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SCIENTIFIC AND INDUSTRIAL RESEARCH.—III

IN the conception of the strategy of research which we have thus far developed, the first place has been given to the supply of research workers of the type required to serve the needs of the broad programmes of research contemplated. We have stressed the need for creative and imaginative minds, and in considering the functions of the universities in training such workers, it was recognized that while specialists are essential they may have to take their place in team-work, and that freedom of research requires that the specialist should be competent to move freely across the compartments of science which are at present imposed by the teaching and organization of science. Further, it was recognized that provision must be made to assist in bringing to the fore directors or managers of research of the requisite calibre.

We have now to consider more fully the tactics by which these requirements can be further fostered and developed. Admittedly, in referring to the question of leadership, we have already entered the domain of tactics: the provision of senior fellowships of research is a matter of tactics, whether we view it from the point of view of facilities and organization for research or of encouraging the development of men of the right type for responsible positions in the direction of research. There are, however, two points to be noted here before proceeding to consider the question of tactics in general.

It is, however, no part of the strategy of research to provide directly for the leaders required, any more than it is the function of the universities. It is necessary to emphasize this in view of the tendencies in the recent report of the British Association Committee on Post-war University Education and elsewhere to suggest that the universities are forcing-houses for leaders, either in industry or in other spheres. It is true that it is desirable that a larger proportion of the leaders of industry, for example, should spring from those whose training qualifies them to appreciate and appraise the scientific or technical factors in a situation or problem. It is true that the training the honours graduate in science receives takes little cognizance of such matters as social and ethical values. To urge that this situation should be improved, however, is not to suggest that the universities should change their functions or that they should depart from their tradition of imparting exact scholarship, and training those skilled in the special knowledge and technique that scholarship demands. It is to urge that such training should be based on a wider education, and that the educational system should be such that there are no impediments to originality and to those who possess creative and imaginative minds. It is with education at the pre-university level that we are concerned here, and this is the aspect that brings the educational system and policy of the country as a whole into the purview of research strategy. There could be no more fatal blunder than to introduce into the selection of scholars for the universities other considerations than those of intellectual ability, originality and independence of mind, so far as these can be assessed.

We would not imply that character is not important. Rather, if the conditions at university and secondary school are right, it will be developed as a matter of course. But its selective influence will make itself felt when the graduate enters the larger world, in so far as its importance is recognized by the community, just as physical fitness is recognized as important. We cannot tolerate conditions at the universities of Britain which would lower the moral and physical standards of the community, and it is right that in our replanning of the universities, past neglect should be repaired. But it remains true that their prime preoccupation should be with the training of the mind and with the maintenance of high intellectual standards, not of mere book learning, but of scholarship, the capacity to think clearly, to weigh evidence, to handle knowledge effectively.

Granted then that the educational system of Britain has been re-organized and the university system expanded to provide industry and the nation as a whole with the right type of men and women for positions of research, administration and production adequate to the present needs, we have to consider next the tactics by which both the supply and the quality are to be maintained. These are the matters with which in the main the recent statement from Nuffield College is concerned, though a good deal of the same ground is covered by the subsequent report of the Association of Scientific Workers.

The first point to which attention should be directed here is that which has been repeatedly emphasized since the debates on scientific research in the House of Lords last year. If we are to be assured of an adequate supply of the right type of men and women for research and for like positions where scientific knowledge is required, the conditions of service must be sufficiently attractive. This must apply not merely to positions in industry and in Government departments but also in the universities themselves. The close relation between research and teaching in the universities, which has rightly been stressed, means that there must be a reasonable balance between standards of remuneration and status in both teaching and research posts. Again, from the point of view of research itself, maintenance of the highest standards of teaching makes it essential that the salaries and status of university teaching appointments should compare favourably enough with conditions elsewhere to attract to such work a sufficient proportion of the ablest minds of each generation.

These points are well brought out in the Nuffield College statement, which in general terms supports the more specific proposals which have been advanced by the Association of Univers ty Teachers and the Association of Scientific Workers for regrading and for a more adequate scale of salaries for university appointments. Improvement of the low standards which at present obtain in university appointments in this respect is in fact now generally recognized as a tactical measure of the first importance, but the magnitude of the scales must be determined as part of a general policy of rendering a scientific career, especially in research, more attractive. Nor can we separate consideration of salary scales from the consideration of other conditions which affect the attractiveness of a scientific career to men of outstanding ability.

Other conditions may also be considered broadly both from this point of view of making the career of research or of teaching sufficiently attractive to the best minds of each generation, and from the other point of view of making the best possible use of such ability when a scientific career has been chosen. Failure to attend to this second aspect would in fact not only soon render such careers less attractive to the ablest workers and adversely affect recruitment but would also lead to the steady loss of such workers by transfer to other occupations which they found more congenial and where their ability had fuller scope. For this reason it is important that the immediate demands for research workers, and the necessity for increasing university staffs so as to ensure that they have adequate time for teaching and for research, particularly in the newer universities, as the Nuffield College statement notes, should not lead us to overlook the question of keeping some reasonable balance between supply and demand. Violent fluctuations in this respect, with consequent intermittent and perhaps widespread graduate unemployment, can have a very detrimental effect on recruitment. The dangers in this respect to which Mannheim has directed attention and which were stressed again by Mr. Roy Glenday in his recent book should not be ignored. Some attempt on the part of industry and of other institutions to formulate as quantitatively as possible over a period of years the requirements for scientific and other academically trained personnel would be a tactical measure of first-class importance.

It has been recognized elsewhere that there is waste of scientific ability because of its deflexion to administrative or other duties which might be carried out by others not possessed of the same order of scientific ability. The report of the Association of Scientific Workers rightly directs attention to the handicap which an inadequate staff of laboratory technicians may place upon the research worker at the universities. It should be a cardinal point in our post-war short-term policy at least to see that the training of a sufficient number of such technicians is expedited so as to secure the fullest possible use of the services of the first-class scientific ability already available in our research laboratories both in the universities and elsewhere.

This point was particularly well put by the Parliamentary and Scientific Committee in its report on "Scientific Research and the Universities in Post-War Britain". The Nuffield College statement, however, makes the further point that apart from the necessary increase in trained scientific personnel —which may be a process occupying a considerable time—much more could fruitfully be spent in equipping existing research workers with more adequate resources, and high priority should be given to this. Proposals regarding technical services advanced by the Association of Scientific Workers in respect of the larger universities obviously represent a need by no means confined to the universities themselves.

Equipment for research, either at the universities or elsewhere, is not only a matter of priority, but may well prove a matter enforcing co-operation and co-ordinated planning of research at the universities and at centralized research institutes of the type of the Massachusetts Institute of Technology, as Sir Alfred Egerton has urged.

Here, however, we are concerned primarily with questions of personnel. Next to questions of adequate remuneration and equipment may be placed those of status. It is important to remember that if we would avoid the waste of scientific ability on administrative duties, which in point of fact a research worker of outstanding ability may be ill-qualified to discharge, this is not to imply that his status as a scientific man should be regarded as a bar to promotion to administrative positions. It is of the utmost importance that there should be no such disqualification where a scientific worker shows himself possessed of high administrative ability ; but it is equally important that means should be found of encouraging the outstanding research worker while he continues to do the research for which he is best qualified, without wasting that ability by transferring him to a position of higher status in which his ability is less effectively used.

Closely linked to this question of status is that of freedom of investigation and of publication. It is for such exceptional men that it is important to preserve the maximum freedom of investigation which Prof. A. E. Trueman stresses in "Science and the Future". It is worth considering whether, and if so, in what ways, the outstanding investigator might not be rewarded by the higher responsibility which is implied by allowing him to choose his own problem and tackle it in his own way.

The question of publication may be equally important, though this has received less attention except perhaps in the report of the Federation of British Industries Industrial Research Committee. But apart from the question of status or incentive, which is bound up with this question, publication of the scientific aspects of a research is important from the point of view of research itself as well as of the scientific worker. The advancement of science depends on the fullest possible publication of research, and Lord McGowan's words on this point in his address on "The Future of the Chemical Industry" last October are particularly welcome, in view of the contrast in this respect between the practice and outlook of industry in Great Britain and in the United States. Strong support for a more liberal policy of publication has also been forthcoming from Mr. Samuel Courtauld, who advocates the maximum degree of publication consistent with reasonable safeguards against abuse as the best policy for accelerating the healthy growth of every industry based on applied science. Such a policy would simultaneously remove the disadvantage of scientific workers in industry to which Lord McGowan referred, and to that extent increase the attractiveness of an industrial career in research.

Thus far we have been considering conditions of service mainly from the point of view of making a scientific career, especially in research, as attractive as possible to the ablest workers. We have now to consider factors which will promote the most favourable conditions for creative work, and will maintain or even enhance the originality and individuality which we have been at pains to recruit. The value for this purpose of close contact between teaching and research has been recognized, and much the same considerations apply to the promotion of closer relations between research workers in academic and industrial research.

Interchange and mobility of research workers is an invaluable stimulant to freshness of outlook and new ideas, and the Nuffield College statement devotes an important section to the consideration of this problem. Increase in the mobility of research workers, whether between one branch of industry and another, or between industry and the universities or Government departments or vice versa, is not only essential to ensure the best possible distribution of the available supply of research workers, but is also a stimulant to creative thought and the corporate attack on common problems, and especially borderline problems, the value of which it is almost impossible to estimate. Moreover, it is important to note that this should be a two-way traffic. As the Nuffield College statement indicates, there should be systematic provision for research workers engaged in industry to return to the university or to spend a period at a specialized research centre, both to keep their fundamental equipment up to date and to derive refreshment from day-to-day contact with colleagues engaged in other fields of research.

The senior fellowships in science established by Imperial Chemical Industries, Ltd., are one means by which such interchange may be fostered. Joint research councils of the type recently established by the University of Manchester and the Manchester Chamber of Commerce may well develop other means for associating industrial research workers with their local university colleagues. Clearly such measures must also bring academic workers into closer contact with the industries most closely allied to their special branches of work.

The adjustment of conditions of work so that they are more comparable in the different fields is one means of facilitating such mobility and interchange ; but one of the most important is the institution of a common system of superannuation, as the Nuffield College statement suggests. Such a system, applying to research workers in all types of institutions, including workers in universities, Government research stations and research associations, technical colleges and polytechnics and scientific workers employed in industry, would, by the adjustment of existing methods of superannuation, make it possible for research workers to move from university work to industry, or to work under Government or a local authority or vice versa, without any loss of pension rights. Extension of this system to cover the countries of the British Empire would facilitate the interchange of scientific men over the Empire as a whole, while clearly such arrangements as those between the Imperial College of Science and Technology and the Massachusetts Institute of Technology for the regular interchange of staff and postgraduate students should be encouraged in this and in every possible way.

One such means, particularly at the universities, is the sabbatical year recommended by the University Grants Committee, as enabling scientific workers to give undivided attention to research problems for a long period or to travel and exchange experience with colleagues in other laboratories at home and abroad. This principle is strongly supported by the Association of Scientific Workers in its recent report; and it was noted as one for inquiry by Sir Ernest Simon in his pamphlet on the "Development of British Universities". That was also the note struck by Bruce Truscot in a suggestive discussion of the whole question in which he suggested that adoption of such a project might be premature until some other academic and financial reforms had been effected. The importance of timing in tactics should never be overlooked; but in the meantime, in addition to suggesting that, as a privilege, leave of absence might be asked for and given much more than it is, Bruce Truscot indicates two directions in which the practice might be extended. First, exchange professorships, both within the British Isles and between Great Britain, the Dominions and the United States should be encouraged and so far as possible arranged by a central organization representing the whole of the British universities. Secondly, he suggests the granting of leave purely for purposes of original work and investigation, subject to adequate control.

The second suggestion, in particular, is one that should also be explored by Government departments and by industry, for there is no room for doubt as to the value of such interchanges and wider co tacts. There is, however, a further point in regard to the easier interchange between industry and the universities discussed in the Nuffield College statement which deserves to be noted. This is concerned with the subjects of investigation in such interchange between industry and the universities, and bears particularly on the question of freedom of science and of publication. It is argued by some that universities should avoid all association with industrial research of which the results cannot be freely published and made generally available. This attitude is taken up in regard to work being done wholly or partly in a university laboratory, both on the ground that scientific work at the university ought to be carried on without any profit motive and that secrecy always interferes with the free interchange of ideas among the research workers, and creates the wrong atmosphere both for fully successful fundamental research and for teaching.

If that objection is well founded, it merits serious attention in this connexion, for the whole object of our tactics is to create the atmosphere in which research can be most fruitfully carried on and in which originality and creative thought are fostered. It is plainly undesirable, as the Nuffield College statement points out, that the universities, the primary task of which is to combine disinterested research designed for the advancement of knowledge with teaching work of a high standard, should to any considerable extent allow themselves to be diverted to work which they would not undertake on its own merits. That may be unlikely to happen, but it is against the interests of industry itself to allow the fundamental research at the universities to be neglected or impeded.

It is therefore necessary from the point of view of personnel as well as of organization to exercise caution in using university laboratories or research workers for applied research which would involve any restrictive conditions or slackening in the pursuit of science. The danger may perhaps be overstressed. It should be possible to second a university research worker for such work for a period, as difficulties are fewer when the work is not undertaken in a university laboratory. Moreover, while it is right to guard against the danger of university departments falling too much under the influence of particular firms or industries, to the detriment of their main tasks, we must not limit the pursuit of applied science in university institutions where this arises naturally out of the more fundamental work and can be carried on with full freedom to discuss the problems and to publish the results.

Possibly the best solution of this problem will be found along the lines suggested by the Nuffield College statement. If there were a general code of conduct recognized as applicable to university scientific workers undertaking outside industrial work for private firms, it would be a comparatively easy matter to work out a special code to cover these problems. With easier interchange between the different branches of research and a clear code of professional conduct, transfers would present far fewer difficulties than in the past, and a two-way traffic between the universities and industry could be fruitfully established without some of the professional complications which at present arise.

The entire problem is obviously one to be tackled jointly by the universities, professional associations and industrialists, and it is one in which the initiative might well come from the professional associations of scientific workers. Indeed, it would be difficult to exaggerate the importance of the contribution which such associations might make in this field of tactics which we have here been considering. Admittedly the responsibility for executive action will rarely lie with them, but without their advice and co-operation the right atmosphere and the appropriate conditions for the most fruitful research are unlikely easily to be worked out. However firmly the universities hold to their own highest traditions of disinterested inquiry, however far they succeed in establishing conditions where research can be carried out at leisure and free from financial worry or embarrassment, however much there and in industry the spirit of service to the community adds an incentive to that of the quest for truth, the co-operation of professional associations will still be required. It must be admitted that in the past such associations have been slow to recognize their opportunities or their wider responsibilities.

MEDICAL EDUCATION IN GREAT BRITAIN

THE report of the Inter-Departmental Committee on Medical Schools, of which Sir William Goodenough is chairman, is summarized on p. 322 of this issue. The report itself must be read if the Committee's recommendations are to be fully understood. Some of them involve considerable changes in outlook and teaching in both the schools and universities of Britain; others profoundly concern the general public; yet others will hearten the reader and lead his thought beyond the technical details of medical education. For medical work must always be closely bound up with the structure and work of society, and the medical practitioner has to play an important part in social evolution. Any serious consideration of his training must therefore be just what this report is—a sociological as well as a medical document. Several of the reforms which it proposes are similar to, if not identical with, the reforms recently suggested by the Planning Committee of the Royal College of Physicians (which were summarized in the *Lancet*, 607; May 6, 1944, and the *British Medical Journal*, 668; May 13, 1944), so that the views of these two committees can be considered together. In both, the inevitable interaction between scientific method and the older ideal of the art of medicine is evident, and both reports seek to preserve the best elements of the two methods of approach to the patient. Both emphasize the future need to ensure the maintenance of health rather than to await the onset of disease.

The recommendations of the Goodenough Report have the support of "the vast majority of those who are responsible for and engaged in medical education and research in all parts of Great Britain". They must therefore carry great weight. This report points out that, while some of its recommendations could be introduced during this War, others need time to mature. Even if this were not true, doctors cannot be quickly produced, and both the reports under consideration should be read by those who are confronted with the very urgent need for large numbers of doctors in India (see *Nature*, 658; May 27), and elsewhere. In the U.S.S.R., where the need has been, and still is, urgent, a system based on the idea of industrial 'shifts' has been utilized. It is good to know that the Goodenough Committee, which is able to plan for a country in which the need is less insistent, prefers quality to rapid production. Wide publicity should be given to its firm statement that medical schools should regard themselves as under a definite obligation to do all in their power to meet the need for more doctors, but that they should not take in more students than they can train properly. This Committee urges that, in order to shorten the time lag between the initiation of the reforms which it proposes and the production of their results, action should be taken as soon as possible to create postgraduate courses for practitioners, to build up an adequate supply of teachers, and to assist medical schools by means of financial grants, priority of building materials and labour, and so on, and by provision of adequate staffs, accommodation and equipment. But the Committee also urges that all its recommendations should be initiated as soon as possible, because the success of many schemes of non-medical post-war development will depend upon an adequate supply of doctors who have the right training and outlook. Greatly increased financial support from public funds will be required if we are to secure a sound foundation for national health. The total capital expenditure that should be incurred may amount, within ten years, to ten million pounds at pre-war costs, and recurrent grants will have to be increased until they total, after ten years, three or four million pounds a year at pre-war values. These increases in recurrent grants would thus represent, after ten years, only 2 per cent of the estimated cost, in the first year, of the national health service. It will be agreed that this is a "reasonable price for the community to pay for a service which is vital to the promotion of national health".

As the Goodenough Report says, "Properly planned and carefully conducted medical education is *the* essential foundation of a comprehensive health service". The Committee thinks it advisable to stress this point, because current discussions of a health service show signs of premature concentration on the detailed structure of such a service and neglect of its essential foundation, and because problems of medical education and research are not the exclusive concern of the medical schools and the medical profession. The general public should maintain a lively and understanding interest in them. The doctor of the future will, the report suggests, become the adviser on the health of both the individual and the community, and will have the responsibility of ensuring one of the principal aims to which national policy is being directed, namely, the achievement by everyone of the highest possible standard of physical and mental health. This is but a modern statement of that spirit of service which has been at all times the distinguishing mark of the medical man.

While the nation can, the Goodenough Committee thinks, rightly be proud of British medical practice and education as it is, the doctor has not been adequately trained in the past to shoulder his new responsibilities for national health. He has studied disease itself more than the promotion of health—and disease chiefly as it is seen in individuals. He has been taught, as the *British Medical Journal* (648; November 20, 1943) pointed out, too much about how people die and too little about how they live. One of the basic proposals of the Goodenough Committee is that emphasis must be placed throughout the whole of undergraduate and postgraduate medical training on a sound knowledge of how to produce and maintain a healthy nation. This is made clear in the section of the report devoted to social medicine. A new orientation of medical education is required to give effect to this general idea. It involves a big expansion of the social work of hospitals and radical changes in the outlook and methods of most of the teachers. The developments discussed in this section on social medicine will interest the layman profoundly.

The layman will be no less interested in the chapters of the report devoted to child health, maternity and psychiatry. Better provision for the welfare of children and their mothers will have to extend beyond the sphere of medicine; but doctors will have to play a leading part in them. In general, the teaching about children and their mothers has not been adequate, and proposals are made to remedy this deficiency. If, moreover, the doctor is to grasp modern conceptions of disease or to treat some illnesses properly, he must have better instruction in the normal and abnormal working of the human mind. Every medical school ought therefore to have a department of psychiatry, the work of which should be related to that of other departments. The supply of teachers for these departments also is inadequate, and their training is an urgent need.

In their discussions of all these matters the two reports under consideration agree in main principles. Both also express similar views on the necessity of teaching principle and method rather than fact, especially during the early training of the medical student, on the requirement that at least a year should be spent in a resident hospital post, on the need for drastic reorganization of the medical curriculum with a concomitant reform of the examinations held, on revision of methods of selecting medical students and on the need for adequate training and remuneration of the teachers of medicine and for the betterment of the position of the clinical teacher.

The Committee of the Royal College of Physicians proposes that all university fees should be abolished—a proposal which is not so revolutionary as it sounds when we remember that, as the *British Medical Journal* has reminded us (665, May 13), the present fees paid cover only about one third of the cost of the education given. The Goodenough Committee does not go so far as this. It is not, indeed, within its terms of reference to consider university fees in general. But it makes proposals for the financial maintenance of the medical student throughout his whole training and others for the supervision of his health, housing and recreations which go much further than mere remission of fees. If they are adopted, no parent, however meagre his means, need hesitate to launch his son or daughter upon the varied adventures in public and private service which medicine makes possible; nor need he worry about his child's health or future opportunities. The daughter, moreover, would no longer have to run the risk of exclusion by the medical schools. Co-education of men and women would be universal and Exchequer grants could be withheld if reasonable numbers of women were not admitted.

This question of the selection of the prospective medical student would seem, indeed, to be the keystone of the recommendations of both these committees. For both insist that the right kind of student must be obtained at the very beginning and that all classes of society must be enabled to provide candidates for medicine. Both committees further insist that the medical student's character and personality must be adequately considered when he is being selected. Both dislike selection by examination alone, because this favours undesirable specialization at school and thus may prejudice that broad school education which the doctor especially requires.

Whatever the decision may be about the necessity or otherwise of a selecting examination, it is clear that the task of interviewing every candidate for admission to our medical schools would be a formidable one. It would not be easy to make sure that the interviewers created and maintained in the future a uniform standard of selection all over the country. They would have to interview, the *British Medical Journal* (655; May 13) states, some 2,500–5,000 prospective students every year; and, if the number of doctors is going to increase considerably, as the Goodenough Committee suggests that it will, this task of interviewing would increase in proportion. Nor will everyone feel disposed to give the school record too large a share in the selection of our future medical men. The real characters and abilities of boys and girls are not always discernible at school; they can also be easily misunderstood by some interviewers who may have nothing to guide them but what they can learn at a single interview, together with a school record of doubtful value and perhaps the opinions of a school teacher who, however able he may be, must often, especially in large schools, imperfectly understand some of his pupils. Both school teacher and interviewer might easily fail to discern abilities which, even if they did not fit a pupil to become a good medical practitioner, might help him to do good work in other fields of medicine.

