NATURE

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

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NATURE

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A STATE SCIENTIFIC SERVICE IN BRITAIN

In recent weeks the general public has learnt a great deal more of the scale and importance of the contribution made by scientific men, in the Government service and outside it, to the war effort. In the developments leading to the atomic bomb, radar and numerous other fields, the significance of that contribution, both in peace and in war, is now far more widely appreciated, and Lord Hankey in his recent book "Government Control in War" stressed the need for organizing more effectively something of a Scientific Civil Service. The White Paper under that title which has now appeared[1] deals with the reorganization and recruitment of that Service during the reconstruction period. It falls into three parts. The first part outlines the Government proposals for effecting the reorganization of the Scientific Civil Service. The second part deals with questions of recruitment to the scientific service during the reconstruction period, which were left undetermined in the White Paper dealing with the administrative, executive and clerical classes last November. The core of the present White Paper, however, is the annex containing the report of the Barlow Committee on Scientific Staff. This report, dated April 23, 1943, is appropriately considered first. In general, it may be said that it fully substantiates much of the criticism of the conditions of service of scientific men in Government departments which found expression in debates in the House of Lords and the House of Commons and elsewhere.

The Committee, over which Sir Alan Barlow presided, consisted of Sir Edward Appleton, Mr. W. F. Lutyens and Prof. E. K. Rideal, and was asked to consider in particular the comparison between the initial salaries of administrative and scientific entrants; the question whether the existing conditions of service for scientific workers provide adequate prospects for the average entrant; and whether sufficient facilities exist for free interchange of scientific personnel, and in particular research men, between the Government service on one hand, and the universities, industry and outside bodies in general on the other. Inquiries were confined in the main to the Defence Departments and the Department of Scientific and Industrial Research: the Committee did not regard the engineering or medical services as coming within its scope. The Committee, however, sets out what it regards as the essential principles which should be followed to secure a higher standard of recruitment into, and so raise the general level of, the scientific establishments of the Government service, and emphasizes that it is essential that its recommendations should be implemented at the earliest possible opportunity, without waiting for a fuller post-war inquiry. It will be recalled that the present terms of service of scientific staff derive from the recommendations of the Carpenter Committee which reported in 1930, and that although those recommendations were endorsed by the Royal Commission on the Civil Service, they were not brought fully into operation until 1936.

All the evidence before the Barlow Committee points to the main conclusion that the Government failed in peace-time to attract into, and retain in, its service a proper proportion of the best scientific workers produced by the universities of Britain. The fault seems, to the Barlow Committee, to lie partly in the standards of remuneration and the prospects of promotion offered, but at least as much in general conditions of service and the relations between Government research organizations and the scientific world outside. In general, for scientific workers of average ability, of whom any large scientific organization is bound to require a substantial number, Government employment offers prospects, up to a certain level, which compare not unfavourably with those offered in most universities and in industry for men of like ability, and at present the Committee has no special comments to offer on the pay and prospects of such workers. It is in regard to the man of more than usual ability that improvement is necessary, and the Committee is emphatically right when it lays down as a first essential that the scales and system of promotion of the scientific classes should ensure that the best scientific men should have equal prospects of pay and promotion with the best men in the administrative class at least up to the top of the grade of 'principal'. The Government's present proposals in this connexion, taken in comparison with those relating to the salaries and organization of the administrative class, are criticized by the Institution of Professional Civil Servants in a pamphlet entitled "A New Deal for Government Scientists?"[2]; for the outstanding scientific man would still be well below the outstanding administrator in salary level, and neither the average nor the outstanding scientific officer has been given parity with administrative officers.

In devoting the major part of its report to this question of attracting to the service of the State a proper proportion of the ablest men of science coming from the universities, the Barlow Committee is clearly in harmony with general opinion in Britain as revealed in discussions on the organization of scientific and industrial research during the last two years. Dealing first with remuneration, the Committee points out that there has been some divergence of practice between departments in implementing the Carpenter Report, and it considers that departments should be prepared to offer initial salaries above the minimum of the junior scientific officer scale to candidates who have spent one or two years in post-graduate research. The existing provisions for recruitment direct into the grade of 'scientific officer' could also be utilized, and there should be regular recruitment to that grade at a later age by means of an examination similar to that applied by the 1851 Commissioners.

Evidence submitted to the Committee was unanimous as to the necessity of providing rapid advancement for outstanding men, and the Committee recommends that the existing authority to give special advances within the scale to a limited number of officers should be extended. The problem of securing rapid advancement beyond the grade of 'scientific officer' for the outstanding scientific worker is primarily that of so regulating the proportion of higher to lower posts as to ensure reasonable prospects of promotion. The outstanding man should be able to reach the grade of 'principal scientific officer' in the early thirties, and to this end the Committee recommends full use of the Carpenter Report recommendation under which such promotion should be made by reference to outstanding individual work, even if the research officer is lacking in capacity for organizing and directing the research work of others. While the Treasury should be ready to authorize special additional posts, in return the Treasury might require that the nomination for any such post should be approved by the Inter-Departmental Scientific Panel, establishment of which is recommended to maintain a uniform standard for such special advancements and promotions and to improve administrative liaison between the departments. Moreover, any step which assists the heads of scientific departments to a fuller knowledge of the work done in other departments would in itself be of value.

Beyond this, in regard to remuneration, the Committee also recommends that the salaries of the highest posts on the scientific side of the Government service should be increased. This would also have the effect of narrowing the gap between the pay of such posts and that of the highest posts on the administrative side; but the Committee goes further and urges consideration of the possibility of more frequent transfers of suitable men of science to the administrative class. Here it raises a fundamental issue the importance of which has been widely recognized already in comment on the White Paper. It is not merely that the report challenges the whole idea that the scientific worker as such is by training and outlook inherently unfitted for high administrative office. When the Barlow Committee recommends that the provision of special machinery to ensure that scientific workers serving in departments without any administrative cadre of their own should be considered for transfer to administrative vacancies in other departments, it is not merely thinking of opening up wider avenues of promotion for men of science; it has equally in mind the benefit to Government business from the introduction of a different outlook, particularly in departments where the work is concerned with scientific and technical processes.

This broadening of the basis of recruitment to the highest posts in the administrative class of the Civil Service is of the utmost importance to enable the Civil Service to become competent to deal with the affairs of the post-war world; and it is to be hoped that neither this point, nor the corollary of the freer admission of scientific men to posts where they exercise more and more influence over social planning and administration—that men of science themselves must be more adequately trained in the humanities and cultural subjects and early specialization avoided—will not be overlooked in the debate which is likely to ensue on the White Paper. It would indeed be a tragedy if the Institution of Professional Civil Servants, which seems to have misconstrued completely the Barlow Committee's concentration on the improvement of the conditions for the outstanding man of science, failed to lend the weight of its support to proposals of the highest significance from the national point of view.

We can find in the Barlow Report no substantial foundation for the suggestion, indignantly and rightly repudiated by the Institution, that existing scientific staffs are inferior in quality to their colleagues outside the Government service. That is no valid deduction from the conclusion that the Government service in peace-time did not attract and retain a sufficient proportion of the best men of science coming from the universities of Britain ; and in the important section of its report dealing with general conditions of service, the Committee's observations are pertinent to the average as well as to the outstanding scientific officer. Moreover, it recognizes clearly that there should be the closest contact between research and development, and that a high standard of recruitment is as necessary on the development as on the research side. It makes indeed no firm recommendation as to the continued distinction between the scientific and technical grades, but is of the opinion that the designation 'chemist' might be discontinued and the present long salary scales for technical officers and chemists divided into two.

One of the dangers to which a Government scientific branch is inherently liable is the tendency towards isolation from the rest of the scientific world. This is detrimental both to their work and to recruitment, and to overcome that tendency the Barlow Committee makes various suggestions. Extra-mural research contacts are of great benefit, and heads of scientific departments should try constantly to improve contacts with both university authorities and students. Temporary interchanges of staff with the universities, special leave with pay to attend scientific meetings and conferences, as well as exchanges of staff with industry, direct contact between Government scientific branches, especially in administration, and transfers of scientific staff from one department to another are desirable ; though research workers should, wherever practicable, remain associated with projects which they themselves have started. It does not recommend, however, a unified State Scientific Service with a single establishment and responsible to a common head. Great importance is attached to the introduction of a scheme on the lines of a 'sabbatical year', under which selected scientific staff would be allowed special leave to work at a university or other institution in Great Britain or abroad, and attention is directed to the desirability of locating research establishments so far as possible within easy reach of a university or intellectual centre and in close proximity to other establishments working on kindred problems. Direct contact at all levels between the staffs of different establishments should be made easy.

One of the greatest disadvantages of the Government scientific service is the extreme emphasis upon secrecy. This both makes it difficult or impossible for the Government worker to enter into discussion with similar workers outside, and also prevents his obtaining recognition in the scientific world of the value of his work. Such conditions are not only a formidable barrier to recruitment but also to scientific work itself, by hindering the fertilization or stimulation of new ideas ; and it is satisfactory to note from the White Paper that the Government views sympathetically the recommendation that secrecy restrictions should be as much as possible relaxed, and scientific workers encouraged both to publish work of their own and to discuss their work with persons outside the service engaged on similar problems. Furthermore, the Government particularly approves the Barlow Committee's recommendations for dealing with this tendency to isolation, and proposes that one of the first tasks of the new Inter-departmental Scientific Panel should be to consider how they can be implemented.

With regard to secrecy, the Barlow Committee suggests as a solution that it should not be assumed as a matter of course in peace-time that the whole of the work of a research establishment must automatically be regarded as secret ; matters of fundamental research should be regarded as *prima facie* suitable for discussion with outsiders, and the questions on which absolute secrecy is prescribed should be kept to the minimum. The head of a research establishment should have discretion, and be encouraged to allow his staff to discuss their work confidentially with members of outside institutions who are engaged on similar problems, and a system should be possible whereby members of the staff engaged on secret work could submit theses for higher degrees. Fuller use might be made of advisory councils to secure professional recognition of the work of Government scientific workers, and lectures by eminent men of science and 'colloquia' should be encouraged, and adequate lecture-rooms, libraries and workshops provided. Finally, the Committee points out that control of civilian scientific staffs by uniformed officers tends to be prejudicial. Uniformed officers should act as advisers on behalf of the user services rather than as direct controllers of research and development. Further, heads of laboratory units should have more freedom in procuring equipment.

No scientific worker will mistake the importance of the Barlow Committee's Report or the weight of the support it brings to policies and principles that have long been advocated in these columns. It is the more satisfactory to find that many of the recommendations of the report have been accepted by the Government and incorporated in the Government's proposals, which in some respects go beyond those of the Committee. Moreover, the White Paper points out that the investigation of these questions had begun under the Coalition Government, which was equally resolved on the reorganization of the scientific service ; and it may therefore be hoped that consciousness of the contribution made by science towards winning the War, and of that which science can make during peace to the efficiency of production, to higher standards of living, to improved health and to the means of defence, is shared by all political parties.

The Government proposes to establish an Inter-departmental Scientific Panel, of which Sir Edward

Appleton will be chairman, with the further responsibility of keeping under review the well-being and efficiency of the Government scientific service. It will also make proposals for any desirable changes in the organization or conditions of service necessary to this end, in addition to that proposed by the Committee of maintaining a uniform standard for promotions and special advancements and improving administrative liaison between departments. In order that pension arrangements may not constitute a barrier to interchange of staff with the universities, almost all scientific officers in the permanent service of the Government will be brought under the Federated Superannuation Scheme for the Universities. The salaries of the most highly qualified members of the scientific service are to be brought into relationship with those of the administrative class, and at the recruitment stage they are to be aligned to them. Special provision will be made for recruiting, above the normal minimum salary, university graduates with research experience, and also for recruiting direct to grades above basic, scientific workers who possess special qualifications or experience which a department requires.

The Government has also accepted the recommendation that ultimate prospects should be improved, including provision for the promotion, above the level of 'principal scientific officer', of individual research workers of exceptional ability, without necessarily expecting them to carry administrative responsibility. Furthermore, the present class of 'assistant' is to be strengthened, re-named the 'experimental officer' class and more fully used, much of the work at present done by scientific officers being devolved on scientific assistants. There will be provision for promotion from this class to the scientific officer class under conditions which will be considered later by the Scientific Panel; but the Government also proposes a provincial differentiation in salary scales, to which the Institution of Professional Civil Servants has already objected and which may well be the subject of wider and reasoned criticism. It is proposed to recruit the whole of the scientific service centrally through the Civil Service Commission, and with this in mind Dr. C. P. Snow's name will be submitted for appointment as additional Commissioner with special responsibility during the reconstruction period for the recruitment of scientific and experimental officers.

This scheme of reorganization applies to staff employed directly by Government departments, but the adaptation of these arrangements to suit the needs of the staff employed by other institutions working under the ægis of the Medical Research Council, for example, the Agricultural and Fishery Departments and the Development Commission, is now under consideration. Finally, in the second part of the White Paper, there are set forth the lines on which it has been agreed with the national staff side of the Whitley Council that the general principles outlined last year in the White Paper "Recruitment to Established Posts in the Civil Service during the Reconstruction Period" can best be applied in the scientific field, and in accordance with which recruitment will be carried out. These conditions include the restoration of open competitions for entry to the Scientific Civil Service as soon as possible, with special reconstruction competitions over a period, publication of full particulars throughout the Forces, with arrangements to ensure that any possible candidates serving in Europe or the Far East have an opportunity of being considered, and provision for retention in a permanent capacity of specially selected senior temporary officers, above the maximum age allowed in the open reconstruction competitions, who possess exceptional ability or experience, as well as for retention in the basic grade of assistant experimental officer of a proportion of the best of the temporary officers, above the age of thirty, in the existing grades of Assistant II and Assistant III.

The Institution of Professional Civil Servants has published, in the pamphlet already mentioned, a careful analysis of the new scales—those for the administrative class are outlined in a further White Paper published simultaneously—which shows that both for scientific officers and experimental officers the new careers should be a considerable improvement on the old. The outstanding scientific officer would have a career roughly equivalent to that of the good average administrator, but the average scientific officer would compare unfavourably with his administrative colleague. Apart from the question of provincial differentiation introduced for scientific men for the first time, the Institution's main objection to the proposed scales is that the scheme still leaves the scientific worker in a position inferior to that of his administrative or executive colleague. There are further details in regard to superannuation and the application of the scales on which discussions are proceeding, but the Institution clearly recognizes that there is for the first time to be a real Government Scientific Service, recruited centrally through the Civil Service Commission, instead of a haphazardly recruited series of departmental classes. Nevertheless, to meet the widely varying qualifications of scientific workers, the grading will have to be interpreted broadly, and the proposed Interdepartmental Scientific Panel must approach its task in no niggardly spirit.

Whatever criticism may be advanced in matters of detail, there can be no doubt that the whole scheme represents a definite advance in recognition of the value of the scientific worker, and it is clearly the outcome of much sympathetic thought, practical knowledge and experience. Moreover, in certain features, such as the provisions for superannuation and a sabbatical year, publication of results and the like, which encourage mobility of staff and the interchange of thought, it may well make a contribution to the stimulation of scientific and industrial advance far beyond the bounds of the Government service. Such features call for close and sympathetic study by industry as well as by the universities in order to realize the full effect of the recommendations of the Barlow Committee.

To recognize this is not to suggest that the new proposals provide all that is required. They represent indeed substantial recognition of the fact that no Government without an adequate staff of scientific workers is properly equipped to direct the affairs of a modern country pervaded by scientific technique, especially when the range of Government control over industry and economic life tends to grow. But they do not in themselves indicate that there is any real appreciation that the administrator himself, be he Civil servant or Minister, requires some appreciation of the scientific outlook, some basic understanding of science itself, if he is to handle competently issues of State into which scientific and technical factors increasingly enter.

To that extent scientific workers generally will be at one with the Institution of Professional Civil Servants in refusing to be content with any scheme which leaves the man of science in a position inferior to that of his administrative or executive colleague. The Barlow Committee has rightly stressed the importance of attracting into the Government service a proper proportion of the ablest scientific workers produced by the universities of Britain. It is no less important, however, that the conditions of a scientific career, either within the Government service or without, should be such as to attract a fitting proportion of the ablest and most promising young minds among those who year by year enter the universities. That is the real reason for insisting on parity so far as possible between the administrative and scientific sides, and for reducing still further the difference in the prospects of the outstanding man who enters on an administrative as compared with a scientific career. If at the same time, as has been suggested, the general history of science and scientific method were made a compulsory examination subject for the higher Civil Service posts, and on their side scientific workers themselves saw to it that other cultural subjects were not neglected in the curriculum for a science degree, there is every reason to believe that under the Interdepartmental Scientific Panel the new proposals may provide the scientific worker in Government service not merely with improved conditions of remuneration, but also with a status and a freedom which will be a stimulus to creative effort and form the basis of an attractive and distinguished service.

[1] The Scientific Civil Service. Reorganization and Recruitment during the Reconstruction Period. (Cmd. 6679.) Pp. 16. (London: H.M. Stationery Office, 1945.) 3*d*.
The Administrative Class of the Civil Service. (Cmd. 6680.) Pp. 16. (London: H.M. Stationery Office, 1945.) 3*d*.

[2] A New Deal for Government Scientists? Pp. 12. (Institution of Professional Civil Servants, 17 Hans Place, London, S.W.1. 1945.) n.p.

ARISTOTLE'S CRITICISM OF PLATONISM

Aristotle's Criticism of Plato and the Academy
By Harold Cherniss. Vol. 1. Pp. xxvii+610. (Baltimore, Md.: Johns Hopkins Press; London: Oxford University Press, 1944.) 33*s*. 6*d*. net.

MR. CHERNISS'S large volume will be most welcome to all serious students of Greek philosophy; none the less that it lays a heavy burden of duty upon them. There is already a vast literature in many languages dealing with the meaning and value of the criticisms of Plato by his most eminent pupil, and a wide discrepancy of opinion on almost every aspect of the problem. Often it is disputable whether a particular criticism is directed against Plato himself or against some Academic of the first generation, Speusippus, Xenocrates or another, and his version (or perversion) of the master's meaning. Where the *critique* is levelled against Plato by name, it is often uncertain what precise pronouncement of Plato is being attacked and what the precise point of the attack is meant to be. Even when Aristotle expressly quotes the words of a Platonic dialogue for controversial purposes, his quotations are often not quite accurate (presumably because the very format of a Greek book made 'verification of references' almost impossible). Even when the quotation is exact, we often see that its meaning has been twisted by Aristotle's habit of treating metaphorical language as though it were meant for a literal statement of matter of fact, or his tendency to assume that a word has in Plato the same precise sense as it bears in his own technical vocabulary. How, then, are we to deal with criticisms which, like most of those aimed in the "Metaphysics" at the "Theory of Ideas", are concerned with statements never expressly made in the Platonic dialogues at all? If Plato said these things, it must have been in what Aristotle calls his 'unpublished' teaching. How can we trust implicitly either Aristotle's apprehension of Plato's meaning, or even his accuracy in reporting Plato's words? Small wonder that there should be in the literature to which such a problem has given rise *quot homines, tot sententiæ*.

