taken to measure only those showing no evidence of clustering. These measurements of diameter were made at right angles to the direction of shadowing, since the size of particles should be little affected in this direction by the deposition of metal. When plotted they give an almost symmetrical Gaussian distribution curve that has its maximum at 165 A. and a width of 80 A. at half-height. Measurements on the unshadowed photographs[4] had led to a particle diameter of *c.* 200 A. We are not now in a position to discuss in detail either this lack of evidence of molecules corresponding to multiple sedimentation boundaries or the large spread in particle-size about its mean value. It seems probable that a factor in causing such a spread is shrinkage suffered during desiccation by these particles which, like most other

protein molecules, are strongly hydrated in solution. In this connexion it will be noted that shadow lengths are in general less than ten times the particle-diameters, and that there is consequently a very considerable flattening of the particles considered as spheres.

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[1] Williams, R. C., and Wyckoff, R. W. G., *Proc. Exp. Biol. Med.*, in the press.
[2] Williams, R. C., and Wyckoff, R. W. G., *Proc. Exp. Biol. Med.*, **58**, 265 (1945).
[3] Williams, R. C., and Wyckoff, R. W. G., *J. Appl. Phys.*, **15**, 712 (1944).
[4] Stanley, W. M., and Anderson, T. F., *J. Biol. Chem.*, **146**, 25 (1942).
[5] Williams, R. C., and Wyckoff, R. W. G., *Science*, in the press.
[6] See, for example, Schaefer, V. J., and Harker, D., *J. Appl. Phys.*, **13**, 427 (1942).
[7] Eriksson-Quensel, I-B., and Svedberg, T., *Biol. Bull.*, **71**, 498 (1936).

SOME FACTORS CONCERNED IN THE PROCESS OF STARCH STORAGE IN THE BARLEY GRAIN

By H. K. ARCHBOLD

Research Institute of Plant Physiology, Imperial College of Science, London

CARBOHYDRATE synthesis in the barley plant displays two distinct phases, associated respectively with vegetative development and the succeeding period of ear development. The first phase is characterized by the irreversible synthesis of polysaccharides of the cellulose type based on C_6 and C_5 sugar and uronic acid units, which compounds account for 75 per cent of the carbon assimilated before the ear shoots. Starch appears only rarely, locally and in small amounts. The second phase is concerned almost exclusively with starch synthesis, and this substance, accumulated solely in the grain, may constitute 30 per cent of the total dry weight attained and more than half the dry matter of the ear.

The early view that sugar arising from the photosynthetic activity of the leaves was translocated up to the ear and there condensed to starch was superseded early in the present century by the notion that reserve materials were stored, mainly in the stem, during the vegetative stage of growth, and after the ear had shot formed its principal source of carbon. In 1920 Beaven[1] expressed the position as follows: "Some time before the grain is ripe the plant ceases to gain solid matter. Its last effort is to transfer its accumulated reserves into the grain, but all or nearly all the dry matter of the ear is first stored up by the leaves or stems of the plant. . . . It is mainly on the extent to which this uplift takes place that plenty or scarcity of the food of man depends."

The basis of this view was the recognition of the fact, pointed out by Dehérain and Dupont[2] in 1901, that during the period of active starch synthesis, the leaves of cereals were senescent and so unlikely to be capable of producing the requisite sugar by photosynthesis; but it overlooked their suggestion of an alternative assimilating surface together with their demonstration of the assimilating power of the stems. From this conception of migration as a distinct and important physiological process, Beaven termed the ratio of grain to total tops the 'migration ratio' and selected high-yielding varieties on this basis in the belief that high ratios implied efficient migration. Afterwards Engledow and Wadham[3], from thorough studies of the yielding power of cereals, concluded that only the 'migration ratio' appeared to hold any promise as an index of yielding power. There were at that time no adequate chemical data to lend quantitative support to this quite unequivocal hypothesis, but by 1924 Colin[4] and Belval[5] showed that sugar concentration in the cereal stem, chiefly sucrose and fructosan, increased to quite high levels prior to flowering, and afterwards declined as the grain filled. These results were considered not only to support the migration theory but also to specify the principal migratory substances as the sugars of the stem; at the same time the notion was stressed that the upward movement was in some way initiated by the demands of the developing ear.

In the last decade two lines of work have led to a reconsideration of the position. Seasonal changes in dry weight of barley and wheat were studied concomitantly with sugar changes by Archbold[6] and Barnell[7,8]. Both groups of data suggested that the amount of sugar stored in the stems was insufficient as almost the sole source of carbohydrate for the ear. In the meantime, Boonstra[9] and Smith[10] had shown, by experiments with shaded wheat ears, that the ear itself is an important assimilating organ, an observation later extended to barley by Watson and Norman[11]. These experiments, besides establishing the assimilating function of the ear, weaken the simple assumption that increase in dry weight of the ear accompanying loss in weight of the stem necessarily denotes upward migration of previously stored material. It now seems likely that the earlier view is correct, and that starch synthesis proceeds simultaneously with the formation of its precursor by photosynthesis, storage of reserves during the vegetative stage of growth playing no essential part. Assimilation for this purpose is not, however, confined to the leaves, but is carried on in turn by all the green surfaces of the plant. A short account of the considerable body of evidence which has now accumulated supporting this view forms the subject of this article.

The first aim of the studies was to establish the part played in the nutrition of the ear by the immediate translocation of newly assimilated carbon and by the upward movement of temporarily stored products, including among the latter nitrogenous compounds. Analysis of some forty-eight samples of plants grown under a variety of manurial treatments established that there were no unidentified sources of possible migratory substances. The whole dry weight of leaves and stems was accounted for in the common groups, sugars, organic acids, proteins, cellulose polysaccharides and so on. Apart from the sugars, the organic acids formed the largest single fraction of the water-soluble material, and although not of importance in the present connexion there is no reason to suppose they are without metabolic significance; indeed, striking responses to manurial deficiencies have been established. A special search was made for sugar combined in forms other than those usually estimated, but only a small amount of 'glycoside' glucose liberated by N acid hydrolysis was found. This occurred mainly in the leaves and showed a downward drift with time, but since the maximum amount present was of the order only of 1 per cent of the dry weight of the mature ear, it can be dismissed as a possible reserve substance. Throughout a long series of experiments no evidence of

significant loss of constituents of the water-soluble fraction of the dry weight other than sugar has been found; if anything, this group tends to increase a little in the stems rather than decrease as the ear develops. The whole relevant change in dry weight of the vegetative organs is therefore accounted for in terms of the losses of sugar and of the fraction insoluble in water and alcohol, namely, proteins and polysaccharides.

Having delimited the possible sources of supply for the ear to sugars, and to 'cellulose' and protein, it was possible to examine the total dry-weight changes by simply weighing the alcohol/water-insoluble fraction and estimating sugar in the extracting fluids. Proceeding along these lines, it was found by Archbold and Mukerjee[12] that at no time did the roots provide material for upward translocation. Root sugars were always extremely low (maximum 1 per cent of total plant sugar) and there was no evidence of polysaccharide breakdown in these organs. The roots may thus be safely disregarded. Major changes during ear development were therefore confined to the stems and leaves, and in these organs to the cellulose/protein fraction and the soluble sugars, both of which declined continuously from maxima reached at about the time of ear emergence. These losses, measured in four seasons, were equivalent to 8–18 per cent of the dry weight of the mature ear for sugars, and 1–10 per cent for the cellulose/protein groups, with averages of 12·5 per cent and 5 per cent respectively. Part of this latter loss will represent transferred nitrogen, and so is a maximum estimate of possible polysaccharide loss. If it be assumed that the whole of this loss from leaves and stems represents material moved into the ear, the maximum amount which can be supplied in this way is about 20 per cent, leaving at least 80 per cent to be supplied by assimilation proceeding simultaneously with ear growth. It must be concluded that the conception of migration as a distinct and important process initiated by the shooting of the ear is not well founded and that the ear differs in no essential way from the internodes of the stem as regards its development. Primary assimilate from the subtending leaf provides the carbon for the growth of each internode, any excess appearing as sugar; similarly the ear depends largely upon leaf assimilate for its early growth, but later stores the products of its own photosynthetic activity as starch. In spite, therefore, of the high concentrations of sugar reached in the barley stem (5–14 per cent according to nutritional conditions) the absolute amounts are not large relative to total ear weight, and the indications of the earlier experiments are borne out, that the stored sugar is at best only of secondary importance as a source of supply to the ear.

In order to investigate further the factors controlling sugar movement, a second series of experiments (Archbold[13], and Archbold and Datta[14]) was carried out, in which carbohydrate shortage was artificially induced in an attempt to divert to the ear both carbohydrates immediately formed by assimilation and those stored in the stem. For this purpose the three main centres of assimilation, namely, leaves, stems and ears, were in turn put out of action either by removal (leaves) or by shading of the organ (stems and ears). The treatments were carried out on one or more occasions during the four weeks prior to ear emergence, the period of rapid sugar accumulation in the stems, and again at about the time of completion of stem growth, contemporarily with the maximum stem sugar level. Defoliation three weeks or more before ear emergence was followed by an immediate fall in stem sugar, but after about seven days the level rose again slowly to a very much reduced maximum coincident in time with the maximum in control plants. Later defoliation resulted in a continuous fall in stem sugar; this treatment therefore prevents or much restricts accumulation of sugar in the stems, and at the same time stem growth, as measured by increase in the cellulose/protein fraction, is also restricted. Ears nevertheless continued to develop, attaining a final dry weight ranging, in several experiments spread over three seasons, from 0 to 25 per cent less than that of normal plants. Shading the stem two to four weeks before ear emergence resulted in a temporary check in stem sugar accumulation, which was afterwards resumed at the normal rate; stem growth was again restricted and the dry weight of the ear reduced by amounts up to 20 per cent, largely due to a reduced number of grains. Finally, early shading of the ear reduced only slightly the level of sugar in the stems and exerted negligible effects on its growth, while the dry weight of the ear was reduced by 30 per cent. Composition of the leaves was unaffected by either of the shading treatments, so that leaf sugar was not depleted to meet carbohydrate deficiency elsewhere, and accordingly it may be assumed that in these circumstances leaves continue to export the normal amount of sugars, and furthermore, that the leaves are the main source of the sugar normally accumulating in the stems. The time sequence of sugar change remained unaltered, so that the main effect of the checks on sugar accumulation in the stem was to lower the maximum attained; the reduction was large after defoliation, but only small after shading of stems or ears. In the subsequent phase of falling stem sugar the relative rates of sugar loss were either unaltered or slightly lowered in the treated plants, and approximately zero levels were always reached at the same time as in control plants. Depletion of the stem sugar was not therefore accelerated by the induced carbohydrate shortage, the rate of loss being apparently chiefly dependent upon the maxima reached and so upon sugar concentration. This conclusion is supported by the behaviour of earless tillers. If ears are removed during the phase of rising sugar content in the stem, additional accumulation occurs and concentrations up to 18 per cent may be reached. The maximum again coincides in time with that of control plants, and later sugar is lost at rates even greater than that in normal tillers, although no ear is present.

When defoliation and shading treatments were delayed until stem sugar had reached its maximum value, ears had emerged and attained about 40–50 per cent of the final dry-weight and, moreover, active starch synthesis was now in progress. At this stage treatments were without effect on the rate of sugar loss, nor was there any induced breakdown of polysaccharide to supply the ear, while only shading of the ear had large effects upon the ear itself. The reduction in ear dry-weight due to this late defoliation ranged only from 0 to 9 per cent, and due to stem shading was of the order of 5 per cent. The effect of ear shading, however, remained of the order of 30 per cent, equivalent to at least half the total amount of starch, from which it seems that after ear emergence the ear may be altogether autonomous in respect of starch synthesis.

Taken together, this group of experiments indicates

that only very limited diversion to the ear of sugar newly assimilated in the leaves is possible, as represented by the slightly reduced maxima attained in the stems after early shading of stems or ears; there is no evidence of diversion of previously stored sugar, or of induced polysaccharide breakdown in response to the carbohydrate shortage supposedly arising as a result of treatment. The sugar accumulating in the stems is shown by the defoliation and stem shading experiments to originate in the leaves; but the presence of excess sugar is not in itself sufficient to ensure continued growth, since accumulation proceeds in plants with shaded stems or ears accompanied by restriction of ear growth and in the former case of stem growth as well. Only after early defoliation did there appear to be a condition of true carbohydrate shortage. The complex mechanisms controlling starch and cellulose synthesis do not therefore respond directly to the supply of carbohydrate but require that the plant shall be intact and in the light, and it seems that under normal environmental conditions, as well as those imposed in these experiments, sugar accumulation results from over-production in relation to the capacity of these mechanisms rather than as a necessary reserve substance. The accumulated sugar is not, however, in a static condition, and the levels are presumably only maintained by a process of continuous replacement, since arresting the supply of fresh assimilate either by defoliation or by exclusion of carbon dioxide from the surrounding atmosphere leads to an immediate fall in sugar-level.

The absence of effect upon stem sugar losses, when assimilation was partially prevented at the time of maximum stem sugar, is particularly striking and suggests that the role of stored sugar as a reserve for the ear is very questionable. It has been shown that this sugar cannot form a large part of the carbon supply to the ear, and the continued development of ears in defoliated plants, where this store of sugar is virtually absent, shows that it is not essential to later stages of ear growth. Finally, the high rate of loss of sugar from stems deprived of ears shows that the ear is not concerned in the control of this process. The question then arises as to whether in fact this stem sugar is not lost as part of the normal senescent drift of the stem itself rather than by upward translocation to the ear. The distribution of sugar between the several internodes lends some weight to this view. Each internode appears to behave as an independent unit, depending for its sugar supply upon the attached leaf, a fall in sugar ensuing when the leaf is no longer functional, and moreover the evidence suggests that there is no rapid interchange between one internode and another.

It is recognized that conclusive evidence of the precise fate of sugar in the cereal stem is not yet forthcoming, and the view that it is not lost by upward translocation requires substantiation. Alternative possibilities would appear to be conversion *in situ* to other compounds or loss as carbon dioxide. At present the former possibility is quite unexplored, but a start has been made in the study of the respiration of the stem. Carbon dioxide output during the hours of darkness and at prevailing night temperatures has been measured for whole tillers, and for defoliated and earless stems, during the phase of falling stem sugar. On the assumption that sugar loss is continuous throughout the twenty-four hours the average rate of loss (0·35 mgm. per gm. dry weight per hour) in whole tillers showed good agreement with the respiration rate (0·32 mgm. per gm. dry weight per hour, calculated as hexose) observed for the dark hours. If, therefore, the day-time respiration is of the same order as that at night and the carbon dioxide reassimilated during the day appears in a form in which it can be synthesized to starch, it might be concluded that all the sugar lost is accounted for by oxidation to carbon dioxide. However, the agreement for the stems alone was less good, and here the rate of sugar loss (0·45 mgm. per gm. dry weight per hour) was apparently higher than the equivalent carbon dioxide output (0·25 mgm. per gm. dry weight per hour). Moreover, not only are essential respiration requirements met in defoliated stems with very low sugar contents; but also in stems of nitrogen-deficient plants, where respiration rate is presumably low, rate of sugar loss is high owing to the high sugar-levels induced by this deficiency. More data are therefore required before a definitive estimate of the proportion of stem sugar lost in respiration can be made, and it can only be suggested that perhaps half the sugar may be accounted for in this way.

Failure to induce sugar movement by partial prevention of assimilation, together with the clear indication that in plants with shaded stems or ears factors other than carbohydrate deficiency were operative in controlling sugar utilization, led to an attempt by Archbold and Datta[15] to influence sugar movement by exploiting the known effects of nitrogen deficiency on sugar content. Nitrate was supplied to the plant at the time when sugar was accumulating rapidly in the stem and also at the time of the sugar maximum. On both occasions uptake was rapid for about a fortnight and the nitrogen content of tillers already present was more than doubled, while at the same time new tillers arose. The plants developed the deep blue-green colour characteristic of high nitrogen status and remained green for some time longer than controls. Active reduction of nitrate took place immediately and at first the additional nitrogen was found distributed between all the organs, about 30 per cent going to the leaves and 40 per cent to the stems after the earlier of the two applications, but by harvest all had been transferred to the ears. Concurrently with this rapid nitrogen uptake, sugar accumulation in the stems was restricted, presumably by preferential utilization of the leaf assimilate for union with the reduced nitrate. There followed a slow rise of stem sugar to a lower maximum than in the control plants, and still later a slow rate of loss in the senescent phase of the stem. This course of sugar change differs from that found after early defoliation only in that the restriction of the sugar accumulation is not so great. When the addition of nitrate was delayed until sugar was maximal in the stem, the onset of sugar loss was actually also delayed, although 80 per cent of the nitrogen taken up appeared at once in the stems and ears. At this stage, therefore, addition of nitrate prolonged the time during which the stems remained green and at the same time maintained a high sugar-level, again indicating that sugar loss from the stem is associated with senescence rather than with ear growth. At both stages, synthesis of nitrogenous compounds was apparently effected at the expense of newly assimilated carbon.