The humble potential patient in all of us may be even more doubtful of tests of intelligence or aptitude which might, it is suggested, help in the selection. It will not be surprising, indeed, if many readers of these reports reject all the arguments which would seek to reduce the importance and efficiency of that popular scapegoat, the examiner. They may not wish to adopt the desperate remedy once proposed by no less an authority on the human mind than William McDougall, namely, examinations for the selection of examiners; but they may suggest that examinations can be altered and that it should not be an insuperable task so to modify the university entrance examination—which is the standard of entry to medicine required by the Goodenough Report—that it would at any rate help to select the qualities required in the medical student. It might even turn out that the main faults of the examination system lie not in the system itself, but in the type of questions asked and especially in the practice of allocating marks by number. If the selecting examination included an oral examination, which should, so many experienced examiners think, be a feature of all examinations, because it gives the candidate a golden opportunity to reveal just those qualities which cannot be expressed on paper or in a practical test, this could be made the occasion of the interview desired by these two reports.

Taking it by and large, the layman who is to be treated when he is ill by the future doctor may prefer that the character and personality of the medical student should not be accorded too high a value when he is being selected at the outset of his career by individuals who may never, even if they happen to be specially qualified psychologists, assess them correctly. In any event, these qualities will develop during a course of training which should, if it is properly designed, eliminate the misfits and direct them to more suitable work. The Goodenough Committee, in fact, specifically proposes that there should be means of eliminating such misfits as early as possible in their undergraduate careers. Selection can, in other words, be imposed too early, and the value of the natural selection of the medical school and the hospital can be under estimated. This is especially true of the medical student, who cannot possibly know, until he begins to handle patients, whether he either wishes to be, or is fitted to become, a practising doctor. It would therefore seem to be wiser to emphasize selection at a later stage of his career, when he has tasted clinical work. Little would be lost by this if the Goodenough Committee's excellent provisions for the direction of each student into the sphere of work for which he proves to be best fitted are adopted. This would amount, in effect, to the selection by each student of his own career. It seems a pity that all university students cannot be given, by means, for example, of a first year during which they could taste, under the guidance of a tutor, every field of university work, a similar chance to select, under supervision, the work which offers them the best chances of combining in their lives a natural inspiration and interest and service of practical value to themselves and to the community. For the value to medicine of the non-medical worker is well recognized. The Goodenough Committee would, in fact, make special provision for the assistance of workers in other fields who may wish to switch over to the study and practice of medicine. There is no better background, it says, to a medical training than a university course in some other faculty, and it believes that the medical profession would benefit if more graduates in classics, history, languages or pure science entered it.

Although many readers of these two reports may prefer the proposals of the Goodenough Report for the selection of the medical student to those of the Committee of the Royal College of Physicians, all will agree with both committees that the masses of detail which now clutter up the medical curriculum should be resolutely pruned away. The emphasis, both Committees think, should be, during the early training in any event, on the teaching of principle and method. It will not be easy to select for removal the detail which the medical student will not require unless he should be able to show, at a later stage, that he is fitted to become, say, an anatomist, a surgeon, a pharmacologist or to enter some other field of work which requ res the acquisition of detailed knowledge. The Goodenough Committee rather emphasizes the difficulty of this task ; but it does not shirk it. Such pruning could, its report suggests, reduce the duration of the medical training to four and a half years, and the report indicates the advantageous use of the time thus saved. This Committee further recommends that the curriculum should be constantly reviewed in the future by each medical school rather than by any body specifically appointed for this purpose. It will be necessary, however, not to exalt the teaching of principle and method so high that the value of factual knowledge is depreciated too much. The Goodenough Committee emphasizes the teaching of observation and deduction of the meaning of facts observed and also the proper statement in words of these facts and deductions. But, although the student who crams facts can pass many examinations, whether they be medical or not, the training of the memory must not be neglected. Much of the practising doctor's efficiency depends upon a memory for detail, because it is done under conditions and in places which preclude consultation with others or reference to books. On the other hand, many of the existing text-books in common use should, it is widely agreed, be either scrapped altogether or entirely rewritten. The Goodenough Committee's plans would markedly reduce the doctor's need for books and works of reference: in place of them it would substitute constant living and personal contacts with specialists and others whose job it would be to keep the student and the practising doctor up to date and in touch with the latest methods and knowledge. There would be, for example, abundant and wisely planned postgraduate courses for practitioners and for any others who required them. The reorganization of the medical teaching centres and their better distribution about Great Britain would largely remove the geographical difficulties of any individual doctor who wished to keep his knowledge and practice up to date.

The training given to the student should provide him with an abiding eagerness to excel in current practice and to forge new tools for the service of his fellows. The Committee of the Royal College of Physicians emphasizes the convergence in medical education of the vocational education of the medical school and hospital and the academic training of the university. Sir Thomas Lewis (*Lancet*, 619 ; May 13, 1944 ; and 649, May 20, 1944) has discussed the same theme in some detail. The Goodenough Committee's proposal that every medical school should be an integral part of a university would give the medical student both these kinds of training. Clearly he must have both, even at the cost of the proposed disappearance of the Scottish extra-mural medical schools which have given much good training in the past.

The early clinical training should, the Committee of the Royal College of Physicians believes, be an organized system of teaching correlated with the pre-clinical studies and with pathology, and it proposes an undergraduate clinical course, lasting three years, during which the teaching would be directed to principles and methods and the development of judgment rather than to the acquisition of factual knowledge. The Goodenough Committee formulates in detail a similar scheme, which is coupled with a scheme of pre-clinical teaching. The report urges the immediate initiation of this scheme. The whole scheme could not be adopted at once, because it involves far-reaching changes, some of which require some years for their completion. They are outlined on p. 322 of this issue. Those which concern the appointment of more whole-time clinical teachers and the betterment of their salaries and conditions of work need not be long delayed and are urgently required. It should not be very difficult, especially in these times of rapid large-scale reorganization, to establish quickly one or more of the medical teaching centres described by the Goodenough Committee ; or to put into operation this Committee's plan for a Postgraduate Teaching Centre in Hammersmith ; or to establish the experimental undergraduate medical school recommended for the University of Oxford. If these were started any faults in the schemes laid down for them would be the more quickly dete:ted and remedied, and also more readily integrated with the national health service, which will itself require amendment as expérience of its practice grows. Universal co-education of men and women in medicine, which the Goodenough Committee places in the forefront of its programme, should certainly be introduced immediately. It has, this Committee tells us, been the normal and successful practice for many years in all the medical schools outside London. It is time to end for good this injustice to our women. It would be of little use, however, to introduce this urgent reform unless steps were also taken to implement the Goodenough Report's further recommendations that all hospital appointments for qualified practitioners should be filled by open competition, and that the sex of the applicant should not be a bar to these appointments.

The mention of the qualified practitioner brings us to the important recommendations made by both the reports under consideration with regard to medical qualification. The Committee of the Royal College of Physicians would institute a final medical examination consisting of two parts. The first part would examine the candidate at the end of the three years clinical course which this Committee recommends, and this would be designed to test the candidate's knowledge of principles and methods rather than his knowledge of facts. On its results the candidate would receive his medical degree ; but this would license him to practise medicine only in a hospital under supervision. He would still have to show that he is fitted to practise independently. To demonstrate this he would have to spend a compulsory year during which he would hold paid resident hospital appointments in general surgery, general medicine, obstetrics and gynæcology, pediatrics and child health and in special studies. At the end of this year of hospital work the second part of the final examination would be taken. If the results of this showed that the candidate had sufficient practical and vocational ability, he would get his licence to practise independently. His further career would presumably be bound up with the national health scheme.

The Goodenough Report proposes a scheme conceived on the same general lines, but with only one examination ; and many will think that it is the better scheme of the two. There has been, this report says, enthusiastic support for its recommendation that every medical student, after he has qualified but *before* he is admitted to the Medical Register and allowed to practi e independently, shall be required to serve as a junior 'house' officer for a year at one or more approved hospitals. Before this War about half the students admitted to the Register did this, and during the War, regulations and conditions have raised this figure to more than 90 per cent. These 'house' appointments should be confined, the Goodenough Committee thinks, to departments of general medicine and surgery and each appointment should last at least six months. While they last the student should be enabled to obtain experience in special departments, but 'house' appointments in these special departments and in departments of obstetrics and gynæcology should be held *after* he has been admitted to the Medical Register. The Goodenough Committee does not propose a second examination at the end of this compulsory period of hospital appointments. It would be sufficient if the student submitted, when he applied for admission to the Medical Register, certificates to the effect that he had held the required appointments to the satisfaction of the authorities concerned.

The uninstructed layman, who may be concerned very closely by these proposals, will no doubt heartily welcome them. They should, if they are combined with the Goodenough Committee's other recommendations, ensure for the public, in both health and sickness, the care of doctors who are doing their job because they like that kind of work and because they wish to serve their fellow men and women ; and the work would be done by doctors of both sexes who would be as up to date as any planning can help to make them. If the public should get this kind of service—and it is to be hoped that the doctors themselves will be allowed to plan it, if only for the reason that they began to feel their way towards it long before any Government realized the necessity for any organized system of national health—the public itself has an obligation on its side. It must help the doctors. It must help to keep them as free as any other citizen to organize and do what they consider to be in the best interests of their patients. It must trust them when they say that their main purpose is to serve, as the best of them have served since the days of Hippocrates, their fellow men and women and to keep them in health, rather than to wait until they have to be treated for lack of health. We must all help also by allowing ourselves to be used, either as models of health or for the instruction of medical students in the signs and symptoms of disease. We must realize that we are members of a society inseparable from modern medicine and must therefore think as well as we can about the aspirations and difficulties of our doctors. We must think, too, of the betterment of the lot of women and children, which the recommendations of the two reports under consideration would inevitably bring about. These two reports, in fact, express, in a particular field, a major trend of modern thought which is exerting its practical effects all over the world.

BOOKS: THE WAREHOUSE OF KNOWLEDGE

THE technical agencies in education and in the dissemination of knowledge are growing in kind and variety. In our basic seminaries—the schools—we have the teacher in the class and lecture rooms, the experimental laboratory, the workshop and garden, the cinema, the radio, and so forth. These are immediatly effective; but very seldom may the pupil refer back to them when and where he will.

In this respect the text-book differs from all these. Although the film, for example, can describe and illustrate, especially scientific phenomena, in such a way that no text-book could emulate, nothing but the book can claim the quality of permanence or give the enthusiastic pupil that pride of possession which is an essential need to the immediate aim of acquisition of knowledge and the ultimate aim of a good education. The pupil can refer back time and again to his books, he can read and re-read until he has digested all those books have to offer.

Furthermore, books and journals are practically the only means whereby an individual person is able to keep a record of the progress of knowledge. *Nature* itself, for example, is not only a forum for scientific discussion and a newspaper for men of science, but it also aims at building up a printed and therefore a permanent record of scientific progress and discovery, so that an issue of *Nature* of thirty years ago is in certain respects as valuable as this week's issue. This cannot be said of any other of the above-mentioned agents of education, in so far as any one individual person is concerned, since so few can hope to make a library of films.

Books and journals, therefore, must for a very long time continue to hold a unique position both in general education and technical training.

Unfortunately, unless help is quickly forthcoming, we shall soon find that the supply of books for all purposes, including general education, scientific advancement and research, medicine and so on, will be totally inadequate to meet even essential requirements.

A brief review of the present position carries this conviction.

The last year of peace was bad. We were living in suspense, and even education authorities were making do with books in hand rather than make their normal annual purchases. Publishers themselves restricted their activities because of the threat of war.

Thus, book production for 1938–39 was small, but the paper now allocated to publishers for books amounts to 40 per cent of their 1938–39 consumption —and a recent ruling of the Paper Control has made it impossible for publishers even to obtain their full quota.

Certain agreed restrictions such as thin paper, small page margins and small type have enabled such books as the ordinary novel to be produced on very much less paper per book, but other types, such as school books, were already produced on a strictly economical basis. Accordingly, the numbers of school and university texts, etc., that can be produced has probably been cut by something like 50 per cent throughout the period of the War.

In 1939 publishers carried good stocks of books and paper; but this reserve of paper has now been used, and the stock of books is rapidly decreasing.

Figures collected by the Publishers' Association from representative publishers show the following result:

	Books
Stocks at end of 1942	33,136,254
Printed during 1943	12,184,277
	45,320,531
Sales during 1943	18,146,471
Stock at end of 1943	27,174,060

With pre-war stocks of paper gone, the production for 1944 can reasonably be put at 10,000,000 books only. The sales for the year, though really governed by supplies, could not be put at less than 25 per cent up on 1943. This would give us the following position:

	Books
Stock at end of 1943	27,174,060
Estimated printed during 1944, say	10,000,000
	37,174,060
Estimated sales during 1944, say	22,674,060
Estimated stock at end of 1944, say	14,500,000

Thus one more year will put the publishing of books, etc., on a real hand-to-mouth basis.

It must also be remembered that much of the stock shown in the above figures are still pre-war books in slow but constant demand—many of them are important books of their type, but they are not books that are in urgent and immediate demand. Accordingly, it is quite likely that some 10,000,000 of the stocks shown above should be deleted altogether from consideration of books available for immediate urgent necessity.

But the consumption tends to increase not merely rapidly but alarmingly. Schools that have made do for several years now wish to return to efficiency again. An enormous scheme is on foot for Army post-war education. And so it goes on. For home and export, books of all sorts are vociferously demanded.

What is the publisher to do? The demand is for all types of books—one type cannot be sacrificed to help another. Orders pour in.

The publisher is practically driven to printing small editions. This is a most uneconomic proceeding and entails increased prices to the public. An even worse effect is the additional work per book thrown on to printers and binders. Making ready, as it is called, is a very lengthy process and these short runs materially reduce both binders' and printers' output.

So we arrive at the state when even an increase of paper will not immediately ease the situation. It will take time to get back to longer runs, and it is vitally urgent that this return to economic methods of production be initiated forthwith.

Incidentally, publishers may be almost entirely absolved of pressing for financial gain. Excess Profits Tax sees to that, and larger sales will only swell the Government's receipts—not the publisher's.

Printers and binders have, of course, been denuded of labour. Notwithstanding early official statements that books were necessary to the prosecution of the War, the book trade has been largely unprotected, and surely the time has now come to give the trade a chance to turn out the millions of books that are admittedly essentially required.

As mentioned above, demands are being received for books for Army education. Extra paper is promised for these, but printers and binders are not able to deal with additional work. As pointed out, a general increase in paper supplies would tend to ease the situation, but it is not possible to impose further demands on printers and binders whilst they are handling the present multitude of short runs.

However, the offer proves additional paper is available, as indeed do long-established cases of books produced of a popular technical nature for which paper has been made available by one or other of the Services. We do not know who has the authority to say which books are sufficiently valuable to the Services to merit Government paper, but we question his decision in many cases.

However, the Government has plenty of paper at its disposal, as indeed H.M. Stationery Office must now rank high as regards the quantity of its publications. Is this continuous stream of Government-backed but apparently unofficial pamphlets and booklets of greater value than the type of books which have been in demand for many years? Who has decided that this is the best use for paper in wartime?

The current consumption figures for paper as follows are of considerable interest:

	Tons
Newspapers	250,000
H.M. Stationery Office	100,000
Periodicals .. .. .. (nearly)	50,000
War Office (included in H.M.S.O. quota)	25,000
Books (including the extra 2½%) ..	22,000
American Book Publishers' quota for 1943 was	128,000

Presumably much of the War Department paper went on training booklets and the like. Surely training has now decreased to some extent, so that the publishers could have some or all of the now redundant paper. What about the Civil Defence Services? Surely these are organized now and could reduce their requirements for paper. And so with other Government Departments. At the same time, this reduction of H.M. Stationery Office paper consumption would reduce their compulsory orders to printers and binders. This would further help to square out the vicious circle now fettering the book trade.

For four years, educationists and men of science have valiantly shouldered the heavy burdens imposed by the short supply of essential literature in the form of text-books and technical journals. But surely science can claim war-time priority; furthermore, war or no war, progress in education must not be allowed to stop altogether, though it must, of course, *pro tem.* reduce its pace.

At present, of the 420,000 tons of paper in the country available for printing, only little more than 5 per cent is allowed for books—and this comprises books of all kinds, including those which with no stretch of the imagination can claim to have literary or educational merit. This position can and should be adjusted if educationists and men of science are to be encouraged to give of their best—and their roles at the present time, and even in the more difficult years of peace-making and reconstruction to follow, are of the highest importance. Readjustment can be made fairly simply by modifying the percentage of quotas.

INDUSTRIAL TOXICOLOGY

Industrial Toxicology

Being the Croonian Lectures for 1942 of the Royal College of Physicians of London. By Dr. Donald Hunter. Pp. 80. (Oxford: Clarendon Press; London: Oxford University Press, 1944.) 10*s.* net.

ANY review of the present field of industrial toxicology necessarily suffers from the fact that it is more or less an 'interim' report, issued during a period when comparatively little has been added to the pre-war knowledge of existing toxic substances, and before the expected development of many new agents which may or may not prove injurious to workers exposed to them.

It is well that existing knowledge should be brought up to date, both from the biological as well as the purely chemical and physical aspect.

The latter is specially emphasized in Dr. Donald Hunter's review of a large number of toxic substances encountered in industry. Immunity from danger in handling many substances essential to industry both in war and peace depends to a large extent on accurate recognition of the chemical and physical properties of those already known to be toxic. Such knowledge can be usefully applied in forecasting the probable potential toxicity of new substances the harmful effects of which have not yet been emphasized by the results of bitter practical experience.

In Dr. Hunter's review, the relationship of chemical constitution and physical properties to biological activity is shown by many examples in the various groups of metals, aromatic compounds and chlorinated hydrocarbons. A typical difference in effect of the same element in different chemical combinations is the contrast between the manifestations of poisoning by inorganic lead, where true lead encephalopathy is now rarely seen, and the cerebral disturbance, sometimes terminating in violent mania, which is the outstanding phenomenon in poisoning by the organic compound, tetra-ethyl lead, and is unaccompanied by the classical symptoms of lead colic, palsy or punctate basophilia. The picture of severe chronic benzene poisoning, with the most frequent effect of aplasia of the bone-marrow, is also quite distinct from the specific capacity of the nitro- and amino-derivatives of benzene to convert hæmoglobin into methæmoglobin, and the special tendency of the amino-derivatives to attack the bladder, causing papillomata which may become malignant.

The large group of chlorinated hydrocarbons used in the rapidly growing cellulose lacquer and plastics industry show very clearly this variation in toxic effect according to chemical constitution. Halogenation appears to be closely related to liver damage, and increase in the chlorine molecule, though compensated to some extent by decrease in volatility, generally increases the toxic effect. Thus tetrachlorethane, no longer used as an aeroplane dope on account of its high toxicity, is about four times as toxic as carbon tetrachloride, while trichlorethylene is much less likely to attack the liver than either.

Recent investigations on the biological effects of toxic substances are described less fully. Only a very brief reference is made to an investigation on the mode of action of carbon tetrachloride when exposure is relatively mild and of long duration, as opposed to the better-known acute intoxication arising in connexion with its use as a fire extinguisher. Much light was thrown by this investigation on the true origin of the gastro-intestinal symptoms frequently observed in workers using tetrachloride as an industrial solvent.

A slightly more detailed account is given of an examination of the effects of trinitrotoluene, the experimental subjects being a number of students who volunteered to fill shells during their vacation. Very valuable information was thus gained as to the reaction of living tissue to T.N.T. without the accompaniment of severe or irreparable injury.

Of the newest group of industrial agents, the glycols, comparatively few have been fully investigated, but some, including ethylene chlorhydrin and diethylene dioxide (dioxan), have already given proof of their potency for causing damage. The cases of fatal dioxan poisoning which occurred in 1934 should act as a special warning against the assumption that substances which have never actually proved toxic can be regarded as harmless. Dioxan had not only been shown to be comparatively innocuous to animals, but the five men who died from hæmorrhagic nephritis had been exposed to it for nearly sixteen months without apparent ill-effect. It was only when exposure to the vapour was intensified by the speeding up of the machine and by the necessity for the men to put their heads into the vat containing dioxan that severe injury to the kidneys occurred.

The new aliphatic chemical industry, which has made great strides since 1925, may be expected to expand still further in the post-war years, and many substances of the group to which dioxan belongs may then reveal their true biological effects. At present their chemical and physical properties are better known than their potential toxic action, and it is to be hoped that this knowledge will be applied on the basis described in this review.

ETHEL BROWNING.

A SURVEY OF STATISTICS

Statistics

By L. H. C. Tippett. (Home University Library of Modern Knowledge, No. 156.) Pp. v+184. (London, New York and Toronto: Oxford University Press, 1943.) 3*s*. net.

FEW sciences are more difficult to present in a concise and readable manner than statistics, which is regarded as a symbol of all that is dull and devoid of human interest. "What you've got," says Idaho Green in one of O. Henry's stories, "is statistics, the lowest grade of information that exists." To give the general reader an idea of the fascination of astronomy, biology and even mathematics is relatively easy; but this is the first attempt I have seen to perform that very useful function for statistics.

Mr. Tippett is to be congratulated on having made a success of his undertaking; and indeed, it is hard to think of anyone better qualified to attempt it. His familiarity with both the theoretical and practical sides of his subject, coupled with his interest and experience in the teaching of statistics, have contributed to an excellent Pisgah-view of a complex, dry and extensive domain. He is never at a loss for a practical illustration in point, but does not lose the thread of the main argument as is so easily done in a discussion of statistical examples. Within the limitations imposed by its length—about 50,000 words with a few tables and no algebraic symbols—he appears to me to have done just what is wanted of volumes in the Home University Library, to have given a general review of his subject for those who want to know what it is about and sufficient enticement to those who are likely to want to extend their knowledge further.