In the work of which the present large volume is the first half, Mr. Cherniss proposes to discuss this vast problem on a scale so far unprecedented, at least in the English language. He is in many ways well equipped for the task. His earlier volume on Aristotle's criticisms of the "Presocialists" revealed him as an excellent scholar, and he seems, moreover, to have made himself acquainted with almost everything which had been previously published on his present subject down to the present day in a way which can only awaken admiration and envy. Whether his own conclusions come in the end to be generally accepted or not—and I conceive that he himself would readily admit that on many points the last word has by no means been said—his book will remain an indispensable storehouse of learning and acute criticism from which future investigation will have to start, whether it ends by confirming his verdicts or not. Even those contemporary students whose views he is most concerned to overthrow will be sincerely thankful to him for his achievement, though they may not always feel themselves 'killed dead' by his great guns.

Properly speaking, it would be premature to attempt any 'review' of the book until Vol. 2 is before us. Only there does the writer intend to deal with the most difficult part of the whole subject, the alleged identification by Plato of his "Ideas" with *numbers* of some kind. In the present volume, he confines himself to acute examination of the strictures passed in the Aristotelian *corpus* on the 'ideal theory' in what Aristotle calls its 'original form' (except in so far as some of the appendixes are concerned more immediately with certain fundamental cosmological issues, particularly with the question whether Aristotle gives any support to the view that Plato at any time disputed either the motionlessness of the earth or its central position in the universe).

In this position of affairs, it seems almost imperative to suspend one's judgment of Mr. Cherniss's work until its publication is complete. From the present instalment, indeed, one may make a wide guess at what is to come, but only a *wide* guess. It is clear that, as is only natural, the writer attaches very great weight to the views of his eminent American predecessor as a Platonic scholar, the late Prof. Paul Shorey, on the life-long 'unity of Plato's thought'. I hope, however, that when he comes to discuss the so-called 'Idea-Numbers', he will handle the theme with less contemptuous impatience than Shorey, who brushes the whole subject aside as a mass of "clotted nonsense". The influence of Shorey's well-known "Unity of Plato's Thought", which is so manifest in the present volume, seems to me to be in the main beneficial. But I sincerely trust that in the sequel yet to come the unity will not be exaggerated, as I think it was by Shorey himself, into something like monotony. A great philosopher can be consistent through a lifetime without merely repeating himself endlessly.

If I occasionally find Shorey's influence unduly strong in certain places in the present volume, it is rather in some of the appendixes than in the main text. Mr. Cherniss is manifestly very anxious to convince himself that, as Shorey also held, Plato adheres from first to last to a cosmology with a stationary earth at the centre of the universe. Now it is certainly possible to make out a case for this view, a case which requires serious consideration, and Mr. Cherniss is fully entitled to do so. But there is also a case for disputing it. *Prima facie*, for example, the "Timæus" appears to ascribe motion of some kind to the earth, and Aristotle says in explicit words that the "Timæus" does this. It is undeniable that Theophrastus somewhere made a statement that appears to represent the aged Plato as having recanted his earlier belief in the earth's central position. This evidence has to be fairly and squarely met, and Mr. Cherniss sets himself to meet it. But I doubt whether he himself would claim that he has done so very convincingly. He argues ingeniously enough that in the passage of the "de Caelo" which has always been understood to assert that the "Timæus" teaches the mobility of the earth, Aristotle is only reporting an interpretation of that dialogue by certain unnamed Academics, which he himself regards as a misinterpretation. The evidence about a change in Plato's view as to the central position of the earth is disposed of by the suggestion that Plutarch, on whom we depend for our knowledge of what Theophrastus said, has misunderstood his author. All this, to be sure, is not impossible, but it is another question whether a judge who came to the consideration of the evidence with a mind not already as good as made up would find it very probable. (To me, I own, it seems a case of 'special pleading', but I too, of course, have my own initial bias.) I admit, indeed, that against those who have tried to find 'Copernicanism' in Plato Mr. Cherniss proves his case once for all.

I trust I have said enough to make it clear that though Mr. Cherniss's work cannot properly be reviewed to much purpose until it is completed, it is one of capital importance and will be indispensable in future to all serious students of Plato ; and, indeed, of Greek philosophy generally. Unfortunately, the use which such students can at present make of Vol. 1 is seriously hampered by the absence of an index. This will, no doubt, be supplied in Vol. 2, and one hopes on the generous scale which such a book deserves.

A. E. Taylor.

ADVANCED MATHEMATICS

(1) Théorie des fonctions

Par Prof. Georges Valiron. (Cours d'analyse mathématique, 1.) Pp. vi+522. (Paris : Masson et Cie., 1942.) n.p.

(2) Les coniques

Par Prof. Henri Lebesgue. Pp. vii+190. (Paris : Libr. Gauthier-Villars, 1942.) 150 francs.

THE two books under notice, published while communications between France and England were cut off, have only recently reached Great Britain.

(1) This, the first part of the latest course of mathematical analysis, is an excellent book. In a volume of 522 pages the author deals thoroughly with functions of both real and complex variables. After proving a standard theorem, he usually applies it to an example of great intrinsic importance, often one prominent in recent research. This gives a delightful freshness to the treatment. By the aid of numerous historical notes, the reader learns how an idea first arose, and how it developed. For example, in explaining the idea of an integral, we have a reference to the early work of Cauchy and Lejeune-Dirichlet, a full account of that of Riemann, a little on that of Stieltjes, and then a whole chapter on the Lebesgue integral. Finally, we are shown the necessity of a further generalization, such as that due to Denjoy, and told where it can be studied.

To make room for the considerable amount of matter not usually found in such courses, the author has omitted elementary work likely to be well known to his readers, and has used rather small print. Unlike many recent English writers, he has included a chapter on elliptic functions. There are also sections on vector analysis, Riemann's zeta function, numerical integration, and many other subjects which, although there is no index, can be traced from a very full table of contents. The second volume will deal with functional equations.

(2) The name of Lebesgue is so well known in connexion with his theory of integration that we may be unaware that his primary interest was in geometry. At various times he wrote several papers on conics. Shortly before his death, he collected ten of these together to form the five chapters of the present book. He intended to write an introduction to each chapter, but was not able to complete more than the first two.

It is said that Prof. Lebesgue never read a mathematical paper through to the end, but always turned away to develop the subject on his own lines. He wished the readers of his own book to do likewise, and to work out for themselves any of the numerous stimulating suggestions that he provided. This makes it comparatively unimportant that the author was unable to give a final revision to his work, and to impart greater unity to its somewhat miscellaneous contents. The first chapter gives suggestions for replacing the usual treatment of conics by new methods, chiefly concerned with homographic transformations of the plane. The second and third deal with focal lines and focal circles. The fourth chapter is devoted to Poncelet's polygons, making considerable use of the work of Cayley and Sylvester. The fifth chapter is an unusual treatment of diameters of plane algebraic curves, using the theory of finite groups.

The colloquial and sometimes ironical style of some of the pages may surprise the reader, but, according to the preface by his friend, M. Paul Montel, they recall the author's characteristic and attractive lectures.

H. T. H. Piaggio.

A PHYSICAL THEORY OF THE SOLAR CORONA

DURING the recent visit of several distinguished Indian men of science to Great Britain, the Physical Society prevailed upon some of their number to deliver addresses to English audiences on subjects of their own choosing. On November 23, 1944, Prof. M. N. Saha described to a crowded audience in the rooms of the Royal Society his theory of excitation in the solar corona. An abridged account of the lecture and the discussion which followed it has already appeared[1], and the full text is now published by the Physical Society[2].

Prof. Saha believes that many outstanding phenomena observed on the sun, such as prominences, spots and chromospheric flares, can best be explained by assuming that nuclear reactions take place all over the solar surface, and especially vigorously in certain limited parts. Nuclear processes in the deep interior were first invoked some years ago to account for the sun's energy generation; but Saha now suggests that similar reactions occur on a reduced scale at or near the surface. He bases his opinion on two sets of facts, both of which, he believes, point to this conclusion. First, the occurrence of He I and He II lines in the spectrum of the chromosphere is completely inexplicable on present theories. The ordinary thermal ionization theory (itself Saha's work) is successful enough in explaining ordinary Fraunhofer lines of excitation potential of order 5 eV., but fails to account for such lines as He II 4686 A., a prominent low-level line of excitation nearly 75 eV. observed in the flash spectrum. Secondly, Edlén's brilliant identification[3] of the coronium lines, which calls for the existence in the outer atmosphere of the sun of iron atoms which have lost 9–13 electrons, nickel atoms which have lost 11–15 electrons, and calcium atoms which have lost 11–12 electrons, requires a coronal excitation of the order of 500 eV., and evidently necessitates drastic revision of our ideas of solar physics. Saha provides this revision and claims to resolve both difficulties simultaneously in his new theory.

No particular nuclear reaction need be postulated to account for the helium super-excitation in the chromosphere: any one of the many nuclear processes producing α-particles is sufficient. These particles (which are, of course, unobservable on the sun) are supposed by Saha to be shot out at high speed from some sub-surface reaction, and projected through the reversing layer and chromosphere. There they will ionize solar atoms along their path by collision, losing energy the while until each can retain a captured electron, so forming ionized helium, and eventually another to give neutral helium. Those particles which capture electrons in excited states will be in a condition to emit the spectra of He II and He I respectively, which will thus be expected (as indeed they are observed) in the low and high chromosphere respectively. The presence of the line D_3 (He I, 5876 A.) in absorption above disturbed areas of the solar surface suggests the presence of a temporary helium-rich atmosphere above spots which may result from these nuclear reactions.

A more specific mechanism is postulated by Saha to account for the super-excitation in the corona. He supposes that in the reversing layer, below the base of the chromosphere, a nuclear process takes place which is identical with or closely akin to that of uranium fission. The products are high-energy stripped atoms which are shot through the solar atmosphere, ionizing solar atoms by collision in its lower parts, and capturing electrons and emitting X-rays and forbidden coronal radiation farther out.

Among the debris produced by their passage are electrons—δ-rays which are knocked forward and escape, to constitute the electron atmosphere which we know as the outer corona. The reaction produced in the laboratory by neutron bombardment of uranium or thorium is of the type

$$_{92}U^{235} + {_0n^1} = xA^{M_1} + yB^{M_2} + Z_0n^1 + Q,$$

where A and B are new nuclei of masses M_1 and M_2 and charges x and y; Z is the number of neutrons (usually three or four) evaporated: and Q ($\sim$200 MeV.) is the energy released. In binary fission of this type, A and B are usually unstable and pass by a chain of β-ray emissions to stable end-products. The energy Q is distributed between these according to the law of conservation of momentum; and the important point is that it is so high that the fission particles separate with velocities much larger than the orbital velocities not only of their outer electrons but also of many of those in the inner shells. As a result, the fragments start their independent career highly ionized and moving at speeds of the order of the orbital speeds of electrons in the inner orbits of atoms. Saha shows that if the initial process is a ternary or quaternary fission, the fragments, after stabilization through β-emission, are likely to be atoms from calcium to nickel emitted with a kinetic energy of about 60 MeV. For an iron atom this means that the outer 15 electrons cannot be retained, and the fragment starts out with the ground structure $1s^2 2s^2 2p^6 3s$. Saha calculates the range of particles of this kind in a solar atmosphere of plausible constitution, and decides that only such fissions as occur at or above the reversing layer can contribute to the coronal radiation: those which occur deeper in the sun give particles which are stopped by collision before they penetrate the chromosphere.

The subsequent history of the stripped atoms is as follows. The Fe^{+15} ion (itself spectroscopically unobservable) loses energy by collision with solar atoms along its trajectory and eventually captures an electron, bound or free, to become Fe^{+14} in an excited ($3s\,nx$) or normal ($3s^2$) state. In the former case it emits the extreme ultra-violet spectrum of Fe XV before reaching the ground-state. There are no metastable levels, so no visible radiation is to be expected. Then the process of electron capture is repeated and the Fe^{+13} ion is formed. Allowed transitions here can again give rise only to radiation of extremely short wave-length, but this time the ground-state is an inverted doublet, and the forbidden transition $^2P_{1/2} - {^2P_{3/2}}$ results in the emission of the famous green coronal line of Fe XIV. Successive electron captures gradually build up the next electron shell, and the spectra Fe XIII . . . Fe IX are emitted. Most of these contain forbidden lines in the accessible region, and most of the observable lines in the corona are attributed by Edlén to such of these ions as have metastable ground-levels, or to their isoelectronic analogues in nickel or somewhat similar calcium ions.

The theory thus depends upon the occurrence of ternary, quaternary or possibly unsymmetrical binary fissions in uranium or thorium near the sun's surface. Uranium has not yet been detected spectroscopically in the reversing layer; but faint lines attributed to ionized thorium have recently[4] been discovered in the Fraunhofer spectrum. Presumably no great abundance of fission nuclei is necessary, since the coronal radiation is, after all, very weak relative to the thermal radiation of the whole sun; it can be observed only during total eclipses or by taking extraordinary precautions against extraneous light at other times. A more difficult point concerns the apparent selection of iron, nickel and calcium as fission products. Why should no lines of, say, highly ionized cobalt, manganese, copper or potassium appear? This is partly a spectroscopic matter: the elements found are better suited for identification than all the others except cobalt, and here, as elsewhere, absence of the spectrum of an element is no guarantee of the absence of the element. A faint coronal line at 4359 A. is indeed attributed to Co XV. But there is no denying that the iron, nickel and calcium lines represent most of the coronal emission, and the contiguous elements, even if they turn out to be represented among the fainter lines, are likely to be relatively rare. Saha attributes this to the greater probability that fissions will result in even atomic numbers than in odd, the former having many more stable isotopes than the latter. This leaves some doubt concerning chromium and titanium (especially the former, which has predicted forbidden lines in the accessible region), and an alternative explanation put forward by Edlén in his original paper[5] deserves consideration. He noted there that the observed lines belong to elements common in meteorites, the implication being that coronal matter is not directly of solar origin at all, but is a cloud of meteoritic gas collapsing on to the solar surface. Saha will have none of this on energetic grounds, however, and points out that the velocities involved (622 km./sec. from infinity to the solar surface, less to the corona) are not sufficient to produce the observed ionization.

The fate of Saha's stripped atoms, once they have emitted the coronal lines, is doubtful, for it depends on the ranges of the various particles in a part of the solar atmosphere where the composition is as yet rather uncertain. It might be supposed that the process of electron capture outlined above would go on as the ion continued its progress through the corona, and that accordingly lines due to Fe VIII, Fe VII . . . Fe I and the corresponding nickel and calcium lines should be emitted at greater heights. But between Fe VIII and Fe III the capture is in *d*-orbits, where the capture cross-section is small, so that even where other conditions (for example, presence of deep metastable levels with accessible transitions) are favourable, the lines will be expected to be faint. In fact, the probability of electron capture may be so small that these less highly ionized particles may escape into regions devoid of hydrogen atoms or electrons before they can make further captures. The lower ions will in that event play no part in coronal emission, though they may become of interest to geophysicists!

The value of the new theory, if it can be supported at the many points where observational verification is possible, lies not only in the explanation it affords for the observed high excitation in the inner part of the corona, but also in the light it throws on the spectrum of, and intensity distribution in, its outer parts. That it suggests that the outer corona is not in equilibrium but consists of outward streaming δ-rays continually ejected from solar atoms by fission fragments is an advantage; for questions concerning the origin, maintenance and stability of the outer corona have hitherto been embarrassments to those who held it to be an atmosphere in equilibrium. Saha's conception of the chromosphere and inner corona as a sort of gigantic cloud chamber, where the tracks of individual particles are invisible but where the particles are so abundant that their recombination spectra are observable, is more than a picturesque illustration. It removes the difficulty of accounting for the extremely high 'temperature' needed to produce the coronal lines. It was always incredible that temperatures of millions of degrees could exist in parts of the solar atmosphere where a black sphere would be expected to reach at most 4,500° C. It is now clear, if Saha is right, that this phenomenon is quite local, and is comparable with the local luminescence produced in our own atmosphere by meteors. (Perhaps a better comparison, in view of the direction of motion of the particles, is with terrestrial rockets.)

Many points remain to be cleared up, of course, and much experimental and theoretical work must be done before the theory can be regarded as more than tentative. But as a first attempt to account for the extraordinary features of the solar corona brought to light by the identification of the emission lines in its spectrum, this theory merits and will receive astrophysicists' serious consideration.

A. HUNTER.

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THE CITY AND GUILDS COLLEGE

ENGINEERING AT THE IMPERIAL COLLEGE

By PROF. E. F. D. WITCHELL

THE City and Guilds College forms the engineering section of the Imperial College of Science and Technology, the centenary of which was recently celebrated (see *Nature*, Nov. 3, p. 518 *et seq.*). As its name implies, the City and Guilds College itself owes its existence to the City Livery companies, who met at the Mansion House on July 3, 1876, under the presidency of the then Lord Mayor and decided to devote attention "to the promotion of education throughout the country and especially to technical education". As a result of this meeting, the City and Guilds of London Institute for the Advancement of Technical Education was established in 1878 and was incorporated in 1880. The provisional committee of the Institute recommended "that the objects which the Guilds had in view would be best attained, firstly, by the establishment of a Central Institution or College for the advanced education of those who had already acquired sufficient knowledge of science or the arts to profit by instruction in the industrial application of these; secondly, by conducting examinations in technological subjects; and, thirdly, by the establishment of local schools for artisans and workmen, and by co-operating with and otherwise assisting local effort, more especially, but not exclusively, within the Metropolis".

The first of these recommendations led to the establishment of the College in Exhibition Road. The foundation stone of the building was laid in 1881 by the Prince of Wales, who opened the new building three years later.

The College was known as the Central Institution, and its declared objects were "to afford practical, scientific and artistic instruction which shall qualify persons to become: (I) technical teachers; (II) mechanical, civil and electrical engineers, architects, builders and decorative artists; (III) principals, superintendents and managers of chemical and other manufacturing works.

"The main purpose of the instruction to be given in this Institution will be to point out the application of the different branches of science to various manufacturing industries, and opportunities will be afforded for the prosecution of original research with the object of the more thorough training of the students and for the elucidation of the theory of industrial processes."

It was proposed to carry out these objects by instituting five departments, namely: (1) Chemical Technology; (2) Engineering; mechanical, civil and electrical; (3) General Manufactures; (4) Architecture and Building Construction; and (5) Applied Art.

Students were required to pass an entrance examination in mathematics, pure and applied; chemistry; physics; drawing and modern languages. The courses in all departments were to be of three years duration, and the diploma of the College (A.C.G.I.) was to be awarded to those who had studied satisfactorily during the course and passed the various examinations with credit.

Three professors were appointed in April 1884, namely: Henry Edward Armstrong, as professor of chemistry; William Cawthorne Unwin, professor of engineering; and Olaus Henrici, professor of mechanics and mathematics. Later in the year, William Edward Ayrton was appointed professor of physics. These four professors were charged with devising the schemes of education which should be adopted for training students following diploma and special courses in the various departments. The general scheme proposed for diploma students provided that the first-year course should be a common course for all students no matter in which department the student wished to graduate. The subjects studied were mathematics, chemistry, physics, engineering drawing and engineering workshop practice. In the second year a small amount of divergence from the common course was permitted, especially for students in chemistry; but for engineering students almost all the course in electrical, civil and mechanical engineering was substantially the same. In the third year the student spent the whole time in the department of his choice, with the exception that during the winter term one day per week had to be devoted to study in another department. Mathematics was studied by all students throughout the three years of the course.

It will be seen that the scheme recognized the importance of making a fairly wide training in general and applied science the basis for a satisfactory course in technological studies, and it deliberately discouraged too early specialization in any one branch of learning.

Evidence that the course as devised was sound in principle is provided by the fact that the alterations in the scheme during the last sixty years have been comparatively few. Perhaps even more convincing is the testimony of past students, who affirm how useful in their professional careers they have found the general training received in the College.

