NATURE

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

Vol. 153, No. 3894 SATURDAY, JUNE 17, 1944 ONE SHILLING & SIXPENCE

NATURE

No. 3894 SATURDAY, JUNE 17, 1944 Vol. 153

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Editorial and Publishing Offices
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number : Whitehall 8831
Telegrams : Phusis Lesquare London

SCIENTIFIC APPROACH TO HOUSING PROBLEMS

THERE can be no mistaking the extent to which dissatisfaction is rapidly growing at the Government's failure to take and announce its fundamental decisions in regard to the planning and development of the land and the location of industry in Britain. Mr. Dalton, speaking in the House of Commons on June 7, stated that the Government accepts the main ideas of the Barlow Report, but we still await information as to the measures by which effect is to be given to the general policy of planning. The preparation of detailed housing programmes is already a matter of urgency, but is as yet impossible because neither planning authorities nor private developers know what are to be their respective powers. Again, housing policy is intimately related with industrial location policy, for local authorities cannot proceed with housing plans if they are uncertain where the people are to be working.

What perhaps has brought home generally the danger of piecemeal planning is the Minister of Health's admission that the first 300,000 permanent houses are to be built on sites chosen without reference to any sort of national policy for planning the use of land. More than half these sites were bought by authorities whose choice was dictated by local interests and circumscribed by private rights, and Mr. Willink appeared to be quite unconcerned that the remainder should be purchased by authorities still without guidance as to whether public interest is to be the effective determinant in the use of land, let alone whether, from the national point of view, the particular sites those authorities have in mind ought to be used for housing. This is the negation of national planning, and has rightly received forthright condemnation in one of the latest interim reports from the Central Committee on Post-War Reconstruction of the Conservative and Unionist Party Organization.

This report, "Foundation for Housing", prepared by the Conservative Sub-Committee on Housing, with Sir Harold Bellman, J. D. Trustram Eve and K. M. Marr-Johnson as its technical advisers, insists that the first step in framing a housing policy must be to determine where the houses shall be built. This depends first and foremost on the location of industry; but while housing is a non-controversial issue in party politics to-day, many fail to realize, as this report points out, that without planning on national lines a successful housing policy is impracticable. The sub-committee "views with grave apprehension the results which are likely to accrue if housing policy is pressed ahead without preliminary decisions on questions of location of industry and in advance of a solution of the problem of compensation and betterment. . . . Activities of different Government Departments, valuable as they may be, are no substitute for a single comprehensive policy on the issues of location of industry and the protection of agricultural land. We cannot therefore press too strongly for the formulation without delay of national policy on these fundamental points."

In this attitude the Committee should be assured of wide support. It has been repeatedly urged in these columns that failures and faults in our inter-war legislation have been due to the absence of a sufficiently national and positive policy in such matters as the geographical distribution of industry, the protection of agriculture, the co-ordination of transport and the control of the growth of our cities. The warning in this report that, in the absence of an early announcement of the Government's planning policy, the train of housing is in danger of being diverted on to the wrong track, needs the more emphasis in view of the approval with which the pre-fabricated houses have been welcomed, in spite of the warning that they are a temporary expedient.

A particular recommendation of the report is that, as a first step to a forecast of the future distribution of the industrial population, an immediate study should be made by the central authority of the location and extent of war factories throughout Great Britain, of the transport facilities which are available in each case and of the provision, temporary or permanent, for the accommodation of labour. That recommendation is in keeping with the recent report of the Welsh Reconstruction Advisory Council*, which indicates that the Council regards the conduct of a continuous survey of current developments in industry, agriculture and the public services as an important part of its task, and emphasizes the desirability of the regional offices of the Ministry of Production and the Supply Ministries keeping the Council informed of important changes in the location of new plants, in production programmes at particular existing plants and in projects for the post-war use of war factories. A like emphasis on organic evolution, the continual reaction to changing environment based on full technical knowledge, not merely of raw materials and processes, but also of markets, and the participation of scientific and technical workers, not as the tools but as the guides of the politician and financier, characterizes the presidential address of Dr. F. J. North to the South Wales Institute of Engineers.

None the less, the Conservative Sub-Committee insists on its main point, that only by creating effective machinery for the attainment of the three main objectives agreed upon unanimously by the Barlow Commission, and by solving in one way or another the problem of compensation and betterment, can the Government lay the foundation of a successful long-term housing policy. While the Committee welcomes the appointment of a Minister of Reconstruction, it looks for the publication of the promised White Paper, in which it hopes to find proposals for the early creation of a central authority as envisaged in the Scott and Uthwatt Reports, as well as the Barlow Report. In the absence of a single comprehensive policy on the issues of the location of industry and the protection of agricultural land, it sees no alternative to the continued promiscuous growth of the cities of Britain and the drift of the people from the countryside, with ensuing aggravation of all the evils which must inevitably result.

Nothing that has yet been said on behalf of the Government has dispelled a widespread suspicion that official allegiance to national planning is little more than the enforced acknowledgment of a principle which it would be political folly to disregard, but which it has proved inconvenient to translate into practice. Similarly, the belief is hardening that the reason for the delay is due not to the admitted difficulty of reaching an agreed decision on the compensation and betterment proposals of the Uthwatt Committee, but to unwillingness to do so. In its memoranda to local authorities last November, the Ministry of Town and Country Planning gave a lead, but the plan for Plymouth recently published shows how weak are the Ministry's suggestions for avoiding coastal ribbon development in the present uncertainty and absence of legal powers.

This plan for Plymouth is in some respects more far-reaching than the County of London Plan prepared for the London County Council by J. H. Forshaw and Prof. Abercrombie. More than a key to the future of Plymouth itself, it aims at preserving the diverse features of the neighbouring area, one of the most beautiful regions of England, and for this purpose Prof. Abercrombie and Mr. J. Paton Watson's proposals assume the support of the neighbouring rural and county councils. They visualize the metamorphosis of the city from an area clogged and untidy into one decentralized into planned communities, on the basis of a stable population, with the central mass lightened, and a series of suburban satellites.

In spite of the wide appeal of this attempt, not merely to remodel Plymouth but also to improve for the nation the amenities of an entire region, these features of the plan are not the most important at the moment. Here once again is conclusive demonstration that housing by itself is not enough. Still more important is the demonstration that with proper planning and with the aid of the Government by pooling nationally the differing values of land, much of the cost of the scheme can be offset, and any small cash loss would be more than balanced by gains in other ways. Again, here is a convincing demonstration of the national value—if not necessity—of co-operation on a regional basis in planning reconstruction. Only by such co-operation can the district be safeguarded from irreparable damage.

There could, in fact, have been no more timely demonstration to the public and to Parliament of the kind of Government help that is essential. Here is the evidence that local reconstruction cannot be carried out either by private enterprise or public bodies without the security which Parliament must give. Statutory powers are needed now for the immediate acquisition as reconstruction areas of districts which have been 'blitzed' and for their purchase at pegged prices of land. Public ownership is vital, and the local authority must also be able to look to both a central pool for compensation and to a regional policy and a national pool so that betterment and depreciation may be equated.

The first major task of the housing programme

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

in Britain is clearly that of making good the damage due to enemy action and the slower but equally destructive ravages of war-time neglect. Then will come the work of overtaking the arrears of a hundred years neglect by providing every family with a separate and generously designed dwelling and by establishing an adequate reserve. Both these tasks are, as the Plymouth plan shows, related to planning in wider fields, and this is no less true of housing policy in the next period when it is determined by the need for replacement. This is well brought out in a P E P broadsheet entitled "Old Houses" which, giving an interesting analysis of the social obsolescence of housing, emphasizes that the volume of replacement should depend on the number of new houses that are needed for their own sake. Any decision as to the amount of replacement should be based on a close analysis of the causes of obsolescence in housing.

This broadsheet is thus of special interest in view of the temporary character of the prefabricated houses intended to meet the immediate post-war shortage, and should facilitate the fuller understanding of this complex aspect of the housing problem. While the rate of deterioration of a house depends on the soundness of the original building, the broadsheet emphasizes that social changes can make houses out of date just as surely as any deterioration in the physical structure. Many of the points made in regard to the effect of changes in the living habits of the middle classes, the character of a neighbourhood, the growth of road traffic or industrial location are so obvious as to be almost trite, but their implications are seldom thought out or realized, and the broadsheet proceeds further to show the exact bearing of obsolescence on the post-war housing programme.

Obsolete housing can be dealt with either radically by demolition and replacement, as in slum clearance, or remedially by rehabilitation. The former is the proper course where the original design and layout were poor and mean; but the only sound test as to when the original design and layout should be considered so inadequate as to call for demolition must be selective and designed to destroy and replace none except unfit houses whatever their age. P E P suggests that local authorities should be in a position to adopt a flexible minimum standard and to require all houses to conform to that standard. It is equally important, though more difficult, to reduce the rate of obsolescence of new houses, and in this field the report of the British Building Mission on Building Methods in the United States and the admirable series of Post-War Building Studies which are being issued by the Ministry of Works may well be expected to encourage building the new post-war houses to the highest available standard, while at the same time providing as much scope as possible for flexibility in internal and external arrangements.

Rehabilitation, in its two forms of reconditioning and of conversion, can also play an important part in the post-war housing programme, and the P E P broadsheet points out that little is yet known about the labour economies which would result from large-scale rehabilitation and conversion. The experimental work now being done in Westminster, Islington and other London boroughs should throw some light on the only means by which many houses could be made satisfactory for a new purpose. Moreover, reconditioning and conversion, even if not profitable for individual house-owners, may be worth while from the point of view of the community as a whole, and may, therefore, deserve a subsidy. Again, they have another advantage in checking urban sprawl at a time when the present phase of growth of the town population, as well as of the population at large, is probably approaching its end.

The social function of housing, beyond the mere provision of homes, in promoting also association, neighbourliness, civic sense, architectural dignity, amenity and a feeling of stability finds worthy expression in the Plymouth plan; but it is no easy task to provide a system of housing and type of lay-out which will continuously relate the fabric of a constantly changing society to its even more rapidly changing needs. That is a task in which the constant and thorough application of scientific research to the technical problems of construction is essential, and also the no less assiduous examination of the many social and economic problems involved in the same impartial scientific spirit. The first and most obvious precautionary measure is, as the P E P broadsheet observes, to see that new housing is built to a standard of accommodation and size which is closely related to the needs of the coming generation of householders; that it is built to a scale and in conformity with a lay-out which will permit the establishment and maintenance of a healthy society, provided with public and communal buildings and the requisite social services; that precaution is taken against the hazards of congestion, overgrowth and malformation by an intelligent development plan, understood and appreciated by officials and citizens alike; and that the standards of other community needs—roads, recreation grounds, shops—should be adequate and in proportion.

A secondary objective would be flexibility both in the interior planning of a house, so as to allow some alteration and extension without prohibitive cost, and also as between different dwellings in the same neighbourhood in order to facilitate moves from a smaller to a larger house or vice versa as the family increases or contracts. The maintenance of adequate standards and the decrease of the rate of obsolescence will only in part depend on new housing in the new decades. The major part of the problem will be to deal with existing housing and still more with existing communications and towns, and here the P E P broadsheet leads us back to the fundamental need for control of the use of land in the public interest. The many instances of social obsolescence have arisen out of the chance pattern of land ownerships in old and growing towns, and effective reconstruction can only be carried out on the basis of a temporary or permanent acquisition of large areas of land by a planning authority.

Given the machinery for dealing comprehensively with demolition, development and re-development to a prepared plan and time-table, questions of policy can then be determined with reference to the density of housing, the case for temporary construction, the life of buildings (for planning purposes) and their functional grouping. But, if the community is to enjoy in its housing programme the full benefits and possibilities which science has placed at its command, it is no less essential that at the centre there should be taken speedily the decisions in regard to the control of land and the problems of betterment and compensation which must be made by the central government. Then local authorities or individuals can prepare and give effect to the plans designed, not only to provide homes, but also to give them a pattern and a setting which preserve as much as possible of our cultural and scenic heritage.

EXAMINATIONS EXAMINED

The Case for Examinations

An Account of their Place in Education with some Proposals for their Reform. By J. L. Brereton. Pp. viii+226. (Cambridge: At the University Press, 1944.) 8*s*. 6*d*. net.

THE author of this book has set before himself three aims: to present a case in favour of examinations, to put forward proposals for their reform, and to give an account of their influence, chiefly in the field of secondary education from about 1858 onwards. As to the third of these aims, his abundant experience in connexion with the Cambridge Local Examinations has enabled him to achieve a noteworthy success. The clear record of historical fact certainly makes the book useful for reference. As to the first two aims, no one knows better than the author that he has been treading on extremely debatable ground.

The book was practically finished when the Norwood Report on Curriculum and Examinations in Secondary Schools was published; but the author was able to add a chapter on that report. The reviewer, having perused Mr. Brereton's book as originally completed, was quite prepared to find him in his final chapter smiting hip and thigh the concocters of the Norwood document, and the expectation was fulfilled. It would be hard to find two pieces of writing on the same theme more utterly at variance than Mr. Brereton's book and the Norwood Report. According to the former, the very life and soul of education are derived from the stimulus afforded by mass examinations, which only need reform in certain directions. According to the latter, no true education is possible in the secondary schools until the prevailing mass examinations, yielding in plenty a stimulus of the wrong kind, have been reformed out of existence.