Mr. Tippett begins with four chapters on raw statistical material and its arrangement, presentation and summarization. The points he makes about pitfalls in the interpretation of numerical data, elementary as they seem, are so important to the average citizen that one wonders whether some part of this branch of the subject should not be taught in schools. I do not quite share his view about the readiness with which unpublished official information is put at the disposal of the private research worker. There seems to be a school of thought which holds that any material collected at the public expense by public servants for the public benefit should on no account be made public. But perhaps this feeling is coloured by war-time experience. It is to be hoped that after the War the State will realize that as much as possible of the information it collects should be published, or at least put at the disposal of 'unofficial' research workers.

The next group of chapters deals with sampling, probability and statistical laws. A further chapter on statistical reasoning is exceptionally good, and it is a real relief to see someone having a tilt at the prevailing methods of presenting numerical information about the progress of the War. One gets very tired of statements that our production of something or other is ten times what it was a year ago (which means that a year ago it was only one tenth of what it is now) or that the total tonnage of bombs dropped on Germany in some selected period is four times the weight dropped on England in some other period. Considerations of secrecy are admittedly paramount; but all the same censorship covers a multitude of statistical sins.

The concluding chapters deal with statistics in affairs and statistics and the other sciences. Mr. Tippett has only the space to deal with these topics in broad outline, but he contrives to give a very fair impression of the enormously wide interests of the statistician at the present day.

One criticism may be advanced. In the list of books for further reading at the end Mr. Tippett, with misplaced modesty, omits a reference to his own book on "The Methods of Statistics", a useful work which has done a good deal to spread the newer methods among scientific workers.

M. G. KENDALL.

MEDICAL SCHOOLS IN GREAT BRITAIN

THE GOODENOUGH REPORT

ON pp. 315–318 some of the main recommendations of the Report of the Inter-Departmental Committee on Medical Schools* are discussed. The length of the report and the detailed survey which it presents of existing medical organizations and the radical reforms which it recommends make it impossible to do more at present than to give here a brief summary of its main contents.

While the unity of medicine and the individual freedom enjoyed by medical schools in academic matters must be preserved, medical education must in the future develop the mind and character of the medical student in such a way that he can acquire a liberal university education, a scientific foundation for his work, an adequate knowledge of disease, a proper outlook on the promotion of mental and bodily health, a sympathetic understanding of people and their environment and sound judgment and ability to observe accurately, reason logically and assess the value of new knowledge. The emphasis in training should be on principles and methods rather than on the learning of facts, and there should be a bias towards the needs of the future practitioner. The report bears in mind the Government's plans for the future health of the nation.

The unit of organization for the future national system of undergraduate medical training should be a medical teaching centre, consisting of a university medical school and a group of teaching hospitals, comprising parent and associated hospitals situated as near as possible to the medical school, together with those clinics of the health service of the district which can be used for teaching. All these would function as a unit, but each constituent body in each teaching centre would retain full authority in its own field of responsibility.

Reviewing the existing medical schools in relation to this unit of organization, the report lays down the principle that every medical school should be an integral part of a university. Of the thirty existing medical schools in Great Britain all but four are university medical schools. The report proposes that the three extra-mural medical schools in Scotland, namely, the School of Medicine of the Royal Colleges of Medicine and Surgery, Edinburgh, the Anderson College of Medicine, Glasgow, and St. Mungo's College, Glasgow, should cease to train students. The report gives a valuable history of the development of these Colleges and also of their relationship with medical education, and pays a tribute to the excellent work which they have done in the past; but it is considered that they are not adequate to the modern needs of medicine. The work of these Colleges and the possibility that the proposals of this report may eventually result in the disappearance also of the 'Conjoint' diploma granted by the Royal Colleges of Physicians and Surgeons of London are discussed by the *British Medical Journal* (154; July 29, 1944). The Goodenough report also proposes that the West London Hospital Medical School should cease to train students within the next four or five years. The Committee recognizes its excellent work, but its proposed disappearance is related to the report's other recommendations relating to the University of London. Medical education in London, indeed, constitutes a special problem the various aspects of which the report considers at considerable length.

No changes are recommended in the administration of the university medical schools in Scotland, Wales and the English provinces, except that it is recommended that the governing bodies of the hospitals should be represented in the government of the medical schools wherever this is not at present the practice. The Committee also thinks that, although participation by the dean of a medical school in academic and teaching work is valuable, the dean of the future will probably not be able to continue this kind of work and that he will have to be a whole-time salaried official. But in London administrative changes will be necessary. It is recommended that all London University undergraduate medical schools should become separate legal entities, that the University of London and its medical schools should be more closely associated and that the University should be represented on the governing bodies of its medical schools. Both the University and its medical schools will need to make contributions to this development. Further, the geographical distribution of the London medical schools was, the Committee thinks, unsatisfactory even before the War. This subject is discussed in relation to the tendency of the population of London to move from the inner to the outer areas of London, to the consequent likelihood that hospitals in the centre of London will not get so many patients and to the need to provide individual medical schools with increased teaching facilities.

The complexity of this problem can only be realized by reading the discussion of it in the report. The Committee's conclusion is that, as soon as possible, Charing Cross Hospital should move to a site in Middlesex and St. George's Hospital to a site, say, in South London where hospital accommodation is urgently needed; and that, when this is done, the medical school of each of these hospitals should expand and provide both pre-clinical and clinical training. These moves would leave a distribution of medical schools and their parent hospitals which would be reasonably satisfactory, except in the area in which University College Hospital, Middlesex Hospital and the Royal Free Hospital are grouped, together with nineteen other hospitals, within a radius of one mile. Six of these hospitals are, moreover, special hospitals in which postgraduate education should be developed. It seems extremely doubtful, the report says, that this area will, under a co-ordinated hospital system, be able, in a few years' time, to provide adequate clinical teaching for three medical schools of the size that is contemplated by the report. It is therefore suggested that the London School of Medicine for Women and the Royal Free Hospital should consider a removal. A site in the northern suburbs of London, such as Highbury, is suggested.

The Committee's views on the selection of students are also progressive and in line with modern trends of educational thought. They are discussed elsewhere in this issue. Financial assistance to students is considered in detail. Scottish faculties of medicine draw students from all classes of the community, but England and Wales do not draw them from so wide a field, largely because parents do not understand how much assistance can be obtained and because

* Report of the Inter-Departmental Committee on Medical Schools. (Chairman: Sir William Goodenough.) Pp. 306. (London: H.M. Stationery Office, 1944.) 4s. 6d.

secondary school students are not sufficiently encouraged to take up medicine. The report states that grants to medical students should cover the whole period of training and should cover the cost of maintenance, which is the greater part of the cost. The machinery for awarding public funds for this purpose should be simplified and private organizations and charitable trusts should keep in touch with those who administer public funds. Medical schools should have more adequate funds for the assistance of students.

The wide range of interests in medicine and the fact that lack of money need not debar anyone from taking it up should be brought home to all parents. It is the primary obligation of British medical schools to train students born in Britain, but suitably qualified students from abroad, and especially those from the Commonwealth and the Empire, should be welcomed. Every university should have a students' health service with a medical man in attendance. Medical examination of students at the beginning of their training and at intervals thereafter, the provision by the universities and medical schools of nourishing meals at reasonable prices and of facilities for exercise, games and recreation are recommended, and the value, especially for medical students, of residential college life is stressed, because the relations of people to one another will play such a large part in their future work. Many students will have to live in lodgings until accommodation of this kind can be provided, so that supervision of lodgings and the health of students living in them should be a responsibility of those who are training them.

Dealing with the larger question of the number and distribution of British medical schools, the report points out that it is expected that the number of civilian practitioners will continue to grow for some years to come. To provide for this it is better to expand the existing medical schools rather than to create any new ones. Plans for these expansions are given.

The Universities of Oxford and Cambridge are considered separately. At Oxford the medical school was, before 1937, mainly a pre-clinical one, but during the War, a complete undergraduate medical training has been given. The University does not wish to continue this in its present form, but wishes to retain it in a specially modified form, designed to develop teachers, investigators and consultants, rather than general practitioners. There would be only a small number of students and these would be carefully selected and would be instructed individually, with special emphasis on the scientific approach to medicine. Only about fifty students would be admitted to the pre-clinical course and about 20–25 a year to the clinical course. Students who had taken their pre-clinical courses elsewhere would be admitted and exchanges with other universities in Britain and overseas would be encouraged. The Committee thinks that there is a fair chance of the development in Oxford of the kind of medical teaching centre which its report proposes, and it thinks that Oxford should have the necessary financial aid to continue a small clinical school after the War. It would, the report says, be opportune to give, after the War, an existing undergraduate medical school this kind of opportunity to develop on new lines; it might open up a new era in medical thought and practice. "One radical experiment in the training of medical students promises a most effective means of fostering improvements," which may well influence the character of medical education in the next generation. At Cambridge, the recent discussions there of a scheme to establish a clinical school are reviewed, and the report concludes that such a school should not be established until the local hospital services are raised to a very much higher standard. Active postgraduate clinical departments should first be created. These are most desirable and can be developed piecemeal. A beginning might be made with departments of psychiatry, experimental medicine and radio-therapy.

Dealing with hospitals the report points out that in the past the needs of medical education have not been emphasized sufficiently and teachers of medicine have not had sufficient voice in the management of teaching hospitals. It is suggested that parent teaching hospitals should not become university hospitals, but that the reforms desired should be obtained by giving the governing body of the medical schools sufficient representation on the governing bodies of the parent, and also, though this is not so important, of the associated hospitals. The governing body of the hospitals should be personal to the hospital. The full medical members of the staff should have complete individual responsibility for clinical management of their patients and a medical committee should advise the governing body on medical matters. If a medical superintendent exists, he should not have executive powers over clinical management of patients unless these are delegated to him on the advice of the medical staff. The report considers it important that common advisory machinery should be used by all parts of the medical teaching centre for the selection of the medical staff other than the junior grades, and that grants from public funds should be received through university channels. For details of the clinical instruction to be given in these hospitals or groups of hospitals and of the relations of their staffs to the universities and medical schools the report itself must be consulted. The report insists that every means should be used to bring every hospital into relation with a medical teaching centre and that the spirit of education should permeate the whole service. The medical teaching centre would thus become the centre of a wide zone of influence. If central health service councils are established as a result of the introduction of the national health service scheme, the universities should be given adequate representation on them and should have representatives on the local health services councils in their areas. All these university representatives should have the same status as representatives of other interests.

A section on the staff of pre-clinical departments of medical schools does not propose any fundamental changes, except that it is hoped that selection and appointment of candidates for regius chairs will be transferred by the Crown to the universities concerned. Higher salaries are proposed for teachers of pre-clinical subjects and there should be more senior posts in this category and time to enable junior grades to do research and to read more. Fundamental changes are, however, proposed in the staffing of clinical departments other than those of pathology. At present only a small proportion of the senior clinical staff hold whole-time appointments; the chief occupation of many, if not of most, is private practice and usually they are not paid salaries. Most are selected without reference to the medical schools, and usually there is nobody who is responsible for the organization and direction of clinical teaching and research. To remedy these faults, the report proposes detailed schemes for the creation of more whole-time and part-time appointments and for the selection of those who will hold them. These would vastly improve both clinical education and the present very unsatisfactory position of the clinical teacher. To this the report adds a long and detailed consideration of the whole curriculum and proposes drastic changes in it.

Some of its proposals for the selection of medical students are discussed on pp. 311–314. Premedical studies are not, the report considers, satisfactory. Training in the physical and biological sciences is, the Committee thinks, best begun at school, and it should be continued at the medical school in close association with training in anatomy and physiology. In the secondary schools this would involve changes in the teaching of science and the provision of suitable laboratories and other accommodation. More teachers would be required by the schools, and improvements in the quality of the teaching, especially in the teaching of biology, are needed. Such changes require time. Considering interim arrangements, the Committee says that it would accept the School Leaving Examination suggested by the Norwood Committee as an exemption from the First Medical Examination, provided that excessive specialization should not be possible, that general science should be taught over most of the school career and not merely during the last two years, that the syllabus should not be a special one for medical students and that general science should be treated non-vocationally with emphasis on principles and methods rather than on the acquisition of facts. Appropriate modifications are suggested for Scotland. Until this plan can be put into practice, medical students should attend a special pre-medical course in general science for one year at the university and should pass an examination in it of approximately the same standard as that of the senior school leaving examination. To emphasize the Committee's desire that the syllabus for this course should, like that proposed for schools, not have a vocational bias, this first medical examination should be called, not the First Medical, but the Pre-medical Examination. The report emphasizes that entry to this examination should be restricted to those whose general education is high enough to allow their entry to the medical course and to those who have prepared for it at a university or university college. The practice of preparing for it during their last two years at school should be discontinued as soon as possible.

The report then discusses what it calls the pre-clinical subjects, namely, anatomy, physiology (including biophysics and biochemistry), elementary normal psychology and pharmacology. The student's training in these largely determines, the Committee thinks, his attitude and methods in the clinical course to follow. Teaching of these pre-clinical subjects should be organized in the closest association with other university departments and with the parent teaching hospital. To bridge the gap between the pre-clinical and clinical courses an overlap of personnel would help, and there should be freer access to patients for the teaching of anatomy and physiology. One medical school is considering teaching anatomy and physiology as two aspects of human biology, and this idea appeals to the Committee, although most medical schools are unlikely to adopt it at present. A committee should organize the pre-clinical studies. An amendment of the Anatomy Acts or new legislation might help to remedy the present shortage of material for the teaching of anatomy. Some instruction in the recording of facts and in the deduction of their meaning should be given. There is urgent need in every medical school for the drastic elimination from the curricula and from the examinations of masses of detailed information. A change of outlook by the teachers should also direct the student's attention to the importance of health and the prevention of disease. More studentships, scholarships and maintenance grants are required to encourage postgraduate students to act as members of research teams.

Certain special arrangements in London occupy a section of the report which recommends that pre-clinical and clinical departments should be near to one another and that, with certain exceptions, every medical school in London should provide for both these parts of the training. Elementary teaching in chemistry, physics and biology for students who have not had this at school should be concentrated at the colleges only, such as University College, King's College, Bedford College and Queen Mary College, which have science and other faculties.

The teaching of pathology receives special consideration. Normally there should be at a teaching centre four departments in this subject, namely, morbid anatomy, bacteriology, chemical pathology and clinical pathology, each with a whole-time professor or other senior officer and adequate staff. A director should be in charge of the whole, and he could be one of the departmental heads; he would have charge of pathological investigations in the parent and associated hospitals. A medical student does not need detailed knowledge of pathology or technical skill; his training in the principles of pathology should be spread over the whole clinical period. There should be day-to-day collaboration between clinicians and pathologists at the bedside, in the out-patients departments and in the laboratories.

In the clinical courses the report seeks, as it does throughout the whole training, to organize correlation between the various subjects taught. An introductory clinical course of not less than four months is proposed to effect a smooth transition from pre-clinical to clinical courses. This course should indicate the relation between the earlier studies of the human body in health and later studies of it in illness, should encourage students to carry to these later studies the scientific thought and criticism which they have learnt earlier and should teach them to observe and interpret the clinical signs of disease. Such a course will make heavy demands on the time of teachers and on clinical facilities. A medical student needs a unified knowledge of medicine and has to acquire it largely from specialists, and this creates problems associated with the growth of specialization. The report proposes that in the training of specialists a sound postgraduate experience should precede specialization. The teaching of students by means of clinical units would be continued, but the report proposes to link these with the academic heads of the five divisions into which it divides the whole training; and it recommends that there should be periodical informal meetings of all the teachers and also that the views of the students should be obtained. For the details of the very interesting discussion of this complex subject, which contains much historical material of great interest, the report itself must be consulted. Among valuable recommendations are the emphasis on principle and method, the need to give proper attention to the problems with which general practitioners are faced, and to minor ailments and the early signs of disease and to rehabilitation. Some surgical procedures are better taught after graduation.

The report gives a valuable history and discussion of the functions of the General Medical Council. There is need, it considers, of some central source from which medical schools could obtain guidance, and the report proposes to extend the powers of the General Medical Council to enable it to appoint inspectors, who would not be members of the Council, to visit medical teaching centres and report upon the courses of study, staff, accommodation and other matters. Copies of the reports of these inspectors and the comments of the Council and of the institutions concerned should be sent to the University Grants Committee. There follows the recommendation that every medical school should provide a single organized course, and should make it compulsory that every medical student should complete this course before taking a clinical examination which might qualify him for admission to the medical register. This would prevent the practice of taking qualifying diplomas not granted by universities (such as the Conjoint diploma, the diploma of the Society of Apothecaries, etc.) before the university course is completed. Some students, having obtained such a diploma, do not at present take their university degree in medicine at all. In London especially there is constant and detrimental competition between the University and the English Conjoint Board and the Society of Apothecaries. Only 5 per cent of the male students admitted by the University of London to take the university degree actually do take it as their first medical qualification, while 86 per cent register by means of the Conjoint diploma and only 45 per cent eventually take their university degree. A further recommendation is that the University of London should remodel its examinations so that these should reflect the aims and spirit of the training and should include more features of the 'internal' kind of examination, which is defined as an examination regulated by the university which trains the student who takes it and conducted by the student's own teachers in collaboration with external examiners. The latter, together with the inspectors of the General Medical Council, should safeguard the public interest. This suggested reform of the examinations held by the University of London also applies to the Universities of Oxford and Cambridge. A system of internal departmental examinations might complement and relieve the burden of these final examinations and encourage students to pay proper attention to all parts of the training.

Postgraduate training and research are dealt with in Part II of the report. Assuming that suitable central machinery should determine specialist status and that the specialist should first obtain general hospital experience, the report recommends that the intending specialist should be regarded as a trainee while he holds hospital appointments and should have sufficient time for reading and research and should be adequately paid. He should complete at least six months experience in general medicine and surgery as well as his pre-registration hospital experience. Watch should be kept for potential teachers among these intending specialists. There should be travelling fellowships for them, and nothing should debar a general practitioner from training to be a specialist. The most useful contribution of existing postgraduate medical schools would be to provide clinical appointments for specialist trainees. In Great Britain there is a singular lack of facilities for training specialists in hospitals dealing with special branches of medicine. Institutes dealing with these special subjects should be established, on a national plan, as departments of medical schools and universities based on large special hospitals. The Goodenough Committee's views on the education and status of specialists may be compared with those of the committee appointed by the General Medical Council to consider the registration of specialists, the report of which is summarized in the *British Medical Journal* (188 ; August 5, 1944).

Corresponding arrangements should be made for the training of specialists in pathology and public health ; but adequate training in tropical medicine and hygiene cannot be obtained in Great Britain. After obtaining his theoretical and laboratory training in this subject here the intending specialist should hold approved hospital appointments abroad. Regular postgraduate study is required by practitioners, but refresher courses are only a short-term expedient and practitioners should be brought into regular association with the work of hospitals and of specialists by such means as clinical assistantships and personal associations. Refresher courses will, however, be necessary for many years and they should be specially designed for the practitioner. If it be decided that they should be compulsory, adequate financial arrangements will be needed similar to those embodied in the National Health Insurance scheme. The universities should organize these refresher courses and should approve teachers who give them. Such schemes of postgraduate education should be organized by a committee appointed by the university with a supervisor who would integrate his work with that of the Dean of the faculty of medicine. The exceptional resources of London as a centre of postgraduate education are not being utilized properly. The British Postgraduate Medical School should be an integral part of a postgraduate hospital centre in the inner area of London. This would seem to be impossible at present, but a satisfactory organization for postgraduate medical education can be created round the British Postgraduate Medical School on the basis of the Hammersmith (L.C.C.) Hospital and the existing special hospitals. These should be reconstituted as a federal organization with institutes dealing with the principal special subjects, and a scheme for this is outlined. The University of London should, however, like other universities also, appoint a committee on postgraduate medical studies. The award of postgraduate medical diplomas is also unsatisfactory. There are too many of these and the standards on which they are awarded vary considerably. They should all be awarded by the Royal Medical Colleges, excepting those given in public health, clinical pathology, bacteriology and tropical medicine, which should be awarded only by the universities providing the courses of instruction in these subjects.

Innumerable problems await research, and men with the ability for and impulse to do research must be found ; they must be given favourable conditions for their work and the tools that they need. Young research workers should mainly recruit themselves, but they should be guided and given reasonable security in their careers. Scientific workers in fields other than medicine are required. The report reviews the work and methods of the Medical Research

Council and makes important proposals with regard to the provision of staff, accommodation and access to patients required for medical research. Basic research grants from public funds and others from private and public sources are required, and the Medical Research Council would be assisted if the funds granted to it by Parliament were determined annually.

Part III of the report deals with future financial requirements and with machinery for the distribution of Exchequer grants. The report must be consulted for details of these ; but it may be noted that the University Grants Committee is given the responsibility for the distribution of basic research grants and Exchequer grants for educational facilities. It is suggested that this Committee, should appoint an advisory panel of persons with current experience of medical education and teaching hospitals.

PHOTOCHEMISTRY IN RETROSPECT

By DR. T. IREDALE
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PHOTOCHEMISTRY now appears to be a well-established science with a highly developed technique of its own and an adequate foundation of theory, based largely on indisputable facts established by the molecular spectroscopist. Recent text-books[1] leave the reader in no doubt as to the correct avenues of approach to this subject. Its devotees must be prepared to undertake the detailed study of absorption spectroscopy, reaction kinetics, the behaviour of free radicals, and the electronic transitions in solids, some of which are still largely unexplored fields. The more serious student, however, will be disappointed to find that the historical approach to photochemistry has been greatly neglected in these books, excellent as they are in other respects. In the historical treatment of a science interesting sidelights are often shed on scientific method, and the lessons we can learn from them are of peculiar value. For example, it would be instructive to reveal why certain lines of investigation were dropped, how some apparently slight but fundamental observations led to developments of the greatest magnitude, why a fundamental law universally acclaimed and applied appears now to be worth only passing consideration. Photochemistry in particular, which has reached the greater part of its present stature within the last twenty years, has some interesting things to reveal which come within these categories.