The original proposals of the City and Guilds of London Institute envisaged giving instruction in general manufactures, architecture and building and applied art, as well as in chemistry, technology and engineering. A School of Art Wood Carving was instituted and lectures were given in architectural and allied subjects; but it soon became evident that the College buildings, although judged to be large and capacious by the standard of those days, could not adequately house classes in all the intended subjects. In 1887 Prof. Ayrton estimated that the new College was providing for little more than half the work for which it was originally intended, and only two years later Prof. Unwin reported that experience indicated that the resources of the Institution, both as to staff and apparatus, would be considerably taxed by the two hundred students for which the building was designed.

In 1893 the name of the College was changed from the "Central Institution" to the "Central Technical College". Under this name the College continued to function until it became part of the Imperial College in 1910, when it was renamed the "City and Guilds (Engineering) College", and eventually the "City and Guilds College". The style under which it was known during the first twenty-five years of its existence is still retained in "Old Centralians", the name of the Association of past students of the College.

By 1893 the number of students following the courses in engineering and chemistry exceeded two hundred, and it seemed obvious that the whole of the accommodation in the College would be required for the proper teaching of these subjects. In 1897 the School of Art Wood Carving was transferred to the Imperial Institute, and the rooms which it had occupied were used for a laboratory for mathematics and mechanics. The basement of the Royal School of Art Needlework, which was built in 1901 on the site immediately south of the College, afforded much-needed accommodation for the Electrical Machines Laboratories, which had previously been inadequately housed; and the transference of the Electrical Laboratories in turn enabled an extension of the Civil and Mechanical Engineering Laboratories.

In 1900 the 'internal' side of the University of London was established and the College became a School of the University in the Faculty of Engineering.

The chief event in the College history since that date has been its incorporation with the Royal College of Science and the Royal School of Mines to form the Imperial College of Science and Technology. The immediate effects of the amalgamation occurred in 1913, and were the closing of the Chemical Department, the fusion of the Mathematical Departments of all three Colleges into one department, and the division of the Civil and Mechanical Engineering Department into Departments of Mechanical Engineering and Civil Engineering. Further facilities for research were provided, and the size of the College was approximately doubled by the building of engineering workshops in the rear of the building and the erection of the Goldsmiths Extension on the land immediately to the north of the original building. Most of the design of the general lay-out of these extensive laboratories is due to Prof. W. E. Dalby, who had succeeded Prof. Unwin as University professor of engineering in 1904. The foundation stone of the Goldsmiths Extension was laid in 1909 by King Edward VII and the building was finished in 1914. Owing to the War, the official opening of the building was postponed until 1926, when the ceremony was performed by the present King, then Duke of York. A much later addition to the College was the transference of the Aeronautical Department from the Royal College of Science, and still more recently the formation of a Department in Chemical Engineering.

The increase in the number of students has more than kept pace with the increase in accommodation. As mentioned above, the College was originally designed to accommodate two hundred students. This figure was exceeded in 1893 and kept steadily rising until, in 1911, it reached a total of 589 registered students, of whom 430 were working full time.

From the beginning, the teaching given in the College was fashioned on an experimental approach to knowledge rather than on precept. Lecture courses were, of course, given in all the subjects selected for study, but in all departments the importance of experimental work performed by the student was emphasized and the need for accuracy in such work was stressed. This point is well illustrated by extracts from the programme of the Central Institution for the session 1892–93. In the course of instruction in the Department of Mechanics and Mathematics, we read: "In the laboratory the experiments are performed by the students themselves. The experiments are all quantitative; that is to say, in each experiment the student has to make some definite measurement . . ."

Again, it is stated of the Department of Physics and Electrical Engineering: "The instruction is given largely by tuition in the laboratories, the lectures being rather for the purpose of aiding the students in their laboratory practice than of forming a distinct course by themselves". In the Chemical Department the object of the general first-year course is thus described: "The object aimed at in this part of the course will be to encourage habits of accuracy and thoughtfulness and to teach the art of experimenting with a logical purpose rather than to impress mere facts".

In the experimental sciences instruction by inquiry and experiment must always be slower than that given by lectures, but there can be little doubt which method is the better from an educational point of view. Training in careful habits of thought and logical deduction is an important part of any system of education, and the student is more likely to learn these by the success or failure of his own experimental work than by listening to lectures, however clear or eloquent they may be.

Experimental work also teaches the student that accuracy in observation and performance is needful for success. He learns the degree of accuracy which can reasonably be expected in such work and, what is perhaps quite as important, the limit of that accuracy. For this reason laboratory work has always occupied an important place in the College curriculum, and there has been insistence upon the writing of careful and complete records of the work.

It is difficult to assess the influence which the College has exerted on the practice and profession of engineering. It would, however, be easy to compile an impressive list of past students who have taken and are taking a leading part in the profession both in Great Britain and abroad, and who acknowledge the benefit to themselves of the training they received. They are to be found in all branches of engineering, administrative, executive, commercial and professional. Most graduates naturally practice in that part of the profession in which they were trained, but many who were trained in one branch now occupy responsible positions in some other branch. Thus men trained in mechanical engineering are to be found as wireless broadcasting engineers, electrical graduates are in charge of mechanical plant and so forth. The facility with which the men pass from one branch of engineering to another, and seem to acquit themselves worthily in each, is a tribute to the soundness of the College tradition of insisting on a training in general engineering before allowing specialization in any one branch.

It must be remembered that, when the College was founded, technical education was only just beginning, and the students passing from the College in the early days had the responsibility of proving to the profession that technical training was really worth while; to-day the need for such training is taken for granted and every town of reasonable size has some sort of technical institute. Even thirty-five years ago the students often found it wise when seeking employment with an engineering firm to conceal the fact that they were university graduates; now, a degree is becoming a *sine qua non* for employment.

It would be extravagant to claim that the College is responsible for this change in the general outlook in Britain of the engineering profession, but it can be justly claimed that it has contributed largely to this more satisfactory state of affairs.

THE UNITY OF SCIENCE

ON October 20 a meeting of the Association of Scientific Workers was held at Gas Industry House, S.W.1, "to explore the inter-relations between the natural and social sciences". The chair was taken by Sir Robert Watson-Watt, and the chief speakers were Prof. J. D. Bernal, Mrs. J. Robinson and Mr. Dennis Chapman. In his opening remarks, the chairman explained that the meeting had been convened to examine the implications of the increasingly closer relations which were growing between workers in the natural and social fields of science. He therefore stressed the indivisibility of science in furthering what he called the "engineering efficiency" of the community. He announced that the Lord President of the Council, the President of the Board of Trade, and the Minister of Supply and Aircraft Production had been invited to attend the meeting, and all three Ministers had expressed their keen interest in the matter under consideration. The Lord President had replied that he would consider sympathetically any proposals formulated at the meeting which would be conveyed to him; the Minister of Supply and Aircraft Production was represented at the meeting by one of his directors of scientific research.

Prof. J. D. Bernal distinguished two aspects of the principle of the indivisibility of science. The phrase might be used in the philosophical sense of the unity of all knowledge, or in the highly practical sense of employing all the resources of scientific method regardless of the material to which it was applied. By establishing this principle in the practical sense, the artificial barriers hitherto separating 'natural' and 'social' scientists would be broken down. Prof. Bernal remarked that the demarcation between the natural and social sciences was of relatively recent origin; in seventeenth-century England, when modern science began to flourish, this line of distinction was not drawn, and indeed, some of the most eminent of the early fellows of the Royal Society were those who had distinguished themselves in what would now be called the social sciences.

He went on to say that there had for long been a distinction between the observational and the experimental sciences ; but this was breaking down as a direct result of the growing use of statistical method. Statistical methodology had come to mean designing experiments in any field in such a way as to yield the maximum information, and not merely providing ways of analysing data. The natural and social sciences were being brought together in a twofold manner : first, by a common statistical technique ; second, by a common area of operation. The integration of the problems and methods of the natural and social sciences was well illustrated by the war-time need to ascertain the effects of air-raids on production. Here the task was not merely to discover the number and physical effects of bombs but also to assess the dislocation to the life of an industrial community, and this involved the study of human behaviour, including its economic aspects.

We were now experiencing a transition to a controlled and consciously integrated human life. Hence the great need for social experiments, designed to provide the information whereby their outcome could be evaluated with precision. Prof. Bernal believed also that we were witnessing a revolution in the methods of government, and this had a direct bearing on the use of science. The problems of a community that the man of science might be called upon to solve were as much 'social' as 'natural'. The object of the meeting was to facilitate in practice, as well as in theory, the integration of the two groups of sciences. One of Prof. Bernal's specific proposals was that the Association of Scientific Workers should consider stimulating broad surveys of the national economy in relation to its transformation from war to peace.

Mrs. Robinson, speaking as an economist, gave a warning to those who expect to get definitive and conclusive answers to economic questions. Problems of economics and allied studies were, she thought, necessarily 'grubby' as compared with the neat and clear-cut problems of physical science. Hence it was fruitless to pursue a perfectionist aim. Moreover, sectional economic problems could not be solved in isolation from the economic setting of the community as a whole. It was of no use declaring, for example, that a machine would work more efficiently if it were made of diamonds. Schemes had to be formulated under the restriction of their possible application in industry. Mrs. Robinson said that a start had been made in merging the efforts of various scientific workers in studying coal production, housing and town-planning. As illustrative problems which might be attacked by composite working parties, she mentioned : (1) the analysis of accumulated medical statistics ; (2) the interaction between health and conditions of living ; (3) economic aspects of bacteriological control of milk ; and (4) output per man hour in industry ; why, for example, was industrial efficiency in the United States, as judged by output per man hour, reckoned to be twice that of the United Kingdom ?

Mr. D. Chapman deplored the loose way in which British sociologists were organized. The Institute of Sociology was, he thought, out of touch with realistic work in the field, and sociology in the universities tended to be associated with the arts or with social philosophy rather than with science. Sociology at the London School of Economics was, by virtue of its location, he thought, unduly dissociated from scientific work in other parts of the University of London. Sociological research was very costly, and in the absence of adequate funds, sociological inquiries in England had inevitably been descriptive, and qualitative rather than quantitative. In his view this tended to make them trivial in character. The strongest branches of the social sciences were educational, industrial and social psychology, where there was a tradition of experimental method.

He made it clear that a very great deal of administrative action had its scientific aspects, and there should thus be scientific study of the problems at issue. Thus there was a marked contrast between the success of the Directorate of Selection of Personnel at the War Office, due to the application of scientific method to selection, and the primitive methods employed by the Ministry of Labour in dealing with comparable problems. Mr. Chapman deprecated the limitation under which the War-time Social Survey had had to operate, being wholly engaged on problems, sometimes of a trivial nature, referred to it from outside. He directed attention to the fact that Government Departments like the Ministry of Works and the Ministry of Town and Country Planning had appointed scientific advisory bodies which did not include social scientists. Other departments, like the Ministry of Health, did not employ social scientists though there were many problems which could be adequately dealt with only by persons with training in that field. Finally, he suggested that some co-ordinating body should be set up as a Social Science Research Council.

In the discussion which followed, a wide range of problems came to light, the solution of which depended on the joint efforts of workers in both the natural and social sciences. Several instances were cited from the work of the Ministry of Fuel and Power. The future of the coal industry was threatened not only by a reduction in manpower but also by the inefficient utilization of coal. The efficiency of plant using coal probably turned as much on the care used by the plant operator as on any other factor. Yet little was known about ways of bringing about an increase in the care given by operatives. No serious study had been made of the causes of the success or failure or indifferent results of various bonus schemes. In this problem technical, social, and economic factors were closely interwoven. Similar considerations applied to the study of the optimal retail price of coal of different grades of quality from the point of view of fuel economy. Thus, the method of applying flat-rate increments was a strong financial inducement to use good quality coal that was in short supply.

As an illustration from a different field, attention was directed to the apparent conflict between the needs of health on one hand, and taste on the other, in controlling the quality of milk by inoculating dairy herds against tubercular infection. There was danger in over-emphasizing one aspect at the expense of the other. In this connexion a special plea was made for integrating sociological and psychological considerations in scientific planning, and for encouraging the social scientist to study the relative importance of economic, æsthetic, health and other values in various contexts. Furthermore, the problem of how to change values and inducements was, it was suggested, a legitimate subject for scientific study.

Many other problems were suggested for investigation by 'working parties' composed of men of science with diverse training. Various speakers made suggestions for increasing the effectiveness of working parties. One suggested the inclusion of a trade unionist; another suggested including an administrator. The Association of Scientific Workers had already set up one working party to study problems of fuel and power. Yet another suggestion was to the effect that a working party be appointed to investigate the factors which prevented the community as a whole from reaping the benefits of scientific effort; this was described by one speaker as an investigation into 'social pathology'.

A good deal of the discussion was devoted to the possibility of extending into civil life the kind of 'operational' research that had been so successful in the Services and supply departments. In the Air Ministry, for example, an 'operational' research team working with Telecommunications Research Establishment had been assigned the task of introducing radar devices at R.A.F. stations. In time the team grew into an advisory body which was consulted on a very wide range of tactical and strategical problems arising out of the use of operational equipment. Most of the crucial problems could only be studied adequately by the closest co-operation between workers with very diverse training, background and interests. The work required close and constant contact with executive officers of the R.A.F.

As regards securing Government sanction for the application of scientific discoveries, comment was made on the 'vertical' structure of British government administration, and the consequent difficulties in getting inter-departmental co-ordination to operate schemes of the TVA type.

Several speakers referred to the resistance encountered, at different political and administrative levels, to the application of science to the problems of the civilian community. In the Services, once the policy had been adopted, the hierarchical structure could be used to ensure the introduction of new techniques in a way which was scarcely to be hoped for in private industry.

It was unanimously agreed to set up a Joint Sciences Committee to consider the proposals formulated at the meeting.

EFFECTIVE AND INEFFECTIVE STRAINS OF LEGUME NODULE BACTERIA

By Dr. H. G. THORNTON, F.R.S.
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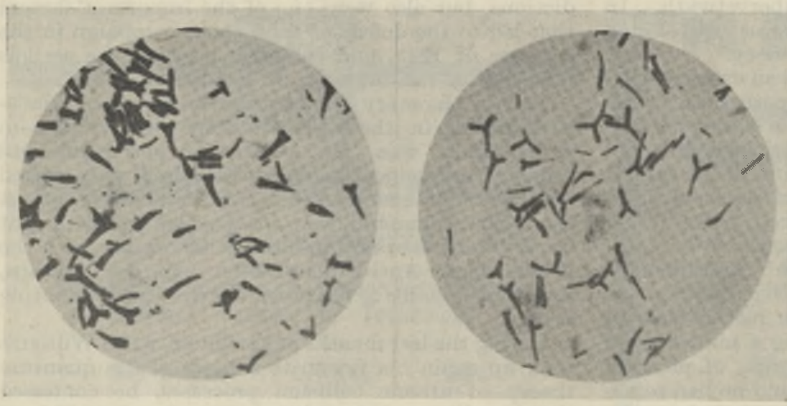
PROF. A. I. VIRTANEN, in a recent article in *Nature*[1], gave a brief summary of the work carried out in his laboratory on legume nodule bacteria. We await with interest the publication of these results in detailed form. It is already clear, however, that some of our investigations at Rothamsted have been on lines parallel to his, and that our results are complementary to some that he describes. A summary of our work where it touches on that at Helsinki may therefore be of interest.

Nature of the Ineffective Response

In observations on the structure of nodules produced by effective and ineffective nodules, Chen and Thornton[2] found that in ineffective nodules the host cells filled with bacteria were far fewer in number than in effective nodules, and also that these cells and their contained bacteria disintegrated after a period of active life which was but a small fraction of that possessed by those in effective nodules. In the strains compared, the differences in volume and duration of this central 'bacterial' tissue were found to account quantitatively for the difference in nitrogen fixation, in that the quantity fixed per unit volume of bacterial tissue in unit time was similar for the effective and ineffective strains. This result was obtained with strains both of clover and soy bean *Rhizobium*.

The transient nature of the 'bacterial tissue' in ineffective nodules may explain two observations recorded by Virtanen in his article. First, the absence of red coloration in ineffective nodules may thus be explained. Quantitative data are needed to relate the amount of pigment with the degree of effectiveness; but we have examined nodules produced by several hundred strains covering the whole range of effectiveness, and we confirm the observation that red colour is rarely detectable in the centres of very ineffective nodules. But the red pigment is formed in the central 'bacterial tissue,' so that the very short time during which this tissue persists in ineffective nodules may well be insufficient to enable a visible amount of red pigment to accumulate in them. Thus the absence of visible pigment may be the result of the characteristic behaviour of ineffective nodules and not its cause; this absence cannot therefore be considered to prove that the pigment is necessary to nitrogen fixation in the nodule, though it may well be. This caution as to interpretation in no way detracts from the great interest of the red pigment, or of its identification with hæmoglobin[3], or of Virtanen's observations on the change from red to green.

Secondly, Virtanen states that his ineffective nodules were found to contain bacteria in the rod stage. In nodules produced by all strains of *Rhizobium* that we have observed, the recently infected tissue contains rod-shaped bacteria imbedded in the slime of the 'infection threads'. Similarly, in the disintegrated region of old nodules, such bateria as remain are in the rod stage often imbedded in slimy masses. In active effective nodules these rod-shaped bacteria are not conspicuous because the regions in which they occur are small compared with the large volume of the central bacterial tissue, where the bacteria within the cells of the host plant usually occur as swollen 'bacteroids'. But in ineffective nodules this latter tissue has so short a life that in most of those observed at any one time it has either not yet formed or has already disintegrated; in both these conditions only rod-shaped bacteria are found. We have observed, however, that the swollen 'bacteroids' found during a short period in ineffective nodules are in general similar in shape to those in effective nodules (see photomicrograph), though strain differences unrelated to effectiveness do occur[2]. It is true, however, that the relation found by us of the quantity of nitrogen fixed to the volume and duration of the 'bacteroid'-containing tissue carries the implied suggestion that no detectable fixation occurs in those parts of the nodule where the bacteria are present as small rods, and is thus consistent with Virtanen's view. But in order to explain the behaviour of ineffective strains, it is necessary to discover why the nodules produced by them fail to develop an adequate volume of the central tissue containing the swollen



Strain *A* (effective) Strain 2027 (very ineffective)

BACTERIA FROM THE CENTRAL TISSUE OF CLOVER NODULES PRODUCED BY TWO STRAINS OF *Rhizobium*.

bacteria or to maintain it from disintegration. This is certainly the result of a maladaptation between the bacteria and the plant, since individual plants can be found in which a normally effective strain of the bacteria will behave ineffectively, and vice versa. It was found in this Department by P. S. Nutman (unpublished work) that *Trifolium pratense* possesses recessive genes that produce a typical ineffective response with a normally effective strain of *Rhizobium*. Our results suggest that the ineffective response may be related to the induced production by the plant of substances inimical to the bacteria[4].

Changes in Effectiveness of Bacterial Strains

The abnormal responses given by plants possessing certain genetical compositions do not produce any lasting change in the bacteria. If these are re-isolated from such abnormal nodules and supplied to a normal plant, they will produce the degree of effectiveness typical of the original bacterial strain. It has been claimed by previous workers that continued passage through the host legume will progressively alter the effectiveness of a bacterial strain. The negative results of Virtanen's attempt to change the effectiveness of a strain in this way are in general agreement with unpublished results obtained here, in which effective and ineffective strains of clover *Rhizobium* showed no progressive changes in effectiveness on plant passage, although they readily developed extreme variants in effectiveness on culture in some sterilized soils as well as under other laboratory conditions.