Preliminary attempts to determine whether such new assimilate was essential for elaboration of the nitrogen have only served to stress the complexity of the problem. By supplying nitrate to detached

tillers in the light either in air or in a carbon dioxide-free atmosphere it was found that sugar loss was accelerated in the presence of the added nitrogen, whether or not carbon dioxide was excluded. The additional sugar loss, however, bore no obvious relation to the amount of nitrate reduced, and indeed in one case, where the initial nitrogen level of the sample was high, no reduction of the nitrate taken up could be observed, although the high rate of sugar loss still occurred. Nevertheless, the experiments with added nitrogen fall into line with those dealing with carbohydrate shortage in that accumulation of stem sugar in intact plants was inhibited by the treatment, but rate of sugar loss was not accelerated. Numerous well-known experiments with detached leaves have shown that stable sugars can be taken up and converted to starch, or lead to production of nitrogenous compounds when supplied along with a suitable source of nitrogen. The failure of the barley plant to utilize stored sugar in this way may therefore be due to the location of the sugar rather than its chemical form, and the preferential use of primary assimilate arise from the ease with which it can be brought into association with the appropriate enzyme mechanisms. At present it is not known whether the starch-forming enzymes occur exclusively in the grain, but in the meantime formulation of schemes whereby fructosans or pentosans might be converted to starch appear superfluous, since evidence of upward translocation of the former is lacking, and the evidence points to an irreversible synthesis of the polysaccharides from which the latter might be derived. Rather a single starch precursor may be postulated largely produced *in situ* in the ears and possibly identical with the translocatory substance (sugar ?).

Since the carbon used for ear development and especially for starch synthesis derives principally, if not entirely, from current assimilation, the available evidence regarding the functional importance of the several plant organs in this respect may be summarized. From a number of defoliation experiments it is estimated that, after ear emergence, the leaves supply not more than 10 per cent of the final dry weight of the ear compared with a contribution of 30 per cent by the ears themselves. Before ear emergence the leaves may contribute a further 15 per cent, mainly leading to polysaccharide and protein synthesis. There remains the rather large amount of 45 per cent attributable by difference to stems and sheaths, of which somewhat less than half is contributed before emergence of the ear. Attempts to confirm this estimate by experiments in which stems were shaded or in which only stems were left exposed to light led to conflicting results owing to the different effects of treatment other than the prevention of assimilation. Shading the stem at the time of ear emergence had little effect on the final dry weight of the ear, indicating a small assimilatory capacity at this stage, a view supported by the failure of stems deprived of ears and leaves to accumulate sugar as compared with those from which only ears were removed. When stems alone were left exposed to light, however, a higher estimate of the apparent assimilatory capacity was obtained. As a rough approximation perhaps half the material of the ear accumulated before emergence may be attributed to activity of the leaves and half to the stems and sheaths, of which latter half a large proportion is probably derived from the flag leaf-sheath[13]. The rapid senescence of the leaves after ear emergence suggests that the estimate of 10 per cent or less for their contribution during the period of active starch synthesis is probably correct, leaving the mode of division of the remaining 40 per cent as between stems and ears uncertain. The data thus confirm the view that leaves are relatively unimportant as regards starch synthesis, and make their essential contribution in the period before ear emergence. If the discrepancy between the estimates of the stem contribution is in part due to under-estimation of the contribution of the ear itself, this organ may prove to be almost wholly responsible for the immediate starch precursor.

The experiments summarized here, dealing with the sugars of the barley plant, cast doubt upon the hypothesis that the stored sugar of the stem is a reserve for maintaining the growth and development of the fruit. If the alternative view be accepted that this sugar is lost as part of the inevitable senescence of the stem itself, then the function of accumulations of sugar not only in other monocotyledonous stems, for example, the sugar cane, but also of other types of storage organ may need reconsideration in this light. In storage roots such as carrot or sugar beet it is well known that the separated crown can produce a flowering stem though deprived of the bulk of the stored carbohydrate ; similarly, in tubers such as artichoke and potato, the so-called reserves of inulin and starch are not essential to successful regeneration. Thus, while it is manifest that some part of the 'carbon' of the storage organs must undergo metabolic changes leading to shoot formation, the amount involved is probably small in relation to the total carbohydrate reserve, and the same general interpretation is possible for these types of sugar accumulation as for the barley stem ; namely, that sugar is produced in excess of immediate growth requirements and becomes isolated in parenchymatous tissue, from which it disappears slowly with the senescence of the 'storage' organ. These two types of sugar storage would then fall into line, as regards absence of essential function in subsequent growth, with the sugar of the fleshy fruits, which cannot be regarded as a substrate for future growth. The resulting unification of the conceptions of the status of these three types of sugar accumulation emphasizes the view that sugar concentration of itself plays no part in initiating plant syntheses, but rather that stable sugar arises when assimilatory capacity is in excess of that for utilization. The necessity for a better understanding of the factors, of which nitrogen supply is of first importance, controlling sugar utilization is obvious.

If any function is to be attributed to the sugar in such organs as the shooting stem of the cereal it may perhaps be concerned with maintenance of turgor in the rapidly elongating cells, but this is frankly speculative, and at present without experimental verification.

[1] Beaven, E. S., *J. Farmers Club*, Pt. 6, 107 (1920).
[2] Deherain, P., and Dupont, C., *C.R. Acad. Sci.*, **133**, 774 (1901).
[3] Engledow, F. L., and Wadham, S. M., *J. Agric. Sci.*, **13**, 390 (1923) ; **14**, 80 (1924).
[4] Colin, H., and Belval, H., *C.R. Acad. Sci.*, **175**, 441 (1922).
[5] Belval, H., *Rev. Gen. Bot.*, **36**, 303, 336, 343 (1924).
[6] Archbold, H. K., *Ann. Bot.*, N.S., **2**, 403 (1938).
[7] Barnell, H. R., *New Phytol.*, **35**, 229 (1936).
[8] Barnell, H. R., *New Phytol.*, **37**, 85 (1938).
[9] Boonstra, A. E. H. R., *Wageningen Med. Land.*, **33**, 3 (1929).
[10] Smith, H. F., *J. Coun. Sci.. Ind. Res. Aust.*, **6**, 32 (1933).
[11] Watson, D. J., and Norman, A. G., *J. Agric. Sci.*, **29**, 321 (1939).
[12] Archbold, H. K., and Mukerjee, B. N., *Ann. Bot.*, N.S., **6**, 1 (1942).
[13] Archbold, H. K., *Ann. Bot.*, N.S., **6**, 487 (1942).
[14] Archbold, H. K., and Datta, C., *Ann. Bot.*, N.S., **8**, 227 (1944).
[15] Archbold, H. K., and Datta, C., in preparation.

OBITUARIES

Prof. Leif Tronstad, O.B.E.

THE death of L. H. L. Tronstad on active service in Norway, while leading a daring operation in March 1945, has deprived his country of one of its most outstanding men of science, and his collaborators in all parts of the world of a valued friend.

Leif Hans Larsen Tronstad was born in 1903 at Baerum, near Oslo; his father, a farmer, died the same year. He studied chemistry in the Oslo Technical School and the Norwegian Technical University at Trondheim, obtaining brilliant successes despite the fact that he was at the same time working as a teacher and in support of his widowed mother and sister. His first important research was carried out at Berlin, during 1928–29, in Prof. Freundlich's laboratory. A qualitative method of detecting thin oxide films on metals, based on changes in the ellipticity of polarized light, had already been worked out by Freundlich, Patscheke and Zocher. Tronstad succeeded in developing the method to give quantitative measurements of thickness, and showed that, when iron was made passive by anodic treatment, the film thickness increased, while during cathodic activation the thickness diminished. This work not only supplied valuable information as to the causes of passivity, but also suggested a new method of ascertaining the thickness of invisible films, and the nature of the film substance.

After further work on films resulting from electrochemical treatment, carried out in Prof. Benedick's laboratory at the Metallografiska Institutet, Stockholm, for which he received his doctorate at Trondheim, Tronstad proceeded in 1931 to the University of Cambridge. There he improved the method further, testing its accuracy by the study of monolayers of fatty acids, the thickness of which could be measured in other ways; part of this work was carried out in collaboration with C. G. V. Feachem.

Later Tronstad returned to Norway and was elected in 1934 to a temporary professorship in technical inorganic chemistry at the Norges Tekniske Högskole; this chair was made permanent in 1936. He was one of the youngest professors in the country, popular alike with students and colleagues, and enjoyed the reputation of being a first-class teacher. At this stage he was joined by A. B. Winterbottom, and the polarized light method of studying films on metals was developed further. Although not well known to-day, its value is likely to become increasingly appreciated as time passes, especially as it can be employed for just that range of thickness where alternative methods are least useful. Moreover, the method can be used for the continuous study of a film *in situ* during its growth in almost any environment.

Tronstad's interests were by no means confined to the study of films. He played a leading part in the organization of the Rjukan hydrogen plant of Norsk Hydro, for the large-scale separation of heavy water, large quantities of which were supplied for scientific research in Great Britain. Determinations of the physical constants of several deuterium derivatives were made by Tronstad and his associates at Trondheim and Rjukan. Tronstad's electrochemical knowledge was of the greatest value to the Norwegian industries, especially those connected with steel, ferro-alloys, nitrogen, refractories and aluminium; he also carried out researches on the effect of minor elements on the corrosion of aluminium and iron. His published scientific papers number about sixty.

Tronstad was greatly attached to Great Britain, where he had many friends. His modesty, sincerity and cheerful good-humour were appreciated by all who met him. He had numerous interests outside science; for example, he was a fine athlete, being in his student days a member of the relay team which set up a Norwegian record for the 4 × 400 metres distance; he was also a lover of natural beauty, and took pride in Norwegian country folk and customs.

During the War, Tronstad was engaged in daring and dangerous work for his country, which led, on the eve of victory, to his death in action. Details of his many-sided war activities must not be given; but it may perhaps be stated that the results achieved, which demanded the highest courage, organizing capacity and scientific skill, contributed directly to the speedy victory of the Allied Nations, besides saving the region which came to be known as 'Southern England' from an even longer and more severe ordeal than it actually endured. He received the Order of the British Empire for his outstanding services.

We would like to thank Mr. A. B. Winterbottom and Capt. J. H. Reimers, as well as the Royal Norwegian Government Information Office, for kind assistance on many points.

E. K. RIDEAL.
U. R. EVANS.

Don Ignacio Bolivar y Urrutia

WITH the death in Mexico on November 20, 1944, of Don Ignacio Bolivar y Urrutia, the world has lost one of the most eminent Spanish naturalists of a generation belonging as much to the last century as to the present. Ignacio Bolivar was born on November 9, 1850, a member of a noble and ancient family. Although interested from an early age in natural history, young Bolivar had to take up law studies, since his parents hoped that these would provide him with a better livelihood; but he took a degree in natural sciences as well. Before he was twenty, Bolivar became an ardent member of a small but very active group of young Madrid entomologists, and spent much of his free time in exploring the Spanish fauna.

When the Sociedad Espanola de Historia Natural was founded in 1871, Bolivar became its vice-secretary, and in 1872 his first scientific paper was published by the Society. In 1875 he joined the staff of the Madrid Natural History Museum as an assistant in the Zoology Department, specializing in entomology. The whole subsequent career of Bolivar was passed in the Museum, of which he eventually became director, and which grew from a small establishment to an imposing scientific institution and a centre of research. In 1877, Bolivar was also appointed to a chair in the University of Madrid, where he continued lecturing in zoology until 1922, and his combined work in the Museum and the University served to make him one of the leading naturalists in Spain and a teacher of more than one generation of Spanish biologists.

Although primarily a taxonomist himself, Bolivar was always a champion of the study of living organisms, and it was due to his efforts that a marine biological station was established in Santander, while the Estacion Alpina de Biologia in Sierra de Guadarrama, also founded by him, was a somewhat unique

centre where Spanish and foreign biologists were able to find modest accommodation and good laboratory facilities amidst unspoilt Nature. This long and fruitful activity was rudely interrupted when at the age of ninety Bolivar became an exile, followed by a group of his colleagues. It was characteristic of Ignacio Bolivar and his younger followers that in Mexico they should take a most active part in the scientific life of the country of their adoption, and are contributing greatly to its scientific exploration. A monthly journal, *Ciencia*, launched by them, rapidly became a widely known medium of biological knowledge in Latin America.

Although Bolivar published some papers on the Hemiptera, on other insect orders and on Crustacea, he specialized from his earliest days on the systematics of the Orthoptera, a group particularly well represented on the Iberian peninsula, where it includes a high proportion of endemic genera and species. The total number of papers published by Bolivar was about two hundred and thirty, and he described more than two hundred new genera and about a thousand species of Orthoptera. His work on this order partly coincided in time with that of Brunner, Saussure, Pictet and Redtenbacher, and he is to be included with them as a creator of the modern system of Orthoptera.

While a great deal of Bolivar's work was purely descriptive, we owe to him also a series of revisions and monographs, and his works on the Tetrigidæ, Pamphaginæ, Pyrgomorphinæ, Truxalinæ and Ephippigerinæ, still remain indispensable for a taxonomist. From the faunistic point of view his main contribution was, of course, to the study of the Iberian fauna, but he ranged widely in his work, from India to the Seychelles and from the Congo, Angola and Spanish Guinea to South America.

Most present-day orthopterists regard Ignacio Bolivar as their master and it was a great and touching occasion when in 1935, during the Sixth International Entomological Congress at Madrid, a group of some fifteen orthopterists of various nationalities gathered round him for a 'family' celebration. For those who knew Don Ignacio personally, it was impossible not to fall under the spell of his vital personality, full of noble and simple charm. His energy was prodigious, and I shall never forget an excursion to the highest peak of Sierra de Guadarrama, when Don Ignacio, then well over seventy years old, led the way on foot for several hours.

The value of Bolivar's work was recognized by the Entomological Societies of London, Belgium and Prague, which elected him honorary fellow, while the Zoological Society of London included him among its twenty-five foreign members. Among many other academic distinctions, he was a doctor *honoris causa* of the University of Pittsburgh. B. P. Uvarov.

Dr. G. C. Robson

Guy Colborn Robson, whose death occurred on May 17, 1945, after a long illness, was born at South Woodford, Essex, on February 11, 1888. He obtained a Classical Scholarship at New College, Oxford, where he entered into residence in 1906. He took Classical Moderations, and then changed over to science, reading for honours in zoology, in which he obtained a first class, and afterwards spent a year in Naples, where he studied the fat-metabolism of crabs infested with *Sacculina*. He joined the staff of the British Museum Natural History in 1913 and was put to work on the Mollusca under Edgar Smith. He became a well-known authority on this group and devoted much attention to their anatomy, as well as the 'conchology' on which earlier classifications were mainly based. He published numerous papers, mainly on the Cephalopoda, including perhaps his most important work, a monograph on the Octopoda, published by the British Museum in two volumes (1929 and 1932). He also studied the biology of *Paludestrina jenkinsi*, a parthenogenetic freshwater snail introduced into Britain some time during the eighties of last century, and now widely distributed throughout Britain.

Robson was attracted to zoology from the philosophical side and it is doubtful whether he was entirely happy in his museum life. His intellectual interests were many and varied—artistic, literary, sociological, philosophical. The latter bent is best shown in his two books, "The Species Problem" (1928) and (jointly with O. W. Richards) "The Variation of Animals and Plants in Nature" (1936). His artistic gifts are evident in the illustrations to his papers and also in his water-colours.

During the War of 1914–18, he served first with the Red Cross and then with the Royal Garrison Artillery and was attached to a coast defence unit. He was bombed during an air attack, and, after spending a year in hospital suffering from shell-shock, was invalided out of the service. He returned to the British Museum, where he spent some of the most productive years of his life and became a deputy keeper. Unfortunately, he never seemed to have recovered fully from his illness, and in 1935 had another nervous breakdown necessitating his resignation from the Museum. He spent the last few years of his life in retirement. E. Hindle.

Some Czechoslovak Men of Science

News has just reached London that several more Czechoslovak professors, displaced when the Germans closed the universities of that country in 1939, have died in concentration camps. They include Prof. V. Dolejšek, Prof. F. Ulrich and Prof. J. Štorkán. Prof. F. Slavík, a mineralogist well known in Britain and now sixty-nine years old, was rescued from Buchenwald by the Allies just in time, and has now been able to travel to Prague. The fate of Prof. F. Záviška, the physicist, is unknown; he has not yet been traced.

It is now known that Prof. A. Šímek, whose death has already been referred to in *Nature* (**152**, 69; 1943), was executed at Mauthausen concentration camp.

Prof. Dolejšek was a distinguished physicist who worked for a time with Prof. Manne Siegbahn in Uppsala. Some of his work on X-ray spectra was first published in *Nature*, and he is perhaps best known for his discovery of the *N*-series of X-ray lines. He died at the Terezín camp in January last.

Prof. F. Ulrich had carried out many mineralogical investigations of considerable local interest and had made important petrographic and geological studies. He was also the author of several authoritative treatises on geology and had been elected honorary foreign member of numerous European scientific societies.

Prof. Štorkán had a distinguished career as a zoologist and was an authority on the Central European fauna. He was only fifty-four at the time of his death. G. Druce.

NEWS and VIEWS

Prof. G. H. Hardy, F.R.S.