During the nineteenth and early twentieth centuries, since the time of Grotthus and Draper, photochemistry made little real progress. The chemical interaction of light and matter was always a baffling mystery. Impetus to experimental work in certain directions was not lacking, because the sister science of photography was always confronted by problems which could not be solved by empirical methods alone. It was not in its applications, however, that photochemistry made its greatest progress.

Some of the most renowned investigations of three or four decades ago were concerned with the thermodynamic implications of photochemical change. This was a rational development, because light sometimes interfered with the laws of thermal equilibrium in a way which necessitated new assumptions and new theoretical treatment. In working along these lines investigators were not so fortunate, for while the chemical equilibria might be explained in general terms of free energy change, the mechanistic consequences of the light absorption itself were not properly understood, and highly speculative theories were put forward to account for this aspect of the phenomenon. This was before the advent of the quantum theory, or rather, before its immediate application, especially to problems of atomic structure.

In 1912 Einstein announced his well-known Law of the Photochemical Equivalence, derived from thermodynamical considerations of radiation equilibria, and later on deduced the same law, based on the Bohr model of the atom. Stark's idea of electron loosening in molecules, put forward some years before, had something in common with Einstein's generalization, which might have been a continued impetus to research, were it not for the fact that it was the exception, rather than the rule, for the law to be obeyed by any of the photochemical changes investigated from time to time. So far, indeed, has this law fallen from grace, that in one of the books previously cited, no mention whatever is made of it. One would not expect such an important landmark in the history of the subject to be relegated so soon to the limbo of forgotten things. The pioneering work carried out by Warburg, Bodenstein, Weigert, Bowen and others to test the efficacy of this law, when seen in its proper perspective, will be found to hold a very necessary place in the development of the subject.

In 1925, J. Franck[2], in a short exposition, correctly interpreted the relation between banded and continuous absorption spectra of diatomic gases, and brought to the photochemist the realization of the excited molecule as distinct photochemically from the normal or excited atom. This may be said to be the beginning of modern photochemistry as we know it to-day. On the spectroscopic side, the volume of research which followed immediately after Franck's discovery forms one of the most amazing chapters in modern physical chemistry. This much the photochemist could learn from it, at least about the simpler molecules he was accustomed to handle : he could deduce from the absorption spectrum what the light quantum did to the molecule. The subsequent complexities of chemical change were not always easy to follow, and sometimes assumed proportions which baffled the ingenuity of the most expert investigator. Thus it was that the light interaction part of a photochemical change, hitherto so elusive, became its most intelligible feature, the kinetics of the following-on reactions presenting much greater difficulties. But as the kinetics are merely bound up with final states of equilibrium, we must expect the last phase of photochemistry to be the standardization, thermodynamically, of the photo-stationary state.

The photochemistry of more complex molecules, apart from polymerization phenomena, has become largely the chemistry of free radicals, although prior to Paneth's instructive experiments in 1929, few investigators would have cared to be dogmatic about the existence of these short-lived intermediaries. The later work of Norrish, Pearson and others demonstrated beyond doubt the important part played by free radicals in photo-changes, albeit the behaviour of these radicals in the condensed (liquid) phase has raised some new and at present unsolved problems.

The applications of photochemistry in the industrial sphere have been few and far between; this is not surprising, when one remembers that many chemical changes accelerated by light can also be carried out thermally, which is often the more economical method. Photochemists with their highly specialized technique are notoriously wasteful of light, employing, as they frequently do, narrow beams of the filtered radiation, utilizing only a fraction of the optical equivalent of the electrical energy expended in producing the light source. The most economical arrangement requires the light source to be in the centre of the reacting materials, so that the stray radiation is reduced to a minimum, which sometimes involves great practical difficulties.

A more profitable utilization of light may come about as the result of further exploitation of so-called electron transfer phenomena. Redox potentials, which are dependent on the activities of ions of variable valency, can be changed appreciably by absorption, by the ions, of light of great intensity, which is responsible for the electron transfer. The construction on the industrial scale of photo-galvanic cells working on these principles will be a problem for the electrochemist. In countries where sunlight is most abundant, there will be possibilities for much applied research along these lines.

[1] "Photochemistry", by G. K. Rollefson and M. Burton. "The Photochemistry of Gases", by W. A. Noyes, jun., and P. A. Leighton. "Chemical Aspects of Light", by E. J. Bowen.

[2] *Trans. Faraday Soc.*, 21, 536 (1926).

THE COSMIC TIME-SCALE

IN a series of recent mathematical papers, culminating in a general review of the subject in more physical terms[1], S. Chandrasekhar has laid the foundations of a statistical theory of stellar dynamics which treats the subject in a way fundamentally different from the ordinary analytical approach. Certain aspects of the theory concerning the dynamics of star clusters and the statistics of binary stars are discussed in detail by Chandrasekhar; they have interesting repercussions on current ideas concerning the time-scale of the universe, and are summarized below.

In this new statistical treatment, no attempt is made to follow in detail the history of any particular star in a gravitational assemblage: its motion is described in terms of a distribution function governing the probability of occurrence of a given velocity at a given time, the initial velocity being specified. The behaviour of each star is regarded as determined in part by the influence of the system as a whole and in part by the relatively rapid fluctuations produced in the local stellar distribution as the members of the system change their relative positions. Chandrasekhar shows[2] that, in an interval of time large compared with the average period of these fluctuations, their cumulative effect is to subject each star to a random acceleration and simultaneously to decelerate it in the direction of its motion by an amount proportional to the time interval. The effect of the near neighbours of a star is thus expressible in terms of a coefficient of diffusion and a coefficient of 'dynamical friction'. The latter term is chosen because the process operates only on stars in motion and it acts systematically as a brake on this motion. It can be shown that a dissipative force of this nature is necessary for the maintenance of a Maxwellian velocity distribution among the constituent stars.

The recognition of the part played by dynamical friction in the evolution of stellar clusters leads to important conclusions regarding the expectation of life of these systems. The technique of this new statistical dynamics can be used to calculate the probability that a star of given initial velocity will acquire (for the first time) another specified velocity at some later time. If for this second velocity we choose the velocity of escape from the cluster (twice the root-mean-square velocity of the stars) we have a means of estimating the rate at which a cluster disintegrates by impoverishment due to escape of its constituent stars. Chandrasekhar expresses[3] the probability Q that a star will escape from a cluster during a time t in the form

$$Q = 1 - e^{-t/t_0},$$

where t_0 is a function of the physical parameters (radius, central condensation, etc.) of the cluster. Taking t_0, in accordance with this expression, as a measure of the half-life of the cluster, and substituting the observed parameters for the Pleiades, he finds a half-life of 3×10^9 years. Now the Pleiades form a typical galactic cluster, one of many such which are presumably permanent or *quasi*-permanent features of the Milky Way system. In so far as we may identify the life-history of the Galaxy with that of its open clusters, then the half-life of the Galaxy is also of the order of 3×10^9 years. Moreover, if we adopt Chandrasekhar's definition[4] of the 'time-scale' of the Galaxy, namely, a natural unit of time during which the aspect of the Galaxy may be expected to change appreciably, then 3×10^9 years is this unit, whether the galactic clusters are permanent features of the system or products of some passing phase of cosmic evolution.

Further evidence regarding the time-scale of the universe comes from a study of the statistics of double stars. Until a few years ago it was believed that the observed frequency distribution of eccentricities among binaries showed that a condition of thermal equilibrium had been attained, and thus that the time-scale adopted for the Galaxy must be long enough ($\sim 10^{13}$ years) to allow establishment of equipartition among the parameters of a binary. It is now known[5], however, that the observed distribution, though a necessary, is not a sufficient condition for the existence of thermal equilibrium, and further, that other aspects of the data, particularly the distribution of energies or semi-major axes, are incompatible with equipartition. In itself this suggests that the time-scale cannot be so long as had previously been believed, and Chandrasekhar's new treatment[6] of the question confirms this. In this approach he examines the stability of a binary as it is affected by the differential effects produced on the components by the gravitational attraction of neighbouring stars. For any given separation between the two stars, there exists a distribution function governing the probability that forces differing by a specified amount will act simultaneously on the two components. In other words, a systematic differential acceleration governed by a definite probability law acts on the system so as to accelerate one star relative to the other. The rate of dissolution of a binary due to this cause is calculated and shown to depend on the masses and separation of the components and on the local stellar density. In the neighbourhood of the sun, the time τ of disruption of a typical binary of semi-major axis a astronomical units is shown to be

$$\tau = 2{\cdot}2 \times 10^{15}\, a^{-3/2} \text{ years},$$

τ being the time needed to produce enough relative acceleration to make the kinetic energy of relative motion exceed the gravitational binding energy between the components. For separations in the range $10^3 - 10^4$ astronomical units, this formula gives times varying from 7×10^{10} to 2×10^9 years. But observation shows that in this range statistical equilibrium has not yet been reached in the separations. That is to say, sufficient time has not yet elapsed for the fluctuating gravitational field even to modify appreciably the semi-major axes, much less to dissociate the systems. Here again, then, the time-scale indicated is of the order of a few thousand million years.

These investigations on the stability of star clusters and of binary stars reinforce the many other lines of evidence which point to a 'short' time-scale of 10^9–10^{10} years for the universe. The 'long' time-scale of 10^{12}–10^{13} years suggested, for example, by considerations of equipartition of translational energy among the stars, and by study of the evolution of moving clusters, finds less and less support among astronomers. Many of the arguments which seemed to demand it depend on mechanisms which, though they operate in one way now, may have operated quite differently in the early history of the universe. Gravitational interactions, for example, were possibly of a different order of magnitude then from what they are at present. The long time-scale is, indeed, appropriate if, as was thought likely some years ago, the energy-producing mechanism in stars is simple annihilation of matter; but the current theory identifying it with the synthesis of helium from hydrogen favours the short time-scale, and is the only one which has been made even remotely consistent with the facts at present known. Furthermore, direct measurements of the uranium/helium and uranium/lead ratios in pre-Cambrian rocks, and of the helium, uranium and thorium contents of iron meteorites[7], give ages ranging from 2 to 7×10^9 years. Again, if we accept the red-shift in the spectra of the extragalactic nebulæ as a velocity effect and extrapolate backwards using their present velocities, we find that they must have taken about $1{\cdot}8 \times 10^9$ years to reach their present positions.

This is no doubt a somewhat naïve approach to the subject, but in a very recent paper on the recession constant of the galaxies, Eddington concludes[8] that "the time-scale for the evolution of the universe is definitely less than 90×10^9 years, and I do not see much prospect of evading this limit". But all these lines of argument are not so conclusive that we can dismiss other methods of attack, and these recent researches of Chandrasekhar provide a valuable check on the currently accepted theory that the time-scale appropriate to the universe is the short one of 10^9–10^{10} years.

A. HUNTER.

[1] *Ann. New York Acad. Sci.*, **45**, 131 (1943).
[2] *Astrophys. J.*, **97**, 255 (1943).
[3] *Astrophys. J.*, **98**, 54 (1943).
[4] *Science*, **99**, 133 (1944).
[5] *Nature*, **137**, 537 (1936).
[6] *Astrophys. J.*, **99**, 54 (1944).
[7] *Nature*, **149**, 235 (1942).
[8] *Observatory*, **65**, 211 (1944).

OBITUARIES

Sir Henry Lyons, F.R.S.

SIR HENRY LYONS was born in 1864: he was educated at Wellington and Woolwich and passed into the Royal Engineers in 1884; in 1896 he was appointed director-general of the Geological Survey, Egypt, and four years later director of the Survey Department of that country; during the War of 1914–18 he was commandant of the Meteorological Section R.E., and during 1916–18 he administered the London Meteorological Office; from 1919 until 1933 he was at first secretary and then keeper of the Science Museum, South Kensington. What a strange series of occupations: the army, geology, surveying, meteorology and museum management; yet it contains the key to his great and undoubted success, for it will be noticed that from the age of thirty-two years he was in charge of important Government departments. Lyons was first and foremost an organizer and administrator; he loved administration for its own sake, especially the administration of scientific organizations, but he was always ready to undertake administration of any kind so long as it involved reorganization and development.

Going to Egypt in 1896 as director-general of the small Geological Survey, he soon saw the need for a much more extensive survey, as little was then known with accuracy of the topography of the vast valley of the Nile and of the regime of the great river which flows through it. The Survey of Egypt was created, and Lyons organized it and directed it for eleven fruitful years. The valley was surveyed and the flow of the river scientifically measured; at the same time archæological remains, especially those to be submerged by the enlarged Aswan Dam, were studied and recorded. In 1906 Lyons published his book "The Physiography of the River Nile and its Basin", which reviewed all that was then known of the geology, climate and hydrology of the whole basin of the Nile. It is the most important scientific work on the Nile which has been produced up to the present time; it contains matter of the utmost importance for science and for the economy and government of Egypt. This work with other smaller publications earned for Lyons his position as one of the outstanding geophysicists and geographers of the British Empire. In 1909 Lyons returned home and lectured for a time on geography at Glasgow.

When war broke out in 1914, our army authorities had never even considered what meteorological help the army would need. The use of the aeroplane and the greater precision required by the artillery soon made it necessary to have a meteorological service at the front, and in 1916 it was decided to form a Meteorological Section of the Royal Engineers; and Lyons was put in charge as commandant. With Lyons' organizing ability in London and Ernest Gold's technical knowledge and immense drive in France, the new service was soon in full operation. By the end of the War the Meteorological Section R.E. had achieved a success which is not sufficiently known and appreciated. The experience and organization of the service built up in 1916 have been the foundations of the vastly increased meteorological service for the forces which is playing such a responsible part in the present War.

In 1916 Sir Napier Shaw, director of the Meteorological Office, found himself completely occupied with the preparation of meteorological information

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Professor of Mechanical Engineering and Dean of the Faculty: S. J. Davies, D.Sc., Ph.D., Wh.Ex., M.I.Mech.E.

DEPARTMENT OF ELECTRICAL ENGINEERING

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CHEMICAL ENGINEERING
(Discontinued during the War)

Postgraduate courses and facilities for research are provided in each of the above departments, which are fully equipped with modern plant and apparatus.

For full information and prospectus apply to the Secretary, King's College, Strand, W.C.2.

GOVERNMENT OF NORTHERN IRELAND

RESEARCH ASSISTANT

A vacancy exists for a RESEARCH ASSISTANT (male) in the Agricultural Entomology Division of the Ministry of Agriculture. The appointment will be temporary and will be terminable at any time on one month's notice.

DUTIES: The officer appointed will be required to assist in advisory work and to carry out entomological research in connection with the control of insect pests of crops and livestock.

QUALIFICATIONS: Candidates should be university graduates with a qualification in Agricultural Entomology, preferably an Honours Degree, or have postgraduate experience.

SALARY: The scale of salary attaching to the appointment is £275 per annum, rising by annual increments of £20 to £335, by £40 to £375, and thereafter by £25 to a maximum of £600. A commencing salary higher than the minimum may be paid to a candidate with special qualifications and experience. In addition a war bonus of 19s. a week is at present payable.

Closing Date for Receipt of Applications.—Applications must reach the Assistant Secretary (Establishments) Ministry of Finance, Stormont, Belfast, on or before Sept. 21, 1944. Applicants should state date of birth and give full particulars of qualifications and experience. They should also enclose copies of two recent testimonials.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

DIRECTOR OF FOREST PRODUCTS RESEARCH

Applications are invited for the post of DIRECTOR OF RESEARCH, Forest Products Research Laboratory, Princes Risborough, which will shortly become vacant on the retirement of the present Director. Candidates, who must be natural-born British subjects, should have high scientific qualifications with experience of, and ability to organize, direct, and develop, research aimed at industrial objectives. Knowledge and experience of wood and its present and potential uses would be advantageous but are not essential. Age should preferably not exceed 50. The salary will be of the order of £1,400 per annum, with superannuation provision under the Federated Superannuation System for Universities.

Applications, giving particulars of age, qualifications, experience, etc., and not less than two personal references, should be sent to the Secretary, Department of Scientific and Industrial Research, Teddington, Middlesex, not later than October 9, 1944. Further particulars of the post may be obtained by application to that address.

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RESPONSIBLE LECTURER IN PHYSIOLOGY

Applications are invited from University Graduates for the full-time post of Responsible Lecturer in Physiology. The successful candidate will be required to have qualifications and experience which will secure recognition as a teacher by the University of London. Salary will be in accordance with the London Burnham (Technical) Scale, with war bonus plus an allowance in respect of special responsibility.

Further particulars and form of application may be obtained by sending a stamped addressed foolscap envelope to the undersigned, to whom applications should be returned by Sept. 20, 1944.

F. J. HARLOW, M.B.E., Ph.D., B.Sc.
Principal.

UNIVERSITY OF BRISTOL

The University invites applications for a TEMPORARY ASSISTANT LECTURER IN MATHEMATICS for the next Session which starts on Sept. 28, 1944, and ends on June 30, 1945. For this period the salary will be £300. The main duties required from the Assistant Lecturer will be to help in the teaching of Applied Mathematics.—Two copies of an application, together with the names and addresses of two persons who will act as referees, should reach the undersigned on or before Sept. 20, 1944.

WINIFRED SHAPLAND,
Secretary and Registrar.

THE UNIVERSITY OF MANCHESTER

BEYER CHAIR OF ENGINEERING

Applications are invited for appointment to the above post in Faculty of Science. Stipend £1,300 to £1,600 per annum, according to qualifications. It is hoped that the successful candidate would enter upon his duties on Sept. 29, 1945, but arrangements might be made to commence at a later date. Candidate should possess qualifications in Civil or Mechanical Engineering or both.

Applications, which must be received on or before Nov. 18, 1944, should be sent to the Registrar, The University, Manchester, 13, from whom further information may be obtained.

UNIVERSITY OF MANCHESTER

There are vacancies in the Department of Chemistry for two Research Assistants in Physical Chemistry (low temperature polymerization), under a grant from the Department of Scientific and Industrial Research. The appointments are for one year from Oct. 1, 1944. Salary £300 per annum.—Applications, with the names of two references, should be sent to reach the Registrar, The University, Manchester, 13, by Sept. 20, 1944.

Applications are invited for the Chair of Obstetrics and Gynaecology in the Royal Faculty of Medicine, Baghdad, Iraq. Candidates should be available for appointment as from Oct. 1, 1944. The salary, payable in Iraqi dinars, is equivalent to £1,800 per annum, in addition to which there would be a monthly cost of living allowance of £24. Private practice would be allowed. Candidates should have had at least 8 years' teaching experience in a British university or other recognized medical school.—Applications should be addressed to the Appointments Department, British Council, 3 Hanover Street, London, W.1.

An old established Company with Works in the Manchester district, invites applications from qualified men between 25 and 30 years of age for: (1) ANALYTICAL CHEMIST, candidates must have a sound knowledge of analytical chemistry with preferably some experience in industry; (2) RESEARCH CHEMIST, candidates should hold a University Degree in Chemistry and have some experience in industrial research. These are progressive and permanent positions for men of ability and initiative.—Applications, in own handwriting, giving age and details of training and experience, should be addressed to Box 751, L.P.E., 110 St. Martin's Lane, London, W.C.2.

Applications are invited for vacancies for Temporary Assistant Technical Examining Officers in the Victualling Department of the Admiralty. Candidates should have the following qualifications and experience: (a) university degree (or equivalent), with Chemistry as principal subject; (b) experience preferably in one of the three main groups of stores dealt with by the Victualling Department — namely, foodstuffs, textiles, or metalware. Successful candidates will be given a training course in examination of all branches of victualling stores. Salaries will be fixed according to age, qualifications, and experience within the following ranges: men, £275—£500; women, £275—£400. Civil Service war bonus, at present £49 11s. per annum for men and £40 9s. per annum for women, is payable in addition.—Applicants should write, quoting F.2911A, to the Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2, for the necessary forms, which should be returned on or before Oct. 11, 1944.

Applications are invited for the following appointments at the Cereals Research Station, St. Albans: (a) BIOCHEMIST (reference number F.2841A); (b) PHYSICAL CHEMIST (reference number F.2842A). Some research experience required in each case. Salary not less than £350 per annum.—Applicants should write, quoting the reference number of the post applied for, to the Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, W.C.2, for the necessary forms, which should be returned completed on or before Sept. 19, 1944.

Physicist, with engineering knowledge required by a Company at Maidenhead to take charge of, and to direct research and development work in, a well-equipped laboratory concerned primarily with the filtration and purification of liquids and gases. The position is a responsible one demanding originality and leadership. Post-war permanency for suitable applicant. Salary, £500 to £650 per annum.—Applicants should write, quoting A.645XA, to Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2, for the necessary forms, which should be returned completed on or before Sept. 19, 1944.

Physicist required for a Company in Birmingham. Must have first-class experience on problems relating to lighting and aircraft and automobile lamps. Approximate salary £450 to £550 per annum. Applicants should write, quoting A.630XA, to the Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2, for the necessary forms, which should be returned completed on or before Sept. 26, 1944.

Scientific Instrument Manufacturers. Executive, with wide experience of the Laboratory Apparatus trade, particularly sales organizing, publicity, catalogue production, laboratory planning, etc., and possessing energy, initiative, and creative ability, is considering a change. Would be interested to receive details of posts offering responsibility and good prospects. (Would also be interested in an overseas appointment, particularly South Africa.)—Write, Box 238, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Applications are invited for the post of SECOND VETERINARY OFFICER, Imperial Bureau of Animal Health, Weybridge. Salary, £600—£25—£850, plus cost of living bonus, also F.S.S.U. on confirmation. Commencing salary dependent upon qualifications and experience. Particulars of the conditions of service may be obtained on application to the Secretary, Imperial Agricultural Bureaux, 2 Queen Anne's Gate Buildings, London, S.W.1.