Infection by Mixed Strains of Nodule Bacteria

Investigations carried out at Rothamsted also have a bearing on those of Virtanen relating to the successive application to the host plant of two strains of *Rhizobium*. H. K. Chen[5] found that when different strains were supplied singly to the host plant, the number of nodules per gram of root attained a limit that was specific to each bacterial strain, though the genetical analysis referred to above has shown that genes in the host plant *Trifolium* also control the number of nodules formed.

As a consequence of this limit, the nodule-producing capacity of a root system can become so saturated that no more nodules will result from a further supply of bacteria whether of the original or of a different strain of *Rhizobium*[6]. This condition readily obtains with peas and soy beans grown in pots, where the root system makes most of its growth in the first few weeks. In clover, the root system of which continues to grow during a long period, the nodules first formed did not inhibit further nodule formation by the same or by a different strain. No evidence could be found of specific immunization by the nodules of one strain against the entry of a different strain.

When two strains were simultaneously supplied in initially equal numbers to pot-grown peas, acute competition in the root surroundings resulted in the preponderance of one of the strains both outside the roots and in the plant. In similar experiments with clover, one pair of strains showed this selective competition; but with another pair, neither strain showed a selective advantage, the percentage of nodules produced by each strain being in proportion to the relative number produced respectively by the strains in pure culture.

The factors controlling competition between strains of *Rhizobium* in soil as well as those that limit the number of nodules produced afford interesting problems that are now under investigation.

1 Virtanen, A. I., *Nature*, **155**, 747 (1945).

2 Chen, H. K., and Thornton, H. G., *Proc. Roy. Soc.*, B, **129**, 208 (1940).

3 Keilin, D., and Wang, Y. L., *Nature*, **155**, 227 (1945).

4 Chen, H. K., Nicol, H., and Thornton, H. G., *Proc. Roy. Soc.*, B, **129**, 475 (1940).

5 Chen, H. K., *J. Agric. Sci.*, **31**, 479 (1941).

6 Nicol, H., and Thornton, H. G., *Proc. Roy. Soc.*, B, **130**, 32 (1941).

OBITUARIES

Prof. E. J. Williams, F.R.S.

THE death at the early age of forty-two of Evan James Williams, professor of physics at the University College of Wales, Aberystwyth, has taken from us one of the most brilliant physicists of our generation. When finally compelled by his fatal illness to give up his work at the Admiralty, Williams returned to the village of Llanwenog, near Llanybyther, in the heart of rural Wales, near the border of Cardiganshire and Carmarthenshire, where he and two brothers were born, and where his mother and his father, a master stonemason, still live.

Educated at Llanwenog National School and then at Llandyssul County School, as was his elder brother, now Dr. D. Williams, of the Aeronautical Structural Department of the Royal Aircraft Establishment, Farnborough, E. J. Williams quickly showed his brilliant qualities of mind. At the age of sixteen, by chance noticing in the local paper that some scholarships were open to competitive examination on the following day at Swansea, but finding the last train gone, Williams made the fifty-mile journey by pillion on his brother's motor-cycle, and won a £60 scholarship, and so began his academic career. From University College, Swansea, he went to Manchester to work under W. L. Bragg, then to Cambridge to work under Rutherford. After a year in Copenhagen with Niels Bohr, he returned to Manchester, and then went on to Chadwick at Liverpool. In 1938, he was elected to the chair of physics at Aberystwyth. In 1939, at the age of thirty-six, Williams was elected into the fellowship of the Royal Society.

Williams was distinguished both as an experimental and theoretical physicist. His experimental work was mainly concerned with studies of electronic and atomic collision processes, using the cloud chamber of C. T. R. Wilson. The most striking of his experimental achievements was the direct demonstration in 1940 by the cloud chamber method of the decay of a cosmic ray meson into an electron.

Skilful though he was as an experimenter, Williams' distinction lay perhaps even more in his rare gift of analysing in detail the mechanisms of complicated physical processes, using a minimum of mathematical analysis and a maximum of physical understanding. In this quality of mind he had something in common with Niels Bohr, in whose institute in Copenhagen Williams did some of his best work. In a series of papers on collision processes, chiefly in the *Proceedings of the Royal Society*, and particularly in a brilliant but little-known paper, "Correlation of Certain Collision Problems with Radiation Theory", published in Denmark in 1935, Williams showed these rare powers to the full. The development of what is now generally known as the Williams-Weiszäcker method of impact parameters, for the approximate treatment of atomic collision problems, has the valuable quality of revealing the underlying physical mechanisms, which are often obscured by the heavy mathematical machinery of more rigorous methods. A particularly fertile application of these ideas was made by Williams to predict the later verified logarithmic rise of ionization with the energy of a very fast particle. As applied to the simpler collision processes, the impact parameter method was at first sometimes thought of as only giving an approximate answer and a visualizable picture of what could be calculated exactly by orthodox quantum mechanical methods. However, in recent years it is coming to be more and more used in solving the very complicated problems of the collision of fast neutrons, protons and mesons; this is so just because the complexities of the problems have made solution by more rigorous methods either very difficult or nearly impossible.

During the War, Williams turned his powerful analytic mind to many of the most important problems of the U-boat war, and made contributions of decisive importance to the winning of the campaign. His first work in this field, made during the summer of 1941, lay in the analysis of the process of attack on U-boats by aircraft. Simple but penetrating arguments, based on the actual observed facts of such attacks and on theoretical reasoning about these facts, showed that certain changes in the depth-setting and spacing of the depth charges should lead to a striking improvement in the number of U-boats sunk. The changes were made and the predicted results were attained, thus revolutionizing the attacking power of Coastal Command aircraft.

During 1942 Williams, who was then head of the Operational Research Section of Coastal Command, studied in great detail the tactics of harassing the U-boats by aircraft during their passage through the Bay of Biscay on their way from their bases to their hunting grounds. It was largely due to Williams' keen analysis and powerful advocacy that an augmented and improved 'Bay Offensive' was staged in early 1943. The results, in terms of U-boats sunk, were not only in startling agreement with his predictions, but also were one of the important factors that led to the defeat of the U-boat campaign in the summer of 1943, and so made possible the serious planning of the invasion of Europe.

Part of the story of the technical battle of wits—particularly in the field of radar—the victory in which made this 'Bay Offensive' successful, has already been told. The tactical battle of wits, waged by Coastal Command and the Admiralty staffs against the U-boat command, were analysed with great insight by Williams, working in close collaboration with the Naval and Air Anti-U-boat Staffs. Some day, perhaps, it may be possible to tell much more of this fascinating story.

During the last months of his illness, when Williams took up again his favourite subject of the quantum theory of atomic collision processes, he confessed that he still found the subtle intricacies of the U-boat war of comparable intellectual interest.

Scientific men of all lands will mourn the loss of this brilliant young Welshman. His death, coming so soon after that of R. H. Fowler, means a sad weakening of the none too wide ranks of British theoretical physicists. P. M. S. BLACKETT.

Prof. Marc Tiffeneau

MARC TIFFENEAU was born at Mouy on November 5, 1873. After leaving school he was apprenticed to a druggist in Sainte-Maxence for a year, after which he went to Paris, where he continued his training for two years longer. Then he studied at the École supérieure de Pharmacie, where at the same time as his friends Valeur and Blaise he came under the influence of Béhal. After an academic career of exceptional brilliance, he acted for five years as a demonstrator in the department. By this time he had qualified as a pharmacist, and in this capacity was attached for many years first to the Hôpital Boucicaut and later to the Hôtel Dieu. In both those hospitals he had the good fortune to find ample facilities for research, of which he took full advantage, for in due course he shared his enthusiasm for chemistry with a large band of ardent workers, among whom Orékhoff and Mlle. Lévy were outstanding.

Tiffeneau was a man with wide interests, and the scientific aspect of medicine made a special appeal to him. It is characteristic of his versatility that he worked in Richet's laboratory and also at the Pasteur Institute, where it was at the suggestion of Roux that he decided to qualify in medicine. In 1907 he obtained his doctorate in science, and in 1910 his doctorate in medicine. He was elected to a chair of chemistry at the Hôtel Dieu in 1924, and to a chair of pharmacology and materia medica at the Sorbonne in 1926; for a man to have held at the same time those two important chairs, and to have achieved distinction in each, is surely exceptional. In 1937 he was Dean of the Faculty of Medicine of the University of Paris. He was honoured by his election into the Académie de Médecine in 1927 and by his selection as member of the Institut de France in 1939 in succession to Urbain. He was also an Officier de la Légion d'honneur. At the time of his death on May 20, 1945, he was president of the French Chemical Society. His wife, a sister of Prof. Fourneau, survives him with two sons.

After Fittig discovered the pinacol transformation in 1859, the mechanism of this action as well as that of the dehydration of glycols of various types

[None of the vacancies in these columns relates to a Man between the ages of 18 and 50 inclusive or a Woman between the ages of 18 and 40 inclusive, unless he or she is excepted from the provisions of the Control of Engagement Order, 1945, or the vacancy is for employment excepted from the provisions of that Order.]

RESEARCH BOARD FOR THE CORRELATION OF MEDICAL SCIENCE AND PHYSICAL EDUCATION

RESEARCH PRIZE

The Research Board has decided to offer an Annual Prize in order to encourage scientific investigation into the basic principles of Physical Welfare.

A first prize of £200, a second prize of £50, will be offered in 1947 for a Thesis embodying Original Research on some aspect of the following field of inquiry:

"The Range of Movement at Joints, considered with reference to normal function and to disability.
"*Either*
In the Joints of the Foot
"*Or*
In the Joints of the Vertebral Column."

Entrants for this research prize should be either of British nationality or ordinarily resident in the British Empire.

Five typewritten copies of the Thesis should be submitted to the Research Board by September 30, 1947.

To ensure that the Thesis falls within the relevant field of inquiry, candidates should previously submit for the approval of the Research Board a statement of the nature of their proposed investigation.

Further information and suggestions can be obtained from the Secretary of the Research Board for the Correlation of Medical Science and Physical Education, The Ling Physical Education Association Offices, Hamilton House, Bidborough Street, London, W.C.1.

ESSEX EDUCATION COMMITTEE

SOUTH-EAST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART
Longbridge Road, Dagenham
SCIENCE DEPARTMENT

Applications are invited for the post of Lecturer in Biology. Candidates should be Honours Graduates with Physiology as subsidiary subject. Teaching and research experience an additional qualification. Duties, to begin as soon as possible, will involve instruction of classes in Biology subjects and Physiology to general degree standard. Salary—Burnham Scale (London allowance).

Forms of application and further particulars to be obtained by sending stamped addressed envelope to the Clerk to the Governors at the College, to whom they should be returned by December 10.

B. E. LAWRENCE,
Chief Education Officer.
County Offices,
Chelmsford.

THE UNIVERSITY OF SHEFFIELD

Applications are invited for the post of ASSISTANT LECTURER in BOTANY. The person appointed must be prepared to lecture and demonstrate to classes of all grades of undergraduate students. Salary £350 per annum, in the first year, according to qualifications and experience, with Superannuation provision under the Federated Superannuation Scheme for Universities and wartime marriage and children allowance. The successful candidate will be required to begin duties early in 1946. Applications (three copies), including the names and addresses of three referees and, if possible, copies of two testimonials, should reach the undersigned (from whom further particulars may be obtained) not later than December 31, 1945.

A. W. CHAPMAN,
Registrar.

CITY OF BIRMINGHAM EDUCATION COMMITTEE

BIRMINGHAM CENTRAL TECHNICAL COLLEGE
Suffolk Street, 1
Principal: Dr. D. S. ANDERSON
DEPARTMENT OF PHYSICS AND MATHEMATICS

Applications invited for post of full-time lecturer. Good honours degree in Physics of British University; industrial experience additional qualification. Teaching ranges from elementary to London Special B.Sc.

Salary in accordance with new Burnham Scale.

Particulars of the appointment and form of application sent by Principal on receipt of stamped, addressed, foolscap envelope. Forms of application to be returned to Principal not later than December 31, 1945.

P. D. INNES,
Chief Education Officer.

COUNTY BOROUGH OF DONCASTER EDUCATION COMMITTEE

TECHNICAL COLLEGE,
Dr. G. Lawton, B.Sc., Ph.D.

ASSISTANT LABORATORY STEWARD required for full-time work in all Scientific Departments including Biology, Chemistry, Engineering and Physics. Previous experience and skill in laboratory arts desirable. Person appointed will be responsible to Chief Laboratory Steward for control of staff of Laboratory Assistants. Salary £228 12s. per annum, plus war bonus (at present £59 16s. per annum). Applications, in writing, must be submitted to the undersigned by December 8, 1945.

V. H. HOSKIN,
Chief Education Officer.
Education Offices,
Doncaster.

BRITISH COTTON INDUSTRY RESEARCH ASSOCIATION

SHIRLEY INSTITUTE, DIDSBURY, MANCHESTER

Wanted, young man to assist with the design and control of experiments in cotton spinning and with the writing of reports. A technical qualification such as B.Sc.(Tech.) will be an advantage, but not a necessity, and applications will be considered from candidates with a general scientific qualification, an aptitude for the work and an interest in technical matters. Commencing salary, £300-£400 according to age and experience.

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Applications are invited for a LECTURER IN PSYCHOLOGY. Salary scale £400 per annum, rising by annual increments of £25 to £650. A higher initial salary may be paid on the ground of special qualifications and experience. Allowance for travelling expenses. Candidates should be qualified to undertake advanced work in experimental and applied psychology. Further particulars may be obtained from the Secretary, Universities Bureau of the British Empire, c/o University College, Gower Street, London, W.C.1.

THE UNIVERSITY OF MANCHESTER

SECRETARY OF APPOINTMENTS BOARD

Applications are invited for the post of Secretary of the Appointments Board. Candidates should be males under the age of 40 and preference will be given to those having scientific and administrative experience. A University degree though desirable is not essential. Salary from £500 to £750 according to age and experience. Applications should be made *not later* than December 15 to the Registrar, from whom further particulars may be obtained.

W. MANSFIELD COOPER,
Registrar.

CORPORATION OF GLASGOW

PUBLIC HEALTH DEPARTMENT

BACTERIOLOGIST (B.Sc.)—Junior Assistant required for Central Laboratory. Previous bacteriological experience desirable. Salary £350 × £10 × £450 per annum plus war increase, at present £48 per annum for females, and £60 per annum for males. The appointment is super-annuable. Applications, accompanied by recent testimonials, to be sent to the Medical Officer of Health, 23 Montrose Street, Glasgow.

CANTERBURY AGRICULTURAL COLLEGE

LINCOLN, NEW ZEALAND

Applications are invited for the CHAIR OF AGRICULTURE (ANIMAL HUSBANDRY). Salary scale £1,000 (N.Z.) rising to £1,075 (N.Z.). Appointment is for three years in first instance. Allowance for travelling expenses. Further particulars may be obtained from the Secretary, Universities Bureau of the British Empire, c/o University College, Gower Street, London, W.C.1. Closing date for receipt of applications February 28, 1946.

UNIVERSITY OF TASMANIA

Applications, closing in Hobart January 7, 1946, are invited for appointment as Lecturer in Zoology. Salary, according to qualifications, in scale £500-£650. Method of application and conditions are available from the Universities and from the Agent General for Tasmania, Australia House, Aldwych, London, W.C.2.

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE-UPON-TYNE
DEPARTMENTAL ASSISTANT IN PHYSICS RESEARCH LABORATORIES

The Council of King's College invites applications for the above post tenable in the Physics Department of King's College at a salary of £300 to £420 according to qualifications and experience. Candidates should have considerable experience of experimental research and a wide knowledge of modern physical apparatus and methods, especially those used in spectroscopy, interferometry, photography and high vacuum work, and must be competent in glass blowing.

Ten copies of applications, together with the names and addresses of three persons to whom reference may be made, must be received by the undersigned, from whom further particulars may be obtained, not later than Monday, December 10, 1945.

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

Imperial Chemical Industries Limited have vacancies for Managers of experimental farms. Candidates must possess degrees or diplomas in agriculture and a good knowledge of practical farm management, especially in regard to livestock. One of these vacancies is for a candidate with outstanding qualifications and experience, who must also possess first-rate organizing ability. Salary in each case will be commensurate with the candidate's qualifications and experience. Apply in writing, giving full particulars of qualifications and experience, to I.C.I. Ltd., Central Staff Department, Black Fan Rd., Welwyn Garden City, Herts.

Imperial Chemical Industries Limited have a few vacancies for agriculturists with degrees in agricultural science, for work in the provinces. Preference will be given to candidates with practical experience, between the ages of 22 and 35. Applications from ex-Servicemen, even though they may be out of touch with recent developments in agriculture, will be welcomed. Apply in writing, giving full particulars of qualifications and experience, to I.C.I. Ltd., Central Staff Dept., Black Fan Rd., Welwyn Garden City, Herts.

Imperial Chemical Industries Limited have vacancy for a grassland officer. The post is an important one, and will carry a commensurate initial salary and good prospects. Only men possessing first-rate academic qualifications in agricultural science and a specialized knowledge of modern developments, as applicable to grassland, will be considered. Apply in writing, giving full particulars of qualifications and experience, to I.C.I. Ltd., Central Staff Dept., Black Fan Rd., Welwyn Garden City, Herts.

General Secretary. The Society will, in the near future, proceed to appoint a General Secretary.

The salary will range from £700 to £1,000 per annum according to qualifications and experience.

Those interested should, in the first place, apply in writing giving full particulars including references and address the communication to the Honorary Secretaries, Society of Chemical Industry, 56, Victoria Street, London, S.W.1.

Boots Pure Drug Co., Ltd., invite applications for the position of BIOCHEMIST in the Chemical Research Department. Candidates should have an Honours Degree in Chemistry or its equivalent, and preference will be given to those with one or more years' research experience. Apply by letter to the Director of Chemical Research, Boots Pure Drug Co., Ltd., Nottingham, giving age, qualifications, experience and publications.

Lecturer in Chemistry required for the Military College of Science at Stoke-on-Trent. Candidates should preferably hold an Honours Degree in Chemistry and have specialized in Physical Chemistry. Experience in teaching would be an added recommendation. Salary: Age 25 and over—on range of £400 to £600 a year, plus Civil Service War Bonus at present £60 a year, according to qualifications and experience. Lower rates apply in the case of successful candidates under 25 years of age. It is anticipated that a scale of pay with annual increments and a higher maximum salary than at present offered will be introduced within the next few months. Successful candidate would be required to take up duties as early as possible.

Write quoting F4645A to Ministry of Labour and National Service, Appointments Department, Technical and Scientific Register, Room 670, York House, Kingsway, London, W.C.2, for application form, which must be returned completed by December 31, 1945.

Telescope. 3″ Negretti and Zambra equatorially mounted. £70 or offer. Eden, Martin's Nest, Chandlers Cross, Rickmansworth.

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attracted the attention of many chemists the world over, and among those chemists Tiffeneau takes a leading place. Indeed, no one more than he had exploited this important aspect of molecular rearrangement so exhaustively and with greater experimental skill and ingenuity. Some conception of his comprehensive outlook may be gathered from a perusal of the elaborate résumé on glycols which he wrote for the "Traité de Chimie" edited by Grignard, Dupont and Locquin. By his studies on the semihydrobenzoin and semipinacolinic transpositions as well as on the vinyl dehydration of glycols, he threw much light on the question of distribution of affinity in molecules. Further, the reaction of semipinacolinic deamination furnished him with an excellent means of contrasting the migrational aptitude of hydrocarbon radicals. Among the numerous topics which he investigated may be mentioned the isomerization of epoxides, the elimination of halogen from iodohydrins, and the stereochemistry of compounds of the type of ethylhydrobenzoin. Dealing more particularly with hypnotics and anæsthetics, he advanced pharmacology by his work on the relationship between chemical constitution and physiological action, and he also experimented with the effects of adrenaline, ephedrine, hordenine, organic compounds of mercury, and many other substances.