Manifestly such irreconcilable differences of opinion must be due to causes which are fundamental. Those causes are not far to seek. In their preface, the signatories of the Norwood Report announce their intention to set out suggestions for the freer treatment of the curriculum which is demanded by a "child-centred education" and made possible by the greater freedom secured by their proposed reorganization of examinations. The belief in the child, the individual child, as the centre of all education, gives, they say, a perspective and a vision to education, and assigns to their right places as means to an end all "the paraphernalia of education"—including examinations. That is the idea which pervades the Report from beginning to end. The same idea was taken as axiomatic in the White Paper, which preceded the Education Bill. There we read that "the key-note of the new system will be that the child is the centre of education", not, be it noted, the official or the taxpayer or even the teacher, but the child. Further, to quote the Norwood Report again, "an education which is really child-centred can come about only if freedom is allowed to those who alone can make the individual child the centre of education, namely, the teachers themselves".

From the freer treatment of the curriculum thus based on a child-centred education Mr. Brereton entirely dissents. He is quite clear that "Great Britain will not maintain her position in the modern world unless she repudiates the educational philosophy set out in the Norwood Report". He is clear that the Board of Education, in holding as "a cardinal principle" that the examination should follow the curriculum, not determine it, has only upheld a theory which everyone knows to be ignored in practice—and rightly so. He makes much of the stimulus which the prospect of an examination supplies, but little or nothing of the stimulus inherent in the situation when lively youngsters and a capable teacher are jointly intent on the job in hand. He offers definitions of external and internal examinations which imply the superiority of the former because they involve the element of competition. He defends competition, and evidently has little use for the modern progressive teacher's preference for a co-operative ethic in the classroom.

Seeing that an examination syllabus must go far to settle the content of the curriculum, Mr. Brereton makes good suggestions for reform, and in doing so he quotes John Dewey to good purpose. Nevertheless, the name of Dewey looks rather out of place in a book written in defence of our English examination system. The natural opposite of the child-centred school is the adult-centred school. Until recently, the latter held the field, as it largely does to this day. In the present century, however, the idea of child-centred education has emerged almost simultaneously in England and the United States. As an American writer says, "the doctrine of self-expression is assuming a rôle co-ordinate in importance with that of adaptation". From the first, that is, from about 1900, Dewey has been the inspirer of child-centred education in America and to some extent in England. He has, however, shared a common fate of reformers in being misunderstood. Some of his followers, with their project methods, for example, have overdone the sound principle of free self-expression on the part of the child. In his last book, dated 1938, Dewey seeks to correct the tendency of "many of the newer schools to make little or nothing of organised subject-matter of study and to proceed as if any form of direction and guidance by adults were an invasion of individual freedom". In fact, Dewey's philosophy of experience does recognize, even more directly than Mr. Brereton seems to have noticed, what Mr. Brereton calls "the close inter-connection between the development of the higher faculties of the individual and the world of men and things in which he lives". But there is this difference. Mr. Brereton has lived and worked where the examiner has been in the saddle and has ridden that portion of mankind that goes to school, whereas Dewey only mentions examinations incidentally, and only to lament "the spectacle of professional educators decrying interest while they uphold with great dignity the need of reliance upon examinations" and kindred "paraphernalia". He issues a warning to well-meaning enthusiasts, but there is not the slightest evidence that he would apply such an antidote as our vast and complicated examination machine. He would be more likely to say, trust your teachers, and if they cannot even trust themselves, reform your system until they feel strong enough to do so. In other words, he would assuredly prefer the spirit of the Norwood Report to that of Mr. Brereton's book.

T. RAYMONT.

BRITISH ELECTRIC POWER STATION PRACTICE

Electric Power Stations

By T. H. Carr. Vol. 1. Second edition revised and enlarged. Pp. xii+507. (London: Chapman and Hall, Ltd., 1944.) 32s. net.

MORE than 10 per cent of all the coal mined in Great Britain is used in electric power stations, and the electrical energy produced in these stations is an important factor in determining the standard of living of the population of Great Britain. Books on power stations are scarce, so that the appearance of a new edition of the only up-to-date British publication is a matter of considerable interest and importance.

The volume under review comprises a foreword by Sir Leonard Pearce, two author's prefaces, nine chapters and a subject index. The chapters deal in turn with some fundamentals of station design, civil engineering and buildings, circulating water systems, cooling towers, coal-handling plant, ash-handling plant, boiler plant, pipework and turbine plant. Twenty-nine pages are devoted to fundamentals of design. They provide an ill-assorted series of what purport to be general principles relating to plant rating, choice of thermal cycle, choice of voltage of generation, and station operation. Civil engineering works and buildings are considered in a more comprehensible manner; but the treatment remains scrappy. Some of the facts provided, for example, the tables giving floor areas and volumes of boiler and turbine houses per kW. installed, are potentially useful to those who are interested in power station design. Circulating water systems and cooling towers are described in some detail; but insufficient emphasis is given to the fact that modern developments in cooling tower design and construction are having a profound influence on the economics of electricity supply. Coal and ash-handling plants of all the principal types encountered in Great Britain are briefly commented on in the light of operating experience. The chapter on boiler plant deals with chain grate and retort stokers, pulverized fuel systems and apparatus, natural circulation and forced circulation, steam generators, and instruments used in connexion with steam production. A chapter is devoted solely to steam and water pipes, joints and valves. Turbines and their accessories are considered in the final chapter.

The volume is illustrated by 249 figures which are in the main well-chosen, apart from a few which are too elementary to justify their inclusion in an important treatise. The figures provide more and better information than does the descriptive matter.

The author has done his best to emphasize points of special importance, and has been unsparing in his efforts to safeguard his readers from dangers and difficulties encountered in power station design, construction and operation.

His work is pervaded by a sort of naïve enthusiasm which is quite infectious; but this leads him to make numerous interjections which, although intended to help, actually hinder the reader from getting a proper grasp of the subject in general. The English is frequently so faulty that many sentences are incomprehensible, and the work is further marred by several gross typographical errors. The few calculations which are included are of an elementary and inconsequential nature.

There are only scrappy references to American or other foreign plants, and even those which are included are not direct. Power station development in the United States has always been in advance of that in the rest of the world, and many European stations have novel and interesting features which should be made known to our home engineers.

The author has made an effort to supply a long-felt want in British engineering literature. It is evident from the fact that the second edition of his book has been called for within three years that he has had some measure of success. In the opinion of the reviewer, however, the volume under consideration is in most respects of indifferent quality, and does not adequately meet the requirements of specialists interested in power station design, construction or operation.

C. W. MARSHALL.

LANGUAGES, NATURAL AND ARTIFICIAL

The Loom of Language

A Guide to Foreign Languages for the Home Student. By Frederick Bodmer. Edited and arranged by Lancelot Hogben. (Primers for the Age of Plenty, No. 3.) Pp. 670. (London: George Allen and Unwin, Ltd., 1943.) 15s. net.

TO anyone who learnt languages in the traditional fashion, Dr. Bodmer's work must bring a feeling of frustration. In the time spent at the average school on memorizing one language, the intelligent student could, by the method here displayed, learn to understand a group of related languages.

The first part of the book deals with the evolution of languages, with alphabet, accidence, syntax and classification. The second part instructs the reader first how to begin the task of learning the essentials of a language, and then gives the basis of Teutonic grammar and of the languages of Latin descent. Part 3 deals shortly with those languages, such as Russian and Chinese, furthest removed from our own, with the history of the artificial languages, and with a suggestion for yet another planned language for international use. Finally, there is a series of basic vocabularies for the Teutonic and Romance languages and of Greek roots of international currency.

Anyone with some knowledge of European languages reading this book will emerge at the other end with an enriched vocabulary, a sounder understanding of their meaning, and a new capacity for interpreting the unknown words in his future foreign reading. In school an enthusiastic teacher could have no better text-book.

For an adult who wishes to learn a language, the reviewer offers the following prescription. Prepare the way and mount enthusiasm by way of "The Gift of Tongues" by Margaret Schlauch. Proceed next to Part 2 of "The Loom of Language", and finish with the appropriate volume from "The Basis and Essentials Series" edited by Charles Duff. It is only fair to say that these suggested volumes are included in Dr. Bodmer's bibliography.

The reviewer, after the toil of learning French and the consequent enjoyment of its literature, was dashed to discover that the author rates it as having an "ostentation-value as a female embellishment". Although it is no stigma to be unable to speak French, one doubts whether it is wise to applaud Lloyd George and Wilson because Clemenceau had to speak to them in English. Perhaps the outcome of the conversation might have been different if the Anglo-Americans had had some knowledge of French, and with it an inkling of the workings of the French mind.

The planned language here outlined appears in theory to have many points in its favour. In its final form as seen in "Interglossa" by Prof. L. Hogben, one fears that it will probably meet the same fate as its predecessors. If an international language is to be planned, might it not be better to start from a basic accepted language with an added international vocabulary of scientific and technical terms ?

An edified and entertained reviewer recommends this book to all students of languages. If any such students happen to have bourgeois tendencies, they will no doubt be occasionally galled by the author's political interpolations to about the same extent as the author would be if he read "Who are the People" by Colm Brogan. J. MARSHALL.

ELEMENTARY PHYSICAL CHEMISTRY

Elementary Physical Chemistry
By Prof. M. Randall and Prof. L. Esther Young. Pp. xiv+455. (Berkeley, Calif. : Randall and Sons, 1942.) 4.50 dollars.

Introduction to Physical Chemistry
By Prof. Alexander Findlay. Second edition, revised and enlarged. Pp. vii+582. (London, New York and Toronto : Longmans, Green and Co., Ltd., 1942.) 15*s*. net.

RANDALL AND YOUNG'S book is described on the cover as for second- and third-year college students and as a broad survey of elementary physical chemistry. It is not easy to equate this with a corresponding treatment in Great Britain. Some of the topics are elaborated in great detail and others, in the reviewer's opinion, are considerably advanced. The early introduction of the idea of flow-sheets for simple reactions is a novelty, and the precise definitions of concentrations and the implications which flow from them is a good but unusual feature in elementary books of this kind.

The volume is produced, possibly owing to war exigencies, in what looks like imitation typescript and is termed 'photolith'. This method gives good illustrations, which are often drawn from industrial practice; but it is rather trying to the eyes and not conducive to prolonged reading. This may be due to habit.

Findlay's volume is written from the British point of view, and its treatment is in marked contrast to that of "Randall and Young". It deals much more with the experimental side of the subject, and does not go so deeply or so dogmatically into theory. It covers most of the usual field in this subject and should prove a useful aid to students who are beginners as well as to those who are a little more advanced. One characteristic feature is the assignment of dates to the workers who are mentioned.

The book starts on the basis of the atomic theory and ends with an elementary discussion of heterogeneous equilibrium. The thermodynamical treatment is a little old-fashioned ; activity is only dealt with in elementary fashion. These may be matters of personal taste. The ambiguities in methods of expressing concentration which become important in all but very dilute solutions are not very clearly brought out. This may be an obsession of the reviewer and could scarcely be expected in a book of this standard ; nevertheless clarity in such definitions is very helpful in more advanced work.

CHEMICAL ANALYSIS

Textbook of Quantitative Inorganic Analysis
By Prof. I. M. Kolthoff and Prof. E. B. Sandell. Revised edition. Pp. xvii+794. (New York : The Macmillan Company, 1943.) 21*s*. net.

Systematic Qualitative Organic Analysis
By H. Middleton. Second edition. Pp. viii+280. (London : Edward Arnold and Co., 1943.) 8*s*. 6*d*. net.

BOTH these text-books have this in common, that they have entered into a second edition and that deservedly, for they are extremely useful works which, although primarily meant for university students, are profitable to chemists who have proceeded beyond this stage. There, however, the resemblance ends for, apart from the fact that one deals with quantitative inorganic and the other with qualitative organic analysis, they differ markedly in the manner of treatment of their respective subjects. The former is a comprehensive text-book dealing very thoroughly with the theory and quite adequately with the practice of inorganic analysis, while the latter is severely practical and is meant almost entirely for laboratory use. Perhaps both books could gain something one from the other ; the American work would benefit if a few more practical examples were included, particularly in electro-analysis, in amperometric titrations and in nephelometry ; Mr. Middleton's book would undoubtedly gain if, here and there, some theory were introduced.

In this new edition of "Kolthoff and Sandell" (previously reviewed in NATURE, 139, 821 ; 1937) a number of the chapters have been revised, while the sections on errors, organic reagents and spectrophotometry have been expanded. There has also been introduced a discussion on polarographic analysis or, as the authors prefer to term it, amperometric titrations. A folder has been added inside the back cover and carries a leaflet containing atomic weight tables, four-figure logarithms and some gravimetric factors.

The text of the book on organic analysis (the first edition was reviewed in NATURE, 144, 366 ; 1939) has not undergone much change. Some of the analytical schemes have been rewritten, while some thirty additional compounds have been included.

Both books are well got up, they are clearly written, and the text is in each case singularly free from errors. G. R. D.