Translations of Scientific and Technical Papers from Danish, Dutch, French, German, Italian, Norwegian, Russian, Spanish and Swedish originals. Thirty-five years experience.—George Borrow, 6 St. Stephen's Grove, London, S.E.13.

Wanted Urgently for research work: eyepiece camera with focusing ocular for photomicrography.—Box 231, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

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required for the prosecution of the War; to relieve him Lyons took over the administration of the Office. He carried out the work with his usual ability for more than two years; but his period of service was too short and the conditions too abnormal for him to have left any permanent impression on the organization of the Office.

In 1920, after having served for a year as secretary, Lyons was appointed keeper of the Science Museum. Only those who knew the Science Museum in 1920 and were familiar with it just before the present War broke out can appreciate the great work carried out by Sir Henry Lyons at the Museum. In 1920 the Science Museum was a good museum, one of the best—if not the very best—of its kind in the world; but it was only a museum, governed by all the traditions of museum keeping and museum visiting. Lyons had no use for traditions; in fact the chief element in his success as an administrator was his willingness to break with traditions. Lyons wanted the museum to educate, and he knew that to do that the visitors must be interested. So every exhibit which could work was made to work, and if it could not work a working model was constructed in many cases. Life-size reproductions of famous workshops and laboratories were erected and demonstrations of modern scientific developments, such as radio and television, were arranged. Perhaps one of his most successful innovations was the series of demonstrations, accompanied by lectures and discussions, of new technical processes, such as the properties and manufacture of plastics. Instead of considering children a nuisance in a museum, he welcomed them and arranged one of the galleries especially for them. These are but a few examples of the changes made, but they illustrate the breath of life which Lyons breathed into the Museum. The Science Museum, while remaining one of London's greatest holiday attractions, has become one of its greatest educational institutions.

Lyons retired from the Science Museum in 1933 and was then free to devote himself to the voluntary work which had occupied so much of his time even while holding official posts. Varied as had been his official work, equally varied was the services he gave voluntarily to science and other interests. These probably occupied as much of his time, after returning to England in 1906, as his paid posts. It is quite impossible even to mention them all here, so I will confine myself to a few of which I had personal knowledge.

I first corresponded with Captain Lyons, as he then was, in 1913 or 1914, when I was engaged in India on writing up the meteorological results of Scott's Antarctic Expedition, 1910–12. As secretary to the committee appointed to publish the scientific results of the Expedition, Lyons was responsible for organizing the staff engaged on the work, and he supervised the printing and publication of the resulting books and monographs. It was a big undertaking and all of us engaged in the task were grateful to him for his helpful interest in our work. The imposing array of volumes containing the scientific records of the Expedition is a lasting monument to his disinterested zeal for science.

When I became director of the Meteorological Office in 1920, Lyons was one of the two representatives of the Royal Society on the Meteorological Office Committee, of which he was a member for twenty-three years (1918–41). The senior representative of the Royal Society is always the vice-chairman of the Committee (the Under-Secretary of State for Air being the permanent chairman) and generally presided at the meetings. Sir Henry became vice-chairman on the retirement of Sir Arthur Schuster in 1932. At the meetings and between meetings Lyons was always helpful; his short term as administrator of the Office had given him an insight into the difficulties with which the director has to contend, and his advice was always good and willingly given.

Sir Henry also succeeded Sir Arthur Schuster in 1928 in a much more important voluntary office, namely, the secretaryship of the International Council of Scientific Unions. It was a great piece of good fortune for international science that these two able Englishmen should have directed the work of the Council for the first eighteen years of its existence (1919–37). Lyons' great administrative ability, perfect command of the French language and unfailing good temper were valuable assets in guiding the Union through the difficult time between the two world wars, when international relationships were not easy.

The great work which Sir Henry has done for the Royal Society, as foreign secretary and treasurer, has been recorded by the president of the Royal Society (*The Times*, August 12). He was not just a good treasurer, he pulled to pieces and built anew the whole financial side of the Society's business. In this work his bent for science, his pride in the Society and his love of administration all found scope, and the result is worthy of a great Society and of a great administrator.

I cannot detail the work Lyons did for the Geological, Royal Geographical and Royal Meteorological Societies—he was a fellow of the first, a secretary of the second and president of the third; it is sufficient to say that he left his mark on all three. Needless to say he received many honours, including the Grand Cordon Medjidieh, 2nd class Osmanieh, Hon. D.Sc. Oxon., Hon. D.Sc. Dublin, F.R.S., knighthood (1926) and several medals awarded by scientific societies.

It was not, however, his great ability which endeared Lyons to those who came in contact with him; it was his utter absence of affectation, his friendly greetings and pleasant smile. Everyone who knew Lyons even slightly feels a loss in his death on August 10, and those of us who knew him well realize that we have lost a friend who cannot be replaced.

Sir Henry Lyons was the son of General T. C. Lyons, C.B., and married Helen Julia, eldest daughter of the late Mr. P. C. Hardwick in 1896. Lady Lyons was often with Sir Henry on his visits to international meetings and at official ceremonies, and was equally successful as hostess or guest. Our sympathy goes out to her and to their son and daughter in their great bereavement.

G. C. SIMPSON.

WE regret to announce the following deaths:

Dr. Agnes Bluhm, an authority on social hygiene and heredity, of the Kaiser Wilhelm Institute for Biology, Berlin-Dahlem, aged eighty-one.

Mr. A. Deane-Butcher, C.B.E., formerly director-general of irrigation, Sudan and Southern Nile, on August 21, aged sixty.

Dr. Ethel Miles Thomas, formerly head of the Department of Botany in University College, Leicester, on August 29.

Sir Arthur Smith Woodward, F.R.S., keeper of geology in the British Museum (Natural History) during 1901–24, on September 2, aged eighty.

NEWS and VIEWS

Chair of Social Institutions, University of London

As announced in *Nature* of August 13, p. 206, Mr. T. H. Marshall has been appointed to the newly instituted University chair of social institutions tenable at the London School of Economics. This chair has a double function. Within the general field of sociology the professor will be responsible for promoting the study of modern social structure, which includes both analysis of the functions of social institutions and investigation into the character and composition of social groups. At the same time, Mr. Marshall succeeds Mr. C. M. Lloyd as head of the Social Science Department. This Department has grown steadily in size and range under Mr. Lloyd, and has been working to capacity throughout the War to meet the demand for trained social workers. But the development and expansion of the social services is likely to be even greater after the War, and universities will be under pressure to take more students and to train them more rapidly. In such circumstances great care will be needed to ensure that quality is not sacrificed to quantity, and to prevent any deviation from the twofold aim of raising the academic status of the Social Science Department within the University and raising the professional status of the trained social worker in the world outside. An important step in this direction can be made by integrating the work of the Social Science Department more closely with that of the other departments of the School. The dual character of the new chair should make this easier than it has been in the past. Mr. Marshall is at present reader in sociology in the School.

Dr. James Philp

DR. JAMES PHILP has been appointed director of research for the South African Wattle Growers' Union, Pietermaritzburg. He is also acting in an advisory capacity to the Forestry Division of the South African Government, with which he was previously engaged as its first forest geneticist. Dr. Philp was on the staff of the John Innes Horticultural Institution, Merton, until 1934, and during the succeeding eight years was in charge of the cereal division of the plant breeding section of the Egyptian Ministry of Agriculture.

Medicine in Turkey

THE July issue of the *Asiatic Review* contains an interesting article on the history of medicine in Turkey by Dr. H. Avri Aksel, chief surgeon to the Haseki Hospital, Istanbul, and a member of the Turkish Medical Mission which recently visited Great Britain. He points out that Turkish medicine, which has a history of six hundred years, is a continuation of the medicine of the Selcuk Turks who for centuries ruled in Anatolia and left a great many traces of their civilization. In the middle of the fourteenth century, the rapid expansion of the Turkish Empire and particularly the respect paid by the Sultans and their viziers to science and scientific men was the cause of Turkey being flooded by a great many men of science from Persia, Egypt, Irak and India. The number of hospitals increased and rose to fifty after the conquest of Istanbul. The medicine of the early days was very elementary, being rather a system of master and apprentice rather than a science taught in the schools, and knowledge was gained by practical experience.

The sixteenth century was the most brilliant age. Science and art reached great heights. Medicine was taught to students in well-organized courses, and for the first time lessons on anatomy were given. At the end of the seventeenth century, Turkish medicine gradually moved from the East and turned towards the West. Turkish medical men who went to Europe with the armies learnt European languages, translated important medical works into Turkish and introduced new methods. The eighteenth century was very important owing to the practice of inoculation against small-pox having begun in Turkey before it did in Europe. In the nineteenth century a big advance in surgery and medicine took place in Turkey. All the new methods employed in European medical colleges were applied. Anatomy for the first time was taught on the human body and a large library was established. There are now about two hundred hospitals in Turkey, innumerable maternity and child welfare centres, and a great many dispensaries and hospitals for infectious diseases and tuberculosis. There are altogether four thousand medical practitioners in private practice and in the service of the State.

Carnegie United Kingdom Trust

THE thirtieth annual report of the Carnegie United Kingdom Trust for the year 1943 (The Trust, Dunfermline) records a year of quiet progress and consolidation, the total grant expenditure showing, for the first time during the War, a decrease, from £69,000 to £62,000. This was due to the transfer to the Council for the Encouragement of Music and the Arts of financial responsibility for large orchestras and opera, the diminution or withdrawal of many of the salvage grants made early in the War, as well as of certain maintenance grants renewed on a diminishing scale, and the improved financial position of beneficiaries who have been offered grants on a deficiency basis. Grants for the equipment of youth clubs increased from £5,695 in 1942 to £9,178 in 1943; but conditions in the book trade have compelled the termination of the limited club library policy operated since 1940 for the benefit of new clubs. A preliminary report on an inquiry into conditions of unemployed young men in Liverpool, Glasgow and Cardiff was published in November under the title "Disinherited Youth", and a report on the Trust's bursary scheme for training youth leaders was also published during the year and circulated chiefly among central and local education authorities and voluntary organizations concerned with the welfare of young people. Grants were continued during 1943 in aid of the administration of the Land Settlement Association, the Museums Association, the National Council of Social Service, and the Rural Development Council of Northern Ireland as well as towards the maintenance of the three central libraries.

Origins of Garden Vegetables

VILMORIN's production of biennial, red-rooted carrots from annual white-rooted wild plants, and Buckmaster's improvement of the wild parsnip, are two outstanding examples of vegetable introductions during the last century. These, and other interesting historical sketches of vegetable introduction, are detailed in a paper by W. F. Giles (*J. Roy. Hort. Soc.*, 69, Pts. 5 and 6, May and June 1944). Peas apparently originated in the East; the Greeks grew the crop in 300–400 B.C. Gerarde referred to several kinds of round-seeded pea at the end of the sixteenth century. It was not, however, until nearly two centuries later that Thomas Andrew Knight introduced the sweeter and more palatable varieties with wrinkled seeds. Scarlet runner beans were introduced from unknown antiquity in South America in 1633. Broad beans came from the East, their use there being of great known antiquity. The tomato was brought to Europe in the fifteenth century, but it has only been improved and attained popularity within the lifetime of our elders. Mr. Giles demonstrated the close affinity of various Brassicas with the wild *B. oleracea* by crosses, which all produced fertile hybrids of great morphological variability, but only incipient horticultural promise.

New Contagious Disease in the United States

A NEW contagious disease with symptoms so mild the sickness may go unnoticed has recently been reported by Dr. Carl H. Smith, of Cornell University Medical College and the New York Hospital. The chief feature of the disease is an increase in the lymphocytes of the blood. Although the number of these white cells may be increased almost ten-fold, they are not abnormal. Fever and vomiting, pain in the back of the head and neck, or pain in the abdomen suggestive of appendicitis may occur in this new disease, but when they do, these symptoms last only a few days. In one case Dr. Smith reports, the child had fever, vomiting and abdominal pain, but a brother and sister had only symptoms of a mild cold. Only since 1939 have cases of this disease, called acute infectious lymphocytosis, been reported. The cause has not been identified, but is believed to be a virus. The disease apparently attacks young children chiefly, and they all seem to recover.

Use of Inter-city Telephone Circuit for Television

ACCORDING to a recent announcement by the American Telephone and Telegraph Company (*Bell Lab. Rec.*, 22, No. 9; May 1944) plans have been made for the construction of a large amount of coaxial cable to be operated by radio relays. Tentatively, the coaxial extension plans call for the installation of 6,000–7,000 route miles of coaxial facilities in the next five or six years to help meet expected increasing demands for long-distance telephone service. These facilities would be suitable for interconnecting television stations for network operations. Work on the 295-mile Atlanta to Jacksonville route is in progress, and is expected to be in service for telephone purposes by the spring of 1945. Present coaxial equipment will provide television channels of 2,700,000 cycles in width. Tests have shown this equipment capable of transmitting the visual images with satisfactory clearness. Further technical improvements will make it possible to use a much wider band of frequencies, which will permit simultaneous use of the same coaxial for an improved (4,000,000 cycles) television channel and a large number of telephone messages.

The New York-Philadelphia cable, containing two coaxials, was installed in 1936 for further experiment. Its use for transmitting visual images for television broadcasts was first demonstrated in 1937. The cable recently has been providing telephone circuits. The first commercial installation was the Stevens Point-Minneapolis cable, containing four coaxials, two being in regular use and two in 'stand-by' use. This is capable of providing 480 telephone circuits with its present amplifiers. It is now equipped to handle nearly a hundred circuits and soon will be stepped up to about 150. One of the cables now in use between Philadelphia and Baltimore and another between Baltimore and Washington contain coaxials which, however, have not yet been equipped for service. The former contains six coaxials and the latter four. As many as six or eight coaxials are likely to be built into some of the new cables. In a six-coaxial cable, for example, with the present amplifying equipment, two coaxials could be used to provide 480 telephone circuits, another two could provide either two one-way television channels or 480 more telephone circuits, and the others would serve as equipped stand-by circuits to protect both services.

Engineering Research in the U.S.S.R.

VOL. 1, No. 2 of the *Engineering Review* (Russian) (dated 1941) contains a collection of papers dealing with the mathematics of stress calculations for rotating disks, springs and conical shells. Other papers in the applied mechanics section describe very large mechanical testing machines and an electrical analogy for the investigation of torsion in bars. The hydrodynamics section has papers on filtration in non-homogeneous soils and the unsteady flow of water in canals. A short summary of each paper is given in English or German.

Marine Water-Tube Boilers

A SERIES of papers read before the Institution of Naval Architects on May 10, 1944, dealt with the design of water-tube boilers for marine propulsion. Designs and data were submitted by Messrs. Babcock and Wilcox, Ltd., International Combustion Co., Ltd., La Mont Steam Generator, Ltd., and Yarrow and Co., Ltd., for a boiler plant suitable for a ship of 7,500 shaft h.p., using oil fuel. The complete set of papers provides a unique opportunity for direct comparison of the designs of modern boilers which should be of great value to marine engineers.

Announcements

PROF. J. A. SCOTT WATSON, agricultural attaché at the British Embassy in Washington, has been appointed to the newly created post of chief education and advisory officer to the Ministry of Agriculture.

AT a recent meeting of the Geological Society of London, it was decided provisionally to admit persons between the ages of eighteen and twenty-three as junior associates. Such junior associates will enjoy most of the facilities offered by the Society, except that they may not attend discussions relating to the management of the Society's affairs, and they will not be entitled to vote at any meeting; they will not continue as junior associates after the close of the calendar year in which they become twenty-three.

MR. W. BOWEN, of the Bowen Instrument Co., Ltd., has made a gift of £5,000 to the Scientific Instrument Manufacturers' Association of Great Britain for the establishment of a fund to provide prizes for the best annual contribution to instrument research, development or design.

LETTERS TO THE EDITORS

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

Non-antigenicity of Gelatin

INTEREST in the inability of gelatin to act as a full antigen, that is, to produce specific anti-bodies when injected into an animal, has been revived by the observations of Haurowitz, Tunca and Schwerin[1], and also by the suggested use of isinglass for blood transfusion[2]. Haurowitz *et al.* find that whereas the intravenous injection of arsanil-azo-globulin into rabbits leads to the deposition of the bulk of the arsenic in the liver and bone-marrow[3], the injection of arsanil-azo-gelatin is followed by rapid excretion of the arsenic in the urine with very little deposition in the liver. The conclusions reached by these authors is that arsanil-azo-gelatin does not act as a full antigen because it is insufficiently deposited in the reticulo-endothelial cells of the body.

The non-antigenicity of gelatin may, however, be due to more than one factor, and at least four possible explanations have been or can be offered for the *in vivo* immunological inertness of this protein (cf. Wormall[4]), namely: (1) gelatin is relatively deficient in aromatic groupings; (2) it is deficient in carbohydrate groupings; (3) it may be rapidly excreted in the urine after intravenous injection into an animal; (4) it is usually prepared from collagen by prolonged treatment with boiling water or steam, and this treatment may well be sufficient to destroy any antigenic power of the preparation.

The introduction of aromatic groupings, including tyrosine, into gelatin does not produce a compound which has antigenic powers comparable with those of the majority of other proteins[5]. Thus, although some of these conjugated gelatin derivatives produce antibodies which react with the corresponding conjugates prepared from globulin and certain other proteins, these antibodies react very feebly or not at all with the gelatin derivatives; the results suggest that the non-antigenicity of gelatin is not due solely to lack of aromatic groupings. Similarly, the failure does not appear to be due solely to lack of tyrosine plus carbohydrate[6].

The third explanation given above receives strong support from the observations of Haurowitz and his colleagues, and it seems possible that the major part of injected gelatin or gelatin derivative is so rapidly excreted in the urine that little remains in the body to incite antibody formation. Gelatin and several other proteins with molecular weights less than 70,000 are rapidly excreted in the urine by anæsthetized cats and rabbits and by isolated perfused kidneys of dogs[7]. On the other hand, proteins such as egg albumin and the Bence-Jones protein, both of which are excreted by the kidney, are known to be fully antigenic; thus loss by excretion in the urine is probably not the only factor which determines the non-antigenicity of gelatin.

The fourth possible explanation can be excluded if it is shown conclusively that native collagen is non-antigenic, but unequivocal proof of this does not appear to be available. Glue is devoid of antigenic activity[8], and so is isinglass, "which is a collagen rather than a gelatin"[2]. Apart from these observations, however, it appears that little attention has been given to the parent protein as distinct from the partially hydrolysed product, gelatin. It would seem desirable that a more complete immunological study should be made of the antigenic properties of the natural unhydrolized collagens. Such an investigation might certainly help to throw some light on the vexed problem of the antigenicity of proteins.

A. WORMALL.

Department of Biochemistry and Chemistry,
Medical College of St. Bartholomew's Hospital,
c/o The Molteno Institute, Cambridge.

[1] Haurowitz, F., Tunca, M., and Schwerin, P., *Biochem. J.*, **37**, 249 (1943).

[2] See Taylor, N. B., and Moorhouse, M. S., with Stonyer, A. J., *Canad. Med. Assoc. J.*, **49**, 251 (1943). Pugsley, H. E., and Farquharson, R. F., *Canad. Med. Assoc. J.*, **49**, 262 (1943). Cited from *Bull. War Med.*, **4**, 464 and 465 (1944).

[3] Haurowitz, F., and Kraus, F., *Hoppe-Seyl. Z.*, **239**, 76 (1936). Haurowitz, F., *Hoppe-Seyl. Z.*, **245**, 23 (1937).

[4] Wormall, A., *St. Bartholomew's Hosp. Reports*, **70**, 199 (1937).

[5] Landsteiner, K., *Biochem. Z.*, **93**, 106 (1919). Hooker, S. B., and Boyd, W. C., *J. Immunol.*, **24**, 141 (1933). Hopkins, S. J., and Wormall, A., *Biochem. J.*, **27**, 1706 (1933). Clutton, R. F., Harington, C. R., and Yuill, M. E., *Biochem. J.*, **32**, 1111 (1938).

[6] Clutton, R. F., Harington, C. R., and Yuill, M. E., *loc. cit.*

[7] Bayliss, L. E., Kerridge, P. M. T., and Russell, D. S., *J. Physiol.*, **77**, 386 (1933).

[8] Ramsdell, S. G., and Walzer M., *J. Immunol.*, **14**, 207 (1927).

Capacity of Hyaluronidase to Increase the Fertilizing Power of Sperm

THE capacity of hyaluronidase to liquefy the highly viscous gel which cements the cumulus cells around the unfertilized tubal egg of the rat was described by McClean and Rowlands[1], and confirmed in the mouse by Fekete and Duran-Reynals[2] shortly afterwards. We suggested that the gel is hyaluronic acid similar to that in synovial fluid and, to enable its disintegration to occur as a preliminary to fertilization, a certain unspecified concentration of hyaluronidase must be established by the sperm in the vicinity of the egg. The fact that intromission of such a large number of sperm is necessary to ensure fertilization, therefore, may well be related not only to the safe passage of one or more sperm into the Fallopian tube but also, and possibly more especially, to the establishment of this requisite concentration of enzyme. Some preliminary experiments, which are described below, have now been carried out in rabbits to investigate the capacity of hyaluronidase to increase the fertilizing power of dilute sperm suspensions.

Ovulation was induced in Dutch and Himalayan rabbits by intravenous injection of 50 I.U. of chorionic gonadotrophin. A mixed sample of semen from 8–12 rabbits was collected in an artificial vagina and its sperm-count estimated using a Zeiss hæmocytometer. The semen was then diluted in Baker's[3] solution so as to contain 2×10^7 sperm per c.c., and from this were then prepared (1) further dilutions to give suspensions of sperm varying between 2×10^6 to 2×10^4 per c.c., and (2) a hyaluronidase-containing filtrate of the sperm, the latter having been inactivated by heating at 50° C. for 5 min. and separated by vigorous centrifugation. This sperm-free filtrate was then mixed in equal proportions with the various sperm suspensions and 2 c.c. of the mixtures inseminated artificially into each rabbit at approximately 7 hr. after the injection of gonadotrophin, that is, 4 hr. before the expected time of ovulation. Sperm counts were again made wherever practicable on the inseminates. The amount of hyaluronidase in the semen, and when possible also in the inseminates, was estimated by its capacity to prevent the appearance of a mucin clot on the addition of acetic acid to a freshly made substrate containing 1 per cent horse serum albumin and 0·25 per cent of a standard preparation of potassium hyaluronate extracted from human umbilical cord. Enzyme activity is expressed in mucin clot prevention (m.c.p.) units. Details of the assay method have been published by McClean[4]. Filtrates of 2×10^7 sperm were found to contain 4–8 m.c.p. units per c.c.