THE appointment earlier this year of Prof. L. J. Mordell to the Sadleirian chair of pure mathematics in the University of Cambridge is a reminder that Prof. G. H. Hardy retired from the Sadleirian chair so long ago as 1942. Throughout his long career as lecturer at Trinity College, Cambridge, during 1906–19, as Savilian professor of geometry at Oxford during 1919–31, and as Sadleirian professor of pure mathematics at Cambridge from 1931 until his retirement in 1942, Prof. Hardy has been a leader of mathematical thought. Forty years ago, mathematical analysis was neglected in England. To-day the English school of analysts commands respect and admiration throughout the world. This development is due almost entirely to Hardy, by the direct inspiration of his own teaching and personality, and through the medium of successive generations of his pupils. An important part was played, particularly in the early stages, by his stimulating book "A Course of Pure Mathematics", first published in 1908 and now in its ninth edition. But it is not possible in this short note to attempt any proper appreciation of the great volume of Hardy's original work, or to recount the imposing list of his collaborators. Chief among these is his former pupil, J. E. Littlewood, who has been a constant partner since about 1912.

The headings under which Hardy's work may be broadly classified (theory of series, theory of functions, Diophantine approximation, inequalities, analytical theory of numbers, Fourier analysis) are closely related, and many of the interrelations can be traced to Hardy's own influence. Thus the impressive body of "Tauberian" theory, with which Hardy and his followers have enriched the theory of series, finds some of its principal motives and applications in the theory of numbers. Again, the researches of Hardy and Littlewood on Diophantine approximation involved a profound study of certain power series near the circle of convergence, and this was no doubt the germ of the famous Hardy-Littlewood-Ramanujan analytical method in the additive theory of numbers, one of the greatest and most fruitful mathematical discoveries of this century. The name Ramanujan recalls what Hardy has described as the one romantic incident in his life—his association with the self-taught Indian mathematician who was to achieve world-wide fame under his guidance. This fascinating story has been told by Hardy himself. It is mentioned here as an example of what Hardy's pupils, one and all, owe to him, perhaps in more orthodox and more prosaic circumstances, in personal interest and sympathetic encouragement of their early efforts—a debt more fully appreciated in later life with the coming of mathematical independence and maturity.

Many honours have been conferred upon Hardy. He became a fellow of the Royal Society in 1910, and was awarded a Royal Medal in 1920 and the Sylvester Medal in 1940. In 1933 he received the Chauvenet Prize of the American Mathematical Association. For forty years he has been a tower of strength to the London Mathematical Society as member of its council, as secretary, and as president. He was awarded the de Morgan Medal of the Society in 1929. Hardy is the author or joint author of several books, all written in the vivid style familiar to readers of his original papers. "A Mathematician's Apology", published in 1940, was received with enthusiasm by the wider public to which it was addressed. Hardy's technical writings, as well as his provocative pronouncements on philosophy and pedagogy, are often enlivened by apt illustrations from cricket or other games, sometimes to the bewilderment of foreign readers.

Anthropology in the University of London: Prof. C. Daryll Forde

THE provision for the study and teaching of anthropology in London is being strengthened by the revival of the department in University College which has been partly suspended during the War. Prof. C. Daryll Forde has been appointed to the chair, and he will take up his duties at the opening of the new session. Prof. Forde first went to University College in 1919, and was there, as student and later as a junior member of staff, until 1928. He worked under Profs. Lyde and Elliot Smith in the period in which the latter gave so strong a stimulus to anthropological studies by the development of his theories on the diffusion of culture. From there he went, with a Commonwealth fellowship, to California, and spent two years on studies of the Pueblo Amerindians of the south-western United States and northern Mexico. In 1930 he was appointed Gregynog professor of geography and anthropology in the University of Wales, at University College, Aberystwyth.

After the publication of the results of his field-work in America, Prof. Forde became interested in Africa. He has carried out field work in West Africa, where he was caught by the outbreak of war in 1939. Since then he has served in the Foreign Office Research Department, as a member of the Nuffield colonial research team, and for the past year as director of the International African Institute. He has published many papers, and his book "Habitat, Economy and Society" is a well-known exposition of work done in the study of primitive societies. These, and a forthcoming book on native economies in Nigeria, indicate his range of work. He is essentially a field anthropologist, holding that such study of simpler societies can lead to a real understanding of the more primitive peoples, and contribute towards a better knowledge of more complex human societies, such as our own.

Marine Biological Association Laboratory, Plymouth: Mr. F. S. Russell, D.S.C., D.F.C., F.R.S.

THE Council of the Marine Biological Association has appointed Mr. F. S. Russell to be director of the Association's Laboratory at Plymouth in succession to the late Dr. Stanley Kemp. Mr. Russell has been a member of the staff of the Association since 1921 and has played a very important part in the work of the Plymouth Laboratory. His work has thrown much light on the factors which control the distribution of planktonic organisms, and on the relationship of these organisms to more strictly fishery problems. Mr. Russell is at present serving in the Royal Air Force and holds the rank of wing commander.

Mrs. Seán T. O'Kelly

MRS. SEÁN T. O'KELLY, wife of the newly elected president of Ireland, is well known as Miss Phyllis Ryan, public analyst, in Dublin. She studied chemistry under the late Prof. Hugh Ryan at University College, Dublin, graduating in 1916, and obtaining

The vacancies advertised in these columns are available only to applicants to whom the Employment of Women (Control of Engagement) Orders, 1942–3, do not apply.

THE SIR JOHN CASS TECHNICAL INSTITUTE

LONDON, E.C.3

APPOINTMENT OF PRINCIPAL

The Governors of Sir John Cass's Foundation invite APPLICATIONS from University Graduates, or persons of equivalent standing, for the APPOINTMENT OF PRINCIPAL of the SIR JOHN CASS TECHNICAL INSTITUTE, one of the London Polytechnics.

The Institute comprises three Departments of Science, namely, Physics and Mathematics, Pure and Applied Chemistry (including Biology) and Metallurgy and also Departments of Navigation, Arts and Crafts and Tailoring. Certain courses of instruction in the Science departments are recognized by the University of London for "Internal" Students.

The Principal will be responsible to the Governing Body for the conduct and administration of the Institute, and must be experienced in administrative organization.

The salary scale will be £960 rising by annual increments of £50 to £1,200 a year (basic) subject to adjustment in the light of any decision which may hereafter be arrived at by the London County Council and the Ministry of Education regarding the remuneration appropriate to the post as a result of a general revision of salaries consequent on the operation of the recent Burnham Report.

The person appointed will be subject to the provisions of the School Teachers' (Superannuation) Acts.

Particulars of the duties and conditions of the appointment and special form of application may be obtained by writing to the Correspondent, Sir John Cass's Foundation, 31 Jewry Street, Aldgate, London, E.C.3, by whom applications on such forms must be received not later than 12 noon on Friday, August 31, 1945.

ESSEX EDUCATION COMMITTEE

SOUTH-EAST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART

Longbridge Road, Dagenham

MATHEMATICS AND PHYSICS DEPARTMENT

Applications are invited for the Headship of this Department which has been created by the division of the existing Science Department into two sections. Candidates should have high academic qualifications in Mathematics or Physics or both, together with substantial teaching experience and preferably some research experience. The successful applicant would be expected to begin his duties on January 1, 1946, or as soon thereafter as possible.

Application forms and further particulars, obtainable by sending stamped addressed envelope, should be returned to the undersigned by not later than August 4.

B. E. LAWRENCE,
Chief Education Officer.

County Offices,
Chelmsford.

CITY OF LEICESTER EDUCATION COMMITTEE

LEICESTER COLLEGE OF TECHNOLOGY AND COMMERCE

Principal: L. W. Kershaw, O.B.E., B.Sc., A.M.Inst.C.E.

APPLICATIONS are invited for the post of Full-time Lecturer in Physics.

Applicants must be Honours Graduates.

Salary will be in accordance with the Burnham Scale.

Further particulars may be obtained from the Principal, to whom applications, accompanied by two recent testimonials and the names of two referees, must be sent on or before July 28, 1945.

H. S. MAGNAY,
Director of Education.

THE ROYAL TECHNICAL COLLEGE GLASGOW

PROFESSOR OF CHEMISTRY

The Governors invite applications for the Professorship of Chemistry.

The commencing salary will be £1,000 per annum, or such larger sum as the Governors may decide in view of any special qualifications or experience possessed by the selected candidate.

Further particulars may be obtained from the Secretary, to whom applications must be sent not later than August 31, 1945.

KENT EDUCATION COMMITTEE

MEDWAY TECHNICAL COLLEGE

SENIOR DEPARTMENTS, GILLINGHAM

Lecturer in Inorganic and Physical Chemistry required to take up duties in September if possible.

Candidates must hold an Honours Degree in Chemistry of a British University. The College is recognized by the Royal Institute of Chemistry for the training of Associates and also conducts full-time and part-time courses leading to the Special Honours Degree in Chemistry.

Subject to agreement with the Ministry of Education this post will be that of a Senior Assistant or Head of Department under the new Burnham Scales.

Forms of application should be obtained from the Principal at the College and returned to him at the earliest possible date.

THE UNIVERSITY OF LIVERPOOL

The Council invites applications for the post of Lecturer in Dental Pathology and Bacteriology. The appointment will be a whole-time one, at a salary not exceeding £800 per annum, and to be fixed according to qualifications and experience. The University will consider applications from candidates in the Forces, or engaged upon other national service, even though they may have no immediate prospect of release.

Applicants must have had training and experience in research methods in a department of a Medical School or similar institution, and should preferably hold a medical qualification. A dental qualification is desirable but not essential.

Applications should be received not later than September 30, 1945, by the undersigned, from whom further particulars may be obtained.

STANLEY DUMBELL,
Registrar.

EDINBURGH AND EAST OF SCOTLAND COLLEGE OF AGRICULTURE

Applications are invited for the post of ASSISTANT LECTURER IN BUILDING CONSTRUCTION.

Candidates must be Registered Architects and should also have had farm experience. The salary for the post is on a range of £350 to £450 per annum, commencing at £400 per annum, with appropriate war bonus in addition.

Applications stating qualifications and experience should be lodged with the undersigned, from whom further particulars may be obtained, not later than July 28.

THOMAS BLACKBURN.

13 George Square,
Edinburgh.

UNIVERSITY OF DURHAM

Applications are invited for the PROFESSORSHIP OF METALLURGY, tenable at King's College, Newcastle-upon-Tyne. The candidate appointed, if now on National Service, will not be expected to take up appointment until his release. The salary will be according to qualifications and experience, but will not be less than £1,100. Further particulars may be obtained from the undersigned by whom applications should be received not later than August 31, 1945.

G. R. HANSON,
Registrar of King's College.

UNIVERSITY OF LEEDS

DEPARTMENT OF PHYSICS

The Council invites applications for a Lectureship in Physics. Duties to begin October 1 or as soon after that date as may be arranged. Commencing salary not less than £500 a year. Further particulars may be obtained from the Acting Registrar, The University, Leeds 2, who will receive applications for the appointment on or before September 1.

UNIVERSITY OF LEEDS

DEPARTMENT OF PHYSICS

Applications are invited for an Assistant Lectureship in Physics. Duties to begin, if possible, on October 1. Commencing salary £350 a year. Further particulars may be obtained from the Acting Registrar, The University, Leeds 2, who will receive applications for the appointment on or before September 1.

NORTHAMPTON POLYTECHNIC

ST. JOHN STREET, LONDON, E.C.1

Applications are invited for the post of full-time LECTURER in the Mathematics Department.

Salary in accordance with the London Burnham Scale for Teachers in Technical Institutions.

Conditions of appointment and form of application on request to the Secretary.

S. C. LAWS, O.B.E., M.A., M.Sc.,
Principal.

UNIVERSITY COLLEGE OF SWANSEA

The Council invites applications for the following posts:

(i) Temporary Assistant Lecturer in Mathematics for one year from October 1, 1945. Salary £350.

(ii) Temporary Assistant Lecturer in Metallurgy for one year from October 1, 1945. Salary £350.

Further particulars may be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications must be received on or before August 7, 1945.

UNIVERSITY OF BRISTOL

Applications are invited for the post of Temporary SCIENTIFIC ASSISTANT on the Staff of the Department of Agricultural Economics, Bristol II Advisory Province, Newton Abbot. Salary £250 to £375 per annum.

Applications, together with three recent testimonials, should reach the undersigned not later than July 31.

WINIFRED SHAPLAND,
Secretary and Registrar.

The University,
Bristol 8.

SHELL STUDENTSHIPS IN GEOPHYSICS

The Royal Dutch-Shell Group of Oil Companies invite applications for studentships in Geophysics from men who intend to make their career in the oil industry. Two studentships of the value of £300 a year are offered, open to men of any nationality who are under the age of twenty-seven years on October 1, 1945. Subject to satisfactory progress the studentships will be for a period of two years from October 1, 1945, and may be renewed for a third year. Students will be required to pursue a course of research in Geophysics at the University of Cambridge and they must obtain, or have obtained, admission as Research Students of that University. Applications for these studentships should be sent to Dr. E. C. Bullard, Department of Geodesy and Geophysics, Downing Place, Cambridge, so as to reach him not later than August 1, 1945. The applications must be accompanied by a statement of the candidate's career (including his date of birth) and by the names of at least two referees.

The Iodine Educational Bureau will

shortly make appointments to the following full-time positions in its expanding organization. Applications are invited from candidates including men not immediately available on account of National Service.

1. A Medical Scientist to study the applications of iodine and its compounds in preventive and curative medicine with a view to developing knowledge of iodine in this field. The work will involve contact with recognized centres of nutritional, biochemical and pharmacological research, and the planning and supervision of research on problems concerning the biological and therapeutic role of iodine. Candidates should possess a medical qualification and preferably should have special experience in pharmacological, nutritional, or physiological science.

2. An Industrial Chemist to undertake a comprehensive study of actual and potential uses and applications of iodine and its compounds in technical and manufacturing processes. Candidates should possess an honours degree in Chemistry and should have a wide general knowledge of chemistry as applied to industry, and research experience in some branch of chemical technology. A knowledge of languages will be an advantage.

3. A Veterinary Scientist to study the applications of iodine and its compounds in animal feeding and veterinary medicine. Candidates should be qualified in veterinary science and be familiar with modern developments in "trace element" research. The work will involve contacts with farmers, feeding-stuffs manufacturers and allied interests.

4. A Bibliographer with experience in scientific and technical abstracting to undertake the preparation of a complete annotated bibliography of iodine literature in the fields of biology, medicine, agriculture, animal health and industry. Candidates should hold a University degree and be familiar with the resources and availability of scientific literature. Experience of bibliographical methods, and previous research experience in one or more of the sciences to be covered would be an advantage. A knowledge of foreign languages, particularly German and French, is essential.

Adequate salary is offered commensurate with the responsibility of each post and the qualifications of the candidate. These posts carry participation in the pension scheme of the Nitrate Corporation of Chile, Limited, of which the Iodine Educational Bureau is a department.

Candidates are requested to quote the number of the position for which they are applying and to address their applications to Dr. Francis C. Kelly, Director, Iodine Educational Bureau, Stone House, Bishopsgate, London, E.C.2.

Applications are invited by J. Sainsbury Ltd., who desire to appoint a Scientist of the highest standing and qualifications to maintain an interest in the fields of agriculture, food and nutrition, to maintain contact with research organizations, to control laboratory and research activities, and to advise the Company on the various ways in which scientific knowledge may bear upon its policy and operations. No appointment will be made under 30 years of age; preferably applicants should be between 35 and 45. Whilst the appointment will be on a full-time basis, and pensionable, the Company will be prepared to arrange matters so that the scientist appointed may be able to engage in personal research. Salary £1,500 to £2,000 per annum according to circumstances.

A Panel of distinguished scientists have consented to advise the Company regarding the scientific qualifications and experience of candidates. Applications, giving full details of previous work, should be made in writing, marked "For the attention of James A. Sainsbury" and addressed to J. Sainsbury, Ltd., Blackfriars, London, S.E.1.

Institute of Fuel. Applications are invited for the position of Deputy Secretary of the Institute. Applicants must be experienced administrators and be fuel technologists. Age approximately between 35 and 45. Salary not less than £1,000 per annum depending on qualifications and experience. Applicants should give the names of three persons to whom reference can be made. Applicants must give full details of their education, qualifications and experience, and reach the Secretary of the Institute of Fuel, 30 Bramham Gardens, London, S.W.5, not later than July 30. Envelopes to be endorsed "Deputy Secretary" in the left-hand top corner.

Senior Laboratory Assistant required in September for the Laboratories, Radley College. Previous experience essential. Salary from £150, according to qualifications. Live in or out. Apply in writing to W. S. Porter, Radley College, Abingdon.

Wanted: Second-hand Epidiascope. Apply Stanley Smith & Co., Worple Road, Isleworth.

Laboratory Assistants required for Research and Development Department; must be used to light metal work—knowledge of vacuum technique and glass blowing desirable. Apply, giving fullest particulars, to: Controller of Research and Development, Adam Hilger, Ltd., 98 St. Pancras Way, London, N.W.1.

Junior Technical Assistant (Male or Female) required for Scientific Department in London. Wages according to qualifications. Write Box 1798, c/o White's, Ltd., 72 Fleet Street, E.C.4.