Like Pasteur, Tiffeneau was a keen French patriot, and during the occupation of Paris by the Germans he did much to keep the spirit of research alive in the University. The news of his sudden death came as a blow to his many friends, who are not unmindful of what they owe to his inspiration.

ALEX. McKENZIE.

WE regret to announce the following deaths:

Dr. F. W. Aston, F.R.S., fellow of Trinity College, Cambridge, on November 20, aged sixty-eight.

Dr. H. E. Durham, who took part in various expeditions to study tropical diseases, and in recent years was supervisor of the laboratories of H. P. Bulmer and Co., Ltd., on October 5, aged seventy-nine.

NEWS and VIEWS

Nobel Prize for Chemistry for 1944: Prof. Otto Hahn

PROF. OTTO HAHN, to whom the Nobel Prize for Chemistry for 1944 has been awarded, in recognition of his discovery (with F. Strassmann) of the neutron-induced fission of uranium and thorium (in its chemical aspects), has for long been universally recognized as the outstanding 'radioactive' chemist of his generation. Born sixty-six years ago, he began his studies in radioactivity in his early twenties under Sir William Ramsay at University College, London, proceeding from there, as Soddy had done previously, to work for a time with Rutherford in Montreal. In London he discovered radiothorium, an intermediate product between thorium and thorium *X*, and in Montreal radioactinium—and also carried out purely physical experiments on the magnetic and electric deflexions, and on the ranges, of the α-particles from thorium *C*. Having returned to Berlin (1906), he isolated mesothorium 1 (1907) and mesothorium 2 (1908), and from that date he continued to contribute regularly to—and in general to lead—the great advances in specialized chemical technique required for pioneering work with the heavy radioactive elements. His thirty years association with Lise Meitner (1908–38) provides a classical example of the happy collaboration of chemist and physicist to the mutual advantage of both sciences. It was terminated only by the rigour of the laws of racial discrimination which were enforced in Hitler's Germany. No doubt it is more than a slight consolation in the face of imposed separation that Meitner and Hahn should each have been able to contribute, one on the physical, the other on the chemical side, to the original elucidation of the problem of uranium fission. During the War, Hahn continued to work on the chemical side of this problem and many of the results which he and his colleagues obtained were permitted full publication by the German censor.

The award of the Nobel Prize is a fitting tribute to a scientific achievement of immense range and singleness of purpose: Hahn may have missed the broader generalizations, the displacement law, the significance of nuclear isomerism—although he discovered the first recorded instance of this phenomenon (1921) and established its essential features as the result of masterly experimentation, he may, in later years, have been in possession of the clue to fission before he would admit it even to himself, but no single man has done more for his subject. In 1906, Rutherford wrote ("Radioactive Transformations", p. 69) "the results so far obtained by Hahn are of the greatest interest and importance"; his subsequent discoveries, over a period of forty years, have maintained that high standard throughout.

Nobel Prize for Physics for 1945: Prof. Wolfgang Pauli

THE Nobel Prize for Physics for 1945 has been awarded to Prof. Wolfgang Pauli, of the Federal Technical Highschool at Zurich, which before the War became through him a centre of theoretical physics. When the danger of a German invasion seemed imminent, he went to the Institute for Advanced Study, Princeton. Among the many brilliant disciples of Sommerfeld, Pauli and Heisenberg are the most outstanding. While he was a student, Pauli wrote the article on the "Theory of Relativity" for the "Mathematical Encyclopedia" which, to this day, is one of the best presentations of this subject. He took an active part in Bohr's interpretation of atomic spectra in terms of quantum theory, and he was the first to attribute to the electron, apart from its three ordinary quantum numbers, a fourth one, $s = \pm \frac{1}{2}$, which was, soon afterwards, recognized by Goudsmit and Uhlenbeck to be the angular momentum (spin). This led Pauli to his main discovery, the exclusion principle; originally derived from experimental facts about spectra (of helium and other atoms) it turned out to be one of the most general rules of quantum theory. It served Bohr as the main tool in his explanation of the periodic system of the elements. After Bohr's theory of electronic structures was superseded by quantum mechanics, Pauli's principle found its natural place in it as the postulate that the wave function of several electrons is skew in the co-ordinates of these. Later, Pauli has shown the close connexion between his principle and the statistics of ensembles, namely, that particles with integral spin (photons, mesons) satisfy Bose–Einstein statistics, while particles with half-integer spin (electrons, protons) satisfy Fermi–Dirac statistics.

Pauli also took part in the development of matrix mechanics. He was the first to treat the hydrogen atom by matrices, and he showed how in non-relativistic approximation the spin of the electron could be represented by a set of matrices, so paving the way for Dirac's relativistic theory of the electron. He has published papers on nuclear physics (hyperfine structure), equilibrium of radiation and molecules, paramagnetism of metals, quantization of field equations (with Heisenberg), wave equations of particles with higher spin, entropy in quantum statistics, and similar subjects.

Charles Chree Medal and Prize of the Physical Society: Dr. J. A. Fleming

THE Council of the Physical Society has awarded the third (1945) Charles Chree Medal and Prize to Dr. John A. Fleming; the presentation will be made on December 6. From about 1905 onwards, Dr. Fleming was the principal colleague of the late Dr. L. A. Bauer, the initiator and first director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, whom he succeeded in 1932 as director and also as editor of the international journal *Terrestrial Magnetism and Atmospheric Electricity*. Dr. Fleming has been president of the International Association of Terrestrial Magnetism and Atmospheric Electricity of the Union of Geodesy and Geophysics since 1944 and general secretary of the American Geophysical Union from its inception.

Dr. Fleming's Department is the only institution in the world devoted to the study of terrestrial magnetism in all its aspects; and under him its work has been extended in new directions, including a wide programme of ionospheric study and both theoretical and experimental investigations in nuclear physics. The field-work undertaken by the Department has contributed greatly to the knowledge of the earth's magnetism where no magnetic surveys have been made and no permanent magnetic observatories exist. Much of this observational work was done under Dr. Fleming's direction; he controlled the organization and equipment of the teams of observers on land and shared in the design and the voyages of the non-magnetic ships *Galilee* and *Carnegie*, which made extensive magnetic surveys of the oceans for some twenty years, and in the planning and institution of the Department's magnetic observatories at Watheroo (Western Australia) and Huancayo (Peru). He has also helped and encouraged magnetic and atmospheric electric observation by official or private agencies in many lands. But for his work our knowledge of the state of the earth's magnetic and electric fields during the past forty years would be materially less than it is. He has also organized and stimulated the geomagnetic and electric researches undertaken by his Department, and notably in the elucidation of the short-lived magnetic effects associated with radio fade-outs and solar eruptions, and, in recent years, in radio science. Though it is not possible always to separate the work of Dr. Fleming from that of his staff, the unique position which the Carnegie Institution maintains in the investigations of all the problems of terrestrial magnetism is unquestionably due to his wise guidance and inspiring leadership.

Science Museum: Retirement of Col. E. E. B. Mackintosh

THE many friends of Colonel E. E. B. Mackintosh will learn with regret of his retirement from the position of director and secretary of the Science Museum on November 30, on reaching the age limit. He has held this position with distinction since 1933, when he took over the directorship from Sir Henry Lyons, soon after the latter had successfully launched the Children's Gallery and introduced the idea of special exhibitions. He extended and developed both these features, and by 1939 had succeeded in evolving an attractive and fascinating gallery, specially designed and arranged for the younger visitors, and providing a most instructive elementary introduction to many branches of science. He has explored the possibilities of different types of special exhibition, and for a number of years has devoted one of the main galleries of the Museum entirely to this purpose. During the period 1933–39, some thirty-five special exhibitions were held in the Museum, not a few of which met with outstanding success, and there is no doubt that the policy of holding these special exhibitions has been well justified. Under Colonel Mackintosh's direction, the Science Museum continued to maintain and even to improve its position in the forefront of the national museums and galleries of Britain, until the War necessitated its closure. The main task of the Museum at this time was to ensure the safety of its contents—objects, archives and records alike—and Colonel Mackintosh succeeded in dispersing approximately two thirds of the collection, together with more than 100,000 volumes from the Science Library, to thirty isolated country houses. A selection of these possessions is now being brought back to London, in preparation for the partial re-opening of the Museum. Colonel Mackintosh will have the good wishes of his many friends in his well-earned retirement.

Dr. H. Shaw

THE Ministry of Education has announced the appointment of Dr. Herman Shaw as director and secretary of the Science Museum as from December 1 in succession to Colonel E. E. B. Mackintosh. The appointment of a professional man of science to this important office is a departure from past practice, and will be generally welcomed. Dr. Shaw received his education at Bradford Grammar School and the Royal College of Science, where he studied physics. During the First World War he served in the Royal Naval Air Service. He joined the staff of the Science Museum in 1925, and later became 'keeper' of physics. His special interest in physical research has been in geophysics, and he was awarded the degree of D.Sc. of the University of London for a geophysical research using the Eötvös pendulum. He has long been associated with the Physical Society, of which at present he is the acting treasurer; he also took an active share in the organization of the Edinburgh meeting of the International Union for Geodesy and Geophysics in 1936.

Mr. Phillip Morris: Vice-Chancellor, University of Bristol

It has recently been announced that the successor to Dr. Thomas Loveday as vice-chancellor of the University of Bristol is to be Mr. Phillip Morris, the present director-general of Army education. Mr. Morris was appointed to the latter post in February 1944 in order to co-ordinate the work of the Directorates of Army Education and the Bureau of Current Affairs. He was educated at Tonbridge, St. Peter's, York, and Trinity College, Oxford, and, after graduation, spent some time on the teaching staff of Westminster Training College. There he decided to take up educational administration and joined the staff of the Kent Education Committee as assistant education officer. In due course he was promoted to assistant director and in 1938 succeeded Mr. Salter Davies as director of education. There, in the early years of the War, he began those first contacts with Army education which finally led to his accepting the position of director-general. While carrying out these duties he won the admiration and respect of all his colleagues. He combined a breadth of vision and acuteness of mind with an administrative ability which is quite unusual. He went into the War Office at a time when few regular soldiers would have dared to say that they understood the organization and administration of the modern army; he not only surprised everyone by the rapidity with which he grasped the situation but also by the insight which he brought to bear upon the problem of the Army's educational needs. The comprehensive educational scheme for the Army which is now in being is, to the understanding person, a monument to Morris's keenness and ability. Mr. Morris hopes to take up his new appointment in January 1946. We wish him every success in a post which, in the coming years, will make great demands on his administrative abilities.

Chemical Research at Leeds

The retirement of Prof. Whytlaw-Gray from the chair of chemistry in the University of Leeds after a tenure of twenty-two years (see *Nature*, Sept. 29, p. 386) will not mean his withdrawal either from the University or from active research; for the Leverhulme Trustees have awarded him a grant which will enable him to devote himself wholely to research. On account of the accurate work on gases which has been carried out in the Chemistry Department at Leeds over a number of years by Prof. Whytlaw-Gray and his collaborators, Imperial Chemical Industries, Ltd., have recently made a generous offer to the University to finance and support a fundamental piece of research on the behaviour of gases and gas mixtures under high pressures and temperatures. This work will be undertaken by Dr. J. Colvin and Mr. J. Hume at the desire of Prof. Whytlaw-Gray. The firm will provide apparatus specially designed and made for this work at an estimated cost of £3,500, and will make an annual grant to cover the expenses of the work. This invitation to Prof. Whytlaw-Gray's colleagues, following the establishment of the I.C.I. fellowships, is additional evidence of the Company's conviction that industry should support the search after knowledge for its own sake, which is so important a part of the work of a university. Although the company is interested in this work in so far as it uses gases at high temperature and pressure in some of their commercial processes, the research will not be directed with the view of producing commercially valuable information, since it is intended to provide fundamental knowledge; no restriction is imposed on the carrying out of the work or the publication of the results.

Chemical Engineering at the University of Leeds

A gift by Mr. Charles Brotherton of £55,000—£50,000 of which is under a seven-year covenant—to provide a new chemical engineering laboratory was announced at a recent meeting of the Council of the University of Leeds. The benefaction is in keeping with the recognition of the importance of the subject now general in Great Britain; the Universities of London and Cambridge have also benefited recently by endowments to provide for this field of study. The Department of Coal Gas and Fuel Industries with Metallurgy, which provides the course in chemical engineering, was established in 1906 to give training in fuel and metallurgy. In 1910 a degree in gas engineering was introduced, following the endowment of a chair by the British gas industry to perpetuate the memory of Sir George Livesey; this was followed later by contributions to a building fund. The degree course in gas engineering has been largely chemical engineering in character, and it was provided at a time when the latter subject met with little academic recognition. In 1942, the scope of the curriculum at Leeds was widened, and a four-year degree course in chemical engineering added to meet the needs of those passing either into the contracting side of the gas industry, or into the chemical industry generally. Among many other generous gifts to the University, Mr. Brotherton has already given liberal support to chemical and gas engineering. In 1942 he provided four undergraduate scholarships, and in 1943 a research assistantship; in 1944 he made a donation of £1,000 for equipment and £1,000 a year under a seven-year covenant for a Brotherton lectureship. Dr. J. S. Forsyth, at present Brotherton research assistant in chemical engineering, has now been appointed Brotherton lecturer in the University.

Research Fellowships in Engineering and Science

In recognition of the increasing mutual dependence of universities and industry, Messrs. Turner and Newall, Ltd., of Rochdale, Lancs, manufacturers of asbestos, magnesia and allied products, have decided to give the necessary funds to provide a total of eight research fellowships in engineering, inorganic chemistry or physics or allied sciences. The fellowships will be financed by them for a period of seven years, and are to be established at specified universities in areas in which the company has certain of its larger factories; they will be known as 'Turner and Newall Research Fellowships'. The fellowships will be distributed among the following universities: Manchester (four), London (two), Leeds (one) and Durham (one). They will be of a normal value of £600 a year each, and the Universities will accordingly receive a total sum of £33,600 over the seven-year period for this purpose.

Science and War

Prof. J. D. Bernal delivered a Friday evening discourse at the Royal Institution on November 23 on "Lessons of the War for Scientists". He said that the share that science had in the war effort can well be balanced by the contribution of the experience of war both to fundamental and applied science in times of peace. The War provided full-scale experience of organized science with the advantages of an over-all directing purpose and without the limitations of shortage of funds and apparatus. Not only was it found possible to apply existing discoveries to practical uses in a far shorter time, but also it was possible to carry out fundamental researches which revealed new factors underlying practical experience, such as, for example, the theory of shock waves and blast. A high degree of integration was reached between scientific men working in different fields, as also in different countries; and this was enormously facilitated by an improved organization of communication and by far greater facilities for travel and visits between men of science. Further, a directing organization of scientific committees grew up, which went far to combine principles of planning and freedom which had often been claimed to be incompatible.

This experience, Prof. Bernal said, extends and confirms what has already been claimed as to the advantages of improved organization and greater facilities for science; but in addition to this, the experiences of the War produced entirely new concepts of the relations between science and practical activities. These evolved, in the first place, out of the use in the field of complicated scientific apparatus, and became towards the end of the War the scientific examination of the objects and purpose of warfare and protection that we have come to know as 'operational research'. Operational research unites, on one hand, the physical, biological and social sciences in the most intimate way, and, on the other, integrates the scientific with the economic and technical fields. The problem that we have now to solve is how to conserve all the advantages and the lessons we have had from war science to deal with the problems of peace, where, though the urgency is not so violent, there is a far greater diversity of problems and a far greater need to take the various and often conflicting desires of people into account.

World Power Conference

A MEETING of the International Executive Council of the World Power Conference was held during November 20–21, to discuss the post-war revival of the activities of the Conference. Sir Harold Hartley, the chairman of the Executive Council, presided; some twenty countries were represented, including Australia, Belgium, Canada, Czechoslovakia, Denmark, France, Great Britain, India, Ireland, Luxemburg, Mexico, the Netherlands, New Zealand, Poland, South Africa, Sweden, Switzerland and the United States. Mr. Harold Hobson, chairman of the Central Electricity Board, led the British delegation. It was decided to hold, if possible, a sectional meeting in 1947 to discuss the general question of fuel economy; the place of this meeting will be decided at a meeting of the Council to be held in Paris next spring. Before the War the Conference published a statistical yearbook containing data on all sources of energy, giving both natural resources and annual production; publication will be resumed as soon as possible. The following resolution was passed unanimously: "In view of the future significance of atomic energy over the whole range of power problems this Council resolves to appoint a small committee to watch developments and to make recommendations to the International Executive Council of the World Power Conference as soon as it is practicable to have an effective discussion of the utilisation of atomic energy for industrial and domestic purposes".

The Night Sky in December

NEW moon occurs on December 4d. 18h. 06m. U.T., and full moon on Dec. 19d. 02h. 17m. The following conjunctions with the moon take place: Dec. 3d. 09h., Venus 2° S.; Dec. 20d. 21h., Saturn 2° S.; Dec. 21d. 12h., Mars 0·7° N.; Dec. 27d. 21h., Jupiter 4° S. In addition to these conjunctions with the moon, Mercury is in conjunction with Venus on Dec. 13d. 04h., Mercury being 2·1° N. Occultations of stars brighter than magnitude 6 are as follows: Dec. 17d. 18h. 26·0m., ε Taur. (*D*); Dec. 31d. 6h. 50·1m., ν Scor. *m* (*D*). *D* refers to disappearance, and the times are for Greenwich. Mercury is in inferior conjunction with the sun on Dec. 7 and is stationary on Dec. 17. The planet sets about 35 minutes after the sun at the beginning of December and rises about one and a half hours before the sun at the middle and end of the month. Venus rises at 6h. 22m., 7h. 04m. and 7h. 42m. at the beginning, middle and end of the month respectively. Mars, in the constellation of Cancer, can be seen throughout the night, rising at 19h. 45m. on Dec. 1 and at 17h. 13m. on Dec. 31. The planet is stationary on Dec. 5. Jupiter, in the constellation of Virgo, can be seen in the early morning hours, rising at 3h. 11m. on Dec. 1 and 1h. 38m. on Dec. 31. Saturn, in the constellation of Gemini, can be seen in the evening hours, rising at 19h. 11m. on Dec. 1 and at 17h. 02m. on Dec. 31. There will be a total eclipse of the moon on Dec. 18–19, visible at Greenwich. The circumstances of the eclipse are as follows:

Moon enters penumbra ..	Dec.	18d.	23h.	38.4m.
Moon enters umbra ..		19	00	37.5
Total eclipse begins ..		19	01	40.5
Middle of eclipse		19	02	20.3
Total eclipse ends		19	03	00.2
Moon leaves umbra ..		19	04	03.1
Moon leaves penumbra ..		19	05	02.3

The winter solstice occurs on Dec. 22d. 05h. The Geminid meteor shower reaches a maximum about Dec. 12–13.

Announcements

SIR JOHN ANDERSON will deliver his postponed address on "Research in Relation to Reconstruction" in the Whitworth Hall of the University of Manchester on December 6. The meeting has been arranged by the Manchester Joint Research Council; cards of admission are obtainable from the Secretary of the Council, c/o Manchester Chamber of Commerce, Ship Canal House, King Street, Manchester 2.