Fertilization was determined by the presence of multi-cellular ova in washings of the Fallopian tube examined under a dissecting microscope. The rabbits were killed 36 hr. after ovulation when the normal fertilized egg consists of 8–16 blastomeres. The expected number of eggs can be ascertained by counting the number of ovulated follicles in the corresponding ovary; the full complement was almost invariably recovered. A normal rate of segmentation was observed, so that unicellular eggs were, therefore, considered to be infertile.

In all, seven experiments, as outlined above, were made. Two of these were carried out to determine the approximate number of sperm necessary for fertilization. The results, which agree well with the observations of Walton[5], indicate that for maximum fertility 1×10^6 or more sperm are required, that only a small number of eggs become fertilized when the inseminate contains 2×10^5 sperm, and that 1×10^5 sperm are probably incapable of causing fertilization. The approximate median effective concentration of sperm varies from $4{\cdot}47 \times 10^5$ to $1{\cdot}82 \times 10^6$. Of five experiments in which hyaluronidase (filtrates of 2×10^7 sperm) was added to the inseminates, four showed that the enzyme was effective in increasing fertility. In these four experiments the median effective concentration of sperm varied between $5{\cdot}44 \times 10^4$ and $1{\cdot}52 \times 10^5$. In one experiment hyaluronidase was ineffective. Inseminates containing 2×10^4 sperm with added enzyme were found to be incapable of causing fertilization. Taken together, the tests show that although the action of hyaluronidase is very variable under the conditions tested, it increased the fertilizing capacity on the average to the extent that treated groups required about one sixth of the sperm concentration to give a 50 per cent response, compared with that in control groups. The range covered was, however, from one thirtieth to equality of concentration in different tests. The probability that the enzyme in fact facilitates fertilization is of the order of at least 50 to 1 in favour.

At this stage of the investigation any discussion as to the method by which the enzyme, even in the absence of a vector, reaches the Fallopian tube would be purely speculative. A rapid spreading action of the enzyme through the lumen of the female reproductive tract similar to that through the skin and subcutaneous tissue would, however, seem to be ruled out by the unpublished observation of McClean that hyaluronidase does not lower the viscosity of cervical mucin. If one assumes, therefore, that this enzyme does not assist in the conveyance of sperm, these experiments incidentally may throw some light on the number of sperm required to be inseminated in order that one or more may reach the Fallopian tube. It is possible that not one of those in the inseminate containing 2×10^4 sperm reaches the tube, and that the number of those in the inseminate estimated to contain 1×10^5 that do, in the absence of added enzyme, is so small that the concentration of hyaluronidase they are able to establish locally is not sufficient to liquefy the gel protecting the egg.

Further investigations are now proceeding into the role of this enzyme in fertilization and its relationship to infertility associated with oligospermia.

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July 13.

[1] McClean, D., and Rowlands, I. W., *Nature*, **150**, 627 (1942).
[2] Fekete, E., and Duran-Reynals, F., *Proc. Soc. Exp. Biol. N.Y.*, **52**, 119 (1942).
[3] Baker, J. R., *Quart. J. Exp. Physiol.*, **21**, 139 (1931).
[4] McClean, D., *Biochem. J.*, **37**, 169 (1943).
[5] Walton, A., *Proc. Roy. Soc.*, B, **101**, 303 (1927).

Abrasion of Soil Insects

IN a recent preliminary note[1], evidence was given to show that abrasion of the superficial layer of wax on the epicuticle would go far to explain the action of inert dusts in causing insects to dry up; and confirmation of these ideas was published by Kalmus[2].

It may be of interest to point out that the permeability of insect larvæ living in the soil can be similarly explained by the abrasion of the cuticle by soil particles. Larvæ of Hepialus and Agrotis, Pterostichus, Agriotes, Aphodius and Phyllopertha, Bibio and Tipula when treated with ammoniacal silver all show obvious scratches. In the caterpillars Hepialus and Agrotis, the scratches occur chiefly on the prominent folds along the sides of the body and the outer surfaces of the true legs. In the scarabaeids Aphodius and Phyllopertha it is the lateral folds, the terminal segment and the rounded back that are most scratched. In the larva of the carabid Pterostichus, the sclerites show many longitudinal scratches; the soft intervening cuticle may be almost uniformly abraded except where it is thrown into depressed folds.

In the wireworm Agriotes, the rate of water-loss varies in direct proportion with the degree of visible scratching. But if the wireworm is allowed to moult out of contact with the soil, it is found to possess a cuticle impermeable to water like that of other

PART OF THE CUTICLE OF A WIREWORM TREATED WITH AMMONIACAL SILVER. REDUCTION BY THE EXPOSED PHENOLS REVEALS THE EXTENSIVE SCRATCHING OF THE SURFACE.

insects. Thus at 20° C. the average rate of evaporation from the wireworm into dry air is about 10·5 mgm. per sq. cm. per hour. In a larva kept out of contact with the soil for ten days after moulting, the rate was 0·4 mgm. per sq. cm. per hour. These observations will account for the fact that the normal wireworm cuticle, though highly hydrophobe, is readily permeable to water[3]. They may have a bearing on the entry of insecticides through the cuticle of soil insects[4].

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Aug. 16.

[1] Wigglesworth, *Nature*, 153, 493 (1944).
[2] Kalmus, *Nature*, 153, 714 (1944).
[3] Evans, *Nature*, 152, 21 (1943).
[4] Woodworth, *J. Agric. Res.*, 57, 229 (1938).

Paracrinkle Virus and Inheritance

IN his recent interesting article[1], Dr. Darlington speculates on the origin of viruses and in particular on that of paracrinkle virus in the potato variety King Edward. He states with reference to paracrinkle that "what is a stable and presumably useful cell protein with one plant genotype acts as a destructive agent with another"; also that "any virus that can be transmitted only by grafting must therefore have arisen from grafting; that is to say, from the invasion of one plant by the proteins of another". We gather from this that Dr. Darlington considers that a protein constituent of King Edward becomes a virus on transference by grafting to another potato variety. While this is a tempting speculation, whatever evidence there is does not support it, and we should like to point out the following facts.

First, unlike the plasmagenes, the paracrinkle virus is not transmitted through the seed. Thus, twenty-two seedlings from the cross King Edward female × Flourball were tested by grafting on Arran Victory, and in no case was the paracrinkle virus present in the seedlings. Paracrinkle thus behaves like the majority of plant viruses and not like a plasmagene.

Secondly, paracrinkle can be transmitted by grafting to certain potato varieties which carry it without symptoms, for example, President. From such infected President plants other susceptible varieties such as Arran Victory can also be infected in series.

There thus seems no fundamental difference in the reaction of King Edward to paracrinkle virus from that of any other 'carrier' variety to the virus 'carried'.

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[1] *Nature*, 154, 164 (1944).

The Melanic Form of *Rattus norvegicus* in London

RECORDS of the melanic form of *Rattus norvegicus* from various parts of the British Isles have been published since Thompson[1] in 1837 first described it as a new species under the name of *Mus hibernicus*. There is very little information about the frequency of melanism at any time in the wild population, and it is therefore impossible to draw an accurate picture of changes taking place in the status of the two forms in recent years. The matter is of interest from an evolutionary aspect, and also from the point of view of rodent control, where, since it is necessary to distinguish between colonies of the black rat, *R. rattus*, and those of the brown rat, *R. norvegicus*, it is desirable to know of the existence and status of melanism in the latter species.

The melanic form is superficially very similar to the black rat, *R. rattus rattus*. It is very dark brown, almost black in colour; but unlike the black rat, which is distinctly paler on the belly than on the back, it is scarcely noticeably lighter on the underside. Some individuals have a white patch on the chest or belly; but this varies considerably in size and shape. In all its structural characters it is identical with *R. norvegicus* and can easily be distinguished from *R. rattus rattus* by the small ears, short tail and absence of long guard hairs on the back.

I examined a sample of the rats caught in the Port of London during the two years Sept. 1941–Sept. 1943, together with a number from a large riverside factory in Woolwich in the second of these two years. The majority of these rats were *R. rattus*, but the sample included 1,266 *R. norvegicus*. The sample was drawn from the six dock areas: the London and St. Katharine Docks, the Surrey Commercial Docks, Regent's Canal Dock, the India and Millwall Docks, the Royal Docks, and Tilbury Dock, as well as from the factory already mentioned. These may fairly be considered as a representative section of the riverside districts of London, so that these rats may be said to constitute a fair sample of the rodent population of this district. They are all, with the exception of Tilbury, which is outside London, surrounded by warehouses, bombed sites and dwelling-houses which are typical of this riverside, and the rodents' environment is probably similar throughout the area.

Locality (riverside)	No. of *R. norvegicus* examined	No. of melanics found
London and St. Katharine Docks ..	115	2
Surrey Commercial Docks	337	0
Regent's Canal Dock	138	4
India and Millwall Docks	98	1
Royal Docks	406	11
Woolwich factory	90	2
Tilbury Dock	82	1
Total	1,266	21

The percentage of melanics in the sample as a whole was 1·66 per cent.

The melanics appear to be uniformly distributed along the riverside. The figures were examined for homogeneity by P. H. Leslie; the variation in the proportion of melanics between the different areas is not in any case significant, and is compatible with variations in random sampling ($\chi^2 = 10{\cdot}25$, $n = 6$, $P = 0{\cdot}20$–$0{\cdot}10$).

Melanic brown rats have also been obtained during the last five years from the following places: Bethnal Green[2], Tooting, Bishopsgate, City Road[3], Leadenhall Market[4], and Dagenham[5], as well as one I found in the Isle of Dogs. It seems likely that melanism is widely spread throughout the London area.

An incidence of melanism as high as 1·66 per cent cannot be accounted for by mutation and recombination alone. The factors responsible for the appearance of this character must, therefore, be well established in the rat population of this district. Earlier records of the occurrence of the variety in London seem to be practically non-existent. This suggests that the black variety must have appeared here quite recently; if this is so, it is unlikely that a balance has yet been struck between the two phases. *R. norvegicus* is probably in a state of transient dimorphism. Confirmation of this must, however, depend on this work being repeated at some future date.

Little is known about the general distribution and status of the melanic phase in the past. The scanty literature on the subject has been summarized by Barrett-Hamilton[6] and Millais[7]. It is possible that local museums may have a certain number of unrecorded skins in their collections.

I am much indebted to Dr. M. T. Morgan, medical officer of the Port of London Health Authority, for his co-operation and help, and to Dr. Arthur Davies of the Seamen's Hospital Society for his kindness in providing laboratory facilities; and I wish to acknowledge their interest throughout this investigation.

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Bureau of Animal Population,
University Museum,
Oxford. July 21.

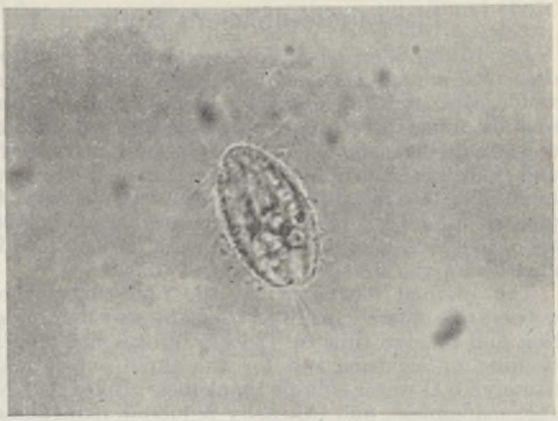
[1] Thompson, W., *Proc. Zool. Soc. Lond.*, 5, 52 (1837).
[2] Hewer, H. R., "Records of the Bureau of Animal Population Surveys in London".
[3] Information provided by the Ministry of Food.
[4] Information provided by G. A. Webber, rodent officer, City of London Corporation.
[5] Claremont, C. L., letter to Charles Elton.
[6] Barrett-Hamilton, E. G. H., "A History of British Mammals" (London, 1916), 2, 613.
[7] Millais, J. G., "The Mammals of Great Britain and Ireland" (1905), 2, 220.

A Ciliate from the Dead Sea

A PIECE of flint-stone, 7 × 7 × 5 cm., was taken by Dr. T. Rayss on August 24, 1940, from the bottom of the Dead Sea near Kalliah from a depth of *c.* 150 cm. of water and handed to me. On the stone, brown spots and vein-like markings were seen, and when some of the material scraped from the veins was examined microscopically, brown cells of a blue-green alga were observed. The following day the stone was submerged in Dead Sea water of s.g. 1·1875, in a closed glass vessel and exposed to light near the window. It was left standing for three years and four months, during which time no visible change in colour was noticed. However, in the meantime, owing to very slight evaporation, the specific gravity of the water rose to 1·2026, and when once again a hanging drop was microscopically examined, four different types of micro-organisms were revealed. These were identified as follows:

(1) *Aphanocapsa* sp. Cells of a blue-green alga, 3·4 μ × 5–10 μ, appearing singly, in pairs or clumps, and were similar to those previously seen on the stone and found in mud samples from the bed of the Dead Sea[1].

(2) *Dunaliella viridis* Teod. Green flagellates, 2·7 μ × 8–11 μ, varying somewhat from their usual shape, previously described[2], due, no doubt, to the increase in salt concentration. Both flagella arise laterally, one overlaps the anterior end, while the other with which the organism moves extends down beyond the posterior end of the cell.



A CILIATE GROWN IN DEAD SEA WATER. UNSTAINED PREPARATION. × 800.

(3) *Amœbæ.* Cells 6–16 μ × 6–27 μ, showing a granulated content, short pseudopodia and slow motility. It still remains to be ascertained whether the organisms are identical with the species of Dimastigamœba previously described[1].

(4) *Ciliate.* Oval shape, 8–13 μ × 16–24 μ, transparent, colourless and having four longitudinal ridges. The organism is very actively motile. The cilia extend around the cell, and two long spines appear at the posterior end. Vacuoles are present; nucleus and cytostome are not visible (see accompanying photograph).

The four different types of organisms were obtained in liquid culture media, exposed to light, containing: 15 per cent salt, 0·03 per cent $Ca(NO_3)_2$, 0·01 per cent KH_2PO_4, 0·02 per cent peptone and traces of $FeCl_3$.

The amœbæ and the ciliate were grown in the dark at 30° C., in a semi-solid agar media consisting of the same liquid media plus 0·6 per cent agar; a small amount of sterile rice starch was added after inoculation.

It is of interest to note that the green flagellates, from only one out of a number of liquid cultures normally grown in the light, completely lost their green colour when grown in a semi-solid agar medium in the dark, and so far have failed to regain their colour when re-exposed to light.

Recently, flint-gravel and water of s.g. 1·1848, collected from the shore of the Dead Sea, was exposed to light. After two weeks a number of the green flagellate *Dunaliella viridis* Teod. and a few amœbæ were observed.

Including the ciliate found actively growing in Dead Sea water, the different groups of organisms which have now been found in the Dead Sea are: bacteria, several blue-green algæ, two species of green flagellates, amœba (possibly more than one species), and a ciliate.

Full details will be published elsewhere.

I take this opportunity to thank Dr. T. Rayss, of the Hebrew University, Jerusalem, for the flint-stone she gave me.

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July 5.

[1] Elazari-Volcani, B., *Nature*, 152, 301 (1943).
[2] Elazari-Volcani, B., "Studies on the Microflora of the Dead Sea" (Jerusalem, 1940).

Manganese-deficient Soils

In 1942, Sherman, McHargue and Hodgkiss[1] described a modification of Leeper's[2] method which would identify: (*a*) manganese-deficient neutral and alkaline soils; (*b*) strongly acid soils that will become manganese-deficient when limed to near neutrality; and (*c*) soils that are likely to contain such excessive quantities of available manganese as to be toxic to plants. There is evidence from analyses of English soils that their method may be useful at any rate in identifying the first two classes of soils.

The method described by the above-mentioned authors was slightly modified to ensure easy manipulation and to save time by the use of separate 20-gm. samples of air-dried soil for the three extractions, namely: (1) water-soluble manganese, (2) exchangeable manganese, and (3) easily reducible manganese. This procedure was adopted instead of the single sample used successively for the three extractions. It will be seen from the results that the small quantities of water-soluble and exchangeable manganese in the extract containing the easily reducible manganese made no difference to the general conclusions. The three samples were then shaken for one hour in a rotary shaker with 150 ml. of extracting agents, that is, distilled water, neutral ammonium acetate, and 0·2 per cent solution of hydroquinone in neutral ammonium acetate. The procedure as described by the authors was then followed.

Three types of soil were investigated:

(1) A light, black, heath soil from Shropshire with a strongly acid reaction under natural conditions.

(2) A heavy Lias clay from south Warwickshire with an almost neutral reaction.

(3) A garden loam from the grounds of the University of Birmingham with a *p*H above 7·0.

Manganese-deficient oats were seen growing on the first two soils while healthy oats were growing on the University soils. The Shropshire soils had *p*H values between 6·4 and 7·9 due to heavy liming, and certainly fall into the category manganese-deficient when heavily limed. The Lias soil from Warwickshire had *p*H values between 6·3 and 7·0 and is therefore an almost neutral soil. The high *p*H of the University soil was due to heavy liming.

MANGANESE IN P.P.M. OF AIR-DRIED SOIL

Source	*p*H	Water soluble	Exchangeable	Easily reducible
Shropshire 1	6·7	1·2	1·1	8·2
,, 2	6·4	0·0	1·5	5·7
,, 3	7·9	0·0	0·8	5·3
,, 4	—	0·5	0·8	2·8
Warwickshire 1	6·5	0·0	4·7	33·1
,, 2	6·3	0·0	1·3	25·6
,, 3	7·0	—	12·3	43·7
University 1	7·5	0·0	2·7	183·0
,, 2	7·7	0·5	2·1	120·0
,, 3	—	1·5	8·9	98·2
,, 4	—	1·1	9·3	113·7
,, 5	—	0·8	10·5	150·0

It is seen from the accompanying table that the easily reducible manganese is the important fraction in identifying manganese-deficient soils. The Shropshire soil had an easily reducible manganese of less than 10 p.p.m., the neutral Lias clay had less than 50 p.p.m. manganese, while the University soil samples all had about or well over 100 p.p.m. of manganese. There is, therefore, further evidence here supporting the conclusion of Sherman, McHargue and Hodgkiss that manganese-deficient soils can be identified by this method.

A survey of soils is of course necessary to establish this method, but should it prove to give results consistent with those of Sherman, McHargue and Hodgkiss and those mentioned here, the method would certainly prove to be useful in advisory work.

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Aug. 3.

[1] Sherman, McHargue and Hodgkiss, *Soil Sci.*, 54, 253 (1942).
[2] Leeper, *Proc. Roy. Soc. Victoria*, 47 (11), 225 (1935).

Science and the Fisheries

This is truly a subject for the *formidable* speculation with which Prof. James Ritchie has treated it[1]. He dreams of a mountainous, nay astronomical, dash of nutrient chemicals in the North Sea, which is to make a remarkable increase in the growth of fish. And why not? Greater changes than that have been made on the face of the earth in the past; but scarcely so simply—except in destruction. The southern, shallower part of the North Sea, where the main nurseries are, has been found to suffer from shortage of phosphate in one or two dry years, and there was no shortage in one or two normal years. Sun and warmth are likely limiting factors. In the meantime, transplantation has been successful in increasing fish-growth, on an experimental scale in the North Sea, and on a commercial scale in the Belt Seas.

The rosy picture given of the United States as the land of the free, in freshwater fishery matters, does not now apply to salmon fisheries, nor I think to many other fisheries of a commercial scale. I dislike the word 'restriction': 'moderation' is a better one, and is part of the practice of husbandry.

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British Liberation Army.
Aug. 19.

[1] *Nature*, 154, 275 (1944).

A New Barium-feldspar from Wales

Dr. A. W. Groves recently sent to one of us a specimen of white vein-material found in the manganese ore from the Benallt mine near Rhiw, Carnarvonshire. He suspected the presence of the rare barium-feldspars celsian and paracelsian, which were discovered in the same mine in 1911[1,2]. We found the optical properties of the mineral differed from those of any known barium mineral, and microchemical analysis has now shown that it is a new barium-feldspar and the first example of an alumino-silicate of barium containing sodium as the dominant alkali. The name proposed for the new mineral is 'banalsite', suggested by its chemical formula $BaNa_2Al_4Si_4O_{16}$.

X-ray photographs show that banalsite is orthorhombic with unit-cell dimensions *a* 8·50, *b* 9·97, *c* 16·73 A. and space-group *Iba* or *Ibam*; the observed specific gravity is $d^{16}_{4} = 3{\cdot}06$, whence the unit cell contents are calculated to be $4BaNa_2Al_4Si_4O_{16}$. No crystal forms are visible on hand specimens, but thin sections reveal indications of a few faces of simple indexes including (110) and (001) both parallel to good cleavage directions. The optic axial plane of the mineral is parallel to (100), $\alpha = c$, refractive indexes $\alpha = 1 \cdot 5695$, $\beta = 1 \cdot 5710$, $\gamma = 1 \cdot 5775 \pm 0 \cdot 0005$ (sodium light). The optic axial angle measured on the universal stage is $2V$ 41° positive. Face-centred cells can be derived from the unit cells of banalsite and sanidine, which have similar dimensions, probably indicating the similarity of the silicon-aluminium-oxygen network in the two structures.