THE LAWS OF NATURE*

By PROF. HERBERT DINGLE
Imperial College of Science and Technology

THE time in which Halley lived was crucial in the history of science in more than one respect, but of all its aspects none is more significant than that which shows the restoration of the possibility of cosmological studies. Astronomy before Copernicus was essentially and altogether cosmological. No heavenly body had an interest of its own; its sole function was to give a clue to the workings of the universe. But with the dawn of the idea that the universe was infinite, and with the almost simultaneous invention of the telescope, the character of the subject changed completely. The bulk of the universe—the infinite company of the stars—was removed from possible comprehension by finite minds, while the previously inscrutable members of the solar system were brought within human ken. Cosmology thereupon became impossible, and the astronomical study of single bodies began. It was Galileo and Newton who resurrected cosmology, though in a new form. The body of the universe might be inaccessible; but its soul—the universal laws of Nature—could be brought within the grasp of the human mind by the new method of "induction of principles from phenomena", which is the crown of Newton's achievement. It is Halley to whom we owe our knowledge of Newton's work, and it is therefore appropriate that in a lecture dedicated to his memory an attempt should be made to estimate the position reached after two hundred and fifty years of effort along the new lines.

Laws of Motion and Laws of Temperature

Broadly speaking, the progress of physical science since Halley lived has culminated in two comprehensive schemes of physical law. The first is typified by Newton's own laws of motion and gravitation, and is represented in our own day by the general theory of relativity and electromagnetic field theory. The second includes the laws of thermodynamics. These two sets of laws have been called 'primary' and 'secondary'. I prefer to call them 'laws of motion' and 'laws of temperature', for the former nomenclature gives a false suggestion of an order of precedence, whereas motion and temperature are, in fact, the two co-equal phenomena of universal significance that together exhaust the scope of physical inquiry. Consider any two pieces of matter at different temperatures anywhere in an otherwise empty universe. Unless our whole conception of things is wrong, one will inevitably move with respect to the other, and it will inevitably change temperature with respect to the other; and in no other respect, so far as we know, will any observable interaction occur. No known physical agency can prevent these effects. Their course may be modified by the introduction of other bodies, but by no known process can the effect of one body on the motion or temperature of another be annihilated.

It is therefore not surprising that the greatest rift in the as yet immature body of physical law should be that between laws of motion on one hand and laws of temperature on the other. Neither group of laws is, of course, as yet completely unified in itself. Gravitational and electromagnetic motions still await a final blending, and the two great laws of thermodynamics also retain a semi-independence of one another. But these divisions are comparatively slight. In the broad view, it is the separation between the domains of motion and temperature that stands out as the great unhealed breach in the unity of physical law.

Now the present laws of motion and laws of temperature exhibit a striking contrast, which in recent years has attracted considerable attention and forms the main theme of this lecture. The most obvious sign of the difference is this. Consider any possible course of events. According to the laws of motion, this might equally well have occurred in the reverse order; but according to the laws of temperature it could not have done so. There is no actual contradiction, of course, for a 'course of events' to which the laws of motion apply is a movement or set of movements, while a 'course of events' to which the laws of temperature apply is a variation of temperatures. We do not, therefore, have to choose between conflicting requirements; but nevertheless the difference is one which would scarcely have been expected in the representation of the behaviour of a single universe, and does not promise well for an eventual fusion of all scientific law into a single scheme.

An example will perhaps make the position clearer. A ball is thrown into the air. As time goes on it gets higher and moves more and more slowly. If this course of events is reversed, we have the ball getting lower and moving more and more quickly, and this is a possible state of affairs. It does, in fact, occur, for after a while the ball comes to rest, and then descends with ever-increasing speed. Next, a hot body is placed near a cold one. As time goes on, the hot body cools and the cold body gets hotter. If this course of events were reversed, we should have the hot body getting hotter and the cold body getting colder, and this is *not* a possible state of affairs. The actual process continues until the bodies come to the same temperature, and then nothing further happens; they remain at the same temperature eternally.

The mathematical expression of the two sets of laws takes account of this difference in the following way. The law of motion of the ball (in the Newtonian form, which is legitimate for this purpose) may be expressed as $F = m\frac{d^2s}{dt^2}$, and if we reverse the direction of time by putting $t' = -t$, we find by substitution that the law is still the same, namely, $F = m\frac{d^2s}{dt'^2}$. The law governing the changes of temperature of the bodies, however, is $\frac{dS}{dt} > 0$, where S is the entropy of the system; and here if we put $t' = -t$ we obtain the law $\frac{dS}{dt'} < 0$. It is the former law, and not the latter, which expresses what actually happens.

The effect of this difference on our ideas of the history of the universe is profound. It is obvious that changes are taking place, and when we can express the laws of change we can extrapolate to the distant past and the distant future. Now if a law permits only a uni-directional change, difficulties appear which are not necessary when the direction of change can be reversed, for in the latter event a *cycle* of changes may be possible, and the infinitely

* Halley Lecture delivered at Oxford on May 23.

distant past or future may be very much like the present. Some of the energy of the earth in its elliptical orbit alternates between the kinetic and potential forms, and there is no reason, so far as the laws of motion are concerned, why it should not go on doing so from eternity to eternity. But the entropy of the universe is always increasing, and that means that as we go back into the past it gets less and less, and as we go forward into the future it gets more and more. Strangely enough, it is the past and not the future that contains the greater problem, as we can see more easily if we think in terms of simple temperature exchange instead of the more recondite conception of entropy. Since the tendency is for bodies at different temperatures to come to the same temperature, we can easily visualize an ultimate future state in which the whole universe has reached a common temperature ; the approach to maximum entropy is asymptotic. But as we go back into the past, we get greater and greater divergences of temperature. The hot bodies get hotter and the cold bodies colder, and this at a more and more accelerated rate until we reach a time when some bodies are infinitely hot and others infinitely cold ; and we must suppose that from such a state they have taken an infinite time to come to their present relative temperatures—a conception impossible to reconcile with our experience of the heat capacity and rate of heating or cooling of bodies. It is true that simple variation of temperature does not cover the whole scope of entropy change, but essentially the same difficulty remains however we look at the matter.

The Second Law of Thermodynamics

My purpose here is to analyse the situation thus presented, in order, if possible, to elucidate the difference between the two great schemes of physical law, but before attempting a task of such magnitude, common sense suggests that we should ask whether there is any escape from the Second Law of Thermodynamics, the particular temperature law which is mainly responsible for the dilemma which faces us. Can we find a fallacy in the arguments which lead to it, or alternatively, if it is unassailable itself, can we find reasons why it is not applicable to the whole universe ? We must consider this question, but I shall deal only briefly with it, for reasons which will transpire.

In the first place, then, I think that when pressed we must admit that this Law is not irrevocably established. During the brief period in which scientific studies have been pursued, we certainly find that entropy tends to increase ; but it does not inevitably follow that entropy has tended to increase throughout all past time and will do so throughout all future time. Lord Kelvin's original statement was : "There is at present in the material world a universal tendency to the dissipation of mechanical energy", and I think we may take the words "at present" as an indication that he was alive to the possibility that the tendency was only temporary. Moreover, since Kelvin's time we have obtained evidence that the danger of extreme extrapolation is not a fanciful one. In our own region of space we find that bodies move towards one another, by 'gravitation' as we call it, but at very great distances they appear to move away from one another. It may equally well be that if we had 'time telescopes' by which to observe the distant ages, we might find a similar reversal in the behaviour of entropy. We certainly have no experience that makes it more legitimate for us to universalize the Second Law of Thermodynamics than it was for the nineteenth century physicists to universalize Newton's law of gravitation.

The point could be put still more strongly, for not only have we no experience of this kind, but we have evidence in the opposite direction. The general theory of relativity, as Tolman[1] has shown, leaves open the possibility that the universe might expand and contract irreversibly without ever reaching a state of maximum entropy. This possibility, beyond the knowledge of the nineteenth century physicists, comes from the reformulation of the laws of temperature made necessary by the requirement of the principle of relativity that the laws of Nature shall be independent of the standard of rest chosen for expressing them.

Again, when we look at the derivation of the Second Law itself, apart from its invariance under changes of co-ordinate systems, we find that in order to make it logically rigorous we have to insert so many provisos that its direct application to the whole universe becomes impossible. Probably the most successful attempt yet made to give precision to the law is that of Carathéodory[2]. An examination of Carathéodory's statement shows, first, that the Law refers only to a system enclosed within a boundary having at least some of the properties of material things ; secondly, that since fields of force cannot be altogether obstructed by such a boundary, they must be assumed non-existent before the Law becomes capable of precise formulation ; and thirdly, that the boundary must be supposed to have certain characteristics which it is not certain that matter possesses.

This last point requires a little explanation. For the rigorous statement of the Law it is necessary to distinguish unambiguously between 'heat' and 'work' as two forms of energy. This has long been a difficulty, and Carathéodory deals with it in the following way. If, when the system gains or loses energy, the boundary does not move, the whole of the energy gained or lost is to be called 'heat'. On the other hand, if the system *cannot* gain or lose energy without a movement of the boundary, the whole of the energy gained or lost is to be called 'work'. In the ordinary case, however, the energy of the system will change and the boundary will move, and in such a case we are to calculate the work and the change of energy, and the difference must be heat.

This is all very clear, but in order to carry out the programme we must know how to calculate the work and the change of energy. The former presents no difficulty, but the change of energy can be calculated only if we can find a material for the boundary such that the energy inside cannot change unless the boundary moves ; in ordinary language, a boundary must be found which is a perfect non-conductor of heat. If we can find such a substance, we can perform known amounts of work on the boundary and measure the energy changes inside, confident that those changes must be equivalent to the work done ; and we are then prepared to measure the energy changes when other boundaries are used. This preliminary work requires an indefinite number of experiments to ensure that, in fact, by no possible device can energy cross the boundary unless the boundary moves ; but even if we ignore that practical difficulty, another of a theoretical character remains. If we have found our boundary, which is a perfect non-conductor when it is at rest, how do we know that it will remain a non-conductor when it is moving ? If it does not, our whole scheme for distinguishing between heat and work, and consequently the logical basis of our law controlling the transformation of heat into work, collapses, for whenever the boundary moves we are unable to calculate the change of energy inside and therefore unable to distinguish the passage of heat from the performance of work. We can, of course, escape from the logical difficulty by *defining* a non-conducting boundary simply as one which prohibits all change of internal energy while it remains at rest, but in that case we sacrifice the necessary connexion of the theory with the experience which it was constructed to represent. We can imagine a substance which is a non-conductor when at rest but when it begins to move exhibits all the properties of a conductor—for example, a flame placed outside it might melt ice inside—and we should still have to call such a substance a non-conductor and give the name 'work' to the heat which it allows to pass. I do not think it is the intention of Carathéodory's theory to be logically invulnerable at the cost of being no longer an account of the laws of thermodynamics.

The result of all this is, then, that unless the universe has a boundary which necessarily possesses some of the properties of matter and necessarily lacks others which some forms of matter, so far as we know, may very well possess, and unless we can exclude the possibility of fields of force which can penetrate the boundary, we cannot certainly apply the Second Law of Thermodynamics to the universe as a whole. It is interesting to recall that in the early days of the doctrine of the degradation of energy, Rankine[3] sought to evade its application to the universe by postulating the existence of a boundary, whereas now it is the non-existence of a boundary that we invoke to the same end. Rankine's arguments, however, have no weight in the light of present knowledge.

For various reasons, then, we must reject the claim, only too often made, that the universe 'must inevitably' have begun with a bang and be destined to end with a whimper. But this, after all, does not carry us very far. After disposing of exaggerated conclusions, we have still to reach balanced and temperate ones, and none of the considerations just advanced weakens the force of the Law as expressing present tendencies. Over the whole range of space and time that we can cover, we have always found its demands inexorably imposed and met. The fact that we cannot conclusively deduce its universality gives us no ground for denying that it might, nevertheless, be universal, and it is wise to face that possibility and see how, if at all, we can reconcile it with the greater range of possibilities suggested by the laws of motion.

I should say, however, that I cannot accept the view, which has found favour in some quarters, that the operation of the Second Law of Thermodynamics constitutes scientific evidence for a supernatural creation at a particular time in a not infinitely distant past. Such a view would indeed dispose of our problem, but not to my mind in a legitimate way. Our object in science is to give a natural, rational account of things, not to invoke inscrutable, *ad hoc* powers to explain them away. No one would admit the validity of accounting separately for every observation we make as a supernatural result of the divine will. Such an explanation would be rejected, not necessarily because it was felt to be 'untrue' but because it would be irrelevant. Our aim is to relate each occurrence to others, thus forming a rational correlation of experiences, and an event is not released from inclusion in the scheme of correlation because it happened a long time ago. If, then, we postulate a supernatural creation on scientific grounds, it can only be because we have got into a difficulty from which we can see no escape. The proper course in that case is to try again or else admit that we are beaten. It is not fair to insist on a rational explanation of easy things and fall back on supernaturalism for the difficult ones. If we bring in supernatural agencies at one point we may as well bring them in at all points, and save ourselves the trouble of constructing a trivial man-made rational order.