THE Lords Commissioners of the Treasury have approved the appointment of Mr. W. F. Grimes, formerly of the National Museum of Wales, Cardiff, to be keeper and secretary to the London Museum from December 1.

DR. JAMES GREIG has been appointed to the University chair of electrical engineering tenable at King's College, London, as from October 1. During 1926–39 Dr. Greig was lecturer in electrical engineering at the University of Birmingham, and since 1939 he has been head of the Engineering Department at Northampton Polytechnic.

THE Society for Visiting Scientists, 5 Old Burlington Street, London, W.1, has arranged a series of meetings to discuss the organization of research within the British Commonwealth. Each area will be dealt with by speakers having special knowledge of it. The meetings will be held at 7.30 p.m. on December 5 (India and the Colonies), December 19 (Australia and New Zealand), January 9 (Canada and South Africa) and January 23 (Great Britain).

LETTERS TO THE EDITORS

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

Propagation and Termination Coefficients for Vinyl Acetate Photopolymerization

MOST vinyl derivatives polymerize to macromolecules by means of the well-recognized chain mechanism in which the monomeric molecules are activated thermally, by catalysts or by radiation. This step is followed by the addition of molecules of monomer, the so-called propagation step, and finally the activity may be removed by a variety of ways leading to the termination of growth of the polymer. In many such reactions termination of growth occurs by mutual reaction between the two active polymers. In this case it is easy to show that

$$- d(M)/dt = k_p(M)(I/k_t)^{1/2},$$

where $- d(M)/dt$ is the rate of disappearance of monomer, I is the rate of activation of monomer M, k_p is the average value of the bimolecular velocity coefficient for the interaction of active polymer and monomer and k_t is the termination velocity coefficient. If transfer is excluded, the chain-length ν is $k_p(M)/(Ik_t)^{1/2}$. Thus measurements of the rate and of the chain-length will enable $k_p/k_t^{1/2}$ to be determined. No matter how the experiments are conducted, only *two* quantities can be measured, whereas there are *three* variables concerned in these complex reactions. Complete analysis of the kinetics of the reaction is therefore impossible. The following technique has made it practicable to overcome this fundamental difficulty and to learn a good deal more about the mechanism of polymerization.

According to the above general theory, we have the relationship that

$$- d(M)/dt = k_p(P)(M),$$

where (P) is the total active polymer concentration. Further, we have that $I = (P)/\tau$, where τ is the mean life of the active polymer. Thus if I and τ can be determined, k_p and k_t can be computed by substitution in the above equations. The photochemical liquid phase polymerization of vinyl acetate proved to be a suitable reaction for this purpose. In this case, $- d(M)/dt$ is proportional to the square root of the intensity of the absorbed radiation. τ can, in this circumstance, be measured by the rotating sector method, and, in a typical experiment, had a value of $2 \cdot 25 \times 10^{-2}$ sec. I was determined by the standard inhibition technique. *p*-Benzoquinone is especially useful for this purpose since it gives rise to a well-marked induction period followed by a rate of polymerization precisely equal to that of the uninhibited reaction.

It turns out that each quantum of absorbed radiation starts off a polymer chain. In the experiment above, $I = 6 \cdot 3 \times 10^{-7}$ einstein sec.$^{-1}$ litre^{-1}. At 15·90° C., $- d(M)/dt$ was $8 \cdot 3 \times 10^{-5}$ moles sec.$^{-1}$ litre^{-1}. Thus, $k_p = 5 \cdot 86 \times 10^2$ litre moles^{-1} sec.$^{-1}$. These experiments were repeated at different temperatures in order to obtain the energy of activation for propagation, which amounts to 4,400 cal. Hence the temperature-independent factor for k_p has a value of $1 \cdot 35 \times 10^6$ litre moles^{-1} sec.$^{-1}$. If we assume the normal value of this factor to be 10^{11}, then this would imply a steric factor of about 10^{-5}, which is reasonable having regard to the nature of this type of reaction.

From the theory, $k_t = (k_p{}^2(M)^2I)/(- d(M)/dt)^2$. The value of k_p is then inserted in this equation and k_t is $3 \cdot 04 \times 10^9$ litre moles^{-1} sec.$^{-1}$.

Experiment shows that *no* energy of activation is required for the termination reaction, and hence the steric factor will have a value of about 10^{-2}. These measurements refer to a chain-length of 1,250. All these experiments were repeated at a chain-length of 2,500 by reducing the intensity of the light to a quarter of its original value, τ increasing to $5 \cdot 51 \times 10^{-2}$ sec. Under these conditions, $k_p = 5 \cdot 56 \times 10^2$ and $k_t = 2 \cdot 86 \times 10^9$. In spite of the large increase in chain-length, it will be seen that the values of k_p and k_t are not much affected. Further, the ratio of these constants remains unaltered, which is very convenient when dealing with the detailed theory of the reaction.

The number average molecular weight of these photopolymers was determined by Mr. C. R. Masson (details will be published in a separate communication) in this laboratory, and it is interesting to note that they agree to within 5 per cent of the kinetic chain-length. This shows quite conclusively that no transfer reaction takes place under these conditions. In addition, these figures prove that when the active polymers mutually destroy each other's activity, they do not link up but remain separate particles.

These facts could be readily explained by assuming that the active polymers are free radicals, but such experiments do not necessarily indicate conclusively the nature of the active particle.

Full details of these experiments will be published elsewhere.

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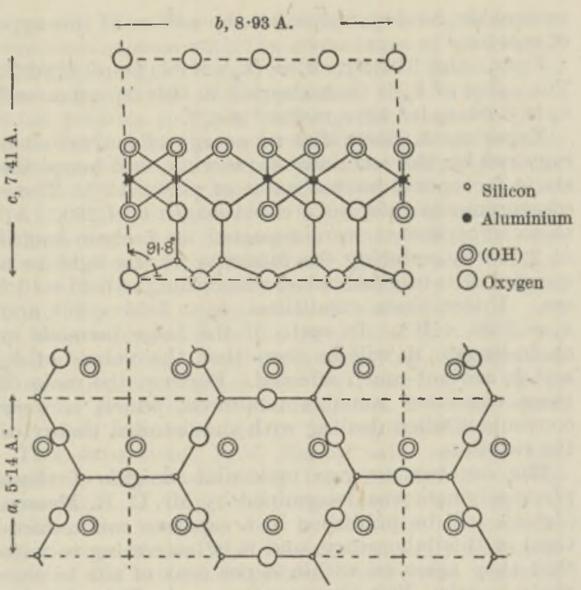
Sept. 20.

Structure of Kaolinite

THE generally accepted structure of kaolinite was elucidated by Gruner[1] from X-ray powder photographs, and Hendricks[2] afterwards gave confirmatory data obtained by electron diffraction. They find a monoclinic structure with cell dimensions $a = 5 \cdot 14$ A., $b = 8 \cdot 90$ A., $c = 14 \cdot 51$ A., $\beta = 101° \; 30'$, consisting of sheets of Si-O tetrahedra and Al-OH octahedra arranged parallel to the basal plane (001), there being two sheets in each unit cell. Gruner based his structure on measurements of some forty reflexions. Other workers[3] have since published lists of kaolinite reflexions aiming at higher accuracy in the spacing measurements rather than increasing the number of recorded reflexions. Apart from the work of Hendricks, we know of no further attempt to study the structure of the mineral since the publication of Gruner's analysis.

We have recently had occasion to examine in detail the X-ray powder diagram of kaolinite under conditions of higher resolution than Gruner employed; using a 20-cm. diameter focusing camera and a 12-cm. diameter cylindrical camera, we have recorded some seventy reflexions. Among the lower-order reflexions in particular we find additional lines to those recorded by Gruner, and attempts to reconcile them with a monoclinic cell failed completely. We were finally led to examine the possibility of a triclinic



cell. The observed reflexions can be accounted for satisfactorily by the following triclinic cell:

$a = 5{\cdot}14$ A. $\alpha = 91{\cdot}8^\circ$
$b = 8{\cdot}93$ A. $\beta = 104{\cdot}5^\circ$
$c = 7{\cdot}41$ A. $\gamma = 90^\circ$

This differs from Gruner's cell in that it is only pseudo-monoclinic and, having half the height, contains only one Si-O, Al-OH sheet. The structure of the sheet, shown in the upper part of the accompanying diagram, is that given by Gruner; the lower part of the drawng shows the relation between the basal oxygen atoms of the cell and the OH layer of the cell immediately *below* and may be compared with similar diagrams given by Hendricks[4] for the other kaolin minerals, dickite and nacrite, which show a closely similar relation between the two adjacent layers. Calculation of the reflected intensities for the ideal structure (that is, assuming regular tetrahedra and octahedra) shows general agreement between the observed and calculated intensities. A more detailed study of the actual deviations from the ideal structure is in progress.

The triclinic character of the lattice results in many more reflexions than would occur if the structure were strictly monoclinic, and provides a general explanation for the broadness of many of the observed lines, which are composite, and also (at least, in part) for the weakness of many of the lines as compared, for example, with those from dickite, a strictly monoclinic kaolin mineral.

A comparison of our results with those of Gruner for the lower order reflexions is given in the accompanying table.

LATTICE SPACINGS, *d*, AND OBSERVED INTENSITIES, *I*, OF X-RAY REFLEXIONS FROM KAOLINITE.

Present values *d*	Present values *I*	Gruner's values *d*	Gruner's values *I*
7·133	10	7·13	10
4·460	4		
4·354	5	4·39	6
4·176	5	4·21	3
4·128	3	4·02	4
3·844	4		
3·733	2	3·76	4
3·567	15	3·57	10
3·368	3	3·35	½–1
3·148	1		
3·094	1	3·08	½–1
2·746	2		
2·556	4	2·556	5
2·527	2		
2·486	4	2·491	5
2·376	2	2·373	2
2·333	6	2·341	8
2·286	4	2·272	5
2·242	1		
2·183	2	2·200	½

Whether the kaolinite examined by Gruner had a different structure from the specimens we have examined is for the moment left an open question. We are examining a large number of kaolinite specimens from widely different localities, and so far they have confirmed our results given above, which were obtained from a sample of specially purified Cornish china clay; none has so far confirmed Gruner's data.

Note added in proof. We have now examined fifteen kaolinites from different localities, and the results confirm those given above.

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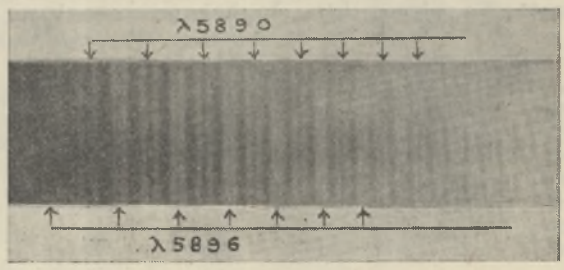
July 26.

[1] Gruner, J. W., *Z. Krist.*, **83**, 75 (1932).
[2] Hendricks, St. B., *Z. Krist.*, **95**, 247 (1936).
[3] Nagelschmidt, G., *Z. Krist.*, **87**, 120 (1934). Favejee, J. Ch. L., *Z. Krist.*, **100**, 425 (1939).
[4] Hendricks, St. B., *Z. Krist.*, **100**, 509 (1939), vide Fig. 2, p. 517.

Splitting of the Sodium Doublet Lines

WHILE demonstrating the interference patterns of various lines by means of a Hilger C.D. instrument in conjunction with a Lummer-Gehrcke plate, a Philips 'Philora' sodium vapour lamp was used to produce the patterns of the sodium doublet λ 5890/96. This lamp is in the form of a U-tube enclosed in an outer vacuum jacket and is excited by 230 V. A.C. mains through the usual electric control gear. The lamp usually takes about 10–12 minutes to reach its maximum intensity. In the first few minutes, each of the two lines showed its normal monochromatic interference pattern as sharp fringes; but as the lamp got heated and acquired its steady state of illumination, the fringe system of both the lines presented a complex appearance. To follow this development of complexity, the lamp was switched off for some time to cool down and then restarted. The fringe pattern was viewed through the telescope from the time it was switched on. As the lamp gained its full wattage (65 W.), each of the fringes in the two wave-lengths began to broaden out and ultimately developed almost symmetrical splitting into two defined components. The magnitude of the actual splitting computed from measurement is, within the limits of experimental errors, 0·064 A. for λ 5890 and 0·053 A. for λ 5896.



At first sight, this effect suggests self-reversal combined with pressure broadening; but the discharge conditions were not quite favourable for partial self-absorption. As Finkelnburg[1] points out, self-reversal may also be a consequence of partial pressure of metallic vapour in the path of discharge; absence of self-reversal may leave the lines merely broadened, giving a diffuse appearance of continuous spectrum to the fringes, which is not the case found here. If, however, a genuine self-reversal is assumed, it would be quite interesting to investigate the broadening in this particular case owing to the nature of the radiation source. As shown by Watson[2], broadening may be traced to a number of factors: (*a*) radiation damping, (*b*) Doppler effect, (*c*) resonance between similar atoms, (*d*) effect of foreign perturbers of van der Waals type, any one or several together contributing to the effect.

On the other hand, if self-reversal is ruled out, we might interpret the observed phenomenon as a splitting of the Stark effect type by foreign perturbers (here neon) carrying permanent fields. There is evidence in favour of this type of broadening by inter-atomic or inter-molecular fields resulting from even mild electrical excitation. Merton[3], Hulbert[4] and Finkelnburg[1] have recorded inter-atomic Stark effects of the Balmer lines of hydrogen, and Finkelnburg[1] has deduced from the observed broadening the electric fields at various pressures. The great line-breadths of Hg in high-current discharge by strong inter-atomic or ionic fields have been observed by Knauss and Bryan[5]. Even splitting of the λ 2537 Hg absorption line into two broad components in solutions has been shown by Reichardt and Bonhoeffer[6].

Other similar lamp sources such as mercury and sodium (another pattern) examined in this way show comparable splitting or broadening effects of smaller or larger magnitude. It is not possible at this stage to say what the predisposing causes of the phenomenon are, until complete experimental analysis under defined conditions is available. This is being undertaken.

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G. K. Mehta.

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Bombay. June 5.

[1] *Z. Phys.*, **70**, 375 (1931).
[2] *Rev. Mod. Phys.*, **8**, 22 (1936).
[3] *Proc. Roy. Soc.*, A, **92**, 322 (1915).
[4] *Phys. Rev.*, **22**, 24 (1923).
[5] *Phys. Rev.*, **47**, 842 (1935).
[6] *Z. Phys.*, **67**, 780 (1931).

Enhancement of the Action of Immune Hæm-Agglutinins by Human Serum

Experiments to determine whether human complement plays a part in the specific agglutination of human erythrocytes by immune serum revealed an interesting phenomenon. The titration end-point of the immune iso-agglutinin chosen for the experiment was found to be considerably increased when certain compatible human sera, diluted 1 : 3, were used in place of saline as a diluent for the iso-agglutinin. When naturally occurring iso-agglutinin was titrated in serum, however, the titre was found to be the same as that observed using saline as diluent (see Table 1).

Seventy-seven immune sera, comprising 49 anti-*Rh*, 7 anti-*Rh* sub-group, 14 anti-*A*, 1 anti-*B*, 3 anti-A_1 (*alpha*$_1$), 2 anti-*M* and 1 anti-*N*, were titrated in serum and in saline. The degree of agglutination as measured by the size and firmness of the masses of agglutinated cells was in each instance much more pronounced when serum was employed for dilution than when saline was used, and in 73 of the 77 specimens there was also a definite increase in titre. Frequently, however, the limit of agglutination in serum was observed to extend to not more than one or two tubes beyond the limit of agglutination of the saline control series.

TABLE 1.

Titre	Immune iso-agglutinin		Naturally occurring iso-agglutinin	
	Saline	Serum	Saline	Serum
1	*c*	*c*	*c*	*c*
2	*v*	*c*	*c*	*c*
4	+	*v*	*v*	*v*
8	(+)	*v*	+	(+)
16	*w*	*v*	*w*	*w*
32	–	++	–	–
64		(+)		
128		(+)		
256		*w*		
512		–		

Read macroscopically: *c* = complete agglutination; surrounding fluid clear. *v* = visual agglutination; surrounding fluid pink.
Read microscopically: ++ = very large clumps; + = large clumps; (+) = smaller clumps with many free cells; *w* = clumps of 4–5 cells; – = no agglutination.

Fourteen naturally occurring agglutinins, which included 5 anti-*A*, 4 anti-*B*, 4 anti-A_1 (*alpha*$_1$), and 1 anti-0, were also examined. Two of the anti-A_1 (*alpha*$_1$) sera were prepared by absorption of group *B* sera with A_2 cells and two were from group A_2B persons. The anti-0 serum was an absorbed cattle serum. In no instance was there any increase in either the degree of agglutination or in the titre when serum was used as diluent in place of saline. The results are summarized in Table 2.

TABLE 2.

Iso-agglutinin	Total no. tested	No. showing increase in titre	No. showing *no* increase in titre
Immune anti-*Rh*	49	46	3*
Anti-*A*	14	13	1*
Anti-*B*	1	1	0
Anti-A_1	3	3	0
Anti-*M*	2	2	0
Anti-*N*	1	1	0
Naturally occurring anti-*A*	5	0	5
Anti-*B*	4	0	4
Anti-A_1 (α_1)	4	0	4
Anti-0	1	0	1

* These sera showed an increase in degree of agglutination, without an increase in titre being observed.

An immune *Rh* serum was titrated in 67 sera to determine whether the capacity to increase the agglutination titre of the immune iso-agglutinin was shared equally by all human sera. It was found that the sera varied markedly in their power to amplify the immune agglutinin, and indeed two very active sera were found to increase the titre of the test *Rh* serum from 4 to 256.

The factor present in the serum which causes the increase in titre is not complement as it is not destroyed by heating at 56° C. for half an hour, or by storing the serum frozen solid (– 10° C.) for many months.

The fact that no difference was observed in the titre of naturally occurring antibodies whether titrated in saline or serum indicates that the increase in titre shown by immune agglutinins cannot be ascribed simply to the effect of the viscosity of the serum.

The differentiation of natural and immune agglutinins by their behaviour in agglutination tests suggests that there is a qualitative difference between naturally occurring and immune agglutinins.

In suspected cases of hæmolytic disease of the newborn, the finding of *Rh* agglutinins in the maternal serum strongly supports the clinical diagnosis, but their presence in a serum is often doubtful when the degree of agglutination is very weak. In several instances during the last two years, we have used the agglutination enhancement test and have established beyond doubt the presence of *Rh* agglutinins in such weakly reacting sera. Also, in cases suspected of having received an incompatible blood transfusion, an anti-*A* or anti-*B* titre in the recipient's serum which is increased by the use of this technique is a strong indication that the antibody has been stimulated by immunization and that blood of an incompatible *A*,*B*,0 group has in fact been given.

A detailed account of the work described in this communication will appear elsewhere.

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B. E. Dodd.
S.W. Blood Transfusion Depot,
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Transition of Fibrinogen to Fibrin as a Two-Step Reaction

It has been assumed by Apitz[1] that the transition of fibrinogen to fibrin is not a simple reaction, but takes place in two stages. The primary product should be a soluble substance, less stable than fibrinogen, which he called profibrin. By suitable choice of the composition of the electrolytes of the medium, we succeeded in studying the two phases of the reaction separately; thus we obtained a substance which has a better-founded claim to the name profibrin.