For Sale: Zeiss Research Microscope, perfect condition with all necessary accessories incl. 1/12 oil-immersion n.A. 1.3. Box No. P.122, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Microscopes, of all descriptions, only a few available, second-hand, perfect condition. Send details of your requirements, enclosing 3d. stamp.—Telephone or correspondence only. Chards, Forest Hill, S.E.23 (Spring Park 1628).

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the M.Sc. degree by research in 1917. She collaborated with Prof. Ryan in a number of investigations, including one on the action of nitrous and nitric acids on diphenylamine carried out with the co-operation of Nobels, Ltd. Later, she set up practice as a consulting chemist in Dublin, and became public analyst for twelve Irish county councils. In this connexion, it is of interest to note that all the members of her laboratory staff are women graduate chemists. She has concerned herself vigorously with the organization of the chemical profession in Ireland and is a past president of the Irish Chemical Association. Her new sphere of activity will, unfortunately, prevent her from continuing to take an active part in the work of her profession.

Educational Director of the British Council : Dr. A. E. Morgan

Dr. A. E. Morgan has been appointed educational director of the British Council and will take up his duties early next month. The post was formerly held by Prof. B. Ifor Evans, who resigned it on appointment as principal of Queen Mary College about a year ago but has continued to assist the Council in an advisory capacity. Dr. Morgan, a native of Bristol, was educated at the then University College there, and at Trinity College, Dublin. He became lecturer in, and then professor of, English language and literature in the University College, Exeter, and later occupied a similar chair in the University of Sheffield. In 1926 he was appointed principal of University College, Hull; and during 1935–37 he was principal and vice-chancellor of McGill University, Montreal. Dr. Morgan became chief special officer for national service, Ministry of Labour, in 1939, and was thereafter a district commissioner for the Special Areas (Durham and Tyneside), and regional information officer at Newcastle-on-Tyne. Since 1941, he has been assistant secretary, Ministry of Labour. The period for which Mr. H. Orton, the acting educational director of the British Council, was seconded to the Council from the University of Sheffield ends on August 31, and he will then resume his duties as head of the Department of English Language at Sheffield.

The R. W. Paul Instrument Fund

The R. W. Paul Instrument Fund was established by a trust created under the will of Mr. R. W. Paul, who died in March 1943. The income from the fund will be administered by a committee composed of representatives of the Royal Society, the Physical Society, the Institute of Physics and the Institution of Electrical Engineers. The committee will consider and adjudicate upon applications which may be submitted for financial assistance by means of grants for the following purposes : (*a*) for the design, construction and maintenance of novel and improved types of physical instruments and apparatus for investigations in pure and applied physical science, particularly in cases where a relatively large expenditure may be justified on experimental apparatus. (*b*) For the assistance of research by provision of equipment, building facilities or financial or other aid in such manner as the committee may determine in each case. Grants from the fund shall not be used to relieve expenditure in any establishment controlled by the Government, or to relieve any university or other educational establishment of its normal financial obligations. When an application is favourably regarded by the committee, an assessor will be appointed to advise in detail on the merits of the application, the feasibility of producing the desired result by means of the proposed instrument or apparatus, the urgency of the need for it and the probable cost of execution of the work.

After a grant has been made, the assessor will report to the committee not less than once every three months on the progress of the work. He may in his discretion recommend additional grants for running and maintenance costs and salaries for the time being of investigators and assistants engaged in a particular investigation, provided that no research fellowship or research scholarship is thus created. The committee will decide the ultimate destination and ownership of all instruments and apparatus produced by means of grants from the fund. Any invention or improvement in existing inventions made by a grantee must be communicated forthwith to the committee, and no grantee may apply for, or obtain, patent rights for such invention without the previous sanction in writing of the committee. Applications may be submitted by any worker or group of workers in Great Britain. Applicants must be British subjects and their qualification in physical research must be supported by the signed recommendations of not less than two of the following persons : (i) president of the Royal Society (if a physicist), or alternatively, the secretary of the Royal Society dealing with physical subjects ; (ii) president of the Physical Society ; (iii) president of the Institute of Physics ; (iv) president of the Institution of Electrical Engineers. Applications should be addressed to the Assistant Secretary of the Royal Society, Burlington House, London, W.1.

Industrial Research Committee of the Federation of British Industries

At a recent meeting of the Grand Council of the Federation of British Industries, it was announced that Mr. B. J. A. Bard has been appointed head of the F.B.I. Research Secretariat and secretary of the F.B.I. Industrial Research Committee. Mr. Bard carried out fuel research under the late Prof. W. A. Bone in the Chemical Technology Department of the Imperial College of Science and Technology, and then read for the Bar ; he practised at the Bar until the outbreak of war, after which he worked first with the Coal Commission and, later, on various industrial production and research problems at the Ministries of Supply and Aircraft Production. The duties and functions of the research secretariat will include the encouragement and fostering of industrial and national interest in research, maintaining contact with all industrial research organizations, and providing a service whereby advice, assistance and information can be obtained and contacts made. Close touch is being maintained with the Department of Scientific and Industrial Research, which is represented on the F.B.I. Industrial Research Committee. A first task will be the organization of a survey of existing research facilities in Britain. Another immediate plan of the Industrial Research Committee is a proposal for a two-day conference, to be held in London in the autumn, of those who are organizing or conducting research in industry, in order that they may present their views and give the results of their experience to industry.

The Industrial Research Committee of the Federation of British Industries is constituted as follows : Sir William Larke (*chairman*), Dr. S. B. Bagley, Sir

Peter Bennett, Mr. W. Bond, Mr. O. F. Brown, Dr. W. T. K. Braunholtz, Dr. P. Dunsheath, Mr. T. A. Fairclough, Dr. W. H. Glover, Dr. W. T. Griffiths, Mr. A. L. Hetherington, Lord Melchett, Mr. R. O'F. Oakley, Dr. C. C. Paterson, Sir Robert Pickard, Mr. R. K. Sanders, Dr. R. E. Slade, Sir Frank Smith, Mr. S. K. Thornley, Mr. B. J. A. Bard (secretary to the Committee and head of the F.B.I. Industrial Research Secretariat).

International Collaboration

THE publication as a "Penguin Special" (price 9*d.*) of E. R. Stettinius' "Lend-Lease: Weapon for Victory" shortly after its original publication as a substantial work of 358 pages (New York: The Macmillan Company; London: Macmillan and Co., Ltd.) is a real service to Anglo-American understanding. Intended originally to facilitate the understanding in the United States of the Lend-Lease Act, it should contribute equally in Britain to the same end. This is important, because, if the new lend-lease agreement with the United States announced in November by the Prime Minister is to be fully understood, it must be remembered that the Lend-Lease Act is for the defence of the United States, and is strictly limited to what is necessary for the effective prosecution of the War by the United States and its Allies. The picture which Mr. Stettinius here paints of the way in which Lend-Lease developed and of the magnitude of the contribution which has been made to victory in Europe in this way is most impressive in its demonstration of the possibilities of collaboration between the United Nations and of the advantages which all might reap from the pooling of economic resources in facing the tasks and problems of peace. At a time when the organization of world order is receiving close attention, it is well that there should be made so widely available such an admirable account of one great experiment in international collaboration which has played a large part in bringing the war in Europe to a successful conclusion. The principle of mutual aid embodied in the Lend-Lease Act and agreements will not come to an end when the war with Japan ends: to it we must also look for the strength to build a world in which freedom and opportunity are secure for all.

British Grassland Society

AT the Fourth International Grassland Congress held in Great Britain in 1937, a group of grassland specialists met to consider the advisability of forming a society in the United Kingdom to promote the study of grassland husbandry. The outbreak of war prevented further progress with the scheme, but in November 1944 a group interested in grassland research met to discuss the foundation of a British Grassland Society, the activities of which would be field tours, discussions and the publication of a journal. The Society was formed early in 1945 and the first meeting was held at Stratford-on-Avon during June 20–22. About one hundred and fifty members attended. At the opening general meeting the following committee and officers were elected for 1945: *President*, Sir R. George Stapledon; *Vice-President*, Dr. Wm. Davies; *Committee*, J. H. Faulder, H. J. Gill, W. D. Hay, F. R. Horne, Prof. T. J. Jenkin, M. G. Jones, Prof. S. J. Watson; *Secretary*, Dr. R. O. Whyte; *Treasurer*, P. A. Linehan; *Editor*, Dr. H. I. Moore. The office of the Secretary is at the Agricultural Research Building, Aberystwyth. It was agreed at this meeting that membership should be confined in the meantime to scientific and technical officers of Ministries, research institutes, war agricultural executive committees and similar bodies. Specialists in countries other than Great Britain can become members.

During the meeting, members visited the Grassland Improvement Station at Drayton, its former substation at Colesbourne in the Cotswolds and representative grassland areas in Leicestershire. At Drayton, herbage crops in seed production and leys of different age, history, seeds mixtures and seeding rates were inspected. An interesting feature of the work at Drayton is the increasing emphasis which is being placed on the interpretation of sward improvement through the animal rather than by means of botanical or chemical analyses alone; live-weight production trials accompanied the experiments. At Colesbourne there were fertilizer trials accompanying the establishment of leys and the seed production of various forage crops. Visitors were impressed at the productivity obtained from this thin Cotswold soil which only three years ago was derelict turf and dense thorn bush. Those from the north were particularly interested in the crops of sainfoin. In a tour through Leicestershire members inspected trials of cocksfoot, perennial ryegrass and other grasses conducted jointly by the Royal Agricultural Society of England and the Leicestershire War Agricultural Executive Committee at Dunton Bassett and Thorpe Langton. They saw the trial now in progress on the famous Mill Field at Medbourne to compare beef production on an old pasture (about one hundred and fifty years old) with that on a new ley in an adjacent field. Members also inspected ley farming and a grass and grain drying plant at Skeffington. Future plans of the Society will be decided shortly. There will probably be an autumn meeting at which papers will be read and a field meeting next summer in some other part of Great Britain. It is proposed to publish a journal, which will be available to members under their subscription to the Society (21*s.* per annum), and to others at a subscription rate to be decided.

Education and Training of Aircraft Workers

THE Royal Aircraft Establishment of the Ministry of Aircraft Production has just issued an interesting and informative pamphlet on the general subject of aeronautical training. If, says the pamphlet, Great Britain is to maintain its superiority in the air, we must enlist the help of intelligent young men and young women, and give them a training in an attractive career full of possibilities. The basis of the scheme now proposed is the highly efficient technical college which has been built up as an integral part of the Establishment. The scheme set forth in the pamphlet is a system of apprenticeship, the apprentices being of three types: (1) engineering apprentices, who are trained to become aeronautical research engineers, and are drawn from boys who have attained a high standard of secondary school education; (2) craft apprentices, who are trained to become skilled craftsmen for service in laboratories and in experimental work; and (3) laboratory assistants, who are employed in the research laboratories, and must have obtained a school-leaving certificate with credit in science and mathematics. Details are given concerning the course of training for each of the three types of apprentice. The course in each case

is prolonged and thorough, and it is shown that for each type there is the possibility and the promise of a successful career.

What are Comets ?

Cienciae Investigación No. 2, February 1945, contains an article with the title "¿ Qué son los cometas ?" by Enrique Gaviola, director of the Córdoba Observatory, which gives a short account of comets from ancient times up to the present. There is nothing new in the article, but it provides a useful summary of our knowledge of these visitors, dealing with the spectrograms of the gases in the head and tail, the masses deduced by the perturbations or lack of perturbations produced by comets, changes in luminosity due to varying distances from the sun, light pressure on the smaller particles, etc. The author conjectures that the asteroids were once brilliant comets—a view which is entertained by others, but lacking in conclusive evidence. There is a very fine photograph of Halley's Comet taken at Córdoba Observatory on May 7, 1910.

Recent Earthquakes

DURING January 1945, ten earthquakes were registered at the seismological observatory at Toledo, Spain. The greatest of these was on January 12, when an earthquake, registering initially at 18h. 52m. 01s. G.M.T., developed an amplitude of 50 μ at 19h. 36m. 13s. G.M.T. on the east-west component. The epicentral distance has been provisionally estimated at 12,830 km. During the same month one strong distant earthquake was registered at the Dominion Observatory, Wellington, New Zealand. This was on January 28 at 07h. 37m. 18s. G.M.T. from an epicentral distance of approximately 22°. The shock was also registered at Christchurch, Auckland and Arapuni. In New Zealand there were twelve shocks humanly felt in the Dominion during the month. The greatest of these was on January 2. It was felt with intensity 5 (Modified Mercalli Scale) in the North Island, south of Wairo Taupo and Wanganui. On January 1 a shock was also felt at Wairo with intensity 5 (Mod. Mer.). The United States Coast and Geodetic Survey, in co-operation with Science Service and the Jesuit Seismological Association, has determined the provisional epicentre of the earthquake of January 12 to be near lat. 34° N., long. 139° E., which is off the coast of Japan, to the south of Tokyo.

During February 1945, fourteen strong earthquakes were registered at the observatory at Toledo, Spain. The strongest of these occurred on February 10 and registered at Toledo at 05h. 11m. 09s. G.M.T., attaining a maximum ground amplitude at Toledo of 115 μ on the north-south component at 05h. 50m. 35s. G.M.T. The epicentral distance is estimated at 10,440 km. The shock of February 20 is estimated to have had its epicentre 660 km. from Toledo. The earthquake of February 18 was recorded at Kew, as was also that of February 26. The United States Coast and Geodetic Survey, in co-operation with Science Service and the Jesuit Seismological Association, has determined the provisional epicentre of the earthquake of February 10, from instrumental reports from twenty-one observatories, to have been at lat. 41·5° N., long. 142° E., which is off the coast of Japan to the east of Hakodate. The initial time was 4h. 57·9m. G.M.T.

During March 1945, Mr. E. W. Pollard recorded seven earthquakes at his observatory at Binstead, Isle of Wight. Three occurred on March 18.

The Film in Science

THE Scientific Film Association is holding a conference on "The Film in Science" at the Technical College, Huddersfield, during August 31—September 2. The opening address will be given by Mr. Arthur Elton, president of the Association, and there will be sessions on the film in education, industry and medicine, and as an instrument of research. Dr. W. T. Astbury will give a lecture on the X-ray examination of proteins. There will be a display of visual aid equipment. Registration forms to attend the conference, and further particulars, can be obtained from the secretary of the Association, c/o Royal Photographic Society, 16 Princes Gate, London, S.W.7.

United Nations Educational Conference in London

A CONFERENCE is to be held in London on November 1 next to consider the establishment of a United Nations Educational and Cultural Organization. The Conference of Allied Ministers under the chairmanship of Mr. Richard Law, Minister of Education, at a meeting in London on July 12, unanimously agreed that the British Government be asked to invite on its behalf the Governments of all the United Nations to send delegates to this conference. A working committee will be set up in London to make preparations for the conference and to assemble and collate opinions and proposals as to the scope and methods of operation of the organization. Draft proposals for the constitution of the organization, prepared by the Conference of Allied Ministers, will be issued shortly and will form the basis of discussion at the forthcoming conference.

Announcements

DR. ALEXANDER S. WIENER, of New York University, has been awarded the Alvarenga Prize for 1945 of the College of Physicians of Philadelphia, "in recognition of his important work upon the various types of *Rh* factors and on their genetic transmission". Dr. Wiener will give the Alvarenga Lecture before the College of Physicians of Philadelphia and the Philadelphia County Medical Society on October 3, 1945, on "*Rh* Blood Factors in Clinical Medicine". This Prize was established by the will of Pedro Francisco daCosta Alvarenga of Lisbon, Portugal, an associate fellow of the College of Physicians of Philadelphia, "to be awarded annually by the College of Physicians on each anniversary of the death of the testator, July 14, 1883". The College usually makes this award for outstanding published work, and invites the recipient to deliver an Alvarenga Lecture before the College.

THE Council of the University of Sheffield has made the following appointments: Dr. H. Motz to be lecturer in engineering physics; Dr. James White to be lecturer in refractory materials in the Department of Metallurgy. Dr. C. Gray Imrie, lecturer in physiology, and Mr. J. MacA. Croll, lecturer in bacteriology, have resigned. Mr. C. H. Hainsworth, lecturer in electrical engineering, and Dr. W. J. Rees, lecturer in refractories, are retiring under the age limit. The Yorkshire Mine Workers' Association is to provide two scholarships in 1946, each of an annual value of £180, open to members of the Association and tenable for a full-time degree course in mining at the University.

LETTERS TO THE EDITORS

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

Anærobic Metabolism of Spermatozoa

It was shown by Iwanow[1] and Redenz[2] that the presence of oxygen is not essential for the survival of the spermatozoa and that they retain their motility under anærobic conditions provided that glucose is present. Later, it was demonstrated conclusively that the metabolism of spermatozoa is predominantly of glycolytic character[3,4,5,6,7]. Up to the present, however, the studies have been largely confined to the investigations of optimal conditions, various substrates and inhibitors of sperm glycolysis, leaving open the question concerning the glycolytic pathways and the enzymes involved in the anærobic processes. The presence in sperm of adenosinetriphosphate, one of the essential factors of glycolysis, has been assumed on the grounds that the sperm contains a phosphate fraction which breaks down to *ortho*-phosphate after short hydrolysis in acid[8].