Experience and Terms of Expression of Experience

The problem before us, then, is this. The present laws of motion and laws of temperature show a non-conformity which is scarcely compatible with our expectations or with our hope that we shall one day arrive at a single comprehensive scheme of physical law; and, further, the laws of temperature, when extrapolated towards the past, lead to a state of the universe which we cannot regard as physically possible. To deal with such a problem we must understand clearly the scope and character of physical laws.

Our aim in science, let me repeat, is to give a rationally connected account of our experience. In order to do this, we must choose *terms of expression* which will enable us to relate together experiences which are in themselves distinct and independent. The experiences are unalterable: they are our primary data, and it is the fundamental canon of science that we accept them unquestioningly. Of course, in the physical sciences, we impose certain tests to distinguish those experiences which are fit subject-matter for our purpose from those which we regard as 'illusions' or 'hallucinations' or 'errors of observation', and hand over to the psychologist, but that is merely a process of selection, not of rejection or modification. The terms of expression which we choose for describing and correlating our experiences, however, are at our choice, and we choose those which enable us to give the most comprehensive rationally connected account of experience. Certain terms of expression are so well established that we have difficulty in recognizing that they are at bottom arbitrarily chosen and not the unique inevitable verbal forms which experience must assume, and the first task that faces anyone who wants to obtain a fundamental understanding of science is to distinguish inviolable experience from deposable terms of expression of experience. The latter, of course, form the language in which laws of Nature are expressed, and their term of office, so to speak, sets an ultimate limit to that of the laws.

Let us take a few examples, to make the difference clear. With a certain arrangement of optical apparatus we observe an alternation of dark and bright bands on a screen. That is an experience. We sometimes describe it as an 'interference pattern', and when we do that we imply a system of waves of light which, when they intersect, can reinforce or neutralize one another. In these terms we can get a consistent, and for many purposes altogether satisfactory, way of describing the experience; but it is not a necessary way, although in the last century many physicists would have thought it to be so. We can also think of a swarm of small particles of light, and in those terms we say the swarm is dense in the bright bands while there are few particles or none in the dark bands. That also gives a consistent, and for certain purposes satisfactory, description of the experience. We can adopt which description we please so far as Nature is concerned, and our choice will ultimately be determined by the power of the respective terms of expression to afford a description of the widest range of experience.

The fundamental arbitrariness of the choice here is now fairly familiar, but there are other phenomena in which it is less so and in which we may not be able to recognize it without some difficulty. Motion affords a good example. What we call motion is an experience, but the expression of motion as a change of position with time is an arbitrary one—extremely useful, of course, and not lightly to be discarded, but still not essential. An occupant of a smoothly running car can determine if he is at rest or moving not by observing any process of change of position with time, but by noting whether the number opposite the stationary pointer of his speedometer is zero or something else, and he can, if he wishes, describe his experiences in terms of his pointer readings without reference at all to the space and time measurements in terms of which an external observer would probably describe them. The speedometer language, in fact, is, in principle, that in which we originally describe most of the motions we observe in the universe, for the spectrum, which informs us whether a star is approaching or receding, is a kind of speedometer in which the displacement of the lines corresponds to that of the pointer. We usually translate this direct expression of the movement into a statement in terms of space and time, but that is merely for convenience; it is not a necessity.

Again, the measure numbers we assign to movements are likewise arbitrary. It is now common knowledge that there is a limiting velocity possible for bodies, namely, a velocity of about 3×10^{10} cm. a second. There is an inviolable experience hidden in this statement, but it is not in that part of it which gives a finite number to the limiting velocity; that is a characteristic of the arbitrary choice of space and time measurements for the expression of motion. If we choose the Doppler effect instead, and measure velocities in terms of the difference of wave-length of spectrum lines, we find that velocities of approach have a finite limit but velocities of recession may have any value up to infinity. Other, equally valid, terms of expression are possible in which *all* velocities may increase up to infinity. What we experience is quite unaltered by the terms of expression we choose, but any 'law of Nature' which requires that bodies at high speeds suffer some intrinsic change of character which makes it inherently difficult for them to move faster is no law of Nature at all, but an illegitimate statement in a language the possibilities of which exceed its lawful scope.

Far-reaching deductions are often made from the supposed fundamental distinction between 'things' and 'processes', the former being static and the latter dynamic. Dialectical materialists make much of this, and from Zeno and Heraclitus onwards, schools of philosophy have been divided into those who attempt to get beneath change to a constant substratum and those who find in change itself the essential characteristic of existence. The fact is, however, that whether a phenomenon is changing or static depends on the terms in which we choose to express it. If we express motion in terms of space and time, we must call it a changing process, and in order to discover whether a body is moving or not, a finite time, however short, must elapse, for we must compare the positions of the body at two distinct instants. On the other hand, if we express motion in terms of the Doppler effect, no change at all is involved. The static position of the spectrum line is the criterion; we do not require two observations at two separate instants, but one single instantaneous observation alone. I have assumed here that the velocity, whether zero or not, is constant, but the same principle holds if it is not. In that case, if we wish to regard the phenomenon as a static one, we must choose an instantaneous criterion of acceleration instead of velocity, and this we find in force. Take the motion of a planet round the sun. We can describe this by stating the successive positions of the planet in time, or the successive velocities of the planet in time, and each of these descriptions shows it as a changing phenomenon. But if we state the gravitational field, and give values of the position and velocity of the planet merely at one instant, we can describe the whole motion in completely static terms, and see the phenomenon as an example of eternal quiescence.

What is true of motion is true also of other things. A lamp burns steadily. In terms of its candle-power it is an example of steadfast constancy; in terms of radiation of energy to space it is engaged in the most rapid and most irrevocable waste known to Nature. Both modes of description are, of course, perfectly legitimate, and it is exactly the same experience that they describe so differently. Similarly, a body at constant temperature may be regarded either as an inert mass or as engaged in a constant interchange of energy with the whole universe. We may, and on occasion do, use both descriptions.

Problems Arising from Terms of Expression

Examples could be multiplied indefinitely, but probably enough has been said to make it clear that the distinction between experience and terms of expression of experience is an important and often a very subtle one, and that problems which seem to be fundamental may actually belong only to the arbitrary terms of expression employed. Such problems are not solved when the terms of expression are changed; they simply become meaningless and disappear, for they have no basis in experience. An example will illustrate how this occurs.

One of the earliest problems presented to the philosophic mind was that of accounting for the movements of the heavenly bodies. The motions themselves were facts of experience. For their description, however, certain terms were necessary; and the early astronomers made the assumption that the stars and planets were carried round the earth on spheres. The spheres had each a simple circular movement, but they could communicate their movements to one another, and the path of the heavenly body showed the resultant movement, from which the separate spherical revolutions had to be extracted by analysis. When we consider that the stars at least, numbering some thousands, all appeared to revolve in precisely the same period round an obviously stationary earth, we can easily believe that the existence of the spheres must have seemed a necessity; but in the light of present knowledge we can see that it was not so, but was a postulate chosen for the purpose of bringing order into the observed motions.

It did so very successfully. Most of the observed motions could be described to a high degree of approximation in terms of simple circular motions, but certain unanswered questions remained. What were the spheres made of ? How were their motions maintained and communicated to one another ? Was the concave sphere of one planet coincident with the convex sphere of the next, or was there a space between them ? And so on. These were fundamental cosmological questions, and no way of answering them suggested itself.

In the course of time a revolution occurred. The spheres were abandoned, the sun and stars reduced to rest, and the earth and planets conceived as revolving round the sun in elliptical orbits under the influence of a force of gravitation falling off as the square of the distance from the sun in all directions. The fundamental experiences—the observed movements of the heavenly bodies—were now describable equally well, and even better, but in totally different terms. Instead of revolving spheres, there was gravitational force—a postulate quite foreign to the earlier scheme. At the same time, the old unsolved problems simply disappeared. It was meaningless to ask the size or composition of the spheres, or the cause of their motions, because they were not actual existences but discarded terms of expression. On the other hand, however, new problems arose of which the ancient astronomy knew nothing. What were the physical properties of a medium which could take the enormous strain of holding the planets in their orbits and yet offer no resistance to their motions ? What was the velocity of the solar system through this medium ? Such questions as these now stood in the forefront of universal problems and appeared as the fundamental enigmas of cosmology ; but, despite the concentrated attention of the greatest minds, they received no answer.

Gravitational force has now gone the way of the spheres, and new terms of expression have arisen. We no longer think of a planet as chained to a distant sun. It moves quite freely along its path, taking the easiest course in a 'space-time' having a 'curvature' which distinguishes one direction of motion from another. Again the same fundamental experiences are described with a still further improvement, and again the old unsolved problems vanish. There is no force to cause a strain between the earth and the sun, and it is meaningless to ask for the physical properties of a medium created to sustain one, or for the velocity of the solar system through such a medium. These questions belonged to the discarded terms of expression of celestial motions, not to the phenomena of the motions themselves. And, with the new outlook, just as with the older ones, difficulties are associated. One of them, for example, is the non-conformity of the petrified space-like universe which it contemplates with the dynamic universe shown by the laws of temperature.

Source of Incompatibility of Motion and Temperature Laws

As I have put the matter, the suggestion is irresistible that we should look not for the solution of this problem through an examination of the details of current theories, but for its disappearance by a change in the terms of expression of the phenomena. That is indeed what I am going to propose, but before doing so I would like to say that I fully realize that such a course should be undertaken only in the last extremity. When a system of concepts has proved to be applicable over so wide a range as that covered by current physical concepts, it needs a critical and otherwise insuperable impasse to justify even the thought of its displacement. Most scientific problems are relatively so superficial that anything so drastic as a change in the basic terms of expression would be beyond reason. When Uranus was found to move in a puzzling way, Adams and Leverrier did not begin to reform the foundations of mechanics. Rather than do that, they were prepared to call a new world into existence to redress the balance of the old, and they did so within the framework of current mechanical theory. This, of course, was the proper procedure, and, as everyone knows, it was completely successful. Indeed, so accustomed are scientific men to dealing with obstacles which can be removed in this way that they show great and usually justifiable reluctance even to entertain the idea of changing their terms of expression. Nevertheless, there are circumstances in which it is necessary to do so, particularly when one is dealing with fundamental questions involving extended extrapolation. That, I think, is the situation here. Of all physical questions, there could be none more fundamental and comprehensive than the one which we are now discussing ; and the same sense of proportion which should make us regard old and tried terms of expression as binding in ordinary matters should induce us to question them when the problem goes to the root of things.

Let us, then, try to strip from our statement of the laws of motion and temperature those parts which belong to the mode of expression, and see if the discordance remains in the character of the phenomena themselves. There is a limit beyond which it is impracticable—at any rate, to begin with—to carry this purifying process, because if we pursued it to the bitter end we should find ourselves left with nothing but bare sense-data inexpressible except by isolated *ad hoc* words between which there would be no possibility of forming even a connected sentence. Prof. E. A. Milne has rightly insisted that, in the last resort, our scale of time measurement—the convention which decides whether a period of time is equal or unequal to another—is arbitrary, and that we might have chosen a very different one. I would go further and say that, difficult as it may be to acknowledge, even the *order* of our experiences in time is, in the last resort, imposed rationally, and is not an inviolable element of the experiences themselves. But we need not, unless ultimately compelled to do so, go to the last extremity. It may be that the source of our present difficulty lies at a higher level of rational thought than that which comes next to bare experience ; and if so, it would be as foolish to go at once to rock bottom as it would be to strip ourselves naked to repair a defect in one of the outer layers of clothing. We will therefore accept our sense data, in the order in which we are accustomed to place them, but freed from all entanglement in formally expressed laws of Nature. For convenience I shall speak of this very primitively rationalized experience as 'bare experience'. We will see if in such bare experience we still find a divergence between the phenomena of motion and those of temperature.

We see at once that we do not ; the phenomena of motion, equally with those of temperature, show a one-way tendency. Corresponding to the fact that bodies tend to come to a common temperature and not to differ in temperature as much as possible, we have the fact that bodies tend to move together and not to separate from one another. This is the familiar phenomenon of gravitation. In speaking of it as a fact of experience I ignore, of course, the apparent recession of the extra-galactic nebulæ, partly because, as a bare fact of experience, that is not a motion at all but a characteristic of spectrum lines, only interpreted as a motion when we have accepted certain rather detailed terms of expression of experience; and even then, as the present disagreement among astronomers shows, not inevitably so interpreted. But I ignore it also because, even if it is taken into account, it does not alter the fact that motions show a one-way tendency, but simply indicates that the tendency is in one direction in some circumstances and in the opposite one in others; it does not make the phenomenon of motion indifferent to the direction of time as the present *laws* of motion do. The indications of bare experience can be represented by the simple idealized situation I pictured earlier. Place two bodies at different points in an otherwise empty universe. They will move in one direction, and not the opposite one, with respect to one another; and they will tend towards the same and not more widely divergent temperatures.