The banalsite occurs massive associated with tephroite, alleghanyite, jacobsite, baryte and calcite in certain rare veinlets and narrow bands in dark purple manganese ore. The tephroite and alleghanyite form thin blade-like crystals showing parallel intergrowths. The orientation of the crystals in these intergrowths and the chemical and X-ray study confirm A. F. Rogers's work[3] on alleghanyite from North Carolina, which showed that alleghanyite is the manganese analogue of chondrodite, and that it bears the same relation to tephroite as chondrodite does to forsterite.

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[1] Russell, A., *Nature*, **86**, 180 (1911).
[2] Spencer, L. J., *Min. Mag.*, **26**, 231 (1942).
[3] Rogers, A. F., *Amer. Min.*, **20**, 31 (1935).

α-Tungsten

IN the course of an examination of the coatings formed on the tungsten electrodes of a spark gap and of a film sputtered from the electrodes on to the walls of a glass container, it has been found that both the coatings and the film contained a considerable proportion of α-tungsten in addition to normal body-centred cubic tungsten.

This observation is of interest since the only previously reported occurrence of α-tungsten is in the product from certain methods of electrolytic extraction[1,2]. So far as is known, these are not in commercial use, and the tungsten electrodes themselves did not contain any of the α-form.

Identification was based on the X-ray diffraction pattern. The specimens gave sharp lines, and the cell size, absent spectra and the relative intensities observed for the permitted lines agreed with the published structure[1].

The lattice parameter, measured in a 19-cm.-diameter powder camera, was found to be $5 \cdot 0408 \pm 0 \cdot 0002$ kX. at 18° C., compared with the previously reported value of $5 \cdot 038 \pm 0 \cdot 003$ kX. at 20° C.[3].

Subsequent to this examination it was found that Mr. H. P. Rooksby had also made observations of certain occurrences of α-tungsten, and these form the subject of the accompanying communication.

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[1] Hartmann, Ebert and Bretschneider, *Z. anorg. Chem.*, **198**, 116 (1931).
[2] Burgers and Van Liempt, *Rev. Trav. Chim.*, **50**, 1051 (1931).
[3] Neuburger, *Z. Krist.*, **85**, 232 (1933).

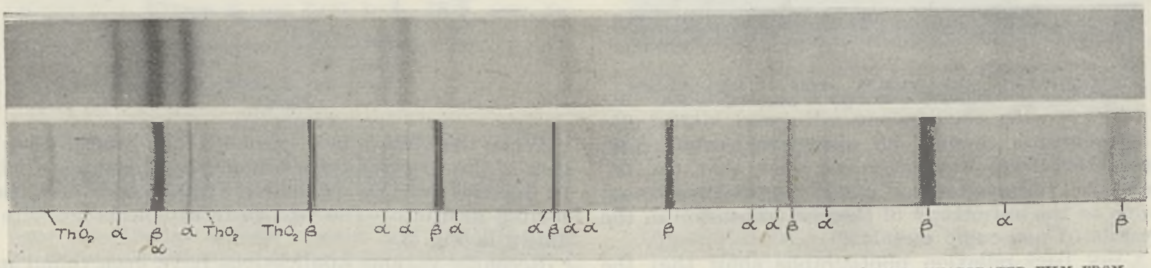
MR. N. J. PETCH has found that the α-form of tungsten occurs in sputtered films and deposits, whereas the only previously reported occurrence was in specimens prepared by electrolytic extraction.

We have also observed this second form of tungsten in the course of examination by X-ray methods of specimens of metallic tungsten from various sources. For example, α-tungsten is often the major constituent of films deposited on the glass envelopes of certain types of vacuum lamps, by evaporation from the tungsten filament. In some instances the α-form appears to be the sole constituent of the volatilized film, but in others it occurs mixed with the normal body-centred cubic form. Phosphorus is usually employed in the lamps that have been examined, for perfecting the vacuum conditions, and it is possible that this has some influence on the structure of the deposited tungsten. No definite evidence which would indicate the effect of the presence of phosphorus is, however, available at present.

Invariably the crystal size of the deposits is so small that the lines of an X-ray powder photograph are diffuse, but even so a sufficient number of reflexions are present for decisive identification of the α-phase. A typical powder photograph of an evaporated tungsten film consisting wholly of the α-phase is shown in the reproduction below.

We have also on occasion noticed the second form of tungsten in powders prepared by reduction of oxide in hydrogen. It has never been found in high concentration in such powders, and the exact conditions of reduction causing its retention have not been explored. But it does appear that impurities such as thoria have some influence. When small percentages of thoria (of the order of 1–2 per cent) are present, the α-phase has been detected in powders that have been reduced at as high a temperature as 800° C., whereas 650° C. has been given as the transition temperature for α-tungsten prepared by electrolytic processes.

The X-ray reflexions for the α-phase in reduced metal powders are sharp, and measurements of the lattice constant give $5 \cdot 041 \pm 0 \cdot 0005$ kX., in very



X-RAY POWDER PHOTOGRAPHS (COPPER $K\alpha$-RADIATION, 19 CM. CAMERA) OF TUNGSTEN SPECIMENS. ABOVE, EVAPORATED FILM FROM TUNGSTEN FILAMENT VACUUM LAMP (α-TUNGSTEN); BELOW, TUNGSTEN POWDER PREPARED BY REDUCTION IN HYDROGEN OF OXIDE CONTAINING 2 PER CENT THORIA (MIXTURE OF β- AND α-TUNGSTEN).

close agreement with Mr. Petch's determination. The X-ray photograph of a tungsten powder containing a proportion of the α-phase is also reproduced in the illustration.

It is apparent from the results described by Mr. Petch and ourselves that the α-form of tungsten may be produced in several ways besides that of electrolytic extraction, namely, by sputtering, by volatilization or evaporation, and, in certain circumstances, by reduction of oxide in hydrogen. The temperature of deposition (or reduction) is probably an important factor in determining the proportion of α-tungsten formed, but the evidence from the examination of volatilized films and reduced powders suggests that impurities such as phosphorus and thoria may also take some part.

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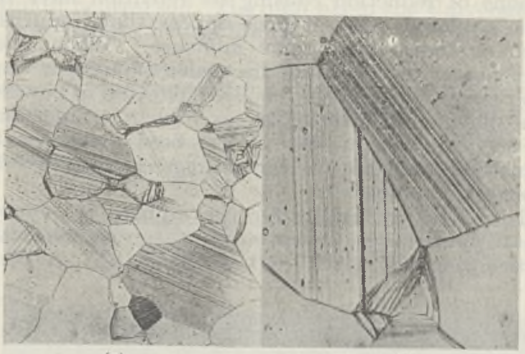
July 26.

Thermal Fatigue of Metals

IN our recent communication[1] the photographs as reproduced were placed in the wrong order, so the lettering on them should read *d c b a*—not *a b c d*. There is a progressive *increase* in the deformation and in the grain boundary migration as the number of thermal cycles is increased.

The deformation, as indicated by the formation of slip lines, and the grain boundary migration, are shown more clearly in the accompanying photograph. This illustrates at two different magnifications the numerous slip lines and the grain boundary migration produced in a cadmium specimen after ten very slow cycles between 30° C. and 150° C. The electrolytically polished specimen, which initially was almost free from slip lines, was immersed in an oil bath, and was heated and cooled with it, the duration of a cycle being approximately seven hours. This was done in order to avoid internal stresses due to rapid temperature changes.



(a) (b)

DEFORMATION IN PURE CADMIUM AFTER 10 SLOW CYCLES BETWEEN 30° C. AND 150° C. (a) × 100; (b) × 500.

Experiments carried out since our earlier communication have confirmed the view that the deformation observed after cyclic thermal treatment is due to the anisotropy of thermal expansion in the crystals of non-cubic metals.

X-ray back-reflexion photographs show that the lattice distortions produced by the deformation remain in the metal and accumulate as the number of cycles is increased. This is the case for zinc, cadmium and even tin, although in the latter metal the outward signs of deformation are less than in zinc and cadmium. In some cases, recovery occurs after a large number of cycles.

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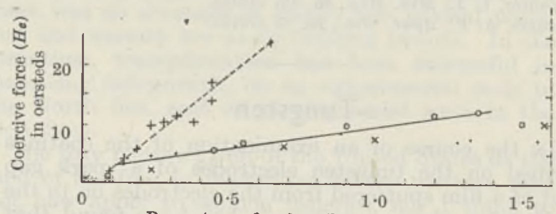
June 22.

[1] *Nature*, 153, 494 (1944).

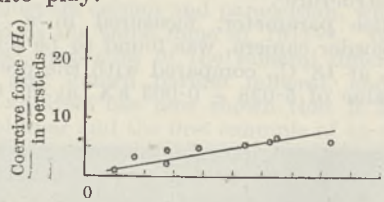
Relationship between Coercive Force and Carbon Content of Plain Carbon Steels

THE straight-line relation between the coercive force and the carbon content of plain carbon steels has been observed by many investigators. The question arises how far can the relation be carried. The data published by authorities such as Benedicks, Metallografiska Institutet, Stockholm, and Cheney, U.S. Bureau of Standards, have been collected in the International Critical Tables[1]. They used samples containing very small amounts of silicon, manganese, sulphur and other impurities. If their results are plotted we obtain a straight line as shown in Fig. 1.



Percentage of carbon (by weight).
·, Cheney; ⊙, Benedicks; ×, Gumlich; +, annealed, 850° C.
Fig. 1.

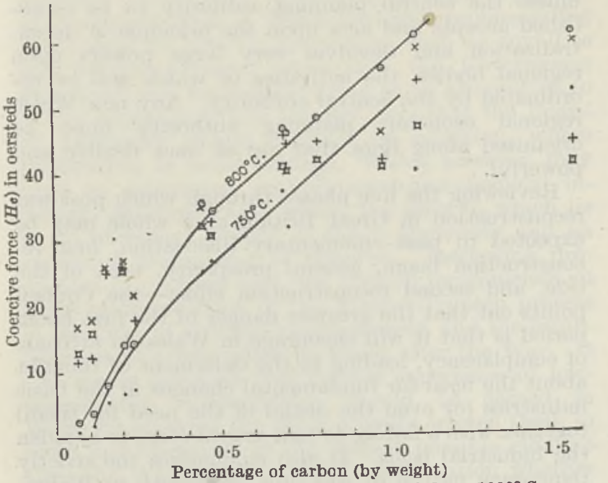
Carbon enters into iron forming pearlite, a structure which can be distinguished from ferrite (iron) under the microscope, when the concentration is more than 0·008 per cent. The amount of pearlite increases as the carbon in iron is increased. If we plot the percentages of pearlite against the coercive forces of the annealed specimens, we obtain the result shown in Fig. 2. The formation of pearlite is complete when the carbon content reaches 0·83 per cent; that is, the eutectoid. After passing the eutectoid, cementite comes into play.



Percentage of pearlite (calculated)
Fig. 2.

When the steel is in a quenched state, the relationship of the coercive force becomes more complicated. It depends on the quenching temperature and the cooling medium. The results from Gumlich are redrawn in Fig. 3.

Recently various applications have been found in this relationship between the coercive force and the carbon content. The instrument, which is known as



., quenched from 750° C. +, quenched from 1000° C.
⊙, quenched from 800° C. □, quenched from 1100° C.
×, quenched from 900° C.

Fig. 3.

a coercimeter, used for the rapid determination of carbon in open-hearth steels, designed by Rogers[2] and his collaborators, may be mentioned as one example. The curve given by them is not explained theoretically, perhaps because the quenching temperature could not easily be controlled. When we compare the curve of Rogers with the curves of Fig. 3, the best quenching temperature range is 800–850° C. This may be taken as the standard range whenever the coercimeter is used in the steel-works.

Many investigators have attempted to correlate the coercivity with the mechanical properties of steels. Metallurgists like Mathews[3] have laid much emphasis on the hardness but have found little success. From the formula

$$H_{c\ max.} \simeq 3/2.\lambda\sigma_i/I_s$$

derived by Becker[4], I think that the tensile strength is a good measure of the internal strain of the polycrystalline material. The tensile strengths in kgm./mm.² of carbon steels are therefore plotted along the dotted line in Fig. 1. Only those steels in an annealed state and containing low percentages of manganese and silicon are selected[5]. It seems that there is a parallel relation between the tensile strength and coercivity of the ferromagnetic material.

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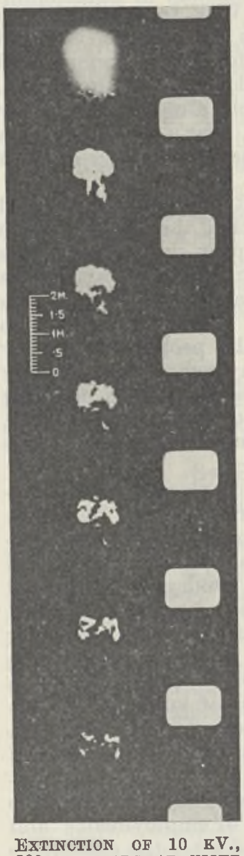
Sanchi, Ki-Kiang,
Szechuan.
June 12.

[1] International Critical Tables, 6.
[2] Rogers, B. A. Wentzel, K., and Riott, L. R., *Trans. Amer. Soc. Met.*, 27, 175 (1939).
[3] Mathews, J. A., *Trans. A.S.S.T.*, 8, 565 (1925).
[4] Becker, R., *Proc. Phys. Soc.*, 52, 138 (1940).
[5] International Critical Tables, 2.

Persistence of Luminosity in Air

Protracted luminosity occurs naturally in air in at least two forms—aurora borealis and ball lightning. In the case of the aurora, a widely accepted theory is available to account for the energy input which causes excitation. There is, however, considerable doubt as to the corresponding energy mechanism which has been presumed to be necessary to account for the strange stability of ball lightning.

The question arises as to what extent it is necessary to postulate an energy source to explain the sustained luminosity which follows an electrical discharge in air and lasts long enough to be noted by a casual observer. The possibility seems to exist that such a phenomenon can in certain circumstances be described adequately as a purely dissipative process which is simply the aftermath of an intense discharge. The laboratory phenomenon of afterglow is a well-known example of the latter process, as negligible energy is put into the gas by the electrical circuit during the afterglow time. Most of the work on afterglow has been carried out at low pressures where durations of several minutes have been observed, but Meek and Craggs[1] have recently shown that afterglow lasting approximately 30 microsec. can be produced in argon at atmospheric pressure.



EXTINCTION OF 10 KV., 280 AMP. ARC AT NIGHT

In a previous communication[2] the appearance of luminous clouds as a sequel to arc extinction was reported. This aspect of arc extinction has now been examined further, and cloud durations varying from approximately 0·1 to 0·3 sec. have been measured. This phenomenon seems to be a form of afterglow which has some resemblance to ball lightning. It was observed in seven separate tests with currents varying from 90 to 320 amp. at 10,000 volts. Great dissimilarities have been noted in regard to the number, shape and rate of shrinkage of the luminous clouds. Some of the tests were carried out at night and recorded by means of a cine-camera which was used without a light filter. A section of the film is reproduced here; in this the arc current is considered to have ceased between the first and second frames from the top. The camera speed was 32 frames per second.

This work indicates that the energy dissipation following a heavy electrical discharge in air can be arranged to take place so as to provide luminous masses of gas which persist for an appreciable fraction of a second. It is not unreasonable to expect that in certain cases the phenomenon can be observed with the naked eye.

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[1] Meek and Craggs, *Nature*, 152, 538 (1943).
[2] O'Doherty, *Nature*, 153, 558 (1944).

RECONSTRUCTION IN WALES

THE first interim report of the Welsh Reconstruction Advisory Council, appointed on June 30, 1942, "to survey, in conformity with the general examination of reconstruction problems now being conducted by the Government, those problems of reconstruction which are of special application to Wales and Monmouthshire, and to advise on them", which has now been issued by the Minister of Reconstruction*, emphasizes that its inquiry is in the nature more of a continuous survey than of an exhaustive examination of specific subjects. The report records the Council's considered opinion as to the state of affairs likely to emerge in Wales after the conclusion of the present War, together with an outline of the kind of measures which will be required in any comprehensive plan for the economic and social rehabilitation and development of the region. It includes a survey of the field already covered by the Council during its first year's work and an indication of the nature of the work which remains to be done.

The first part of the report includes a historical retrospect which emphasizes that the Welsh people claim that experience of the past shows that plans must be made in advance as an essential part of the war effort. The Committee is also insistent that this matter of preparation for the future should not be dissociated from the life of the people affected by entrusting the whole task to any remote central body of experts. In broad outline, at least, such planning must be the function, if not of the people themselves, at any rate of those who know the needs of the people and of the areas.

This part of the report, which clearly owes something to the "Second Industrial Survey of South Wales", makes five major assumptions which underlie all the Council's discussions and recommendations : (*a*) that the War will result in a victory for the United Nations ; (*b*) that the War against Germany will end first and hostilities will consequently taper off rather than cease abruptly ; (*c*) that sooner or later there will be in Great Britain as a whole, and in Wales in particular, a considerable body of labour to be re-absorbed into peace-time occupations, and an economic situation of sufficient difficulty to demand exceptional measures, planned in advance ; (*d*) that the Government's policy will be directed primarily to the maintenance of a high level of employment ; and (*e*) that for a considerable period after the end of the War sufficient control will be maintained over the disposition of essential raw materials, plant and equipment, labour supplies (including demobilization) and the utilization and construction of factory premises to avoid the worst excesses of a 'first come, first served' scramble.

The post-war demand for labour in Wales will be determined by the future course of international trade and by the nature and extent of the home market demand. Certain further assumptions are made with regard to both these factors, and the report then emphasizes that there are other fundamental questions of national policy which will condition any regional plan and concerning which any assumptions are unwise in the absence of decisions by the Government. For example, in regard to planning, the interests of Wales will not be served unless the central planning authority to be established accepts and acts upon the principle of decentralization and devolves very large powers upon regional bodies, the activities of which will be co-ordinated by the central authority. Any new Welsh regional economic planning authority must be organized along lines that are at once flexible and powerful.

Reviewing the five phases through which post-war reconstruction in Great Britain as a whole may be expected to pass—momentary dislocation, first reconstruction boom, general prosperity, turn of the tide, and second reconstruction effort—the Council points out that the greatest danger of the first boom period is that it will encourage in Wales an attitude of complacency, leading to the deferment of thought about the need for fundamental changes in the basic industries (or even the denial of the need for them) together with a failure to take urgent steps to broaden the industrial basis. It also emphasizes the strictly temporary nature of war-time prosperity in Wales : between forty and fifty per cent of all the workers employed by new industries in a large sample area covering nearly half the population of Wales were shown in two recent surveys to be attached to establishments which must almost inevitably either close down or drastically curtail their activities at the end of the War.

Furthermore, there are four potential danger spots which are discussed in some detail. The first of these is the possibility that technological unemployment consequent upon the introduction of strip-mill methods of production in the tin-plate industry at Ebbw Vale, and the necessity to adopt such methods in the west central and western anthracite areas will lead to the emergence of a new set of depressed areas. This is an industry in which there is every reason to anticipate drastic reorganization, rationalization and considerable technological unemployment. It would be fatal to oppose a technical development which has become a necessity if the competitive power of the Welsh industry in world markets is to be maintained, but the Council recommends that careful regard should be had to any means whereby the old works can be used as subsidiary to the new strip mills. The necessary reorganization and concentration will also require agreement between the interests concerned, and this may present difficulties unless undertaken as part of the post-war reconstruction plans.

The second danger is that insufficient thought may be given to the need to make provision in the mining industry for the situation likely to be caused by the post-war closure of uneconomic pits and the early exhaustion of others. For this reason the Council recommends as a matter of urgency that all necessary steps be taken to ensure the availability of a survey of coal resources with the view of deciding the most suitable locations for development. The third danger lies in the existence in a number of areas of former mining and metallurgical townships which have completely lost their basic industry and now serve only as dormitories for workers travelling long distances to strictly temporary war factories. The fourth is the probability of a considerable volume of unemployability in certain areas. A full examination of this problem must be an essential part of any social security scheme which the Government may introduce.

The second part of the report discusses the work of the Council from June 30, 1942 to December 17, 1943. In its survey of industry the report, after

* Office of the Minister of Reconstruction. Welsh Reconstruction Advisory Council. First Interim Report. Pp. 132. (London : H.M. Stationery Office, 1944.) 2*s*. net.

stressing the necessity of securing an early expansion of the export trade in Welsh coal and recommending early steps to remove inequalities such as royalties and wayleave rents, urges that the Government should support mechanical firing as an alternative to oil for tramp and liner tonnage, and that the Board of Admiralty should consider its adoption, where practicable, in naval tonnage. Wales, however, may need an integrated coal-oil-power-and-chemical industry, developed as a whole, the keys to which lie in an abundant supply of cheap electricity and an extensive programme of research. Reviewing production of oil from coal, the Council recommends an early re-examination of the Fischer-Tropsch process in the light of changed circumstances, and the establishment of a trial plant in Wales after the War. It also seems desirable that further experience of low-temperature carbonization should be gained in Wales by allowing the plant already erected there to come into operation at the earliest possible moment after the War, while it is for consideration whether the whole question of the production of oil from coal is not one which cannot be dealt with satisfactorily within the structure of private enterprise.

In regard to the slate industry, the Council recommends immediate consideration of its place in relation to the post-war building programme, while attention is also directed to the particularly useful part which the refugee firms set up in Wales could play in the rehabilitation of the devastated countries of Europe. An adequate expansion of the tourist and holiday industry in Wales is conditional upon an improvement in communications to break down its relative inaccessibility, and the highest importance is attached to the provision of a trunk road from north to south Wales, passing through the beautiful but isolated centre of Wales, and to the early provision of a road crossing over the River Severn. The provision of better road communications across the Severn below Gloucester should be announced as part of the Government's reconstruction programme, the various schemes which have been put forward to be reviewed immediately by technical experts, and all road improvements on each side of the Severn should be related to the new means of communication. Establishment of at least one trans-Atlantic aerial terminus in Wales, suitably linked with the major road and railway routes, is also recommended.