The experiments recorded below were carried out mainly with ram semen, which is particularly suitable for metabolic studies because of the exceptionally high concentration of spermatozoa (2·5–5 million per 1 μl. semen). The semen was collected by Dr. A. Walton and Dr. L. Villalobos at the Animal Research Station, Cambridge. It was brought to the laboratory within an hour after ejaculation, it was then diluted with 5–10 volumes of calcium-free Ringer-bicarbonate solution, centrifuged, and finally the sperm was re-suspended in fresh Ringer solution up to the original volume of the whole semen. Aerobically, such a suspension has a high respiratory activity which remains constant for several hours and compares favourably with the respiration of the whole semen. In the presence of added glucose, the respiration is partly replaced by an ærobic glycolysis. Spectroscopic examination of the sperm suspension reveals the spectrum of all three cytochromes. When air is replaced by nitrogen or by a mixture of 95 per cent nitrogen and 5 per cent carbon dioxide, the cytochromes become fully reduced and the glycolysis rises to reach a level of 100–600 mgm. lactic acid per 100 ml. sperm, per hour, at 37°. With such a sperm suspension the following observations were made.

(1) Spermatozoa contain adenosinetriphosphate which was isolated quantitatively in the form of the barium salt. The amino-group was identified by means of the muscle deaminase, the phosphate groups by acid hydrolysis and subsequent estimation of *ortho*-phosphate. The content was 0·6–1·5 mgm. per cent amino-nitrogen and 2·6–6·6 mgm. per cent easily hydrolysable phosphorus.

(2) When spermatozoa are incubated anærobically without glucose, their content of adenosinetriphosphate decreases rapidly, while in the presence of glucose it can be preserved much longer. This behaviour is in agreement with the observation that in spermatozoa stored anærobically motility is maintained more satisfactorily in the presence than in the absence of a glycolysable substrate.

(3) The metabolism of glucose in the sperm is initiated by the shift of the labile phosphate groups from adenosinetriphosphate to glucose. The enzyme which catalyses this reaction resembles the hexokinase of yeast. Using 1 ml. of sperm to which glucose, adenosinetriphosphate and 0·04 *N* fluoride were added, one finds after one hour at 37° that nearly half the readily hydrolysable phosphorus of adenosinetriphosphate is esterified with the hexose. Without fluoride a large proportion of adenosinetriphosphate breaks down rapidly with the liberation of all three phosphate groups as *ortho*-phosphate. This breakdown, however, unlike that in certain other animal tissues, is not accompanied by the deamination of the amino-group of the nucleotide; in fact, it has been found that the semen has scarcely any deaminase activity towards adenosinetriphosphate, adenylic acid and adenosine. But in semen kept for several hours under sterile conditions, large amounts of ammonia accumulate. This evolution of ammonia does not depend on the presence of intact spermatozoa; it occurs also in the seminal fluid itself. Furthermore, it is accompanied by a sharp rise in the non-protein nitrogen, which exceeds considerably the ammonia nitrogen.

(4) Monophosphohexose added to a suspension of surviving sperm is further phosphorylated in the presence of adenosinetriphosphate. To study the action of the phosphopherase involved in this reaction, the Embden ester was used. This compound was scarcely metabolized by the sperm alone and yielded no lactic acid. However, on the addition of adenosinetriphosphate, the Embden ester was phosphorylated to diphosphohexose and lactic acid was produced. Of 2 mgm. phosphorus added as monophosphohexose to 1 ml. sperm, 26 per cent appeared after 30 min. as readily hydrolysable phosphorus of diphosphohexose.

(5) Diphosphohexose is broken down by spermatozoa and oxidized to phosphoglyceric acid. The oxidation is coupled with a reduction of pyruvic acid to lactic acid. This reaction is inhibited by 0·001 *N* iodoacetate but not by 0·04 *N* fluoride. The dehydrogenases which catalyse the oxido-reduction depend for their activity on the presence of cozymase. The oxido-reduction is coupled with a phosphorylation of adenylic acid to adenosinetriphosphate. One molecule of lactic acid is formed for each molecule of inorganic phosphate which disappears. For example, 1 ml. sperm incubated anærobically at 37° for 30 min., with 0·6 ml. 0·3 *N* pyruvate, 0·3 ml. 0·15 *N* diphosphohexose (Harden – Young ester), 0·4 ml. 0·16 *N* adenylate, and in presence of cozymase, inorganic phosphate *p*H 7·3 and 0·04 *N* fluoride, brought about the disappearance of 1·37 mgm. inorganic phosphorus, and the formation of 3·77 mgm. lactic acid; and synthesized an amount of adenosinetriphosphate corresponding to 0·318 mgm. amino-nitrogen and 1·4 mgm. readily hydrolysable phosphorus.

(6) Phosphoglyceric acid added to the sperm is metabolized very slowly. However, in the presence of adenylate it is rapidly converted to pyruvic, and eventually to lactic acid. The phosphate group of phosphoglyceric acid is taken up by adenylic acid, and reconstituted adenosinetriphosphate is made available again for the initial stages of glycolysis, namely, the phosphorylation of hexose and of monophosphohexose. When 1 ml. sperm was incubated anærobically for 30 min. with 3 mgm. phosphorus in the form of phosphoglycerate, the result was 0·13 mgm. pyruvic acid, 0·3 mgm. lactic acid and 0·25 mgm. inorganic phosphorus. In presence of adenylate, however, the same amount of phosphoglycerate yielded 3·45 mgm. pyruvic acid, 1·62 mgm.

lactic acid, 1·3 mgm. inorganic phosphorus, 30 per cent of the added adenylate being converted to adenosinetriphosphate.

(7) All these enzymic processes are not necessarily restricted to anærobic conditions but occur in aerobically glycolysing spermatozoa as well. They also take place in the sperm of other animals. Bull semen, for example, contains 0·4 mgm. per cent of adenosinetriphosphate amino-nitrogen and is distinguished by a high rate of the phosphorylative oxido-reduction. No lactic acid is produced from glycogen by washed spermatozoa of either ram or bull.

Two major points emerge from this investigation. The fact is established that a close relationship exists between the activity of the spermatozoa on one hand, and the glycolysis mediated by adenosinetriphosphate on the other hand. Next, it is shown that the glycolytic pathways and enzymes involved in the anærobic metabolism of spermatozoa bear resemblance to those of other animal tissues and yeast. Hitherto, the study of enzymes concerned with the glycolysis involved for the most part the use of purified systems separated from the cell structure (for example, muscle, yeast); objections were occasionally raised that results obtained in this manner may not depict the true function of those enzymes inside the cells. However, with spermatozoa the course of reactions catalysed by the glycolytic enzymes has been explored in the cells themselves.

This work is being carried out on behalf of the Agricultural Research Council.

T. Mann.

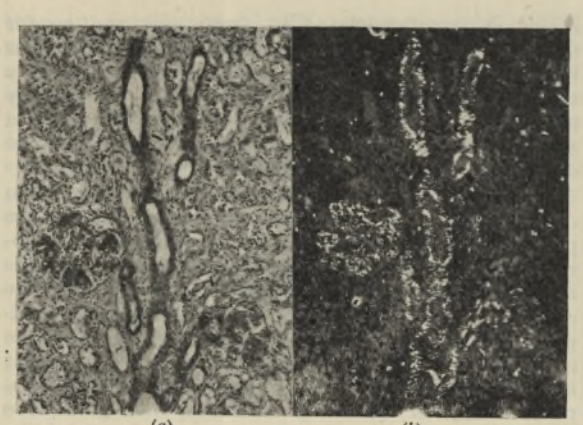
Molteno Institute,
University, Cambridge.

[1] Iwanow, E. E., *Z. Zücht. B.*, **20**, 404 (1931).
[2] Redenz, E., *Biochem. Z.*, **257**, 234 (1933).
[3] Comstock, R. E., *J. Exp. Zool.*, **81**, 147 (1939).
[4] MacLeod, J., *Amer. J. Physiol.*, **132**, 193 (1941).
[5] Lardy, H. A., and Phillips, P. H., *Amer. J. Physiol.*, **133**, 602 (1941); **138**, 741 (1943); *J. Biol. Chem.*, **148**, 343 (1943).
[6] Moore, B. H., and Mayer, D. T., Univ. of Missouri Res. Bull. No. 338 (1941).
[7] Henle, G., and Zittle, C. A., *Amer. J. Physiol.*, **136**, 70 (1942).
[8] Lardy, H. A., Hansen, R. G., and Phillips, P. H., *Arch. Biochem.*, **6**, 41 (1945).

Double-Refringence of the Amyloid-Congo-Red-Complex in Histolcgical Sections

The Congo-red reaction of amyloid in histological sections is the only amyloid stain providing durable preparations. It has, however, so far proved of limited value, as its specificity is compromised by certain hyaline, mucous, fibrinoid or elastic tissue components also 'taking' Congo-red.

We have been able to show that this method can be brought to a very high level of specificity by using it in combination with polarization microscopy. Amyloid structures unstained or stained by the usual routine and other specific methods present no double-refringence of practical importance; but they reveal a very sharp, though not particularly sparkling, optical anisotropy after Congo-red staining (see reproduction). For demonstration, a very bright, unfiltered light source was used. The colour of the effect changes during rotation through 360° of the optical axes of the preparation twice from yellow to green, if conditions are optimal. Other Congo-positive but non-amyloid tissue components do not show this newly acquired double-refringence. Certain hyalines, etc., however, may be strongly anisotropic by themselves, a fact which is argument enough against their being regarded as amyloid.



(*a*) (*b*)

Kidney (No. PI. 93/45). Cortical zone with amyloid degeneration of interlobular artery and two Malpighian bodies. Formalin-fixing, paraffin section, 7 *μ*, hæmatoxylin Congo-red stain: (*a*) between parallel nicols; (*b*) between crossed nicols. × *c.* 50.

Besides the practical importance in histopathology of the phenomenon reported, this 'induced double-refringence' may well be of theoretical interest in connexion with the submicroscopical make-up of amyloid and the physico-chemical mode of interaction between Congo-red as a specific staining matter and amyloid as its 'substratum'. It would, indeed, be most interesting to study similar cases of more or less isotropic systems becoming doubly-refringent by their interaction with isotropic colloidal solutions.

The following details on the effect have so far been gathered (in all experiments, Congo-red from E. Merck, Darmstadt, was used): (1) Congo-red precipitates show no direct optical anisotropy, and Congo-red solutions show no stream double-refringence. (2) The effect depends on the actual presence of Congo-red in the amyloid structures; if the stain is washed out from a section, the double-refringence formerly established disappears. Moreover, the double-refringence appears brighter the more strongly the stain has 'taken', a ratio in which the thickness of the section is equally involved. (3) The effect can be observed in slices mounted in balsam as well as in glycerol, glycerol-gelatine or physiological salt solution. Freezing and paraffin sections do not make any appreciable differences in producing the effect. (4) As to the effect of tissue-fixing, the 'pictures' resulting from formalin and alcohol fixation are equally good. Material fixed in Zenker's solution (containing mercuric chloride, potassium bichromate and acetic acid) proved, however, less favourable; apart from the fact that precipitates occurring in the sections are disturbing by their sparkling double-refringence, the effect, in itself, seems to be far less obvious, even if the precipitates are totally or partly removed by iodine treatment, notwithstanding the fact that the amyloid structures are showing a brilliant Congo-red stain. This might well be the effect of blocking certain reactive groups in the amyloid molecule complex by chromium or mercury, groups which otherwise would have taken part in the reaction with Congo-red. Experiments on this are still in progress; it may be mentioned, however, that iodine treatment of alcohol-fixed material, previous to Congo-red staining, does not necessarily cause a reduction of the ensuing double-refringence. (6) Among acid diazo-

stains chemically related to Congo-red and so far tested for similar properties, only Congo-rubin has been found to produce a certain induced anisotropy with amyloid; this effect, however, is not so readily reproduced as in the case of Congo-red. Trypan-red and trypan-blue may or may not have a very slight similar effect.

The following preliminary conclusions have been drawn from the observations: the double-refringence produced by the interaction of amyloid and Congo-red is an essential and not an accidental one; this is evident by its being largely independent of the refractive index of the imbibition liquid. The amyloid-protein substructure seems to include reactive groups in a certain regular distribution and arrangement in space which allow the Congo-red molecule complexes to fit in by means of corresponding reactive groups in such a way as to create a crystal-like structure.

Peter Ladewig.

Institute of Experimental Pathology
and Cancer Research,
University of Istanbul.
March 19.

Stabilization of Penicillin Solutions by Phosphate

Although penicillin in aqueous solution is rather more stable than was originally supposed, there is, nevertheless, an appreciable loss of activity in a few days at room temperature and in a few minutes at 100° C. We have found it possible greatly to stabilize penicillin solutions by the addition of phosphate (Sørensen's buffer solution). That this is not due to an effect on *p*H was shown by parallel experiments with penicillin in water alone, the *p*H of which was carefully regulated to that of the phosphate solutions.

The degree of stabilization depends on the sample of penicillin, the concentration of penicillin in the solution, and the concentration of phosphate. For example, in 15 min. at 100° C. and a concentration of penicillin of 5 u./ml., one sample lost 50 per cent of its activity in water and 5 per cent in *M*/15 phosphate; a second sample lost 25 per cent in water and 5 per cent in phosphate (see table). Different samples differ also in the amount of phosphate which gives maximal protection; with a concentration of 5 u./ml. penicillin, one sample was protected most by *M*/100 phosphate; a second by *M*/30 phosphate, whereas with a third there was increasing protection with increasing phosphate concentration up to and apparently beyond *M*/3 phosphate.

Destruction of penicillin solutions at 100° for 15 min. in the absence and presence of phosphates. Figures give percentage penicillin destroyed. Phosphate concentration *M*/15.

Sample	Concentration of penicillin							
	5 u./ml.		50 u./ml.		500 u./ml.		5,000 u./ml.	
	water	phos-phate	water	phos-phate	water	phos-phate	water	phos-phate
1	50	5	10	15	30	10	35	5
2	50	5	50	10	70	20	50	15
3	25	5	—	—	5	10	30	10

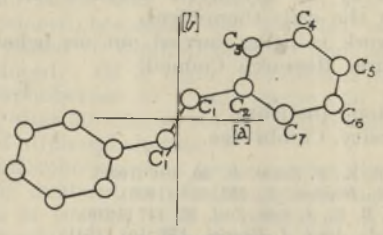
There are several practical applications of these findings. Perhaps the most important is that solutions of penicillin, which frequently become contaminated with organisms such as *Ps. pyocyanea*, may be sterilized by boiling for a few minutes in the presence of phosphate, with but little loss in potency. Secondly, if only small quantities of penicillin are required out of the usual phial of 100,000 units, the addition of phosphate will make it possible to keep the unused portion of the solution for several days with little loss of activity.

R. J. V. Pulvertaft.
John Yudkin.

Command Laboratory,
Northern Command,
York.

Structure of Dibenzyl

With the early work of J. M. Robertson[1] as a sound basis, the crystal structure of dibenzyl has been determined more accurately, using more than seven hundred experimental structure amplitudes in modern three-dimensional Fourier methods, including the new syntheses devised by A. D. Booth[2]. For the first time in Great Britain, professional aid was enlisted for the laborious calculation of the final Fourier synthesis and theoretical structure factors through the co-operation of the Scientific Computing Service.



C_6H_5–CH_2CH_2–C_6H_5

The molecule of dibenzyl has a centre of symmetry, and with the nomenclature shown in the figure the interatomic dimensions are as follows:

C'_1-C_1	1·48 A.	C_4-C_5	$1{\cdot}36_5$ A.
C_1-C_2	1·50	C_5-C_6	$1{\cdot}36_5$
C_2-C_3	1·37	C_3-C_4	1·39
C_2-C_7	1·36	C_6-C_7	1·39

$C'_1C_1C_2 = 115°$; all angles associated with the benzene rings, 120 ± 1°. The C'_1C_1 bond is inclined at 72° to the plane of the benzene rings.

The atomic parameters were derived directly from the maxima of the Fourier peaks, and no assumptions were made about the fine details of the structure. It is therefore possible to get a measure of the accuracy of the analysis from the geometry of the molecule; for example, the opposite sides of the benzene ring are parallel and C_1-C_2 is collinear with C_2-C_5 within 0·5°. Discrepancies of this order suggest that the values given above are reliable to ±0·01 A. and ±1°.

The special interest of these results lies in the acyclic single-bond distances, which are shorter than the normal value of 1·54 A. The system of two benzene rings separated by three single bonds is analogous to the 1 : 5-dienes and polyisoprenes, and that it should possess unusual structural features is in keeping with observations on this class of compounds instanced by the chemistry of certain carbalkoxyl derivatives of hexadiene[3] and the structure of geranylamine hydrochloride[4].

A detailed description of the structure analysis and discussion of the results will be published elsewhere.