This common one-wayness is, in fact, shown in almost all our theories of cosmic evolution, characterizing the motions as well as the temperature phenomena of the universe. Laplace's nebular hypothesis, for example, depicted a primitive diffuse nebula evolving gradually into a complex organization of many bodies, and, quite apart from the laws of temperature, it provided no possibility of the course of events occurring in the reverse direction. Generalizing such ideas, Herbert Spencer's famous definition of evolution, concerned with matter and motion alone, included only a one-way process from the homogeneous to the heterogeneous. Even in detailed phenomena, such as the direction of revolution of the planets round the sun, we recognize that, whatever the laws of motion may allow, the planets do, in fact, go in a particular direction, and we do not regard it as possible that they will change to the opposite one. The actual, as contrasted with the possible, course of events is uni-directional. Somewhere, in building up our structure of laws of motion from the observed facts, we have introduced a liberty of movement which is not in fact taken advantage of, whereas in building up our structure of laws of temperature from the observed facts we have introduced no such liberty. The difference lies in our terms of expression of experience, and not in bare experience itself, and we must look for it there.

[1] "Relativity, Thermodynamics and Cosmology" (Oxford University Press, 1934).

[2] *Math. Ann.*, **67**, 355 (1909). The theory has been expounded very clearly by M. Born in three articles in *Phys. Z.*, **22** (1921).

[3] *Phil. Mag.*, iv, **4**, 358 (1852).

(*To be continued.*)

SOIL STERILIZATION

IN horticulture, as in other industries, the War has focused attention on ways and means which before 1939 had not received the notice they deserved. Among them is soil sterilization as a factor in food production. How to produce the greatest amount of good food has become an urgent problem for Great Britain, and there is little reason for believing that this need will be much less pressing for some years to come. To produce the quantity and quality of food we require, five things are necessary. Site, soil and cultivation must be suitable, the choice of variety must be correct and pests and diseases must be controlled. All these are important, but not every one has received proper consideration. Pests and diseases, for example, not only cause serious losses in food production, but they also waste time, labour and materials. Thus, by employing measures for the control of pests and diseases, a higher yield per plant can be obtained with greater economy than by merely increasing the number of plants.

The more intensive the system of cropping, the more likely is it that disorders will occur and the more necessary it becomes to prevent their arising. It is not surprising, therefore, to find that the demands of war have focused attention on problems of soil hygiene in the most intensive system of all, the production of crops under glass. Growers have found that yields fall off and soil pests and diseases assume serious proportions unless the soil is partially sterilized by the periodic use of heat or chemicals.

The sterilization of soils used under glass is necessary for either of two reasons. In the case of pot plants, for which virgin soil is almost always used, sterilization kills the pests and diseases normally existing in the soil. In the case of glasshouse borders which have carried the same main crop year after year and become 'soil-sick', partly through the accumulation of various pathogenic organisms and partly due to biological and chemical unbalance, sterilization is necessary to restore the resulting loss in fertility.

Cleaning up the soil by sterilization is fast becoming an indispensable routine practice under glass, and to meet the situation war agricultural executive committees have recently added to their machinery pools, apparatus for the steam sterilization of glasshouse soils. In cases where steam sterilization is not practicable chemical sterilizing agents, such as formaldehyde, are being increasingly used. Thus, the time is ripe for consideration of the methods and problems of soil sterilization, and with this in view a joint meeting for the discussion of the subject was held on April 19, between the Society of Chemical Industry (Microbiological Panel of the Food Group and the Agricultural Group) and the Association of Applied Biologists.

Dr. W. F. Bewley discussed the general aspects of the subject. Soil sickness and the depredations of eelworms were problems which, in the early years of this century, faced the glasshouse growers in the Lea Valley and elsewhere. They found by empirical methods that if the temperature of sick or infested soil was raised to 100° C. for a sufficient length of time, the harmful organisms were killed and fertility restored. The commonest method employed for glasshouse borders was to force steam into the soil to a depth of 12 in. or more by means of perforated pipes or an inverted tray. At first, pressures of 30–40 lb. per square inch were used, and steaming was carried on for 1–2 hr.; to-day pressures of 80 lb. or more are employed and steaming is for 20–30 min. only. For small quantities of soil, baking was commonly practised in earlier years. With this method, however, patchy heating and 'over-sterilization' are dangers, although if the soil is moderately wetted before it is baked the danger is reduced. Before use, baked soil must be left 4–6 weeks "to recover".

Low-pressure steaming is a method rapidly coming into favour. The soil is put into a perforated container which fits on to a trough of boiling water, the steam from which penetrates upwards through the soil. Electric sterilizers, in which the soil is heated either by the passage of the current through the soil itself, or by heaters, have also been developed. Plant growth is luxuriant following soil sterilization, and it is now clear that the fertility of glasshouse borders can be maintained over long periods if the soil is sterilized every third or fourth year and manure added from time to time to ensure good organic content and texture. As Dr. Bewley pointed out, however, although sterilization of a poor soil makes it temporarily more fertile, sterilization alone cannot change a poor soil into a rich one.

At the same time that soil sterilization methods were being developed by practical growers, critical investigations were started at the Woburn and Rothamsted Experimental Stations (1908–12). It was found that (1) weeds, weed seeds, and most soil organisms were killed at 60° C.; (2) the nitrifying bacteria and Protozoa were also killed at 60°, but the ammonifying bacteria survived 100° and in the absence of their enemies, the Protozoa, rapidly re-populated the soil; (3) heating increased the amount of soluble organic and nitrogenous matter in the soil and there was a temporary excess of ammonia; (4) seedling growth was not infrequently retarded, presumably owing to the increase in the amount of soluble organic compounds, with a consequent excess production of such substances as ammonia; (5) retardation was greatest when rich soils were heated, but no direct correlation could be established between soil fertility and the degree of retardation. It was concluded that "retardation need not cause any anxiety".

From 1920 onwards, high-pressure steam won increasing favour for the sterilization of glasshouse borders in which tomatoes and cucumbers were grown. Curiously enough it did not become popular among growers who raised pot plants from seed, and so late as 1935 very few 'mixed nurseries' regularly steamed their soil. The reason for this reluctance became apparent when, in an attempt to combat soil-borne disease, sterilized soil was first used on a large scale at the John Innes Horticultural Institution. The results were disastrous in the case of one or two species and harmful in varying degrees to a number of others. At the worst, seeds did not even germinate, while commonly seedling growth was much retarded. Mr. W. J. C. Lawrence described the investigations which led to the unravelling of the complex of factors resulting in this sterilization 'check'. Clay and sand did not react to heating; but humus gave a marked reaction. If lime was added to humus, or to a soil containing humus, before it was heated, the reaction was greater still. Prolonged heating also led to retardation. Most important of all, it was found that the addition of water-soluble phosphate (for example, superphosphate) to soil after heating counteracted the 'check' to seedling growth. From these results, and from the appearance of the plants, it was clear that the application of heat to humus resulted in its decomposition and the production of available nitrogenous compounds which, in excess, were too rich a diet for many seedlings. For example, *Primula malacoides* proved to be highly sensitive to soil sterilization by heating, whereas tomato and cucumber were among the most tolerant. In a few vigorously growing species the excess nitrogenous compounds actually accelerated growth even while the plant was still quite young.

It is now clear why steam sterilization, so widely used for the treatment of glasshouse borders, had not become popular in mixed nurseries for the raising of seedlings. The particular plants used in the experiments at Rothamsted were relatively insensitive to the effects of heating, as are the tomatoes, cucumbers and lettuces grown in glasshouse borders; and retardation or other effects were rarely so marked as to be obvious in the absence of controls. Thus, there was no *prima facie* evidence that extra precautions would have to be taken for the seedlings of other species. The variable results from sterilizing different soils could also be explained, the precise outcome depending in the main on the relative proportions of humus, lime and soluble phosphate present. Soils with relatively high humus and lime and low soluble phosphate contents give the greatest retardation when sterilized. Soils with relatively low humus and lime and high soluble phosphate contents give the least retardation. In the light of these findings an improved technique of steam sterilization for seed and potting composts was worked out at the John Innes Institution, and the benefits of soil sterilization are now available for the vast majority of plant species, without any of the various evil consequences.

The practical requirements of soil sterilization by heat can now be stated in precise terms. (i) In glasshouse borders, pests and diseases occur at a considerable depth, therefore thoroughness of heating is the vital factor. The production of nitrogenous compounds in excess is not usually of serious consequence since tomatoes and cucumbers are not planted in the borders until some weeks after sterilization, and even then not as seedlings but as established plants. (ii) For seedlings and pot plants, the vital necessity is to keep down the production of nitrogenous compounds. This can be done by the efficient use of sterilizing bins in which a relatively small expenditure of heat is adequate for the thorough sterilization of the soil. The addition of superphosphate to the soil after it has been sterilized then partially immobilizes any nitrogen still in excess.

High-pressure steam sterilization has disadvantages for the small grower, of whom there are many. The locomotive boiler and steam tubing employed involve a large capital expenditure, and the apparatus is cumbersome to use. Obviously, it was worth ascertaining whether chemical substances in solution would be as efficient as steam but more convenient, especially for the small grower. Investigations were made first at Rothamsted and later at Cheshunt Experimental Stations. No chemical sterilizer proved to be as efficient all round as steam. Wetting and penetration of the soil present difficulties, and in general the action of the chemical sterilizers is more selective than steam. Thus formaldehyde, the best of the chemical agents, restores fertility well, is a good fungicide, but it is not very lethal to soil pests. Cresylic acid, on the other hand, is efficient against pests but is not very lethal to soil-borne diseases and does not restore fertility so well as formaldehyde. If the effectiveness of steam in increasing crop weight in the tomato is taken as 100, then the figures for formaldehyde and cresylic acid may be reckoned to be less than 90 and 80 respectively. Further, whereas steaming need be done only once in every three or four years to maintain soil conditions, the chemical sterilizers must be applied every year. Improvements in the efficiency of the chemical sterilizers may be expected, however, and Mr. A. H. Dodd described the characteristics of some of the newer substances of the high-boiling phenol type.

Since the Woburn and Rothamsted experiments, practically no fundamental research has been done in

Great Britain on soil sterilization; progress has resulted from methods and experiments of an empirical nature. A new lead has now been given by Rothamsted. Mr. H. Lees and Dr. J. H. Quastel described an ingenious method whereby studies can be made of the effects of certain chemical substances on the metabolic activity of the soil microflora. The 'perfusion unit' employed gives reproducible results, and by its aid it has been established, for example, that potassium chlorate has a selective effect on the bacteria concerned in nitrification. Oxidation of ammonia to nitrite proceeds normally; but oxidation of nitrite to nitrate is inhibited. Further, it has been possible to show that the non-production of nitrate is not a direct effect of the potassium chlorate, but results from the accumulation of nitrite. Lees and Quastel were also able to show that chlorate toxicity is greatly reduced by the addition of nitrate to the soil. Vanadium has a similar effect to chlorate, but smaller; an effect which is general instead of specific. Lees and Quastel's method seems to offer excellent possibilities for further attacks on the problem of what happens to soil when it is heated.

What then is the position of soil sterilization in horticulture to-day? By trial and error methods it has been discovered how to secure the greatest benefits with the slightest risk. Too little fundamental research has been done. For example, it is not known whether excess ammonia is the only product of heating which retards seedling growth; indeed it is not even known whether ammonia is the chief agent concerned in retardation. The action of soluble phosphate on sterilized soil, the chemical effects of electricity in electric sterilizers, the wetting and penetration properties of chemical sterilizers, are other examples of problems awaiting investigation. On the applied side much remains to be done in the design of steam and electric sterilizing apparatus, and there is no reason why what now appears to be a remote possibility, automatic and ultra-rapid sterilization of soil on the moving belt system, should not be achieved under commercial conditions. The use of heavy gases, such as chloropicrin, is another field which awaits the attention of the tool designer as much as the soil chemist.

The main conclusions are clear. Under present and anticipated economic conditions in Britain, horticulture cannot go back to the days when infested and sick soil was tolerated in food production. Neither can it go forward, so far as soil sterilization is concerned, without the co-ordination of fundamental and applied research. W. J. C. L.

OBITUARIES

Mr. J. R. Norman

THE British Museum (Natural History) has suffered a great loss by the death at Tring at the premature age of forty-five and after a long illness of Mr. J. R. Norman, deputy keeper in the Department of Zoology.

Norman was born in London in 1898, and educated at St. Paul's School. His career was then interrupted by military service in the War of 1914–18. He was invalided out of the army in 1918 and resumed his education at the Imperial College of Science and Technology under the late Prof. E. W. MacBride. In 1921 he was appointed an assistant keeper in the British Museum and in 1942 was promoted to a deputy keepership. During the period of the present War he was entrusted with the charge of the branch of the British Museum at Tring.

Norman, after the retirement of the late Dr. Tate Regan, had the care of the fishes, and in this branch of zoology became the leading authority in Great Britain. He was the author of an admirable book, "The History of Fishes", and of numerous technical papers on the subject. Of these the majority deal with questions of taxonomy and morphology over a wide range of fishes and include a monograph on the Heterosomata (the flat fishes) which was published by the Trustees of the Museum. He also described collections of fishes resulting from the "Discovery", "Antarctica", "John Murray" and the "Cambridge Suez Canal" expeditions. His last work, which is on the verge of publication, is a biography of the late Dr. Charles Davies Sherborn of "Index Animalium" fame.

The rearrangement of the Fish Gallery at South Kensington and the guide book to it was his own work, and during his appointment to the charge of the Tring Museum he organized the exhibition there with great success; here he showed the width of his zoological knowledge of birds and mammals in addition to his own special subject. Both places will serve as monuments to his skill and understanding.