The development of the tourist industry is recognized as demanding more study, research and planning than the Council has yet been able to give to it, and after endorsing the recommendations of the Scott Committee on this matter, the Council urges that at least one area in North Wales and one in South Wales should be developed as national parks at the earliest suitable moment after the War, with assistance from public funds if necessary.

The Council further emphasizes that Wales needs to explore very fully the potentialities of a marriage between industry and agriculture. Agriculture, the producers' goods industries, the consumers' goods industries and the tourist industry are all interdependent, and the expansion of each in Wales could, properly organized and co-ordinated, benefit all. General measures are also required to increase the industrial attractiveness of Wales—the provision of buildings of standard design, in advance of demand, on selected suitable sites, widely distributed, and the clearing and levelling of every site which, in the opinion of the regional planning authority, it is desirable to use for industrial purposes, are two suggested measures—while the provision of electric power at an exceptionally low cost is a fundamental requirement for many industries. Here the Council inclines to the establishment of a special Welsh electrical development board. Refitting of dairy farms is one of the most urgent of Welsh post-war agricultural problems, while in many areas there is room for substantial improvement in the general level of cleanliness and hygiene in milk distribution. In regard to grassland and ley farming, a comprehensive examination of the whole position in the light of long-term requirements, and in terms of the quantities of equipment and fertilizers that would be required, as well as of the problems of finance and land ownership that would be raised is desirable. The importance of a long-term policy of afforestation is also stressed, as well as the suitability of Wales for timber-growing ; special study of the types of trees best suited for planting in different parts of Wales is recommended. Stress is also laid on the improvement of facilities for technical education, in which co-operation between industrialists and educational authorities and between the local authorities themselves is essential. In this respect the Council, commenting on the White Paper on Education, regards it as unfortunate that rearrangements should be made within the present structure for one service without reference to the general problem of the reorganization of local government as a whole.

THE FATIGUE OF GLASS UNDER STRESS

By E. OROWAN

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GLASS under stress shows a characteristic fatigue phenomenon of practical importance : it can be broken by stresses far below its ordinary breaking stress as measured in short-time tests, provided that the load is applied for a sufficiently long time. About one third of the short-time breaking stress is sufficient to produce fracture if it is sustained for a number of weeks. In contrast to metals, the stress need not fluctuate periodically in order to develop this fatigue phenomenon, of which the most spectacular everyday manifestation is the sudden spontaneous cracking of glasses or bottles under internal stresses which they may have withstood for many years.

As with metals, the practically important question is whether a 'safe stress' exists ; that is to say, whether there is a stress limit below which the glass can stand up to the load indefinitely. Extensive experimental work has been carried out on the dependence of the time of breaking upon the breaking stress, and the latest investigations[1,2] seem to lead to a relationship between these quantities that can be represented approximately by a straight line if both stress and time are plotted logarithmically. If extrapolation to longer times is justified, this would mean that no safe stress exists, and, therefore, glass would be an essentially unreliable material for use under sustained loads.

In a recent issue of *Nature*[3], J. B. Murgatroyd has discussed this phenomenon. In his view, the influence of the duration of loading is "not easily explicable by Griffith's theory alone", and he suggests an explanation based on the assumption that glass consists of "an elastic matrix which contains small pockets of 'quasi-viscous' material". This model is then worked out mathematically, and a certain agreement is found with the measurements just mentioned; unfortunately, however, the basic equation used to express the strain in the viscous elements is incorrect, and this has the effect of invalidating the conclusions. The relationship between stress S_v, strain σ, time t, and coefficient of viscosity η for a viscous rod under tension is $S_v = 3\,\eta\,\frac{d\sigma}{dt}$, not $S_v = \eta\sigma/t$. The correct mathematical treatment of Murgatroyd's model leads to the existence of a maximum and a minimum value for the strength, reached asymptotically for very short and very long breaking times, instead of the straight line in his Fig. 2. In order to explain, for example, a ratio 3·3 between short-time strength and long-time strength, it would be necessary to assume that in any cross-section only 30 per cent of the area corresponds to the elastic matrix which alone is capable of taking up a sustained stress, and 70 per cent to the material of the viscous pockets, which on this hypothesis would constitute the greater part of glass.

My purpose here is to show that the decrease of the breaking stress with increasing duration of loading can be explained on the basis of the Griffith theory without *ad hoc* assumptions, and that in this way the ratio of the breaking stresses for very short and very long duration of loading can be calculated, in reasonable agreement with experiments. It will be seen that, in the absence of other causes of fatigue, this explanation demands the existence of a safe stress roughly equal to a third of the short-time strength. It suggests that, on extending the duration of loading beyond the range so far investigated, the logarithmic strength – time curve would bend away from the inclined straight line and go over asymptotically into a horizontal line, corresponding to constant strength for very long times of breaking.

Griffith's expression for the tensile strength k of a brittle isotropic solid is

$$k = \sqrt{\frac{2\,\alpha\,E}{\pi c}},$$

where E is Young's modulus, c the depth of the most dangerous surface crack, and α the surface energy. Now it has been found by Obreimow[4] that the surface energy of mica, if measured by cleaving in vacuum, is about ten times higher than in air. According to measurements I have made[5], the surface energy of mica is 4,500 erg/cm.^{2} in vacuum and 375 erg/cm.^{2} in air. Owing to the chemical similarity between mica and glass, a similar ratio may be expected for the latter. If the adsorbed film of air or moisture that is responsible for the reduced value of the surface energy in air can penetrate to the bottom of the crack, this value must be used in the Griffith formula when the material is broken in air, and the higher vacuum value when the tensile test is performed in vacuum. According to the Griffith formula, the tensile strength is then about $\sqrt{4500/375} = 3{\cdot}5$ times higher in vacuum than in air[6]. In fact, Schurkow[7] has found that the strength of silica glass fibres, baked out and broken in vacuum, is 3·5–4·5 times higher than in air.

If fracture occurs after a very short time, the adsorbed film cannot follow the propagation of the crack from the surface zone into the interior; the cleavage surfaces created by the crack propagation will then be clean, and the stress necessary to produce such rapid fracture is obtained from the Griffith formula by using the vacuum value of the surface energy. If, on the other hand, the crack deepens very slowly, the adsorbed film has time to diffuse to the bottom of the crack and reduce the surface energy to the lower value corresponding to cleavage in air. The ratio of the breaking stresses for very rapid and very slow fracture, according to the Griffith formula, is then equal to the square root of the ratio of the surface energies in vacuum and in air, which is about 3·5 if it is permissible to use for glass the ratio obtained with mica. This agrees well with the results of Preston[2], who found that the breaking stress increased 3·2-fold as the breaking time was reduced from 10^5 to 10^{-2} sec. Holland and Turner[1] investigated glass strips in bending; here the breaking stress for rapid loading was about 3·3 times higher than the stress under which all specimens broke within 1,000 hours.

It seems, therefore, that the rate of diffusion of adsorbed matter into the Griffith crack may account quantitatively for the influence of the duration of loading upon the breaking stress. If this explanation be correct, glass should have a safe stress limit below which it would stand loading indefinitely, and this safe limit should be reached in practice in the long-duration tests of Holland and Turner and of Preston. The question whether or not the straight-line relationship breaks down for extremely long breaking times calls for further investigation; this may prove very difficult because, during the test, surface corrosion and devitrification may occur, and their effect may mask the one to be studied.

If the fatigue effect is mainly due to the finite rate of diffusion of the adsorbed film in the crack, certain characteristic phenomena should be expected. First, short-time strength and long-time strength should be equal if the test is performed in vacuum on specimens baked out in vacuum, and they should further be equal to the limiting short-time strength in air. Secondly, specimens that have been subjected for a length of time to a stress exceeding the safe long-time strength, but released before fracture occurs, should show reduced strength in short-time tests, for the following reason. Under a stress that is lower than the short-time strength but higher than the safe stress, the most dangerous surface cracks are propagated slowly, at a rate that is determined by the rate of diffusion of the adsorbed matter. When they reach the depth at which, according to the Griffith formula, further propagation under the given load becomes possible with the vacuum value of the surface energy, sudden fracture occurs. If the loading is interrupted before this happens, the cracks will nevertheless be deepened, and the short-time strength of the specimen reduced.

If the adsorption – diffusion effect is the main cause of the fatigue, it should be possible to increase the resistance of glassy materials to long-sustained loads by covering the surface with a sufficiently inert and impermeable varnish, or by a glaze of which the coefficient of thermal expansion is lower than that of the bulk. For similar reasons, the decrease of the breaking stress with increasing duration of loading should be slower with toughened glass, in which the surface layer is under compressive stress; here the surface cracks are either altogether ineffective, or at least the diffusion of atmospheric matter into them is made slower by the compression of the cracks at the surface.

The viscosity of the glass cannot be expected to influence the strength except at temperatures where the viscous deformation is of noticeable magnitude.

Its influence, however, would be opposite to what is observed with glass at room temperature. Viscous deformation makes the bottom of the cracks less sharp, and thus raises the strength by reducing stress concentrations. An increase of the tensile strength with temperature in the region of incipient plasticity has, in fact, been observed on colophonium and colophonium-shellac mixtures by Hauser[8]. Prolonged action of stress, therefore, would make the specimen stronger, not weaker, so far as the viscosity effect alone is concerned.

[1] Holland, A. J., and Turner, W. E. S., *Trans. Soc. Glass Tech.*, **24**, 46 (1940).
[2] Preston, F. W., *J. Appl. Phys.*, **13**, 623 (1942).
[3] Murgatroyd, J. B., *Nature*, **154**, 51 (1944).
[4] Obreimow, J. W., *Proc. Roy. Soc.*, A, **127**, 290 (1930).
[5] Orowan, E., *Z. Phys.*, **82**, 239 and 259 (1933). Obreimow's original figures for the surface energy contain a factor 4 due to an error in the expression for the moment of inertia of the cross-section of the mica lamella. The values given by me have been obtained from measurements with a somewhat improved technique.
[6] Orowan, E., *Z. Phys.*, **86**, 195 (1933).
[7] Schurkow, S., *Phys. Z. Sowjetunion*, **1**, 123 (1932).
[8] Hauser, F., *Verh. deut. phys. Ges.*, **14**, 18 (1912).

NATIONAL INSTITUTE OF ECONOMIC AND SOCIAL RESEARCH

THE annual report of the National Institute of Economic and Social Research for 1943 is of exceptional interest. In addition to a general report and a report on research in 1943, the report on the library and equipment and the usual list of publications and of research staff at December 31, 1943, it includes a discussion of the Institute's research policy, which is of considerable general interest in relation to the statement in the White Paper on Employment policy of the Government's intention to establish a permanent central staff qualified to measure and analyse economic trends and to call for more quantitative information from industry on current economic movements.

Originally it was anticipated that the proper field of the Institute's work would lie mainly in the measurement of changes, the discovery of trends and the analysis of structure, and its first inquiries were directed to the measurement of the national income in Great Britain, the economic problems of nutrition, the extent and distribution of unemployment and the location of industry. The systematic study of these subjects has now been taken over by Government departments with resources that no private agency could command, although the Institute has been able to supplement official studies by its own studies of the national income, consumption and other subjects.

The Institute's resources have also been fully occupied during the War on related inquiries, and the accelerated extension of realistic and statistical studies in the social sciences due to the War has led to the Institute being approached not only by Government departments and academic workers, but also by business men and their associations, with suggestions for research or requests for assistance in organizing research. Although the War has incidentally added largely to the small number of research workers experienced in realistic and statistical investigation, the need for such study will be as great for a time when hostilities cease as during the War, and the resources of the Institute are likely to be strained by the demands made on them. Even when an authoritarian direction of industry is removed, an exact and comprehensive, constantly adjusted analysis of resources and requirements will remain necessary as a basis both for Government policy and private business decisions.

Economists and other students of the social sciences will find themselves faced, therefore, with demands for guidance which will be unprecedented in scale if not in character. Even when the analysis is dictated by a theoretical approach, the post-war need will be the statement of problems in realistic and quantitative terms. For this, mechanical aids as well as the resources of specialized library and adequate secretarial staff will be essential, and such resources the Institute hopes to provide on a greater scale in future. Calling in the co-operation of experts in different fields, it can promote and arrange for the direction of inquiries and provide the personnel and material aids for their execution. It will endeavour to develop a part of the field itself, and will co-operate with individual students and other agencies working in the same or connected fields; but apart from a small portion of its funds held ready to meet requests for assistance from individual scholars, the bulk of the Institute's resources should be concentrated on one field where there is a prospect of achieving definite results without serious overlapping with the activities of the research departments of the universities.

The executive committee of the Institute has now reached the conclusion that this main effort should be directed to work on the structure and productivity of the national economy in Britain. In its simplest form the object is to examine the way in which wealth is created in Great Britain, to inquire what determines the amount of wealth created in the average man-hour of British labour, how it compares with other countries, what underlies the differences, what causes the gradual increase and what could be done to accelerate it. Two major projects now in train fit naturally into this framework. The statistical inquiry into the national expenditure, output, and income of the United Kingdom in the years between the Wars provides the essential basic data, and the co-operative inquiry into the distribution of the products of industry is an attempt to see how far existing data shed light on these questions. The Institute would also hope to supplement these inquiries with detailed factual inquiries into the experience of specific British industries, directed particularly to the relation of costs and efficiency and to comparisons with industries in other countries.

The general report refers to the circulation of the first issue of the Register of Research in the Social Sciences, which continues to be prepared by the secretary as editor, with the assistance of the editorial advisory committee appointed by the Consultative Conference on the Social Sciences. The Institute has continued to provide facilities for the activities of the National Service Committee for Social, Economic and Statistical Research, and this Committee is preparing a memorandum on the post-war position of the education and employment of economists at the request of Lord Hankey's Interdepartmental Committee on Further Training and Education.

Most of the research work during the year represented the continuation of programmes already in progress, but the Institute took under its wing the inquiries initiated by Mr. R. Titmuss into "Disease Mortality and its Changing Distribution in England

and Wales" and the statistical inquiry into "Methods of Investigating Oscillatory Movements in Time-series" by Mr. M. Kendall. Dr. A. Baykov's study on "The Development of the Soviet Economic System" was enlarged, and final work on its preparation for the press substantially completed. M. N. Momtchiloff's study of the financial and economic experience of south-eastern European countries was published early in 1944 under the title "Ten Years of Controlled Trade in South-Eastern Europe". The programme of work on local taxation studies undertaken by Prof. and Mrs. Hicks was modified, a study on wealth and poverty in local government being postponed in favour of two 'occasional papers', one of which, "Problems of Valuation for Rating", is in the press and the other, "The Incidence of Local Taxation in England and Wales", was awaiting comment by certain Government departments at the end of the year.

Besides the two major inquiries in progress already mentioned, that by Miss P. M. Deane on "The Measurement of National Income of Selected Colonial Territories" was also continued, but at the end of the year the inquiry into aspects of commercial policy was suspended. An investigation into the economic effects of advertising was started in the middle of the year, and M. N. Momtchiloff began work on a new inquiry into the monetary position of the six south-eastern States of Europe. In the spring, a grant was made to the University of Birmingham in support of Prof. Sargent Florence's inquiry, "Location and Optimum Size of Plants in Particular Industries", which is intended to test the hypothesis that there is an important relation between the size of an industry's plant and its location pattern.

Some further details of the research work of the Institute are given this year in a new Publications and Programmes pamphlet which, in addition to listing studies and occasional papers already published and publications now in the press, includes an account of some of the programmes of research on which those publications are based, and also of other publications in active preparation. Among these may be mentioned the study, "Personal Expenditure on Consumption in the United Kingdom, 1920–1938", and the occasional paper, "The Structure of Money Flow Systems", both coming from the major programme of research into national expenditure, output and income directed by Mr. R. Stone; two occasional papers, "Productivity, Prices and Distribution in Selected British Industries" and "International Comparisons of Productivity, Cost Ratios and Share of Wages in British, American and German Manufacturing Production" under the Distribution of the Product of Industry inquiry; and A. Collier's "The Crofter Problem: A Study of Economic and Social Conditions in the Highlands and Islands of Scotland".

FORTHCOMING EVENTS

Wednesday, September 13

BRITISH ASSOCIATION OF CHEMISTS (LONDON SECTION) (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. H. W. Rowell: "The Development of Plastics".

APPOINTMENTS VACANT

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

DIRECTOR OF THE BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION—The Chairman of Council, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1 (marked 'Personal') (September 15).

ASSISTANT DAIRY BACTERIOLOGIST (temporary)—The Registrar, The University, Leeds (September 15).

SPEECH THERAPIST—The Director of Education, Education Offices, 15 John Street, Sunderland (September 15).

TEACHER (full-time) OF MATHEMATICS in the Nautical College Department of the Liverpool Technical College—The Director of Education, 14 Sir Thomas Street, Liverpool (September 15).

SPEECH THERAPIST (full-time)—The Director of Education, Hamilton Square, Birkenhead (September 15).

ASSISTANT (full-time) to teach either MECHANICAL ENGINEERING or ELECTRICAL ENGINEERING SUBJECTS in the Stockton-on-Tees Technical School and Evening Institute—The Director of Education, Shire Hall, Durham (September 16).

SENIOR SPEECH THERAPIST—The Director of Education, Education Offices, Nelson Square, Bolton, Lancs. (September 16).

LECTURER IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, Loughborough College, Loughborough (September 18).

UNIVERSITY READERSHIP IN CHEMISTRY tenable at the Royal Cancer Hospital (Free)—The Academic Registrar, University of London, South Kensington, London, S.W.7 (September 18).

POULTRY PATHOLOGIST for the New Zealand Department of Agriculture—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (September 18).

SPEECH THERAPIST (full-time)—The Director of Education, Education Offices, Wolverhampton (September 18).

ASSISTANT LECTURER IN MATHEMATICS—The Secretary and Registrar, The University, Bristol (September 20).

BOROUGH ENGINEER AND SURVEYOR—The Town Clerk, Town Hall, Walworth Road, London, S.E.17 (endorsed 'Borough Engineer and Surveyor') (September 22).

ASSISTANT REGISTRAR—The Registrar, The University, Sheffield 10 (September 23).

LECTURER (full-time) IN MECHANICAL ENGINEERING—The Principal, Battersea Polytechnic, Battersea, London, S.W.11 (September 23).

LECTURER IN VERTEBRATE ZOOLOGY—The Secretary, The University, Edinburgh (September 25).

LECTURERS (2) IN MECHANICAL ENGINEERING, and a LECTURER IN ELECTRICAL ENGINEERING—The Principal, West Ham Municipal College, Romford Road, Stratford, London, E.15 (September 25).

PHYSICIST (must have first-class experience on problems relating to Lighting and Aircraft and Automobile Lamps) for a Company in Birmingham—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. A.630.XA) (September 26).

CHAIR OF ELECTRICAL ENGINEERING—The Acting Registrar, The University, Leeds 2 (September 30).

CHAIR OF BIOLOGY in Victoria University College, Wellington, New Zealand—The Secretary, Universities Bureau of the British Empire, c/o University College, Gower Street, London, W.C.1 (September 30).

PRINCIPAL OF THE HACKNEY TECHNICAL INSTITUTE, and PRINCIPAL OF THE SOUTH-EAST LONDON TECHNICAL INSTITUTE—The Education Officer (T.1), County Hall, Westminster Bridge, London, S.E.1 (September 30).

PRINCIPAL OF THE WALKER TECHNICAL COLLEGE, Oakengates—The Secretary for Education, County Buildings, Shrewsbury, Shropshire (September 30).

PROFESSOR OF PHYSICS—The Registrar, University College, Singleton Park, Swansea (October 18).

HONOURS GRADUATE IN CHEMISTRY (London, Reference No. F.2719.XA), HONOURS GRADUATES (2) IN METALLURGY (Neath, Reference No. F.2720.XA; Shipley, Reference No. F.2721.XA), and HONOURS GRADUATE IN CHEMISTRY or Member of the Royal Institute of Chemistry, Branch E (London, Reference No. F.2722.XA), on the research staff of a progressive National Organization with home and overseas interests—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting the appropriate Reference No.) (October 21).

LIBRARIAN—The Librarian, Queen's University, Belfast (October 31).

CHAIR OF PSYCHOLOGY in the University of Sydney—The Secretary, Universities Bureau of the British Empire, c/o University College, Gower Street, London, W.C.1 (October 31).

BEYER CHAIR OF ENGINEERING—The Registrar, The University, Manchester 13 (November 18).

AGRICULTURAL SCIENTIST with intimate knowledge of livestock and breeding problems in this country, to take charge of the Board's Livestock Improvement Department—Milk Marketing Board, Livestock Improvement Department, Thames Ditton, Surrey.

CHIEF INSPECTOR (must have had first-class experience in Inspection of Steel and Non-Ferrous Products, and have full knowledge of A.I.D. procedure) by large Steel Foundry in Yorkshire—The Ministry of Labour and National Service, Appointments Office, The White Building, Fitzalan Square, Sheffield 1 (quoting Reference No. 107).

REFRIGERATING ENGINEER for West Africa—The Secretary, Overseas Manpower Committee, Ministry of Labour and National Service, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. 1162).

HEAD OF THE ENGINEERING DEPARTMENT—The Principal, Technical Institute and Secondary School, Dursley, Glos.

GRADUATE (temporary, man or woman) IN SCIENCE AND MATHEMATICS in the Pontypridd Junior Technical Schools (Building)—The Director of Education, County Hall, Cardiff.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Proceedings of the United States National Museum. Vol. 94, No. 3176: Twelve New Species of Chinese Leaf-Katydids of the Genus Xiphidiopsis. By Ernest R. Tinkham. Pp. 505–528. Vol. 95, No. 3178: New American Cynipids from Galls. By Lewis H. Weld. Pp. 24. (Washington, D.C.: Government Printing Office.) [38

Smithsonian Institution. War Background Studies, No. 19: The Peoples of French Indochina. By Olov R. T. Janse. (Publication 3768.) Pp. iv+28+25 plates. (Washington, D.C.: Government Printing Office.) [38