At a *p*H on the acid side of the iso-electric point of fibrinogen, for example, at *p*H 5·1, the addition of thrombin to a solution of fibrinogen does not cause clotting. If now the system is neutralized, say *p*H 6·8, the fibrinogen coagulates, which shows that at the acid reaction it has not been irreversibly damaged.

If the neutralization is not carried out immediately, but after a longer reaction at *p*H 5·1, then the clotting-time after neutralization is the shorter the longer fibrinogen and thrombin have been kept together at the acid *p*H (see table):

Composition of the system: 0·5 cm.³ fibrinogen according to Laki*, 20 mgm. per cm.³ in 0·9 per cent sodium chloride; 0·5 cm.³ *M*/5 potassium dihydrogen phosphate; 0·1 cm.³ thrombin. After different times of reaction, neutralization of 0·1 cm.³ of the reaction mixture with 0·05 cm.³ *M*/5 disodium hydrogen phosphate.

Reaction time:	Clotting time:
10 sec.	6 min.
1 min.	5 „
10 „	4 min. 30 sec.
30 „	3 „ 30 „
60 „	2 „
90 „	40 „
120 „	15 „
300 „	10 „

* Laki, *Z. physiol. Chem.*, 273, 95 (1942). *Stud. Inst. Med. Chem. Szeged*, 2, 27 (1943).

This shows that the formation of fibrin takes place in two steps; the first step, the primary reaction between fibrinogen and thrombin, also takes place at *p*H-values on the acid side of the iso-electric point of the former; the polymerization of the primary product to fibrin, however, is possible only then, when the fibrinogen is negatively charged.

At *p*H 5·1 the presence of thrombin does not cause any physical change of the fibrinogen which could be considered as an indication that polymerization was beginning. The viscosity at a very low velocity-gradient shows only a slight increase[2].

The second phase of the transition is inhibited by neutral salts in such a way that we conclude that the polymerization of the primary product to fibrin is caused by electrostatic attraction. The first reaction is not inhibited by electrolytes; its nature is still obscure.

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(Prepared for publication:
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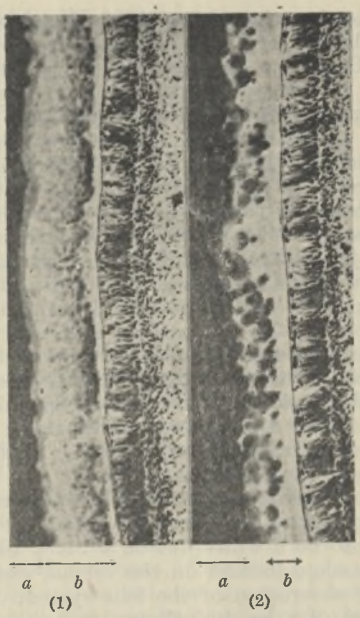
[1] Apitz, *Z. exp. Med.*, 101, 552 (1937).
[2] Pittoni, unpublished results.

Effect of Restriction of Food Intake upon the Incisor Teeth of Rachitic Rats

In previous publications[1], it has been shown that the upper incisor teeth of rats are very sensitive indexes of calcium and phosphorus metabolism. Thus in rats on the Steenbock and Black rachitogenic diet No. 2965 [2], doses of vitamin D cause a response which, so far as present work goes, seems to be specific to this substance. A line of newly calcified dentin occurs in the proximal labial predentin formed after dosage, but little change takes place in that already formed (Fig. 1). This reaction is accompanied by the usual epiphyseal healing made use of in the line test. Changing the Ca : P ratio of the diet given to rachitic rats from 5·6 to 1·9 also causes healing in the teeth and bones, but quite unlike that after vitamin D medication. In the teeth, irregular clumps of calcospherites are laid down promiscuously in the proximal labial predentin. In the bones, an irregular healing occurs in the epiphysis, usually consisting of upgrowths of calcified material in the metaphysis, joining with that in the diaphysis, and often no clear 'line' occurs at all[3].

It appeared to be of interest to compare these changes with those occurring during restriction of food intake, which is well known to cause healing of rickets in rachitic animals. Three litters of rats were kept on the Steenbock and Black diet until they had well-marked rickets. Some were then dosed with 27 I.U. of vitamin D in oil by mouth and maintained on the same diet. The rest were also kept on the rachitogenic diet, but their food intake was so restricted that they lost on an average 3·6 gm. in weight per day. Animals treated in either way were killed and examined on the first, second, fourth, sixth or eighth days after dosage or food restriction. In two of the litters the epiphyses of the restricted rats showed new calcification on the second day, and on the fourth day in the third litter. The changes were quite typical of those seen after vitamin D dosage, with lines forming on the metaphyseal side



LONGITUDINAL SECTIONS OF THE PROXIMAL PART OF THE LABIAL SIDE OF THE UPPER INCISOR TEETH. *a* = DENTIN, *b* = PREDENTIN. × 90.

(1) Section from a rachitic rat given 27 I.U. of vitamin D four days previously. The line of new calcification can be seen in the predentin. (2) Section from a rachitic rat the food intake of which was restricted for two days. The irregular masses of calcospherites in the predentin can be seen.

of the epiphyseal cartilage, and the two reactions were in fact indistinguishable. The line test became positive on the fourth day in all animals dosed with vitamin D.

The upper incisor teeth of the restricted rats reacted within a few hours of dietary restriction. The teeth of the animals dosed with vitamin D also reacted within a few hours. The changes in the teeth of the restricted rats were quite unlike those following vitamin D dosage, but were the same as the changes already described when the Ca : P ratio of the diet was adjusted[3]. In the proximal and intermediate part on the labial side, masses of interglobular dentin gradually filled the whole of the predentin, starting from the already calcified dentin and working, with time, across towards the odontoblasts (Fig. 2).

The changes in the blood calcium and phosphorus of rachitic rats when the Ca : P ratio of the diet is adjusted are the same as those which occur when such animals are starved. Kramer, Shear and Siegel[4] have shown that the blood calcium falls and the phosphorus rises in both cases. The animals may have tetany, and in the present experiments several of the restricted animals appeared to be on the verge of tetany. Thus on chemical grounds, it is easy to explain the resemblance of the reactions in the teeth with both treatments. It is, however, difficult to understand the differences in the responses in the epiphyses, and why the epiphyses of the restricted rats should react in a way identical with that after vitamin D dosage when the chemical changes in the blood are so different. One would have expected a change similar to that after adjusting the Ca : P ratio of the diet.

So far as the teeth are concerned, however, the reparative histological changes seen after vitamin D dosage or dietary restriction in rachitic rats seem to have quite different mechanisms. Dietary restriction and adjustment of the Ca : P ratio of the diet, on the other hand, produce the same changes.

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May 11.

[1] Irving, J. T., *Nature*, **147**, 608 (1941); *J. Physiol.*, **103**, 9 (1944).
[2] Steenbock, H., and Black, A., *J. Biol. Chem.*, **64**, 263 (1925).
[3] Irving, J. T., in the press.
[4] Kramer, B., Shear, M. J., and Siegel, J., *J. Biol. Chem.*, **91**, 271 (1931).

Utilization of the Slipper-Limpet (*Crepidula fornicata*) as Food as an Aid to the Recovery of Oyster-Culture in the Thames Estuary

AN account was given in *Nature*[1] of the very heavy mortality of oysters on certain Thames Estuary oyster beds following and directly attributable to the very severe winter of 1939–40. The financial loss was of a crippling nature, and attention was directed at the time to the need of oyster farmers for financial assistance from the Government for the recovery and restocking of the beds.

During the War, oyster cultivators have had to surrender most of their man-power, with the result that culture has been limited to certain parts of the oyster beds. In these circumstances, as I have found in a recent survey, the American slipper-limpet (*Crepidula fornicata*) has increased on the unworked beds in such numbers as to make dredging for oysters uneconomical while at the same time the total stocks of oysters have remained low. Thus there is greater need for assistance now than in the early years of the War, and in the first place for the cleaning-up of the grounds.

It is now suggested that a practical scheme to help towards the recovery of the oyster-beds is to utilize the slipper-limpet as food and thereby at least partially defray the costs of clearing the grounds. During the War, Korringa[2] has described how the slipper-limpet—which had invaded and spread rapidly on the Dutch oyster-beds since 1929[3] as foreshadowed by me—became economically valuable as food, being either eaten raw or used in the manufacture of food products. The scale of the slipper-limpet utilization has increased enormously (4,500,000 kilograms were used in 1941 and 14½ million kilograms in 1942). In the early period slipper-limpet meats were separated manually; but later, mechanical devices were used with a great saving in man-power costs (letter from P. Korringa).

While the slipper-limpet, either cooked or raw, makes little appeal to the English palate, it seems possible that during the existing shortage of food-materials in Europe the flesh should have a reasonably high value at the present time when suitably worked up as meat product. Such a product was actually produced by a German firm which, however, kept the process secret; but this is not a serious hurdle.

The practical aspect of the problem is that it will exist only for a relatively short period. Although many hundreds of tons of slipper-limpets could be dredged, the supply would sooner or later fall below an economic minimum, though in this period the beds would be cleared. Hence the problem is essentially one for assistance as a post-war measure.

It is estimated from Korringa's data that dried protein constitutes about 1 per cent of the net weight of slipper-limpets, and as thirty tons of limpets could easily be dredged in a day with appropriate gear, a considerable daily quantity of food-material could be produced; the rate of supply could be adjusted within wide limits to meet the requirements of the manufacturing process.

The object of this communication is to direct the attention of the various bodies likely to be interested to the problem with the view of facilitating early action. These bodies are: Ministry of Agriculture and Fisheries as representatives of public oyster beds, and oyster cultivators; Ministry of Food, representing untapped sources of food supply; Department of Scientific and Industrial Research, as concerned in processes of food manufacture; Development Commission, as the body interested in researches dealing with improvements in fisheries; as well as private manufacturers of food products, and representatives of the oyster cultivators whose beds require clearing.

It is obvious that if these limpets could be used as food there would result the double advantage of contributing to the food stocks of Europe and helping the oyster farmers to clear their beds of this pestilent but extremely interesting immigrant from America.

I am indebted to Dr. P. Korringa for recent information relating to the Dutch oyster beds.

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Sept. 1.

[1] *Nature*, **145**, 708 (1940).
[2] Visscher: en Meded: Rijksinst. Visscher. Ond. (August 1941).
[3] *Tijdschrift van de Neder*: *Mala*: *Ver*: 7, Nos. 1 and 2, 12 (1942).

The Anti-Chromatic Reflex

It has long been a matter for surprise that the eye appears to be so perfectly achromatized. It was this which led Euler to conclude that the construction of achromatic lenses must be possible, and in consequence the optician Dollond sought for a method, and thus invented the use of negative flint lenses in association with positive crown glass ones. The celebrated cobalt-blue glass experiment and many others amply demonstrate the fact that the lens system of the eye is uncorrected for colour. It was this fact that presumably led to the remark, which is often ascribed to Helmholtz, that if a lens maker turned out so inferior a lens as that of the eye he would soon be out of business.

Actually the performance of the eye as used in normal vision is of a very high order. Achromatizing the eye by means of a suitable combination of crown and flint glasses improves visual acuity to a very slight extent only. The same is true when monochromatic light, for example sodium light, is used for visual purposes. Further, the resolving power of the eye is only slightly inferior to that of an apochromatic microscopic objective of the same focal length and aperture. But in one important respect the lens system of the eye is greatly superior to such a microscopic objective, namely, in its angle of view, for this in the case of the eye exceeds 100° from the optic axis.

Many explanations have been offered in the past for the absence of coloured fringes from the retinal image. But none of these has proved to be satisfactory. The experiments which I have reported previously, in which micro-stimuli have been employed[1,2], have now led to the discovery of a nervous reflex which has the effect of eliminating the coloured fringes produced by the chromatic aberration of the eye. Because of this effect, it has been called 'the anti-chromatic reflex'. This reflex consists of two apparently separate mechanisms, one for dealing with the yellow fringe, and the other for dealing with the blue one; these are the colours of the fringes normally present in the emmetropic eye. In the uncorrected myope the fringes may be red and blue-green, and in the uncorrected hypermetrope they may be green and purple, or even blue-green and red. In these conditions the anti-chromatic reflex will probably fail to eliminate the fringes, so that they will be visible to the observer.

The mode of operation of the reflex may be explained by taking an example. Suppose the object looked at to be a white dot on a black background, then the image formed on the retina, owing to the chromatic aberration of the lens system of the eye, will consist of a bright yellow dot surrounded by a blue halo of low intensity. The anti-chromatic reflex will now convert the yellow dot into a white one, and at the same time the blue halo will be replaced by black; thus the original appearance of the object will be restored.

It is hoped to publish further details of this reflex shortly.

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[1] Hartridge, H., *Nature*, **155**, 391 (1945).
[2] Hartridge, H., *Nature*, **155**, 657 (1945).

Early Observation of Antibiotic Action

In his book "Essays on the Floating-Matter of the Air" (1881), the physicist John Tyndall describes experiments which he carried out in 1875 refuting the doctrine of spontaneous generation of life. In the course of these experiments tubes of organic infusions were infected with organisms after exposure to the atmosphere. A number of cases occurred when such tubes, which were turbid and swarming with bacteria, became covered with *Penicillium glaucum*, three unspecified kinds being noticed. The bacteria in these tubes lost their translatory power and fell to the bottom, leaving the liquid between them and the superficial layer clear. Tyndall ascribes this to the success of the moulds in the struggle for existence and notes that access of oxygen to the body of fluid must have been hindered. He did not, however, test the clear liquid for its capacity to support newly implanted bacterial life. It is interesting to speculate upon what the consequences might have been had Tyndall allowed himself to be drawn from his main investigation.

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NATIONALIZATION OF MINERAL RIGHTS

IN July 1944 the Institution of Mining and Metallurgy discussed a paper by Prof. W. R. Jones in which he advocated the acquisition by the State of mineral rights. On that occasion he restricted his proposals to minerals as contrasted with *rocks* and so did not include roadstones, building stones, limestone, brick clays, sands and gravels. In a later paper submitted for discussion in September of this year, he has extended his advocacy of nationalization to this larger group.

It is noted that Great Britain is almost unique in the British Empire in that the mineral rights are not vested in the Crown or in the Government. Two important steps have already been taken towards nationalization. Under the Petroleum Production Act of 1934 the ownership of petroleum occurring in Britain is vested in the Crown; under the Coal Act of 1938 the State purchased the mineral rights in coal by compensating the royalty owners on a basis of a fifteen-year purchase of royalties. In addition, it has long been accepted that the royal metals, gold and silver, and also any minerals lying under tidal or territorial waters, belong to the Crown. Prof. Jones now advocates the acquisition of all mineral rights on the same basis as that used in the case of coal. He is careful to point out that State acquisition of mineral rights has nothing to do with nationalization of mines.

In the earlier paper Prof. Jones deals mainly with lead-zinc, tin and china clay. In the case of lead-zinc, it is urged that low-grade ores remain to be worked, which it is in the national interest to use but which cannot be done except under a large co-ordinated scheme involving drainage and centralized smelting. In the case of tin he deduces from the now well-known phenomena that copper lodes give place in depth to tin lodes with a relatively barren zone separating the two, that rich tin deposits may underly many old abandoned copper mines in the south-west of England; but that the problem is a national one which could be tackled only after the acquisition of the mineral rights.

In the second paper Prof. Jones mentions, though he does not perhaps stress sufficiently, the profligate waste of land now resulting annually from the working of gravel, sand, iron ore and other surface minerals.

The most startling feature of the papers is the relatively small cost involved. The figure for all base-metal minerals is only £421,000; for iron ore less than £4,000,000, and for all the minerals of Britain less than £22,000,000.

If the policy is regarded as right for coal and oil, it seems difficult to resist the conclusion that it is right for other minerals, but it would seem that Prof. Jones has only considered part of the problem. The State acquisition of petroleum rights was made *before*, and in intelligent anticipation of, the discovery of petroleum in quantity; and no land owner could truthfully feel himself unjustly deprived of his rightful possessions since he did not know such existed. Prof. Jones's proposals deal with acquisition by the State of other mineral rights by payment to owners in known mineral-bearing areas. It is here that a link with the general trend of policy regarding land planning suggests itself. If the State were to acquire all development rights in undeveloped land (that is, on land which is at present agricultural or afforested or open) and thus effectively control surface development, these rights would obviously include any development of minerals. Quite clearly this would solve the pressing problems arising from surface working of coal, iron ore, gravel, sand, limestone and clay, where so much valuable agricultural land is being wasted through absence of adequate provision for restoration. It would permit the control, in the national interests, of the location of mineral workings of all types and open the way for the much-needed balanced planning of the use of the land of Britain.

L. DUDLEY STAMP.

THE ROYAL STATISTICAL SOCIETY

INDUSTRIAL AND AGRICULTURAL RESEARCH SECTION

THE Council of the Royal Statistical Society has decided that the Industrial and Agricultural Research Section, the activities of which were suspended at the outbreak of war, shall be reconstituted in the form of two separate sections—a Research Section and an Industrial Application Section.

From its inception in 1933, the Industrial and Agricultural Research Section met the needs of the growing number of workers interested in applying statistical methods to industry and agriculture. It held regular meetings at which papers were read and discussed, and published the Supplement to the *Journal of the Royal Statistical Society*, which not only contained these papers with reports of the discussions, but also provided a medium for the publication of new developments in the field of applied statistics.

During the War, statistical methods were applied on a greatly increased scale; in particular the need became apparent in industry for a common meeting ground where the experiences and difficulties arising in the practical application of statistical techniques could be discussed. On the initiative of Dr. B. P. Dudding, an informal Industrial Applications Group was formed in London to fulfil this need, and it was clear from the success attending the activities of the Group that there existed a considerable body of people who, though not necessarily professional statisticians or scientific workers, were very much interested in the practical aspects of the application of these new techniques to industry.

The Council of the Royal Statistical Society feels that the two distinct needs which are now evident will be catered for more adequately by the reorganization which has been effected. The Research Section will be concerned with the theory of statistics and statistical methods and with the development of new applications, while the Industrial Applications Section covers the practical application of statistical technique to industrial research, development, and manufacture, including inspection.

The Research Section, which will meet in London, proposes to hold four meetings during the coming session. Papers read at these meetings will be published in the Supplement to the Society's *Journal*, together with reports of the discussions. Details of the meetings will be announced in *Nature* and other appropriate journals. Visitors who are not members of the Section will be welcome.

The Industrial Applications Section is organized in local groups. In London, Birmingham and Sheffield, groups are already in existence, and the formation of groups at a number of other centres is under consideration. Discussions at group meetings will not in general be published, but should the local group committee consider certain papers to be of sufficient importance, their publication and method of distribution will be considered. Meetings of the groups will be announced in the appropriate journals.

The Supplement to the Society's *Journal* is edited by the Committee of the Research Section under direction from the Council of the Society. It is hoped that, in addition to publishing papers read before the Research Section, it will become a medium for the publication of research work on topics of general interest to statisticians. Such papers need not necessarily be theoretical or mathematical but should expound or illustrate some new development in statistical methodology. At present, papers of this nature are often published in journals devoted to special branches of science and not always readily accessible to workers in other fields.

Membership of either or both Sections is open to fellows of the Society free of charge and to non-fellows who are approved by the appropriate Section Committee, on payment of an annual subscription of ten shillings (for each Section). The Supplement to the *Journal* will be published twice yearly. It will be available to fellows of the Society free of charge and to members of the Sections at reduced rates. Further information may be obtained from the Assistant Secretary, Royal Statistical Society, 4 Portugal Street, London, W.C.2.