Norman was a fellow of the Linnean Society and of the Zoological Society, of which at the time of his death he was a vice-president.

As a colleague he was admirable from every point of view, full of enthusiasm and fertile of ideas for the good of the Museum in general. His kindly disposition made him liberal of help to others.

Owing to the complaint contracted during his military service in the War of 1914–18 Norman was never strong, but the frequent occurrence of ill-health at no time rendered him impatient nor diminished his sense of humour. He did his work and did it well and never complained. He leaves a widow and two children to whom all sympathy is due.

C. FORSTER-COOPER.

WE regret to announce the following deaths:

Dr. H. A. Buehler, geologist and director of the State Bureau of Geology and Mines, Missouri, on March 14, aged sixty-seven.

Dr. J. S. Bury, physician to the Manchester Royal Infirmary and a past-president of the Manchester Pathological Society and the Manchester Medical Society, on June 10, aged ninety-two.

Prof. J. Shaw Dunn, professor of pathology in the University of Glasgow, on June 10, aged sixty-one.

Dr. Robert A. Hatcher, emeritus professor of pharmacology and materia medica at Cornell University Medical College, on April 1, aged seventy-six.

Mr. E. Hatschek, the distinguished authority on colloid chemistry, on June 4, aged seventy-five.

Prof. Edward B. Mathews, emeritus professor of mineralogy and petrography at Johns Hopkins University, on February 4, aged seventy-four.

Prof. W. E. Tottingham, associate professor of agricultural chemistry in the University of Wisconsin, president in 1931 of the American Society of Plant Physiologists, on March 2, aged sixty-two.

Sir Cuthbert Wallace, Bart., K.C.M.G., C.B., president during 1935–38 of the Royal College of Surgeons of England, on May 24.

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

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY

Principal:
J. E. Myers, O.B.E., D.Sc. (Manchester), A.R.I.C., J.P.

DEGREE COURSES IN TECHNOLOGY

The Prospectus of University Courses gives particulars of the courses leading to the Manchester University Degrees (B.Sc. Tech., M.Sc. Tech., and Ph.D.) and Certificates in the Faculty of Technology, in the following Departments:
MECHANICAL ENGINEERING (Professor H. Wright Baker, D.Sc., M.I.Mech.E., M.I.A.E.).
ELECTRICAL ENGINEERING (Professor J. Hollingsworth, M.A., D.Sc., M.Sc.Tech., F.C.G.I., M.I.E.E.).
MUNICIPAL ENGINEERING (R. J. Cornish, M.Sc., M.Inst.C.E., A.M.I.Mech.E., A.M.I. Struct.E., F.R.San.I.).
APPLIED CHEMISTRY, including General Chemical Technology, Metallurgy and Assaying, Fermentation Processes (including Brewing), Electro-Chemistry, Colouring Matters, Foodstuffs, Fuels, and Chemical Engineering. (Professor J. Kenner, D.Sc., Ph.D., F.R.S.).
TEXTILE CHEMISTRY (Bleaching, Dyeing, Printing, and Finishing; Paper Manufacture). (F. Scholefield, M.Sc., F.R.I.C., F.T.I.).
TEXTILE TECHNOLOGY (Professor W. E. Morton, M.Sc.Tech., F.T.I.).
BUILDING (W. B. McKay, M.Sc.Tech., M.I. Struct.E.).
INDUSTRIAL ADMINISTRATION (Post-Graduate Certificate Course). (A. Roberts, M.Com., Ph.D.).

Part-time (Evening) Courses are provided in Engineering, Mathematics, and Physics, leading to the external degrees of London University in Engineering and Science.
MATHEMATICS DEPARTMENT (F. Bowman, M.A., M.Sc.Tech.).
PHYSICS DEPARTMENT (W. H. Taylor, Ph.D., D.Sc.).

For further information apply to the Registrar, College of Technology, Manchester 1.

THE ROYAL CANCER HOSPITAL (FREE)

Fulham Road, London, S.W.3.

Applications are invited for the post of Assistant Physicist in the Physics Department of the above Hospital. Applicants should preferably have had some experience of radiological physics, and, if appointed, will be expected to take part in the routine, research, and teaching work of the Department. Commencing salary £400 per annum (superannuable).

Applications, which must be received not later than July 1, 1944, should be addressed to the Secretary of the Royal Cancer Hospital (Free), from whom further details may be obtained.

UNIVERSITY OF OXFORD

READERSHIP IN PHYSICAL ANTHROPOLOGY

Applications are invited for the above Readership and should reach the Registrar of the University not later than August 31, 1944. Stipend £750 or, if the Reader should hold a stipendiary Fellowship at a College, £500. The Reader will be appointed for seven years and will be re-eligible. Preference will be given to candidates with a biological training and with special interests in problems of racial physiology. Further particulars may be obtained from the Registrar, University Registry, Oxford.

LONDON (ROYAL FREE HOSPITAL) SCHOOL OF MEDICINE FOR WOMEN

(University of London.)

8 Hunter Street, Brunswick Square, W.C.1.

Applications are invited from men or women for the post of DEMONSTRATOR IN THE CHEMISTRY DEPARTMENT from October 1, 1944, at an initial salary of £250 per annum, with superannuation benefits, and war allowance of £30 per annum.

Further particulars may be obtained from the Warden and Secretary, to whom applications should be sent by June 23, 1944.

May 31, 1944.

UNIVERSITY COLLEGE OF SWANSEA

(A constituent College of the University of Wales)
Principal: C. A. EDWARDS, D.Sc., F.R.S.

The twenty-fifth Session will open on Oct. 3, 1944.

Courses of study are provided for—
(*a*) Degrees of the University of Wales in Arts, in Pure Science, and in Applied Science (Metallurgy, Engineering, and Metallurgical Engineering);
(*b*) Diplomas of the College in Metallurgy and in Engineering;
(*c*) The training of teachers for elementary and secondary schools;
(*d*) The first medical examination of the University of Wales.
(*e*) The first year of the course for the degree of *Baccalaureus in Architectura*.
(*f*) The Preliminary Part of the scheme of study for the degree of *Baccalaureus in Pharmacia*.

College courses in Pure Science are recognized by a number of medical licensing bodies as constituting a first year of medical study.

Persons who are not desirous of studying for degrees or diplomas may attend selected classes, provided they satisfy the authorities of the College that they are qualified to benefit by such classes.

The College maintains a Hall of Residence for women students.

Entrance scholarships will be offered for competition in April, 1945.

Particulars concerning admission to the College, and of the entrance scholarships may be obtained from the undersigned.

EDWIN DREW, Registrar.
Singleton Park, Swansea.

KING'S COLLEGE NEWCASTLE UPON TYNE

(IN THE UNIVERSITY OF DURHAM)

Applications are invited for the post of Temporary Lecturer in Mathematics. Duties to commence October 1, 1944. Salary from £350 per annum, according to qualifications and experience. Further particulars may be obtained from the Registrar, King's College, Newcastle upon Tyne, 2, by whom four copies of applications, with the names of not more than three persons to whom reference may be made, must be received not later than June 26, 1944.

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

KING'S COLLEGE NEWCASTLE UPON TYNE

(IN THE UNIVERSITY OF DURHAM)

Applications are invited for the post of Lecturer in Electrical Machinery in the Department of Electrical Engineering. Salary from £500 per annum, according to qualifications and experience. Further particulars may be obtained from the undersigned, to whom four copies of applications, together with the name of not more than three persons to whom reference may be made, should be sent not later than Saturday, June 24, 1944.

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

UNIVERSITY OF MANCHESTER

Applications are invited for the post of LECTURER or SENIOR LECTURER IN GEOGRAPHY, according to the qualifications and experience of the candidates. Minimum stipends: Lecturer, £400; Senior Lecturer, £600 per annum. Duties to commence September 29, 1944. Applications should be sent not later than July 10, 1944, to the Registrar, the University, Manchester, 13, from whom further particulars may be obtained.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of ASSISTANT LECTURER IN GEOGRAPHY. Stipend £350 per annum. Duties to commence September 29, 1944. Applications should be sent not later than July 10, 1944, to the Registrar, the University, Manchester, 13, from whom further particulars may be obtained.

UNIVERSITY COLLEGE OF HULL

Applications are invited for a Temporary Lecturer in Geography. Salary up to £400, according to qualifications and experience. Particulars of the appointment may be obtained from the Registrar, to whom applications must be sent not later than June 23.

UNIVERSITY OF LIVERPOOL

The Council invites applications for the post of Assistant Lecturer (Grade III) in the Department of Organic Chemistry at an initial salary of £350 per annum. If engaged in National Service the person selected will not be required to take up the appointment until released from his present duties.—Applications, with the names of three referees, should be sent to the undersigned as soon as possible.

STANLEY DUMBELL, Registrar.

UNIVERSITY COLLEGE OF WALES, ABERYSTWYTH

Applications are invited for the newly established Research Professorship in Animal Health. The appointment will be for a period not exceeding 10 years in the first instance at a salary of £1,200, with superannuation contribution. While the subject is defined broadly as being a study of the causes and conditions of animal health and includes animal breeding, animal nutrition, and the prevention and control of animal diseases, it is expected that the Research Professor, when appointed, will work in close conjunction with the Welsh Plant Breeding Station established at the College. Further information may be obtained from the Principal.

THE ROYAL INSTITUTE OF CHEMISTRY

In view of the approaching retirement of the Registrar and Secretary (Mr. R. B. Pilcher, O.B.E.), the Council of the Royal Institute of Chemistry will shortly appoint a Secretary, who should be a Chemist of standing, with administrative ability. Salary not less than £1,500 p.a. Any Chemist wishing to be considered for this appointment is invited to send his name, in confidence, to Professor A. Findlay, Pres. R.I.C., 30 Russell Square, London, W.C.1.

Third Laboratory Technician required in the Physiology Department of the London (Royal Free Hospital) School of Medicine for Women, 8 Hunter Street, London, W.C.1. School Certificate and/or some experience desirable, but not essential. Salary according to qualifications and experience.—Application, giving full particulars of age, education, experience, and present salary, should be made in writing to the Warden and Secretary as soon as possible.

Export: Managing Director established New Zealand distributors, visiting England shortly, desires contact Manufacturers binoculars and Cameras and Associated lines. Buying Agencies required now. Substantial orders can be placed immediately manufacturing facilities available.—Write Sawell, 4 Ludgate Circus, London, E.C.4. Central 4353.

Biochemist, 38, British, M.Sc., Ph.D., F.R.I.C., reserved, desires Research post in Public Health, Agriculture or Industry. Long experience in hospital and factories (including control of staff); training in bacteriology, microrespirometry; wide linguistic knowledge.—Write, Box 194, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Research Fellow (Biochemist) required. Applications, with full particulars, to Secretary, Research Institute, 117 Grove Street, Liverpool 7.

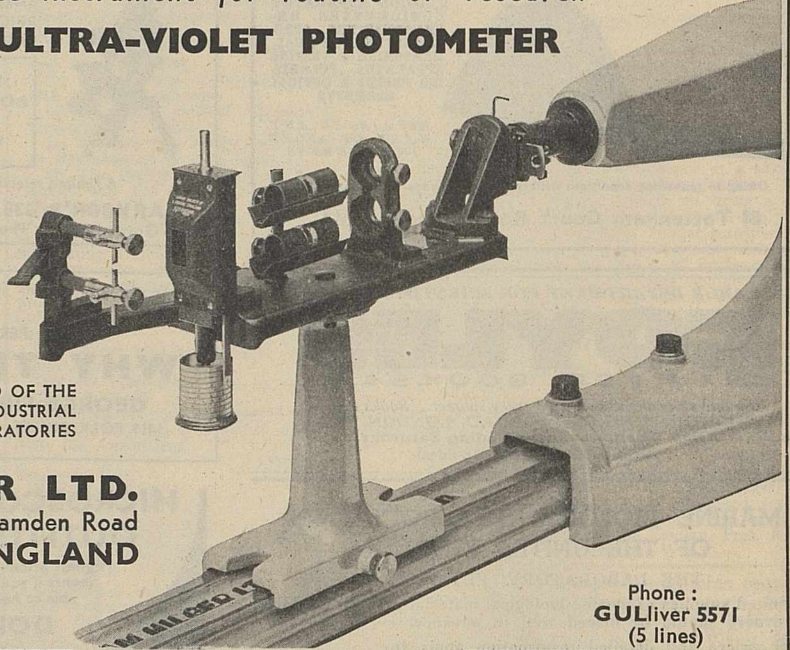
Translations of Scientific and Technical Papers from Danish, Dutch, French, German, Italian, Norwegian, Russian, Spanish and Swedish originals. Thirty-five years experience. —George Borrow, 6 St. Stephen's Grove, London, S.E.13.