G. A. JEFFREY.
British Rubber Producers' Research Association,
48 Tewin Road, Welwyn Garden City.

[1] Robertson, J. M., *Proc. Roy. Soc.*, **A, 146**, 473 (1934); **A, 150**, 348 (1935).
[2] Booth, A. D., *Trans. Farad. Soc.*, in the press.
[3] Bateman, L., and Jeffrey, G. A., *J. Chem. Soc.*, 211 (1945).
[4] Jeffrey, G. A., *Proc. Roy. Soc.*, A, **183**. 388 (1945).

Crystal Structure of Diamond

IN a recent communication in *Nature*[1], Mrs. Lonsdale has questioned the statement made by Sir C. V. Raman[2] that the X-ray data leave the question whether diamond possesses tetrahedral or octahedral symmetry of structure entirely open. The present communication is a reply to some of the specific points raised in her letter.

As is well known, the structure of diamond consists of two interpenetrating face-centred cubic lattices, the two atoms in the basis having the co-ordinates 000 and $\frac{1}{4}\frac{1}{4}\frac{1}{4}$. From the fact that the atoms occupy these special positions in the lattice, it follows that they must possess tetrahedral (*Td*) symmetry of structure, which may be visualized by drawing a set of planes passing through the atomic nucleus and parallel to the cubic and dodecahedral planes, and thereby dividing up the whole electronic cloud into 48 pyramids. Tetrahedral symmetry requires that if the charge distribution in one of these pyramids is specified, those in 23 others should also be the same, these 24 pyramids being distributed (six each) in four non-adjacent octants of the sphere drawn round the nucleus. The charge distributions in the remaining 24 pyramids would also be identical, but different from those in the first set.

As a consequence of the tetrahedral symmetry of the atoms, the crystal as a whole would also possess the same symmetry, except in the special case when the electronic states and configurations of the two atoms are exactly identical and geometrically symmetric about a point midway between them ($\frac{1}{8}, \frac{1}{8}, \frac{1}{8}$). It is easily proved, however, that this special relationship, which results in a higher or octahedral symmetry for the crystal, is not a necessary condition either for the non-appearance of the 200 X-ray reflexion nor for the appearance with a low intensity of the 222 X-ray reflexion. The vanishing of the 200 reflexion is secured if the radial distribution of electronic charge, when *summed up* for a pair of opposed pyramids in each atom, is the same for both the atoms in the basis. This means that the total charge in a spherical shell surrounding the nucleus, and consequently also the integrated total charge, is the same for both atoms. The fact that diamond does not exhibit either piezo- or pyro-electricity thereby becomes intelligible. Further, the 222 X-ray reflexion would only vanish in two special cases, namely, (*a*) when each atom is octahedrally symmetrical, or (*b*) when the atoms are tetrahedrally symmetrical, but the radial distributions of charge are identical in similarly directed pyramids in the two atoms.

Prima facie, neither of these special conditions can be expected to exist; as a result of the valence binding, the electronic distribution would in general tend more towards identity in opposing pyramids than in parallel ones. The appearance of a 222 reflexion is thus naturally to be expected. But any departure, however small, from identity and symmetry of the distributions in opposing pyramids would result in the structure as a whole possessing only tetrahedral and not octahedral symmetry. The spectroscopic behaviour of diamond shows beyond all possibility of doubt that this is so in the majority of cases.

G. N. RAMACHANDRAN.
Department of Physics,
Indian Institute of Science,
Bangalore.
May 17.

[1] Lonsdale, K., *Nature*, **155**, 144 (1945).
[2] Raman, Sir C. V., *Proc. Ind. Acad. Sci.*, A, **19**, 189 (1944).

Energy Spectrum of Mesotrons at Low Energies

THE energy spectrum of cosmic rays has been studied by means of magnetic analysis by Blackett[1], Jones[2] and Hughes[3]. In the present experiment, information regarding the low-energy part of the mesotron spectrum has been obtained from analysis of the absorption curves of cosmic rays in lead and water.

The curves *ABCDE* and *AIJK* in Fig. 1 represent the absorption curves of cosmic rays in lead and water respectively taken under identical conditions. In each case the variation in the number of coincidences with different thickness of absorber interposed between the upper counters of a counter telescope is represented as a function of the absorber thickness.

In the analysis of these curves, it is assumed that the part *CDE* of the lead absorption curve, obtained with a thickness of lead greater than 10 cm., is entirely due to cosmic ray mesotrons. The portion *ABC*, corresponding to a thickness of lead less than 10 cm., represents the rate of absorption of electrons of all energies and of mesotrons with range less than 10 cm. lead or *pc* less than $2{\cdot}3 \times 10^8$ e.v. (Rossi and Greisen[4]).

The effect of the electronic part of the cosmic radiation transmitted through different thickness of an absorber may be determined from a comparison of the relative absorption in two substances (Greisen[5]). Then by subtraction from the total absorption curve, the rate of absorption of mesotrons alone, separated from that of the electrons, may be obtained.

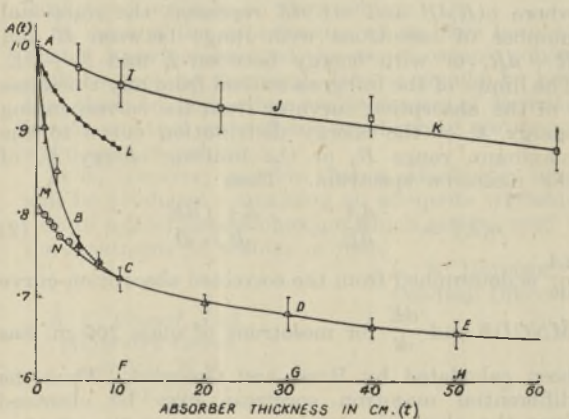


Fig. 1.

We choose water and lead as the two absorbers because the critical energies of these substances differ very greatly. In the case of water, the critical energy is higher and is $1{\cdot}1 \times 10^8$ e.v. As the radiation loss for electrons becomes appreciable for energies higher than the critical energies, and as at sea-level there are very few electrons above 10^8 e.v., one may reasonably assume that the water absorption curve *AIJK* represents mainly the rate of stoppage of electrons and mesotrons due to ionization only.

Now, so far as ionization loss is concerned, 1 cm. of water is equivalent to 0·16 cm. of lead. With this reduction ratio, the curve *AIJK* may be reduced to the lead scale. The reduced curve is shown by *AL*. *AL* represents the rate of absorption of cosmic particles in lead if there were no radiation loss, whereas the actual curve *ABC* represents the rate of absorption of mesotrons due to ionization and of electrons due both to radiation and ionization.

If we extrapolate the absorption curve beyond 10 cm. which is due to mesotrons only in the same ratio as the curve *AL*, we obtain the complete absorption curve of mesotrons and of those electrons which are stopped due to ionization in lead, that is, with energies below the critical energy of lead, 7×10^6 e.v. The curve *MNCDE* obtained in this way really represents the absorption of cosmic ray mesotrons in lead, as electrons with energies less than 7×10^6 e.v. will be stopped by the walls of the counter.

As a check on this result, we have used the calculations of Bhabha[6]. He recently estimated the number of cosmic ray electrons that may be expected to be recorded at sea-level by means of a counter telescope, such as we have used, with different thicknesses of lead interposed between the counters. The ordinates of the total lead absorption curve *ABC* may be corrected for the number of transmitted electrons as suggested by Bhabha. The calculated points indicating mesotron intensity alone are shown in the graph by circles and are found to lie on the curve *MNCDE*, proving that this is entirely due to cosmic ray mesotrons.

In order to obtain the differential energy spectrum from the absorption curve, we assume that for a mesotron of a definite energy E, there is a fixed range of R cm. of lead. The ordinate of the absorption curve $A(t)$ at a thickness t cm. may then be represented as

$$A(t) = \int_t^{R_0} n(R)dR = \int_E^{E_0} n(E)dE, \quad . \quad . \quad (1)$$

where $n(R)dR$ and $n(E)dE$ represent the fractional number of mesotrons with range between R and $R + dR$, or with energy between E and $E + dE$. The limits of the integrals extend from any thickness t of the absorption curve or from the corresponding energy E of the energy distribution curve to the maximum range R_0 or the limiting energy E_0 of the mesotron spectrum. Then

$$n(E) = -\frac{dA}{dE} = -\frac{dA}{dt} \Big/ \frac{dE}{dt} \quad . \quad . \quad (2)$$

$\frac{dA}{dt}$ is determined from the corrected absorption curve *MNCDE* and $\frac{dE}{dt}$ for mesotrons of mass 200 m. has been calculated by Rossi and Greisen[4]. Thus the differential mesotron spectrum may be obtained from the absorption curve.

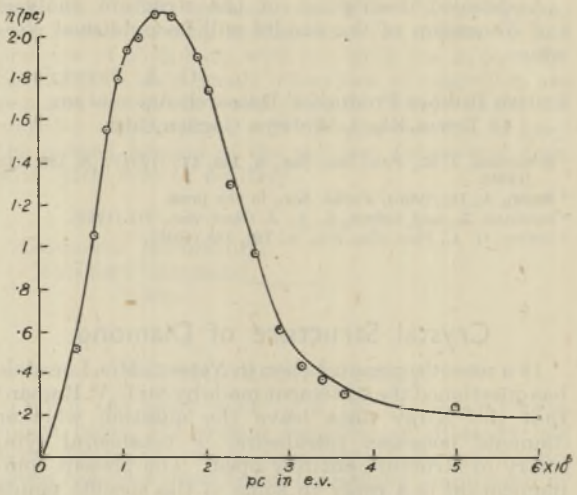


Fig. 2. Differential mesotron spectrum.

The result of the above analysis is shown in Fig. 2. The shape of the differential spectrum is similar to that obtained by Jones and Hughes, but the peak of the spectrum appears to be shifted to much lower energies. The results therefore show that there is a considerably larger number of slow mesotrons at sea-level than is commonly believed; these slow mesotrons are possibly excluded in counter-controlled cloud chamber measurements. Alternatively, it is also possible that dE/dt for low-energy mesotrons is much greater than that given by the simple ionization formula.

Our thanks are due to Prof. M. N. Saha for providing facilities for this work and for his continued interest in it.

S. K. Ghosh.
N. N. Das Gupta.

Palit Laboratory of Physics,
University College of Science,
92 Upper Circular Road,
Calcutta.

[1] Blackett, P. M. S., *Proc. Roy. Soc.*, A, **159**, 1 (1937).
[2] Jones, H., *Rev. Mod. Phys.*, **11**, 235 (1939).
[3] Hughes, D. J., *Phys. Rev.*, **57**, 592 (1940).
[4] Rossi, B., and Greisen, K., *Rev. Mod. Phys.*, **13**, 240 (1941).
[5] Greisen, K., *Phys. Rev.*, **63**, 323 (1943).
[6] Bhabha, H. J., *Proc. Ind. Acad. Sci.*, **19**, 23 (1944).

Production of Difference Tones

In providing a course of instruction in preliminary radio physics for war purposes, there were in our laboratory several audio-frequency generators which were capable of producing tonal frequencies up to and above the limits of hearing. It occurred to me that with two such instruments difference tones might easily be generated. The instruments were connected, preferably in parallel, with a small loudspeaker, and the pitch of each was gradually raised by itself to a frequency just above the limit of audibility. When both instruments were simultaneously adjusted by the dial to the same high frequency, no tone was heard. But when one of them was altered to a small extent, a deep low difference tone of a frequency near the lower limit of audibility was loudly heard by itself. By gradually changing the frequency of one generator, the pitch of the difference tone rises con-

tinuously to any height desired. It is sufficiently loud to be heard over a large lecture room, and is now so demonstrated.

It makes a very convincing experiment to produce the difference tone when all three tones are heard at once, and then gradually raise the pitch of the generating tones above the audibility limit, finally leaving the difference tone to be heard alone. The effect is by far the best that I have ever been able to obtain with 'tonvariators' of any kind. The method seems to be of no use in generating audible summation tones since, as in all methods, the necessary low tones mask the summational higher ones. It may be the case that this method of generating difference tones has been used by others though I have never seen a reference to it.

Prof. H. F. Batho has directed my attention to the fact that difference tones can also be produced by two radio-frequency generators similarly arranged, where the generating frequencies are of the order of a couple of thousand kilocycles per second. In this case the variable condenser which changes the frequency of one generator needs to have its capacity altered only a very small amount in order to cover the audible range. But more gradual tuning can be made by connecting a second small variable condenser in parallel with the first, so that a considerable movement of the plates of the second will be required to carry the pitch of the difference tone through the range of audibility. It is interesting to note that difference tones can be generated by two frequencies of any magnitude up to several million cycles per second.

FRANK ALLEN.

University of Manitoba,
Winnipeg.

Units for Degree of Vacuum

MR. TOWNSEND's recent suggestion for a new unit for degree of vacuum based on the logarithm of the numerical value of the pressure in millimetres of mercury is to be welcomed. The new unit successfully removes the clumsy expressions of the present convention. It is also appropriate to adopt 1 mm. mercury pressure as the reference-level for the new system with logarithm of a pressure ratio.

In defining the new unit there is, however, no need to have an analogy with the definition of the decibel in the method of measuring power ratios; the analogy should rather be with the definition of the bel, one decibel being one tenth of a bel, and being used for the sake of obtaining more convenient quantities in communication engineering problems. Thus the new pressure unit ('vacuum unit') should be defined so that a pressure of a mm. of mercury becomes $A = \log_{10} \frac{1}{a} = -\log_{10} a$ 'vacuum units'.

May I further be allowed to suggest that the name for the new unit might be "McLeod". A pressure of, say, 1×10^{-5} mm. Hg would thus read 5 McLeods, 1×10^{-6} mm. Hg would become 6 McLeods, and 3×10^{-6} mm. Hg would be equal to $6 - \log_{10} 3 = 5{\cdot}52$ McLeods.

R. FEINBERG.

University,
Manchester.

[1] *Nature*, **155**, 545 (1945).

I SHOULD like to comment on Mr. F. H. Townsend's[1] recent communication to this journal, in which he proposed a logarithmic scale of pressure for high-vacuum work.

These new vacuum units provide us with a valuable method for measuring pump speeds. When a pump evacuating a closed vessel into which leakage is inappreciable—a case of great practical interest—is operating at constant speed by volume, the pressure in the vessel is falling exponentially towards zero. Thus the height of vacuum measured in Townsend's units is increasing linearly. I suggest, then, that the speed of a pump may be measured by the rate of increase of vacuum (in the new units) which it produces in such a closed volume of standard size. In fact, if the speed of the pump be V volume units per second, it is 10 V vacuum units per volume unit per second, taking the volume of the standard vessel equal to the original unit. Thus the maximum speed of the pump referred to in Mr. Townsend's letter is 860 'vac.'/cu.m./hr. at 38 'vacs.'. An advantage of this method is that the calculation of how long it will take to exhaust a given vessel to a given vacuum affords rather less scope for arithmetical errors.

As regards naming the new unit, why not call it 'vacuum unit' and, as above, abbreviate it to 'vac.'?

G. A. P. WYLLIE.

Department of Applied Physics,
University, Glasgow.
May 13.

[1] Townsend, F. H., *Nature*, **155**, 545 (1945).

Hexachlorocyclohexane as an Insecticide

MR. E. L. TAYLOR has given[1] an account of work on the acaricidal properties of a 'new' insecticide of the general formula $C_6H_6Cl_6$ (hexachloro*cyclo*hexane). This substance has been available in France for some years under the trade name of 'Aphtiria'. It would appear that a patent covering the method of preparation was taken out in France by M. Louis Gindraux in 1941. It has been used as an insecticide during the War in large quantities by the French Government with excellent results.

The disagreeable odour which is associated with hexachlorobenzene can be masked fairly easily, as the concentration of the active agent is rarely above 2 per cent when used as an insecticide. M. Gindraux (in a personal communication) believes that it is possible to prepare it free from an offensive smell and is engaged actively on the problem.

As most of the experiments which have been conducted have necessitated the use of organic solvents such as acetone, kerosene, etc., it should be noted that these are themselves active causers of dermatitis in man and that cases of skin involvement are common when used in industry.

It is, however, possible that a satisfactory cream will be produced containing an adequate concentration of hexachloro*cyclo*hexane which can be used for the treatment of scabies in man.

L. B. BOURNE
(Medical Officer).

A. C. Cossor, Ltd.,
Highbury Grove,
London, N.5.
May 25.

[1] *Nature*, **155**, 393 (1945).

THE VITAMIN B_2 COMPLEX

AT a joint meeting of the Nutrition Society and the Biochemical Society held on April 28, at the London School of Hygiene and Tropical Medicine, the subject of the vitamin B_2 complex was discussed. The chairman of the morning session, Prof. R. A. Peters, reviewed the early history of vitamin B, describing the experiments on the basis of which the heat-labile vitamin B_1 was differentiated from the heat-stable vitamin B_2, and the composite nature of the heat-stable component was eventually recognized. He read a prophetic passage from a letter written many years ago by Sir Charles Martin, suggesting that vitamin B might be composed of several different factors.

The story was further elaborated by Dr. L. J. Harris and Dr. E. Kodicek in a paper entitled "The Nutritional Significance of the Vitamin B Complex". The vitamin B_2 complex can be sub-divided into the adsorbable factors nicotinamide, riboflavin and pyridoxine, the filtrate factors pantothenic acid, *p*-amino benzoic acid, inositol and choline, and a third group comprising biotin, the folic acid group and the grass juice factor. The history of each of these factors and their biological properties were discussed in turn.