RESEARCH WORK AT THE MILLPORT MARINE LABORATORY*

THIS series of annual reports recently issued by the Scottish Marine Biological Association, covering as they do the war years 1939–44, are of great interest. Not only has the work been well maintained, but also the new wing, representing a considerable extension of the laboratory buildings, opened in June 1939, has been in general use. The staff, in spite of several members being absent on war service, has been extremely active and, in addition, workers from outside have added to the programme in various ways. This has been chiefly on the economic side, but ecological and faunistic work has still continued.

Dr. Orr's analysis of the various marine organisms with regard to their nutritive value, based on two hundred different species, including molluscs, crustaceans, fishes, cœlenterates, echinoderms and worms, shows that molluscs, crustaceans, fishes and worms are of high food value, echinoderms and cœlenterates low. The results have been tabulated. His more recent work has been chiefly an investigation of seaweeds with special attention to those likely to provide substitutes for Japanese agar. This research, later in collaboration with Dr. S. Marshall and throughout in close touch with representatives of the Ministries of Supply and Health, resulted in a satisfactory agar substitute being found in the red alga, *Gigartina stellatus*, which is now being used on a commercial scale. A survey of algæ is also being carried out.

Dr. S. Marshall, who in the early part of the period was occupied with the life-histories of certain copepods, besides this agar work, is, together with Dr. Orr and Dr. F. Gross and J. E. G. Raymont, of the University of Edinburgh, taking part in an interesting experiment in Loch Sween and its small arm Loch Craiglin, by fertilizing the water by the addition of nutrient salts and investigating the effect on the growth of the phyto- and zoo-plankton, and of the fish introduced. An account of this was given in *Nature*[1]. Latest reports show that the added nutrients were rapidly absorbed and an increase in the size of the fish was in many cases large.

The question as to the value of marine plankton as food for land animals was raised by Sir John Graham Kerr in 1941, and Prof. A. C. Hardy of Aberdeen, with the approval of the Agricultural Research Council, took the matter up and devised experiments in co-operation with the Millport Station, primarily to see if plankton could be obtained in sufficient quantities to be used to form an addition to protein meal for animal stock and poultry. Good samples of *Calanus* meal were prepared, but the results during the three years did not yield the hoped-for practical results, although Prof. Hardy regards it as a speculative investigation which was well worth trying as a possible additional source of protein in war-time.

In 1941, Dr. J. E. Harris, working under the Marine Corrosion Sub-Committee of the Iron and Steel Institute, began his researches at Millport on problems connected with the marine fouling of metals. This work has increased considerably and several assistants are now working at the various subjects, including the colonization of the experimental rafts with plant and animal growth. Much valuable information has been obtained in connexion with these researches, the technical side of which will be published in the reports of the Marine Corrosion Sub-Committee. On the biological side, among other points of interest, are K. A. Pyefinch's work on the barnacle larvæ and Dr. M. Mare's on the succession of algæ and on the part played by the bacterial slimes in the development of fouling growth.

Experiments on prawn trawling and on the production of seaweed meal were also made, and besides the work of direct economic importance ecological studies have continued, especially in Kames Bay, by Dr. A. C. Stephen and others, including the molluscan and crustacean fauna, the microfauna of the intertidal sands, and insect larvæ of the shore.

The food of the shag was investigated by A. J. Hadow and W. H. R. Lumby, who show close agreement with Steven's[2] observations, the bird being of little economic importance.

* Annual Reports of the Scottish Marine Biological Association (1938–39, 39–40, 40–41, 41–42, 42–43, 43–44). (185 St. Vincent Street, Glasgow.)

[1] *Nature*, 153, 483 (1944).
[2] *J. Mar. Biol. Assoc.*, 19, 277.

INDIAN PLYWOOD FOR TEA CHESTS

THE long stretch of country situated at the foot of the eastern Himalaya is occupied by a succession of tea gardens which extend up into the outer hills to some 5,000 ft. or so elevation on the west. Since the introduction of the growth of tea into the region, the necessary tea box or chest for packing and exporting the tea has been something of a problem with a varied history. In the supply of those gardens situated in Assam, saw mills were erected in Assam many years ago, but most of the chests required came in as imports from Europe in the form of shooks, battens and metal fittings, put together to form the chest on the spot.

This century has witnessed the advent of plywood and revolutionized the construction of the tea chests. In *Indian Forest Records* (New Series: Utilisation, Vol. 3, No. 4, Forest Research Institute, Dehra Dun, 1945), Mr. V. D. Limaye deals with "The Testing of Indian Plywood Tea Chests" with the object of establishing a standard type. With this objective in view, nine different types of plywood tea chests were subjected to systematic scientific tests at the Timber Testing Laboratory, with the view of establishing a standard tea chest of Indian make, comparable with the best of foreign makes. In India, plywood tea chests are manufactured from various timbers such as hollock (*Terminalia myriocarpa*), hollong (*Dipterocarpus macrocarpus*), mango (*Mangifera indica*), semul (*Bombax malabaricum*), pali, and others. Hollock is the main source of supply. It grows in the forests of Assam.

In the past, boxes of all these timbers have been subjected to systematic research at Dehra Dun. The series of exhaustive tests here described was carried out on nine different types of tea chests, known as the '*O*', '*S*' and '*M*' types made chiefly of hollock timber with the view of analysing their comparative merits, and establishing a standard type of Indian plywood tea chest comparable with the best foreign makes. It would appear that this object has been fulfilled and that in this respect India at last can be considered as no longer dependent on imports. Boxes of each of the nine types, totalling in all 210, and representative of the average quality produced by the mill, were supplied in shook form by the Assam Saw Mills. The most common size of box, namely, 19 in. × 19 in. × 24 in., was chosen for the tests. In each of the '*O*' and '*S*' types, boxes of sizes 14 in. × 14 in. × 14 in., 16 in. × 16 in. × 16 in., 18 in. × 18 in. × 18 in., 18 in. × 12 in. × 18 in. were tested, the thickness of the veneers varying. In the '*O*' type the plywood was all hollock. In the '*S*' type the outside ply is of hollong (*Dipterocarpus macrocarpus*). In the '*M*' type the outer ply is of semul. Boxes made with the side panels with the grain vertical are the strongest.

Summarizing the research work the following results are given: The '*O*', 14 in. × 14 in. × 14 in., and '*S*', 14 in. × 14 in. × 14 in., types of plywood tea-chest are found to be very much stronger than the average of the best five makes of imported birch tea-chests, taken as the datum for comparison. By reducing the thickness of plywood to 3/16 in., it has been found that the cost of a tea-chest can be reduced, owing to economy in timber, without sacrificing the strength required. 18 in. × 12 in. × 18 in. type and 16 in. × 16 in. × 16 in. type are both comparable to the datum birch tea-chests; but the 18 in. × 12 in. × 18 in. type is found to be slightly stronger than the 16 in. × 16 in. × 16 in. type, probably due to a more balanced construction of plywood. The tea-chest of '*O*', 18 in. × 12 in. × 18 in. type, is, therefore, recommended as a standard, if making veneers of two different thicknesses is not considered a great disadvantage from the manufacturer's point of view. If 18 in. × 12 in. × 18 in. type is not considered convenient, then 16 in. × 16 in. × 16 in. type, which is the next best, can be established as the standard. There is no difference of any practical importance between the '*O*' and '*S*' types so far as strength is concerned.

JOHN INNES HORTICULTURAL INSTITUTION

THERE is nothing merely formal or perfunctory, and much that is challenging, in the thirty-fifth annual report, for 1944, of the John Innes Horticultural Institution (from the Institution, Mostyn Road, Merton Park, London, S.W.19. 1945). Dr. C. D. Darlington, director of the Institution, has recently enunciated the hypothesis that "viruses of specific types can be created by grafting particular pairs of individuals". This is based on M. B. Crane's experiments on grafting the apple variety, Lord Lambourne, with other varieties. Lambourne may then become infected with two abnormalities—'rubbery wood' and 'chat fruit'—deemed to be viruses. From the evidence presented in the report, it would seem that such infection could be explained by the assumption that Lambourne is completely susceptible to the two viruses, for which most apple varieties are symptomless carriers. The assumption that viruses are 'created' by the graft union seems at least a little ahead of the facts.

Mr. Crane and Dr. Lewis make the interesting suggestion of raising hybrid raspberries from seed, in order to eliminate virus from the initial stock. Preliminary experiments show satisfactory yields from hybrids, but many facets of the problem require consideration before hybrid seedling production can be regarded as a commercial proposition.

Dr. P. T. Thomas has found that 'bolters' in the potato crop possess an extra chromosome fragment which may presumably account for their premature flowering. Statistical technique has been applied by Dr. K. Mather to the analysis of behaviour and organization of polygenes. This provides more exact equipment for the plant breeder, and makes it possible to predict minimal selective limits, to relate the actual number of genes to their observed expression, and to determine whether hybrid vigour has reached the maximum.

The Institution has adopted the title, "Answers to Growers", for its first *Bulletin* (price 2*s*. 6*d*. from the Institution). Growers appear to have left the Institution in no doubt of their needs and, if their questions are such as to epitomize the work of the John Innes at present, that selection only allows of more factual and experimental answers. The grower is told that hoeing is of value for weed control rather than for moisture conservation; that composting tomato haulms does not destroy any virus they may carry; that the ultimate behaviour of his plants depends a good deal upon the character of the compost used for raising seedlings. Questions about the practical culture of sweet corn are answered. The particular and complex methods of hybrid seed production of this crop by top-crosses, double- and three-way crosses, and by synthetic varieties, are explained. The question, 'What are the best plums to grow?', is answered by stating general principles —correct interplanting of dessert kinds (which are self- and cross-incompatible), the separation of high-nectar varieties from those with low nectar, and the choice of frost-free sites, as plums flower early in the season. Some varieties of apple are shown to resist attack by red spider.

The *Bulletin* has achieved the right practical tone; it is well produced, with a general series of photographs of experiments at the Institute, and the identity of the contributors is but thinly veiled by their initials.

FORTHCOMING EVENTS

Monday, December 3

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Dr. F. C. Bawden: "Virus Diseases of Plants", 3. "The Nature of Viruses" (Cantor Lectures).

FARMERS' CLUB (at the Royal Empire Society, Craven Street, Strand, London, W.C.2), at 2.30 p.m.—One Hundred and Third Annual Meeting. Dr. S. J. Wright: "The Next Phase in Agricultural Mechanisation".

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. H. G. Taylor: "Earthing" (illustrated by Film and Lantern Slides).

SOCIETY OF CHEMICAL INDUSTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Mr. W. G. Atkins: "Jute and the Chemical Industry"; Dr. A. J. Turner: "The Properties and Uses of Flax".

Tuesday, December 4

BRITISH SOCIETY OF INTERNATIONAL BIBLIOGRAPHY (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 2.30 p.m.—Dr. R. T. W. Reynolds and Mr. W. A. Silvester: "Plastics, their Nomenclature and Classification"; Mr. A. E. Tooke: "The Information Bureau of the Electrical Research Association".

ZOOLOGICAL SOCIETY OF LONDON (at Regent's Park, London, N.W.8), at 5 p.m.—Scientific Papers.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Sir Henry Dale, O.M., Pres.R.S.: "Recent Developments in Chemical Therapeutics", (i) "The Beginning—Dyes, Arsenicals, Antimonials, etc.".

ROYAL STATISTICAL SOCIETY, RESEARCH SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. G. A. Barnard: "Sequential Tests in Industrial Statistics".

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Rev. H. St. John Evans: "Anthropology and the Missionary".

Wednesday, December 5

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Dr. C. F. Goodeve, F.R.S.: "The Defeat of the Magnetic Mine".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. Leslie Rowsell Moore: "On the Spores of some Carboniferous Plants".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. F. C. McLean and Mr. F. D. Bolt: "The Design of Radio-Frequency Transmission Lines and Switchgear for Medium-Wave and Short-Wave Broadcasting Systems".

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the FOOD GROUP with the SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—"New Routine Tests and their Application in Modern Food Industry". (1) Dr. A. J. Amos: "New Routine Tests in examining Wheaten Products"; (2) Dr. H. G. Davis: "New Routine Tests in the Dairy Industry"; (3) Dr. F. H. Banfield and Mr. J. C. Morpeth: "Some Newer Methods of determining Meat in Meat Products"; (4) Mr. D. W. Grover: "Physical and Chemical Methods for Moisture Determination".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "Science in India and the Colonies" (Speakers: Dr. S. Siddiqui, Dr. J. L. Simonsen, F.R.S., Dr. E. B. Worthington and Major-General Sir John Taylor, C.I.E.).

Thursday, December 6

MANCHESTER JOINT RESEARCH COUNCIL (in the Whitworth Hall, The University, Manchester), at 11.30 a.m.—Sir John Anderson, G.C.B.: "Research in relation to Reconstruction".

PHYSICAL SOCIETY (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Dr. John A. Fleming: "Geomagnetic Secular Variations and Surveys" (Third Charles Chree Address). (Fellows of the Royal Astronomical Society and the Royal Meteorological Society are cordially invited.)

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Sir James Jeans, O.M., F.R.S.: "Physical Astronomy", (ii) "The Hot Matter of the Stars".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. R. H. Coates and Mr. B. C. Pyle: "The Operation of Large Turbo-Alternators to reduce Rotor-Winding Deformation".

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the BRISTOL SECTION OF THE CHEMICAL ENGINEERING GROUP and the INSTITUTION OF CHEMICAL ENGINEERS, in the University Chemical Department, Woodland Road, Bristol), at 5.30 p.m.—Mr. Stanley Robson: "Chemistry, Metallurgy and Empire" (First Robert Horne Memorial Lecture).

BRITISH PSYCHOLOGICAL SOCIETY (at Bedford College, Regent's Park, London, N.W.1), at 7.30 p.m.—Mr. W. R. Bion: "Some Basic Considerations in the Dynamics of the Group"; Mr. J. D. Sutherland: "Some Sociatric Lessons from Officer Selection".

Friday, December 7

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Air Commodore F. Whittle: "The Advent of the Aircraft Gas Turbine".

GEOLOGISTS' ASSOCIATION (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Dr. A. J. Bull: "Terrestrial Heat and Earth Movements".

Saturday, December 8

BIOCHEMICAL SOCIETY (in the Bearsted Theatre, London Hospital, Whitechapel Road, London, E.1), at 2.15 p.m.—Scientific Papers and Demonstrations.

Friday, December 7—Saturday, December 8

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, DIVISION FOR THE SOCIAL AND INTERNATIONAL RELATIONS OF SCIENCE (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1).—Conference on "Scientific Research and Industrial Planning".

Friday, December 7

At 10.15 a.m.—"Fundamental Research in relation to the Community" (Speakers: Dr. M. Polanyi, F.R.S., Prof. J. W. Munro, Prof. C. D. Ellis, F.R.S., Prof. A. G. Tansley, F.R.S., Dr. C. D. Darlington, F.R.S.).

At 2.15 p.m.—"Planned Research". (Speakers: Sir Edward Appleton, K.C.B., F.R.S., Dr. C. F. Goodeve, F.R.S., Dr. E. F. Armstrong, F.R.S., Sir William Larke, K.B.E., Dr. P. Dunsheath.)

Saturday, December 8

At 10.15 a.m.—"Economic Aspects of Research" (Speakers: Prof. P. Sargant Florence, Mr. F. E. Smith, Prof. M. L. E. Oliphant, F.R.S.).

At 2.15 p.m.—"The Human Factor". (Speakers: Sir Arthur Fleming, Dr. C. P. Snow, Mr. J. Kendall, Prof. J. D. Bernal, F.R.S., Mr. J. A. Lauwerys.)

APPOINTMENTS VACANT

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

ASSISTANT AGRICULTURAL ORGANIZER to the Holland County Council—The Principal, Agricultural Institute and Experimental Station, Kirton, Boston, Lincs. (December 8).

ASSISTANT ADVISORY OFFICER IN MARKET GARDENING to the Kent Education Committee—The County Agricultural Organizer, Brunswick House, Buckland Hill, Maidstone (December 8).

CHIEF ENGINEER AND MANAGER to take charge of operations of Electricity Supply Division of Department of Industries and Labour, Government of Burma—The Ministry of Labour and National Service, Appointments Department, Technical and Scientific Register, Room 670, York House, Kingsway, London, W.C.2, quoting D.1555.A (December 10).

LECTURER IN BIOLOGY (Honours Graduate, with PHYSIOLOGY as subsidiary subject)—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham (December 10).

PRODUCTION CHEMIST (Degree standard, with experience in supervision of manufacture and packing of food or domestic products) by large manufacturing firm (household products) in West London—The Ministry of Labour and National Service, Appointments Department, Technical and Scientific Register, Room 670, York House, Kingsway, London, W.C.2, quoting F.5123.XA (December 11).

MECHANICAL ENGINEER (University degree or A.M.I.Mech.E. or equivalent, with practical training and experience in design of semi-heavy engineering plant, preferably hydraulic and oil-field equipment) by old-established contracting and manufacturing company in London area—The Ministry of Labour and National Service, Appointments Department, Technical and Scientific Register, Room 670, York House, Kingsway, London, W.C.2, quoting C.2950.XA (December 11).

PRINCIPAL OF THE PETERBOROUGH TECHNICAL COLLEGE—The Chief Education Officer, Education Offices, Town Hall, Peterborough (December 15).

SENIOR TECHNICIAN in the DEPARTMENT OF BIOCHEMISTRY—Prof. H. Raistrick, F.R.S., London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1 (December 31).

JUNIOR LECTURER IN THE BIOLOGY AND PHARMACY DEPARTMENT—The Clerk and Treasurer, Dundee Institute of Art and Technology, Bell Street, Dundee.

LABORATORY ASSISTANTS—Grade I and Grade II for the CHEMISTRY DEPARTMENT, and Grade I for the PHYSIOLOGY DEPARTMENT—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

GENERAL SECRETARY—The Hon. Secretaries, Society of Chemical Industry, 56 Victoria Street, London, S.W.1.

LECTURER IN CHEMISTRY—The Principal, Leicester College of Technology and Commerce, Leicester.

LECTURER (full-time) IN ZOOLOGY AND BIOLOGY—The Clerk, Northern Polytechnic, Holloway Road, London, N.7.

LABORATORY TECHNICIAN (male, Grade B), experienced in Hæmatology and Biochemistry and in taking specimens of blood from patients—The Secretary, Harrogate and District General Hospital, Harrogate.

LECTURER IN MATHEMATICS in the Canterbury University College, Christchurch, New Zealand—The Secretary, Universities Bureau of the British Empire, c/o University College, Gower Street, London, W.C.1.

VISITING LECTURER IN PSYCHOLOGY (temporary)—The Secretary, King's College of Household and Social Science, c/o University College, Leicester.

LECTURER IN PSYCHOLOGY in the University of the Witwatersrand, Johannesburg—The Secretary, Universities Bureau of the British Empire, c/o University College, Gower Street, London, W.C.1.

GRADUATE LECTURER to teach BIOLOGY to at least Intermediate B.Sc. standard—The Principal, Norwich City College and Art School, St. George Street, Norwich.

GRADUATE ASSISTANT (full-time) IN BIOLOGY (to First M.B. and Inter. Pharm. standard), and PHYSIOLOGY and ANATOMY for recognized pre-nursing classes, in the South Devon Technical College, Torquay—The Education Officer, Lymington Road, Torquay.


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