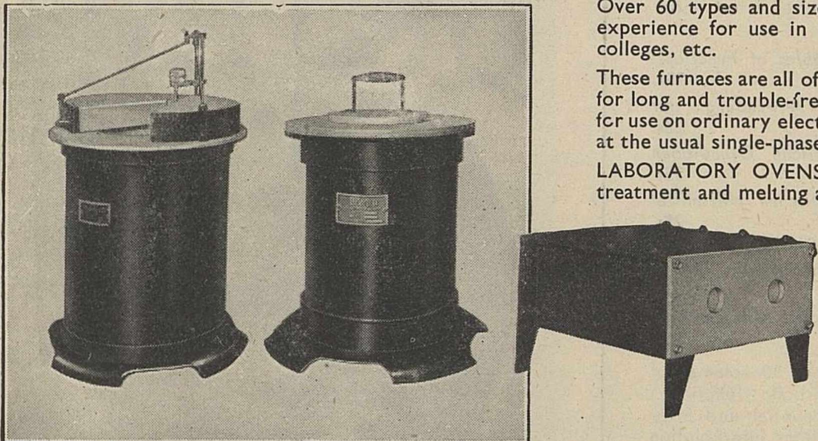
For Sale: Beilstein Vols. 1-8 and 1-8 of first supplement. Offers to Box 199, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

For Sale. A Becker Balance.—Apply Box 200, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Microscope for sale. Good condition. Beck objectives 3 and 6.—Kelvin 4136.

Microscopes, of all descriptions, only a few available second-hand, perfect condition. Send details of your requirements enclosing 3d. stamp.—Chards, Microscope Specialists, Forest Hill, S.E.23.





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NEWS and VIEWS

King's Birthday Honours

The following names of scientific men and others associated with scientific work appear in the King's Birthday honours list:

Order of Merit: Sir Henry Dale, president of the Royal Society.

K.C.B.: Sir Walter Moberly, chairman of the University Grants Committee.

Knights Bachelor: Mr. E. Rock Carling, consultant adviser in surgery and adviser on casualty services to Ministries of Health and Home Security; Mr. A. W. Clapham, secretary of the Royal Commission on Historical Monuments, and lately president of the Royal Society of Antiquaries; Dr. W. A. Daley, school medical officer, L.C.C.; Mr. W. Ll. Davies, librarian of the National Library of Wales; Prof. Alexander Fleming, professor of bacteriology in the University of London, discoverer of penicillin; Prof. H. W. Florey, professor of pathology in the University of Oxford, for services in the development of penicillin; Dr. P. Hartley, director of biological standards, National Institute for Medical Research; Dr. H. S. Houldsworth, Controller-General, Ministry of Fuel and Power; Dr. M. F. Lindley, Comptroller-General of the Patent Office; Prof. G. I. Taylor, Yarrow research professor of the Royal Society.

C.B.E.: Prof. J. D. Cockcroft, chief superintendent, Air Defence Research and Development Establishment, Ministry of Supply; Major K. Gordon, joint managing director, I.C.I. (Fertilizer and Synthetic Products), Ltd.; Mr. J. B. Grant, director of the All-India Institute of Hygiene and Public Health, Calcutta; Mr. T. C. Keeley, for services to Government scientific research and training; Capt. R. N. Liptrot, assistant director of research and development, Ministry of Aircraft Production; Dr. B. H. C. Matthews, head of the R.A.F. Physiological Laboratory; Colonel L. Newcombe, principal executive officer and librarian, National Central Library; Mr. E. F. Relf, superintendent of the Aerodynamics Department, National Physical Laboratory; Prof. W. P. Yetts, professor of Chinese art and archæology in the University of London.

C.B.: Mr. R. R. Enfield, principal assistant secretary, Ministry of Agriculture and Fisheries; Prof. L. C. Robbins, director of the Economic Section, War Cabinet Secretariat.

C.M.G.: Mr. C. W. M. Cox, adviser on education to the Secretary of State for the Colonies; Mr. J. B. Hutchinson, geneticist, Cotton Research Station, Trinidad, and cotton adviser to the Comptroller for Development and Welfare, West Indies; Mr. R. S. Mackilligan, inspector of mines and petroleum technologist, Trinidad; Mr. R. W. R. Miller, director of agriculture and sisal controller, Tanganyika Territory.

C.I.E.: Sukumar Basu, secretary to the Department of Agriculture, Bengal; Mr. G. R. Henniker-Gotley, conservator of forests, North-West Frontier Province, India.

Horace Darwin Fund of the Royal Society

The Royal Society has been offered £2,000 by an anonymous donor to establish a fund for the provision of apparatus and materials for restoring the equipment of laboratories and institutions for scientific research in enemy-occupied territory. It has been stipulated that the fund be associated with the memory of the late Sir Horace Darwin, who did so much to promote the development and use of instruments in research and its applications. The Royal Society has accepted the gift, and has agreed to create a "Horace Darwin Fund". It has been a part of German policy to destroy scientific institutions in invaded countries, after looting apparatus or other equipment likely to be of use, and it may be expected that great difficulty will be experienced in re-starting the scientific life of these unfortunate lands. The help which can be given through the provision of instruments and equipment will be an important contribution to the solution of this difficult problem, and will forge another link in the chain of international collaboration. Contributions should be sent to the Treasurer, Royal Society, Burlington House, Piccadilly, London, W.1.

Research Fellowships in the Medical Sciences at Sheffield

The Council of the University of Sheffield has received a notification from Mr. J. G. Graves, of the intention of the J. G. Graves Trustees to endow research fellowships in medical sciences at the University; the Trustees have transferred to the University £25,000 for this purpose. Alderman Graves is already known for his munificent gifts to Sheffield; he had already contributed handsomely to the building funds of the University and in particular he was the donor of the University Union building, completed in 1936, which provided, for the first time under one roof and on an adequate scale, the facilities for that corporate social life of the students which is so essential a part of a university education. By their present gift, the Graves Trustees have placed the University still further in their debt. For many years the University has been an active centre of medical research, and the achievements of Sir Edward and Lady Mellanby and of H. W. Florey are but outstanding examples from a continuous stream of work directed to the understanding and alleviation of man's bodily ills. The gift will allow the appointment, as soon as circumstances permit, of young workers to fellowships where each will, for a substantial period, devote all his attention to the investigation of some important problem in medical science in an atmosphere already most favourable to such endeavour. The gift not only enriches the scientific life of the Medical School and the University; it may well be expected that in time to come it will bear fruit in medical practice of lasting benefit to mankind as a whole.

Society of Instrument Technology

A Society, with the above title, has been formed for those interested in the design, manufacture, use and maintenance of scientific instruments. Its general purpose is the advancement of instrument technology by the dissemination and co-ordination of information relating to the design, application and maintenance of instruments. It will also provide opportunities for discussion, particularly between the designers and manufacturers on one side, and the users on the other. Among other objects of the Society are the technical education of those who wish to enter, or are already in, the industry and dealing with instrument research, design, manufacture or use; encouragement of research into problems relating to instrument technology; standardization of instruments and accessories by collaboration between manufacturers and users; and the status and prestige of those employed in the industry.

Members of Council and officers of the Society are as follow: *President*, Sir George Thomson; *Members of Council*, Dr. W. J. Clark, Mr. R. E. Iggledon, Mr. G. H. Farrington, Mr. F. C. Knowles, Dr. W. F. Higgins, Mr. D. A. Oliver, Mr. W. B. Wright, Dr. H. S. Gregory, Mr. C. R. Sams, Dr. E. Griffiths, Mr. E. B. Moss and Prof. F. Debenham; *Hon. Treasurer*, Dr. H. B. Cronshaw; *Hon. Secretary*, Mr. L. B. Lambert, 55 Tudor Gardens, London, W.3. It is intended to call a general meeting, probably in the early autumn, at which the constitution and rules, as recommended by the Council, will be submitted for the formal approval of intending members.

Supply and Allocation of Raw Materials

THE second annual report of the Combined Raw Materials Board, to January 26, 1944 (London: H.M. Stationery Office, 2*d*. net), states that the policy of the Board during 1943 has been to concentrate on those materials which were vital to the war effort, were actually or potentially scarce during 1942, and continued to demand action on a combined basis for their effective utilization. The principal metals, and the alloying metals, tungsten, cobalt, molybdenum, vanadium, chromium and manganese, have remained under continuous supervision, while supplies of rubber and hard fibres for rope-making remained critical and demanded continual attention and drastic action. Electrical and instrument programmes in connexion with aircraft and military equipment gave rise to great anxiety regarding mica and especially certain critical grades of it; the same problem of securing an adequate supply and the proper distribution of critical grades brought asbestos within the scope of the Board. The liberation of Madagascar late in 1942 led to a co-ordinated review of supplies of graphite and their allocation, and the loss of practically all supplies of silk at the time when the joint parachute programmes were making heavy calls brought the alternative synthetic fibre 'Nylon' under the Board's supervision. The output of adequate supplies of balsa wood had to be assured to make possible the production of Mosquito aircraft, while balata, bismuth, bristles, mercury, rotenone, pyrethrum and hides all came or were maintained under review during the year.

The nature of the Board's allocations has varied according to the complexity and acuteness of its problems. To ensure the maximum desired or practicable production of a material, and also that each country uses scarce materials economically, the Board works in the closest contact with the operating departments. Problems of shipping and transport have been of prime importance, and certain problems have been treated on an area basis. Combined committees for copper and steel which had been set up in association with the Combined Production and Resources Board at the end of 1942 were supplemented during 1943 by similar committees for aluminium and magnesium, coal, footwear, leather and hides, and pulp and paper. The overall raw materials position did not change radically during 1943; but serious new shortages developed in hides and wood pulp, and a Joint Hide Control Office was set up in Washington to co-ordinate the procurement of overseas hides. The overall stringency is likely to continue indefinitely and well into the post-war period, while a combined committee which investigated the forest products situation reported in October that to maintain minimum supplies of pulp products direct action would be necessary to replenish the labour force in the forests and maintain it at the necessary level. Some measure of curtailment of paper consumption is also considered inevitable.

Towards the end of 1943, the Board was faced with new problems of materials coming or likely to come into partly surplus supply, and, in common with the other combined boards, the functions of the Board were also widened to include the responsibility for making allocations necessary to meet the raw material requirements of territories to be liberated from the enemy. There were no major developments during the year in the actual organization of the Board or its machinery. The final section of the report stresses the dependence of both the United States and the United Kingdom on raw materials from overseas, and the relatively ample endowment in raw materials on which they and the other allied industrial powers have been able to draw.

Post-War Plans for Science

A MEMORANDUM on "Post-war Plans for Science", issued by the Association of Scientific Workers, gives a précis of the statement "Scientific Research and the Universities", issued by the Parliamentary and Scientific Committee, and a more critical review of "A National Policy for Industry" issued by 120 industrialists and of the report "Industry and Research" issued by the Federation of British Industries Industrial Research Committee last autumn, all of which have been discussed in NATURE. Commenting on the proposals by the industrialists for the closer organization of industry, the memorandum urges that organization of the community would be necessary to ensure that the spirit of the proposals is given effect and that the compulsory powers are not abused. With regard to the recommendations of the Federation of British Industries, the memorandum directs attention to the absence of any practical suggestion whereby the consumers or the State could participate in the decision whether certain work should be undertaken because the consumer requires it, or that the Department of Scientific Research should be encouraged to spend more on nationally owned and controlled research institutes for various industries where the results would be published for the benefit of all. While the memorandum sounds a warning against sectional interests being allowed to stunt proposals good and proper in themselves, and calls for a wider vision of the national interest, its criticism is marred by the subjective approach. The prejudice against private industry with which the memorandum starts appears to have clouded judgment to the extent that the writer is more concerned to voice suspicions of any proposals from such a source than to submit them to objective and impartial analysis.

Mineral Resources of Tanganyika

THE Department of Lands and Mines (Geological Division), Tanganyika Territory, has issued an account of the mineral resources of the Territory, prepared by Sir Edmund Teale and F. Oates (Bull. 16. Dar es Salaam, 1943. 15*s*.). This bulletin contains, in Part 1, an account of the relatively few mineral deposits that are, or have recently been worked in Tanganyika. Part 2 includes a much longer list of economic minerals the occurrence of which has been recorded in the Territory, though in many cases in small quantities only. Notes on the manner in which these minerals occur are given, with the view of assisting would-be prospectors.

Further and more systematic exploration appears to be necessary before it can be said that the economic possibilities of these deposits can be properly assessed. Part 3 contains a summary of information regarding certain specially selected minerals, for consideration in reviewing the actual and potential mineral resources of Tanganyika, more particularly in regard to war-time requirements.

Staff Selection

A paper (*J. Inst. Elec. Eng.*, **91**, Pt. 1, No. 40; April 1944) by Messrs. R. C. Woods and A. S. MacDonald discusses staff selection by scientific methods, and makes reference to the designing of tests and to the means of proving their usefulness. The use of statistical methods is considered, a number of tests being described and samples given. The application of these principles to the staff selection problems in a light electrical engineering factory is described, the procedure for staffing a new department is detailed, and reference is made to the other classes of labour which are dealt with in the factory. A note on the selection of engineer apprentices is included. The last section of the paper deals with the technique of the interview. Finally, the authors mention the origin and growth of their work as indicative of its usefulness, and refer to co-operation between various departments in the factory which are concerned with personnel.