Nicotinamide cures pellagra in man, black-tongue in dogs and a corresponding condition in monkeys and pigs. Riboflavin deficiency in man is accompanied by characteristic symptoms. Deficiencies of pyridoxine and pantothenic acid cause a dermatitis in rats and chickens respectively, while biotin cures a seborrhœic pellagra in rats caused by the avidin of egg-white. Choline is a biological methylating agent and can be replaced by methionine. The relationship between folic acid, vitamin B_C, vitamin H and the *L. casei* ε factor was briefly discussed. Nicotinic acid, riboflavin and probably pyridoxine, like aneurine, are components of enzyme systems essential in carbohydrate metabolism.

This point was discussed in more detail by Dr. J. H. Quastel, in a paper on "The Parts Played by Members of the Vitamin B Complex in Enzyme Systems". Aneurine pyrophosphate is co-carboxylase, the coenzyme of pyruvate oxidation; as such, it catalyses a large number of reactions. Magnesium takes an important role in the transformation of pyruvic acid, and may be part of the enzyme carboxylase. Aneurine also appears to be necessary for the oxidation of α-keto-glutarate, important in transaminations and in the oxidation of acetic acid. Nicotinic acid is present in the coenzyme involved in hexose monophosphate oxidation and in cozymase, the coenzyme of alcoholic fermentation. During oxidation of the substrate it undergoes reduction, and is afterwards reoxidized by flavo-protein, the nicotinamide nitrogen being the site of the successive oxidation and reduction. Cozymase combines with numerous specific proteins to form dehydrogenases capable of oxidizing a variety of substrates. It is also associated with amino-acid oxidations, since in transaminations it catalyses the reconversion of glutamic acid into α-ketoglutaric acid. Riboflavin is also a component of a respiratory enzyme, flavo-protein, which will oxidize reduced cozymase; the *iso*alloxazine nucleus is the seat of the oxido-reductive changes. Reduced flavo-protein is auto-oxidizable, but *in vivo*, it is oxidized by cytochrome; it can also be oxidized by such dyestuffs as methylene blue and by pyocyanine. Pyridoxine is also part of an enzyme system, pyridoxal phosphate being identical with tyrosine decarboxylase, while pantothenic acid is believed to be concerned with pyruvate metabolism.

Mr. F. A. Robinson discussed "Some Recently Characterized Members of the Vitamin B_2 Complex". He distinguished between aneurine, riboflavin and nicotinic acid, which are associated with clearly defined deficiency diseases, and the other members of the vitamin B_2 complex, which are not. Pyridoxine was the first of the newer factors to be characterized and synthesized, and recently two of its derivatives, pyridoxal and pyridoxamine, have been shown to be concerned with transaminations, while pyridoxal phosphate is apparently identical with tyrosine decarboxylase. The 'filtrate factor', now called pantothenic acid, and biotin have also been synthesized. All three of these substances are components of 'bios' and are essential for the growth of a number of micro-organisms. Uncomplicated biotin and pantothenic acid deficiencies, not artificially induced, have not been encountered in man. Another substance which was first recognized by its ability to stimulate the growth of micro-organisms is folic acid. This appears to be identical with a growth-factor for chicks, the so-called vitamin B_C, and with the so-called *L. casei* ε factor; both vitamin B_C and folic acid prevent anæmia and leucopenia in chicks. Recently it was shown that α- and β-pyracin, the lactones of the acids derived from pyridoxine, also prevent anæmia in chicks. Folic acid also prevents the anæmia and other symptoms induced by administration of certain sulphonamides, and partly relieves the symptoms of vitamin M - deficiency in monkeys. These are also partially relieved by xanthopterin, the fish anæmia factor, while folic acid is partially effective in fish anæmia. There appears to be a close chemical as well as biological relationship between these factors, but this cannot be substantiated until pure folic acid is available. *p*-Aminobenzoic acid is another growth-factor for micro-organisms now included in the vitamin B_2 complex, and a large number of others have recently been described about which little is as yet known. The lipotropic factors, inositol, choline and methionine, which prevent fatty-liver formation, are regarded as constituting a third sub-group of the vitamin B_2 complex.

Dr. B. C. J. G. Knight read a paper on "Growth-Factors and Growth Inhibitors for Micro-organisms". He gave a list of the growth-factors known to be required by different micro-organisms; some of these are themselves components and possibly precursors of more complex factors. Researches into growth-factors indicated that certain fundamental metabolic processes are common to the life of all cells, and Fildes suggested the term 'essential metabolite' to indicate a substance which participates in such processes. An essential metabolite that cannot be synthesized by an organism is a growth-factor for that organism. Woods showed *p*-aminobenzoic acid to be a specific antagonist for sulphanilamide, and predicted that *p*-aminobenzoic acid would be an essential metabolite. The prediction has been fulfilled and has led to a search for other growth-inhibitors capable of antagonizing known growth-factors. As a result, inhibitors such as pyridine-3-sulphonic acid and 3-acetylpyridine modelled on nicotinic acid, pantoyl taurine and *iso*riboflavin modelled on pantothenic acid and riboflavin respectively, and others modelled on biotin had been prepared. It has also been discovered that the antibiotic effects of mepacrine,

methylene blue, quinine and propamidine are neutralized by riboflavin, but the antagonistic action is probably more complex than in the other instances given. The growth-stimulating properties of aneurine are neutralized by pyrithiamine, the effect being complete or partial according to whether the organisms require the whole or only a part of the aneurine molecule. It had also been observed that the pyrophosphate of the thiazole moiety of aneurine will inhibit carboxylase activity, suggesting that cocarboxylase and the thiazole pyrophosphate compete with one another for the carboxylase protein.

Dr. F. Bergel, opening the discussion on these papers, said there are reasons for differentiating between the major vitamins, aneurine, riboflavin and nicotinic acid, and the minor vitamins, other than the reasons mentioned by Mr. Robinson. He pointed out that the major vitamins are highly specific in their action, only very closely related substances being effective, whereas the minor vitamins can be replaced by a number of analogues, and he cited pantothenic acid and its derivatives as an example. Other speakers in the discussion, however, deprecated the attempt to distinguish between major and minor vitamins, and suggested that in a few years time, both groups may be regarded as equally important. There was also disagreement with the suggestion that folic acid, vitamin B_C and the *L. casei* ε factor are identical.

At the afternoon session, under the chairmanship of Dr. L. J. Harris, Dr. B. S. Platt read a paper on "Fermentation and Human Nutrition". He showed a series of slides, illustrating the manufacture of Kaffir beer, and compared its nutritional value with that of British beer. Although the latter contains appreciable quantities of vitamins, it contains far less than Kaffir beer, and it was believed that this drink supplies factors which are otherwise lacking in the native diet. This was clearly brought out by a study of natives in the West Indies, who suffered from various deficiencies such as greying of the hair, cheilosis and various forms of dermatitis unknown among similar races in Africa where Kaffir beer is a staple article of diet. Investigation showed that when cereal grains germinate, the amounts of most members of the vitamin B complex present increase and that most of these factors are extracted in the steeping process, so passing into the resulting liquor. Although ruminants undoubtedly rely on fermentation in the rumen as the main source of supply of the vitamin B factors, it is not yet possible to state with certainty what contribution is made by bacterial fermentation in the intestinal tract to the vitamin requirements of man. Later, Dr. Platt showed a series of slides, some in colour, illustrating the symptoms of vitamin deficiency encountered during his recent visit to Labrador and Newfoundland.

Dr. Lucy Wills spoke on "The Vitamin B Complex in Anæmia", dealing especially with nutritional macrocytic anæmia and its relation to Addisonian pernicious anæmia. Nutritional macrocytic anæmia has formerly been regarded as due to a deficiency of an extrinsic factor which, according to Castle, is converted by the action of the intrinsic factor in the gastric juice into the anti-pernicious anæmia factor, which is stored in the liver. If Castle's theory is justified, nutritional macrocytic anæmia should be cured by any extract active in pernicious anæmia however given, but this is not the case. Dr. Wills therefore advanced an alternative theory, that this type of anæmia is due to the absence of a factor belonging to the vitamin B_2 complex which does not, as Castle postulated, react with the intrinsic factor to give the liver principle, nor is it an essential part of the latter, though necessary for its proper functioning. In support of this theory, Dr. Wills stated that uncomplicated nutritional macrocytic anæmia in Bombay does not respond to purified liver extracts, but does respond to crude liver extracts and to yeast extracts by injection as well as by mouth. Furthermore, monkeys, in which a similar type of anæmia has been artificially induced, also respond to crude, though not to purified, liver extracts given by mouth or by injection, and to yeast extracts administered by either route. This shows that it is not necessary for the responsible factor to come into contact with the gastric juice. Just before the War, attempts were made to isolate the factor from liver extract; and although it was established that riboflavin, pyridoxine, pantothenic acid and probably nicotinic acid are ineffective, no conclusive results were obtained, as the work was interrupted.

In opening the discussion on the afternoon's papers, Dr. F. Prescott suggested that synthesis of the vitamin B complex by bacteria in the intestine is not of great importance in man. Najjar and Holt gave aneurine in amounts greatly in excess of the physiological requirements and, when the experiments were repeated with smaller amounts, no evidence that the vitamin was excreted in the urine was obtained. Dr. Prescott suggested that the results of sulphonamide treatment are due not to inhibition of bacterial synthesis, but to direct interference with the respiratory mechanism of the body, simulating the effects of irradiation sickness and drug anæmia.

Speakers who took part in the subsequent discussion supported Dr. Platt's view as to the nutritional value of native-fermented liquors, and cited other examples of how native populations made good a deficiency of the vitamin B factors, for example, by drinking the contents of the rumen of freshly killed animals. The necessity for providing an adequate diet for the Colonial populations was stressed. The proceedings of the meeting were summarized by Dr. Harris, bringing to a conclusion a memorable meeting, which attracted a very large audience.

GENETIC TYPES OF MANGANESE DEPOSITS

A COMPARATIVE study of the manganese deposits of the U.S.S.R. by A. G. Betekhtin, based on intensive investigations carried out during the last few years, adds considerably to our knowledge of the conditions governing the formation of manganese ores (*Bull. Acad. Sci. U.R.S.S.*, No. 4, 3; English summary, 43; 1944).

Three groups of marine manganiferous sediments are distinguished:

(*a*) Most of the Palæozoic and Tertiary deposits are associated with siliceous and less common ferruginous chemical sediments, including radiolarian jaspers frequently accompanied by volcanic tuffs. The Tertiary ores of Chiatura, Transcaucasia and Polunochnoye, N. Urals, furnish typical examples similar to the classic deposits of Nikopol in the Ukraine. In the shallow-water facies formed near a shore of Cretaceous limestone, coarse pisolitic and massive psilomelane and pyrolusite occur. Farther

out, the pisolites decrease in size, manganite becomes important and the silica and phosphorus contents increase. Still farther out, under conditions of oxygen deficiency, carbonates appear (rhodocrosite and manganocalcite) with glauconite, and there is marked enrichment in phosphates, sulphides and opal. Eventually the carbonates feather out and finally the ore-horizon is represented only by rare nodules of phosphorite.

(*b*) Deposits associated with calcareous sediments occur in the mountain ranges of west and central Siberia. They are mostly of late Pre-Cambrian age, but important occurrences are also found in the Cambrian of the Alatau. In the western Urals there are similar deposits of Permian age. The chief ore mineral in this type is manganocalcite.

(*c*) Deposits associated with clastic sediments are represented at Labinskoye in the Tertiary of the North Caucasus. Chemical sediments are absent and the ores (psilomelane, pyrolusite or manganese carbonates) occur as cementing material.

In regionally metamorphosed deposits, formed originally by sedimentation, anhydrous minerals are characteristic, for example, braunite and hausmannite, associated with magnetite and hæmatite and quartz. The waters liberated during metamorphism have given rise to veinlets which are mineralogically closely related to the enclosing rocks. Specific cases of this kind in Lower Carboniferous chemical sediments (siliceous and ferruginous) of Kazakhstan are described by Betekhtin and Suslov in the publication cited (pp. 86–99 and 100–108 respectively). Under conditions of more intense metamorphism, manganese silicates develop (rhodonite, spessartite, tephroite, piedmontite, etc.), and carbonate ores poor in silica form manganous marble. Here again, especially along belts of tectonic disturbance, migration and redistribution of manganese is indicated by the occurrence of veins and lenses of concentrated ore. These veins, though otherwise resembling hydrothermal deposits, are free from elements such as gold, silver, lead and zinc; their origin is purely metamorphic. Vein and contact metasomatic deposits genetically connected with the hydrothermal activity of associated acid plutonic rocks are of far greater abundance and importance. The ores vary widely in composition and structure and often occur with a typical assemblage of sulphide minerals. In many of these deposits, however, there is evidence that the manganese compounds were not magmatic derivatives, but were taken from the manganiferous country rocks through which the hydrothermal solutions circulated.

All the above types of manganese deposits become secondarily enriched by weathering processes in the zone of oxidation, the end product being a pyrolusite-psilomelane complex. Betekhtin directs attention to the widespread development in the early stages of weathering of a manganic 'acid', H_2MnO_3, which occurs as dispersed colloidal particles (brown) or as colloform masses (black). Previously mistaken for manganite, this mineraloid is now distinguished as 'vernadite' after the geochemist Vernadsky, who originally predicted its discovery as a natural product. It is suggested that the various members of the psilomelane group may be salts of this acid. Concentration by chemical weathering is further intensified by the tendency of manganese hydroxides to migrate in colloidal solution and, activated by adsorbed alkali cations, to replace quartz and silicate minerals metasomatically. ARTHUR HOLMES.

CHESHUNT EXPERIMENTAL STATION

THE Experimental and Research Station at Cheshunt, Herts, has given a valuable lead to the changing demands of war-time cropping of the glasshouse industry. Discussion of problems relating to tomato and lettuce culture occupies all the annual report for 1943* and provides an index to the concentration of the industry upon food crops.

One of the most interesting items in the report by the director, Dr. W. F. Bewley, is of trials of two Russian varieties of outdoor tomatoes. Stambovoi Alpatyev has a neat dwarf habit, bears fruit of good shape, scarlet and sweet; it seems well worth further trial. Bizon proved to be coarser, and gave badly shaped fruit, though neither variety was resistant to frost exceeding two or three degrees. Two new varieties of lettuce, 5*a* and 5*b*, are being tested commercially; they mature ten to fourteen days earlier than Cheshunt Early Giant. One important experiment with tomatoes involved the lowering of *p*H of the soil by the addition of sulphur and sulphuric acid. Sulphur, at the rate of 4 oz. per square yard, gave only a slightly increased yield of fruit, but the soil, originally *p*H 8·79, was still *p*H 7·45 at the end of the season. Sulphuric acid caused the soil *p*H to fall from 8·62 to 6·39 in a week; but within a month it had risen again to 7·84. It would seem that some upward movement of soil bases takes place. It is fairly easy to make soil more alkaline, but it is not so easy to render it more acid, and the results of any further work on these lines will be awaited with interest.

An earlier annual report described resistance of the tomato varieties Riverside and Manx Marvel to attack by the fungus *Verticillium albo-atrum*. This does not now seem to hold under all cultural conditions, according to P. H. Williams. I. W. Selman has had a similar action of soil conditions in mind in his attempts to provide cultural factors which would enable tomato plants infected with spotted wilt virus to carry a reasonable crop. This should be a very practical approach to minimizing the damage caused by this disease, provided that it is linked with adequate hygiene at the end of the season. Dr. Selman's work on this question is not very conclusive as yet, but his correlations of mosaic infection and soil conditions with blotchy ripening have given much more definite results. Unequal ripening seems to depend largely upon the water-retaining properties of a particular soil mixture. Steaming and the addition of peat without appropriate manurial adjustments, or the use of composts with extreme fluctuations in water content, both favour the trouble, which is, moreover, always increased by mosaic infection. Mrs. Enid Sheard has investigated the pathology of tomato stem rot caused by the fungus *Didymella lycopersici*. The pathogen is more virulent if it has wintered out of doors than at temperatures of about 59° F. Tomato seed does not seem to carry the fungus, and the only really susceptible alternative host so far discovered is the egg plant, *Solanum melongena*. Many organic substances allow saprophytic growth of the fungus, which seems to grow best at a temperature of 20° C. W. H. Read has tried many substances and treatments for control, without much success, though

* Twenty-ninth Annual Report of the Nursery and Market Garden Industries' Development Society, Ltd., Turner's Hill, Cheshunt, Herts, 1944.

mixtures containing salicylanilide give promise of protection upon the stems.

E. R. Speyer, studying the red-spider mite, finds that the application of top-dressings does not check infestation, and the use of petroleum emulsions provides the most practical control. The growth of wheat seedlings to act as bait for wireworm reduced their attack upon lettuce. O. Owen has investigated the interrelations of various nutrient elements for the tomato crop. Magnesium deficiency, for example, is related to nitrogen, and iron to manganese, while manganese and magnesium are possibly interdependent.

STRUCTURE OF BIOLOGICAL FIBRES AND THE PROBLEM OF MUSCLE*

IT is the mark of present-day biology that it looks ever more closely to "the Nature and Property of Local Motion" of the actual molecules of structures, and it is from such a point of view that the problem of muscle is again approached.

The physico-chemical mechanism of life is for the most part a manifestation of the forms and activities of chain-molecules, chief among which are the proteins, which include myosin, now generally accepted as the responsible contractile element of the muscle machine. X-ray studies show that myosin is a member of a *family* of fibrous proteins to which belong also the keratins of hair, etc., the fibrous proteins of the epidermis, and even fibrinogen and fibrin : all these are characterized by a similar molecular plan and by similar long-range elastic properties that rest on changes of form of the molecules themselves. The inference is that muscular activity is a special case of more general phenomena the full interpretation of which implies an understanding of the properties and significance of the keratin-myosin-fibrinogen group as a whole.

The isolated proteins of this group—and this holds too for the myosin in living muscle—exist normally in a state in which the polypeptide chains are in a regularly folded configuration, but they may be pulled out into an extended configuration that is twice as long, and they may also be 'supercontracted' into more highly folded states. X-ray diffraction patterns of muscle, both living and dead, are throughout analogous to patterns that may be obtained from mammalian hairs, the 'supercontracted' state of the latter corresponding to the contracted state of the former. The outstanding common conclusion to be drawn from these photographs is that shortening is not a question of simple disorientation of fibrils, but rather of folding within fibrils.

Thermodynamic tests show that entropy changes play only a minor part in the elastic properties of keratin and isolated myosin, from which it is reasonable to suppose, especially in the light of the X-ray findings, that the various states of muscle itself are also based fundamentally on the potential energy associated with states of folding of the myosin chains. It now appears from recent physiological evidence that such a concept does indeed promise to co-ordinate quantitatively the energetics of living muscle.

A detailed solution of the muscle problem will be reached only as part of the detailed elucidation of protein structure, studied against the background of other macro-molecules, such as the nucleic acids and polysaccharides, with which protein activity is so intimately bound up. X-ray analysis is now being supplemented by investigations with the electron microscope, and some of the evidence so obtained was presented.

* Substance of the Croonian Lecture delivered before the Royal Society by Dr. W. T. Astbury, F.R.S., on July 12.

METER AND INSTRUMENT JEWELS AND PIVOTS

IN order to obtain a more fundamental knowledge of the phenomena relating to meter and instrument bearings and to improve such bearings, research has been carried out for a number of years on behalf of the British Electrical and Allied Research Industries Association at the Meter Testing Laboratories of the Northmet Power Company. A paper read by G. F. Shotter before the Institution of Electrical Engineers in London on May 4 gives a brief survey of the various aspects covered by this research, dealing mainly with the sapphire/steel combination but including other combinations of materials.

The apparatus and methods of test are outlined, followed by a survey of the results from life-tests, including an analysis of the various factors which contribute to wear. The results of a microscopical examination of the units at the end of their life-run are discussed. A brief theory of the boundary lubrication existing in such bearings is given, with a short extract of the detailed discussion of the various factors contained in E.R.A. Reports.

The results of experiments on the resistance of sapphire jewels to impact forces are given; and the phenomena associated with bottom bearings at various loads, caused by parasitic forces existing in meters, are also dealt with. The actions of the ball-type bearing and that of the pivot bearing are compared, and an approximate estimation of the life of bearings in practice, based on life-tests, is made.

A brief summary of the general conclusions reached during the tests is as follows. (*a*) Metals so far tried as alternatives to steel for pivots are in no way superior. The best material tested was osmium-rhodium, which gave good results in the dry as well as the lubricated condition. (*b*) With the exception of osmium-rhodium and possibly natural zircon (90°), the substitute materials tested, particularly glass, proved useless in the dry condition. (*c*) Various forms of oxide were produced, each having its own characteristics ; one or two appeared to be self-lubricating. (*d*) The initial friction of substitute materials was generally higher than that of the steel/sapphire units. (*e*) With the exception of diamond, the substitute materials tested generally show a higher coefficient of friction than the steel/sapphire units. (*f*) The range of penultimate/ultimate test values of friction shows considerable variation. Some materials, for example, natural zircon (90°), show a lower value than that of steel/sapphire. Other units, notably glass, give extremely high values, particularly in the dry condition. (*g*) The type of wear area formed depends on the structure of the materials under test. Homogeneous and amorphous materials normally give circular wear.

FORTHCOMING EVENT

Tuesday, July 24

QUEKETT MICROSCOPICAL SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Conversation and the Exhibition of Specimens.

APPOINTMENTS VACANT

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

PRINCIPAL OF THE GAINSBOROUGH COUNTY TECHNICAL COLLEGE—The Director of Education, County Offices, Lincoln (July 30).

ENGINEERING ASSISTANT—Mr. P. Wilkinson, Staffordshire Potteries Water Board, Engineer's Offices, Albion Street, Hanley, Stoke-on-Trent, endorsed 'Engineering Assistant' (July 30).

LECTURER IN CHEMISTRY—The Secretary, The University, Edinburgh (July 31).

AGRICULTURAL ECONOMICS OFFICER in the Ministry of Agriculture, Government of Northern Ireland—Assistant Secretary (Establishments), Ministry of Finance, Stormont, Belfast (July 31).

ASSISTANT LECTURER IN SOCIAL SCIENCE (Grade III)—The Registrar, The University, Liverpool (July 31).

SENIOR ELECTRICAL ENGINEER for Middle East (in connexion with Oil Pipe-line Construction and Operation)—The Ministry of Labour and National Service, Appointments Department A.9, Room 670, York House, Kingsway, London, W.C.2, quoting D.1292.XA (July 31).

SCIENTIFIC ASSISTANT (temporary) on the Staff of the Department of Agricultural Economics, Bristol II Advisory Province, Newton Abbot—The Secretary and Registrar, The University, Bristol 8 (July 31).

DEMONSTRATOR (man) IN CHEMISTRY (should possess a good Honours Degree and have special qualifications in Organic Chemistry)—The Secretary, King's College, Strand, London, W.C.2 (July 31).

JUNIOR ENGINEERING ASSISTANT—The Waterworks Engineer and Manager, Civic Centre, Southampton (August 3).

CIVIL ENGINEERING ASSISTANT—The Engineer and General Manager, Tees Valley Water Board, Water Board Offices, Corporation Road, Middlesbrough, endorsed 'Civil Engineering Assistant' (August 4).

SCIENTIFIC GLASS BLOWER for Division of Industrial Chemistry, Melbourne—The Secretary, Overseas Manpower Committee, Ministry of Labour and National Service, York House, Kingsway, London, W.C.2, quoting Ref. 4239 (August 4).

ASSISTANT LECTURER (temporary) IN MATHEMATICS, and an ASSISTANT LECTURER (temporary) IN METALLURGY—The Registrar, University College, Singleton Park, Swansea (August 7).

CHIEF NUTRITION OFFICER, Ruakura Animal Research Station, Hamilton, New Zealand—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (August 10).

SECRETARY-EDITOR—The Acting Secretary, The Museums Association, Chaucer House, Malet Place, London, W.C.1 (August 10).

RESEARCH OFFICER IN THEORETICAL PHYSICS, Division of Industrial Chemistry, Council for Scientific and Industrial Research, Melbourne—The Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, London, W.C.2 (August 11).

ACADEMIC ADVISER (man or woman) FOR TUTORIAL CLASSES—The University of London Extension Registrar, c/o London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1 (August 15).

LECTURERS (2) IN MATHEMATICS (one Lecturer must have special qualifications in Applied Mathematics and Mathematical Physics)—The Secretary, The University, St. Andrews (August 18).

ASSISTANT IN ZOOLOGY in the United College, St. Andrews—The Secretary, The University, St. Andrews (August 18).

READERSHIP IN ENGINEERING SCIENCE—The Registrar, University Registry, Oxford (August 20).

LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, The University, Sheffield (August 31).

DEMONSTRATOR IN PHYSIOLOGY—The Registrar, The University, Liverpool (August 31).

PATHOLOGIST in the Giza Memorial Ophthalmic Laboratory, Cairo—Sir Holburt Waring, Bart., Pen Moel, Tidenham, Chepstow, Mon. (August 31).

LECTURER, and an ASSISTANT LECTURER, in the DEPARTMENT OF PHYSICS—The Acting Registrar, The University, Leeds 2 (September 1).

PROFESSOR OF DENTISTRY AND DIRECTOR OF THE DENTAL SCHOOL in the University of Otago—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (September 15).

LECTURER to lecture and undertake researches on FRESHWATER ZOOLOGY, and to assist in the general teaching of ZOOLOGY, and a LECTURER to assist in the general teaching of ZOOLOGY—The Registrar, The University, Liverpool (September 19).

CHAIR OF SURGERY tenable at the British Postgraduate Medical School—The Academic Registrar, University of London, Richmond College, Richmond, Surrey (January 1).

DIRECTOR OF THE BRITISH NON-FERROUS METALS FEDERATION—The Secretaries, Messrs. Peat, Marwick, Mitchell and Co., 18 Bennets Hill, Birmingham 2, endorsed 'Federation Selection Committee'.

PRINCIPAL in connexion with the training of Ex-Servicemen at the Wiltshire Farm Institute—The Chief Executive Officer, Wiltshire War Agricultural Executive Committee, Agricultural Department, County Hall, Trowbridge, Wilts.

PRINCIPAL'S SECRETARY (woman)—The Principal, Studley Agricultural College, Studley, Warwickshire.

GRADUATE IN PHYSICS, with PURE AND APPLIED MATHEMATICS, a GRADUATE IN CHEMISTRY with FINAL PHYSICS, and a GRADUATE IN ENGINEERING with expert qualifications in ENGINEERING DRAWING—The Principal, Mining and Technical Institute, Neath, Glam.

ASSISTANTS FOR (*a*) MATHEMATICS, ENGINEERING SCIENCE and related Subjects, (*b*) ENGINEERING DRAWING, ENGINEERING SCIENCE and related Subjects, (*c*) WORKSHOPS—Machines, Fitting, Welding—The Principal, County Technical College, Dartford, Kent.

LECTURER IN INORGANIC AND PHYSICAL CHEMISTRY—The Principal, Medway Technical College, Gillingham, Kent.

DOMESTIC SCIENCE INSTRUCTRESS for work at the Trowbridge Victoria Technical Institute and in connexion with Adult Classes—The Deputy Director of Education, County Hall, Trowbridge, Wilts.

TEACHER OF ENGINEERING DRAWING, ENGINEERING SCIENCE, PRACTICAL MATHEMATICS, WORKSHOP TECHNOLOGY, JIG AND TOOL DRAWING AND DESIGN to ordinary National Certificate standard at the Redditch Technical School—Mr. G. Brodrick, Education Office, Church Green West, Redditch, Worcestershire.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Proceedings of the Royal Irish Academy. Vol. 50, Section B, No. 9 : The Male Genitalia of the British Stigmellidæ (Nepticulidæ) (Lep.). By Bryan P. Beirne. Pp. 191–218. 2*s*. Vol. 50, Section B, No. 10 : Preparation of 2 : 3 Dimethyl Butadiene and its Polymerisation to 'Methyl Rubber'. By John J. McHenry, Peter J. Drumm and William F. O'Connor. Pp. 219–226. 1*s*. Vol. 50, Section B, No. 11 : On some Nutritional Factors in relation to Blossom-end Rot of Tomato Fruit. By Thomas Walsh and Edward J. Clarke. Pp. 227–236. 1*s*. Vol. 50, Section B, No. 12 : The Level of the Ocean in Glacial and Late-Glacial Times. By A. Farrington. Pp. 237–244. n.p. Vol. 50, Section B, No. 13 : A Further Study of a Chlorosis of Tomatoes with particular reference to Potassium-Magnesium Relationships. By Thomas Walsh and Edward J. Clarke. Pp. 245–264. 1*s*. Vol. 50, Section B, No. 14 : The Postural Mechanism of the Human Foot. By M. A. MacConaill. Pp. 265–278. 1*s*. (Dublin : Hodges, Figgis and Co., Ltd. ; London : Williams and Norgate, Ltd., 1945.) [206

Other Countries

New Zealand Geographer. Edited by Kenneth B. Cumberland. Published half-yearly. Vol. 1, No. 1. Pp. 98. (Christchurch : Published for the New Zealand Geographical Society by Whitcombe and Tombs. Ltd., 1945.) 5*s*. [26

Penicillin. By Sir Howard Florey. (Cawthron Lecture, Abridged.) Pp. 7. (Nelson, N.Z. : Cawthron Institute, 1944.) [96

Ministry of Public Works, Egypt. Physical Department Paper No. 50 : Meteorological Conditions in Caves and Ancient Tombs in Egypt. By L. J. Sutton. Pp. viii+81. (Cairo : Government Press, 1945.) [96

Hebrew Technical College (Institute of Technology) in Haifa. Scientific Publication No. 1 : In Memoriam of the late Prof. G. Zerkowitz. (In Hebrew.) Pp. xii+135+1 plate. (Haifa : Hebrew Technical College, 1944.) [96

Kungl. Svenska Vetenskapsakademiens Handlingar. Serien 3, Band 21, No. 8 : Paracyclische Ovulationen. Av H. Stieve. Pp. 20. Serien 3, Band 21, No. 9 : The Electronic Changes of Excitability in Nerve and their Relation to Accommodation. By Carl Rudolph Skoglund. Pp. 48. (Stockholm : Almquist and Wiksells Boktryckeri A.-B. ; London : H. K. Lewis and Co., Ltd., 1944.) [96

League of Nations. Report of the Delegation on Economic Depressions, Part 2 : Economic Stability in the Post-War World ; the Conditions of Prosperity after the Transition from War to Peace. (League of Nations Publication II A.2. Official No. C.I.M.I. 1945. II.A.) Pp. xxiv+296. (Geneva : League of Nations ; London : George Allen and Unwin, Ltd., 1945.) 10*s*. [96

Exploration du Parc National Albert. Mission G. F. de Witte (1933–1935). Fascicule 30 : Lepidoptera-Rhopalocera. Par L. Berger. Pp. 51+4 plates. Fascicule 31 : Galerucinae (Coleoptera Phytophaga, Fam. Chrysomelidae). Par V. Laboissiere. Pp. 93. Fascicule 32 : Homoptera ; Cicadidae, Cercopidae ; Fulgoridae, Dictyophoridae, Ricanidae, Cixiidae, Derbidae, Flatidae. Par V. Lallemand. Pp. 26+4 plates. Fascicule 32 (Addendum) : Homoptera ; Cicadidae, Cercopidae, Dictyophoridae, Cixiidae, Issidae. Par V. Lallemand. Pp. 6. Fascicule 33 : Batraciens et Reptiles. Par G. F. de Witte. Pp. xvii+262+76 plates. Fascicule 34, Teil 1 : Coccinellidae. Von L. Mader. Pp. 208. Fascicule 35 : Aphodiinae (Coleoptera Lamellicornia, Fam. Scarabaeidae). Par R. Paulian. Pp. 143+23 plates. Fascicule 36 : Languriinae et Cladoxeninae (Coleoptera Clavicornia, Fam. Erotylidae). Par A. Villiers. Pp. 22. Fascicule 37 : Chrysomelidae (S. Fam. Eumolpinae). Par L. Burgeon. Pp. 31. Fascicule 38 : Dynastinae (Coleoptera Lamellicornia. Fam. Scarabaeidae). Par A. Janssens. Pp. 50+3 plates. Fascicule 39 : Halticinae (Coleoptera Phytophaga, Fam. Chrysomelidae). Par V. Laboissiere. Pp. 132. Fascicule 40 : Lagriidae und Alleculidae (Coleoptera Heteromera). Von F. Borchmann. Pp. 53. Fascicule 41 : Lepidoptera Heterocera. Par H. Debauche. Pp. 29+4 plates. Fascicule 42 : Hispinae (Coleoptera Phytophaga, Fam. Chrysomelidae). Par E. Uhmann. Pp. 37. Fascicule 43 : 1. Pentastomida : Hexapoda, par R. Heymons ; 2. Orthoptera : Phasmidae, par K. Guenther ; 3. Hemiptera : Membracidae, by W. D. Funkhouser ; 4. Coleoptera : Silphidae, par A. Janssens ; 5. Dryopidae, par J. Delève ; 6. Lymexylonidae, par L. Burgeon ; 7. Bostrychidae, par P. Lesne ; 8. Geotrupinae, par A. Janssens ; 9. Cassidinae, von F. Spaeth ; 10. Ipidae, von H. Eggers ; 11. Platypodidae, par K. E. Schedl ; 12. Hymenoptera : Sphegidae, by G. Arnold. Pp. 85. Fascicule 44 : Trichoptera. Par G. Marlier. Pp. 17. Fascicule 45 : Reduviidae, Emesidae, Henicocephalidae (Hemiptera Heteroptera). Par H. Schouteden. Pp. ii+56. (Bruxelles : Institut des Parcs Nationaux du Congo Belge, 1940-1944.) [156

Catalogue

Pyrometer Testing Furnace for Works and Laboratories. Pp. 4. (Watford : Wild-Barfield Electric Furnaces, Ltd., 1945.)

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