School Hygiene in Peru

According to an annotation in the September issue of the *Boletín de la Oficina Sanitaria Panamericana*, school hygiene in Peru includes psychobiological investigation of childhood and adolescence, school health medical supervision and physical education. A special week is also set apart for an intensive programme in health education for the whole country. During the second half of 1941, 10,000 children between six and ten years were immunized against diphtheria. Medical examination of teachers before appointment has become the general practice. Sanatorium schools for tuberculous children, some of which are built in the higher altitudes with appropriate climatic conditions, have been established. Retarded children are being given attention and transferred to special schools.

Earthquakes Registered in Spain

During January 1944, twenty-nine earthquakes were registered by the seismographs at the Geophysical Observatory at Toledo. The greatest of these happened on January 16 and registered at Toledo at 00h. 02m. 41s., attaining a ground amplitude of 90μ at the Observatory. The earthquake was destructive in the province of San Juan in Argentina, South America. The nearest earthquake to Toledo during the month occurred on January 7, when eP_gz registered at 12h. 31m. 09s. from an estimated epicentral distance of 230 km.

Gas Industry in Great Britain

The Minister of Fuel and Power has appointed the following committee of inquiry into the gas industry: Mr. Geoffrey Heyworth (*chairman*), Mr. Stuart Cooper, Sir Jonathan Davidson, Mr. Gavin Martin and Prof. D. M. Newitt. The secretary of the committee will be Mr. A. F. James, of the Ministry of Fuel and Power, to whom all communications should be addressed at the Gas and Electricity Division, Ministry of Fuel and Power, New Oxford House, Bloomsbury Way, W.C.1.

The terms of reference of the committee are: "To review the structure and organization of the gas industry, to advise what changes have now become necessary in order to develop and cheapen gas supplies to all types of consumers, and to make recommendations".

Announcements

Franklin Medals for 1944 have been awarded to Dr. W. D. Coolidge, vice-president and director of research for the General Electric Company, for his development of the X-ray tube, and to Dr. P. Kapitza, director of the Institute for Physical Problems, Academy of Sciences of the U.S.S.R., for his work on extraordinarily high magnetic fields, and for designing an efficient liquid hydrogen machine.

Dr. S. Livingston Smith, superintendent of the Engineering Department at the National Physical Laboratory, Teddington, has been appointed director of research of the British Shipbuilding Research Association recently formed by the Shipbuilding Conference in close co-operation with the Department of Scientific and Industrial Research.

Dr. A. J. V. Underwood has resigned from the position of joint honorary secretary of the Institution of Chemical Engineers which he has held for the last eight years.

Dr. R. E. G. Armattoe, director of the Lomeshie Research Centre for Anthropology and Human Biology, and honorary physician in charge of Brooke Park (E.M.S.), Londonderry, has been elected a foreign member of the American Association of Physical Anthropologists.

Dr. Charles Ockrent, who has been working during the War in the Ministry of Supply and more recently has been acting in an advisory capacity in Scotland on the application of scientific control and instrumentation in industry, has been appointed to the scientific staff of the British Drug Houses, Ltd., as manager of production and development.

The following appointments have been made in the Colonial Service: R. D. Linton, agricultural officer, Tanganyika, to be senior agricultural officer, Tanganyika; G. W. Nye, deputy director of agriculture, Uganda, to be director of agriculture, Nyasaland; A. S. Richardson, director of agriculture, Nyasaland, to be director of agriculture, Uganda; E. G. Staples, senior agricultural officer, Uganda, to be director of agriculture, British Honduras; A. S. Stenhouse, agricultural officer, Tanganyika, to be senior agricultural officer, Tanganyika; W. A. Burns, G. S. Cowin, M. A. Molloy and N. R. Reid, veterinary officers, Tanganyika, to be senior veterinary officers, Tanganyika.

We have received from the Freshwater Biological Association a copy of Scientific Publication No. 8 which takes the form of "Keys to the British Species of Aquatic Megaloptera and Neuroptera", written by D. E. Kimmins of the British Museum (Natural History). It provides an admirable account of these insects accompanied by excellent original illustrations of their chief structural features. Its low price of 1*s*. 6*d*. should ensure it being in the hands not only of entomologists but also of all students of the freshwater fauna. It can be obtained from the Director, Freshwater Biological Association, Wray Castle, Ambleside, Westmorland.

LETTERS TO THE EDITORS

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

Evolution of Modern Man (*Homo sapiens*)

THE discovery of a fossil human skull near Keilor, an outer suburb of Melbourne, is a matter of high importance to students of human evolution, who will certainly welcome Dr. Zeuner's[1] confirmation of the great antiquity attributed to it by Mr. D. J. Mahony, namely, that it represents a native Australian of the last (Riss – Würm) interglacial period. In seeking for the homeland of this ancient representative of *Homo sapiens*, neither Dr. Zeuner nor Dr. Wunderly, who was entrusted with the description of the skull, allude to the most probable source of the aboriginal population of Australia, namely, the early pleistocene races of Java, typified by *Pithecanthropus erectus*.

The first to suspect that the Australian aborigines were related to the ancient Javanese was Hermann Klaatsch, who visited Australia in 1904 to make a study of the aboriginal skull. In a report issued in 1908[2] this passage occurs: "My recent experiences show so many connections between Pithecanthropus and Australian and Tasmanian skulls that I am more inclined than before to accept a very close approximation of Pithecanthropus to the first tribe of human beings". The next link in the chain of evidence came in 1914 when the British Association visited Australia. The Talgai skull was then examined and accepted as probably of pleistocene age, an assumption now vindicated by the discovery of the Keilor specimen, for the Talgai, to my eye, is the more primitive of the two. Then, in 1920, Eugène Dubois published an account of two ancient skulls from Wadjak, in Java; he regarded them (I think rightly) as Proto-Australian in type. Even so late as 1931, I was still in doubt as to the ancestral position of Pithecanthropus[3]. Then, with the discovery of later fossil types in Java by Dr. Oppenoorth in 1932, and the subsequent additions made to the Pithecanthropoid family by Dr. G. von Koenigswald, it seemed to me the chain of evidence that links the Australian aborigine of to-day with Pithecanthropus of the early pleistocene was complete, and I said so in 1936[4]. In a great monograph which has just appeared[5], Dr. Weidenreich has reached independently the same conclusion as to the origin of one type of modern man—the aboriginal type of Australia.

Dr. Weidenreich and I are also in agreement in tracing the Bushman of South Africa from the primitive fossil type found in Northern Rhodesia—*Homo rhodesiensis*; we are also both convinced that Sinanthropus lies on or near the line which gave rise to races of the Mongolian type. Here, then, are three of the present-day types of man traced to separate pleistocene origins. Most of us who, a decade ago, were making a special study of the fossil remains of man believed that we should find, some day, the remains of a type which would serve as an ancestor for all living races, and that we should find this ancestral type spreading abroad in the world, exterminating the other early pleistocene types; all the evidence has gone against this supposition. The only man, so far as I know, who guessed that living human races had, in a physical sense, approached nearer to each other as time went on was the Swiss anthropologist, Karl Vogt[6]. Darwin considered Vogt's suggestion, but rejected it as improbable[7]. Yet it is known that convergence of a very similar nature took place in the evolution of horses.

I have mentioned that as regards the origin of modern races of mankind, Dr. Weidenreich and I have reached a large measure of agreement, all save in the case of that most ancient of Englishmen, Piltdown man (Eoanthropus). Dr. Weidenreich is of the belief that all surviving races of mankind have passed through a "Neanderthaloid" stage in their evolution, a stage which was apparently omitted in the case of Piltdown man. He is therefore removed by Dr. Weidenreich from the list of authentic fossil men, his skull being assigned to a modern type of man, while his lower jaw is given to a fossil anthropoid akin to the orang. Virchow solved the mixed simian characters of Pithecanthropus in a similar way, assigning the skull to an ape and the femur to a man. In England we find it hard to believe that there lived in the Weald of Sussex, in earliest pleistocene times, a modern type of man and a rather human-like ape, and that by some strange chance the bones of these two became mingled in the Piltdown gravel bed. Not only was the Piltdown race alive in England when the rest of Europe seems to have been occupied by human stock of the Neanderthal breed, but also this ancient race appears to have come down to mid-pleistocene times; at least it is on such a supposition we can best explain the characters of the Swanscombe and London fossil skulls.

Another problem bearing on the evolution of modern races has again cropped up in connexion with the discovery of the Keilor fossil skull. This skull exhibits a mixture of Tasmanian and Australian features. Dr. Wunderly explains the mixture by regarding Keilor man as a hybrid—the result of a union between Tasmanian and Australian races. We do not know of the existence of these two races until long after the Keilor period; if we believe in evolution, then our attitude to Keilor man should be to regard him as a representative of the ancestral stock from which both Tasmanian and Australian races have emerged. The same problem arises in connexion with the Skhūl people of Mount Carmel. They possess both Neanderthal and 'modern' (Cro-magnon) features. Dr. McCown and I explained the mixture by regarding the Skhūl people as transitional between the older Neanderthal type and the recent or modern type[8]. Those who maintain that the Skhūl people are the mixed progeny of Neander – Modern parents must first convince us that the modern type of man was in existence before the Riss – Würm interglacial period.

ARTHUR KEITH.

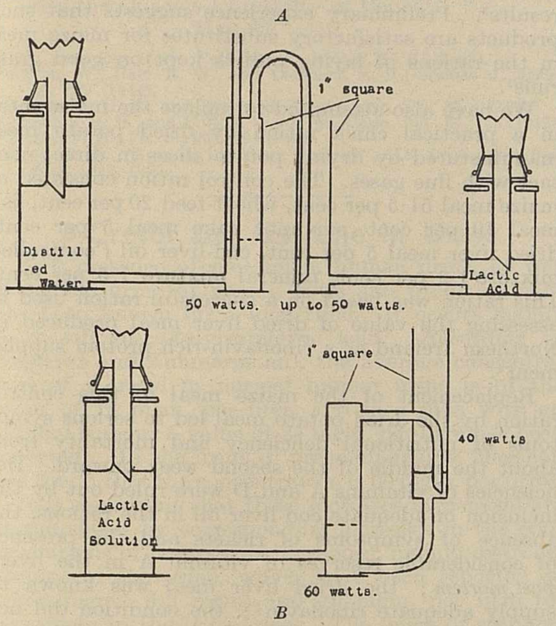
Downe, Kent.
May 22.

[1] NATURE, **153**, 622 (1944).
[2] Reports from the Path. Lab., Lunacy Dept., N.S.W., 1, 163 (1908).
[3] "New Discoveries Relating to the Antiquity of Man", 28, 312.
[4] NATURE, **138**, 194 (1936).
[5] "The Skull of *Sinanthropus pekinensis*; a Comparative Study on a Primitive Hominid Skull", *Palæontologica Sinica*, No. 127 (Dec. 1943).
[6] Vogt, Karl, "Lectures on Man", 468 (1864).
[7] "Descent of Man", Chap. 7, Pt. 1, 274.
[8] McCown and Keith, "The Stone-Age of Mount Carmel", 2 (Oxford, 1939).

Vaporization of Lactic Acid as an Aerial Bactericide

IN an earlier communication[1], an account was given of the bactericidal action of lactic acid vapour. Further work has shown that the methods of vaporization used until that time were inefficient, and that effective bactericidal action is obtained when the concentration of acid vapour in the air is 3·5 mgm./cu. metre.

Lactic acid cannot be boiled at ordinary pressures without decomposition. Dropping the acid or its aqueous solution on to a hot plate also leads to considerable loss of acid. Dispersal as a fine spray is satisfactory from the point of view of avoiding loss or decomposition of acid; but for continuous operation needs cumbersome and expensive apparatus. Lactic acid is, however, readily volatile in superheated steam, and two forms of apparatus for effecting this have been devised and are shown in the accompanying diagram. With appropriate modifications they are, of course, also suitable for the vaporization of other bactericidal substances volatile in steam.



In type *A*, water is fed from a constant-head feed system into a closed electrically heated boiler. The steam from this boiler is then allowed to bubble through the lactic acid in an electrically heated pot into which the lactic acid is fed from another constant-head feed system. The rate of evolution of lactic acid vapour depends on (*a*) the rate of steam flow, to which it is directly proportional, (*b*) the temperature of the pot, which is maintained at any desired point between 120° and 180° C. by adjusting the heat supply.

In type *B* an aqueous solution of lactic acid is fed into a closed electrically heated boiler from a single constant-head feed system. The water is largely boiled off and the concentrated lactic acid passes into an electrically heated pot. The steam from the first boiler is allowed to blow off through the lactic acid in this pot. The wattages of the two heaters are adjusted to maintain the second pot between 120° and 180° C. For given wattages the temperature of the second pot and the output of vaporized lactic acid are controlled by the concentration of the initial lactic acid solution, which may be varied from zero up to 20 per cent lactic acid by weight. For smooth working the boiler must have adequate thermal capacity; a mass of 250 gm. of brass is usually sufficient, but twice this is preferable.

Both types, as illustrated, have a maximum output of about 12 gm. of lactic acid vaporized per hour, and have been constructed mainly from brass, with all joints brazed. Corrosion of the metal and formation of non-volatile polymers appear to be negligible under working conditions; but it is probably desirable to flush out the system occasionally. Distilled water must, of course, always be used to avoid furring up the boiler.

J. E. LOVELOCK.
O. M. LIDWELL.
W. F. RAYMOND.
National Institute for Medical Research,
London, N.W.3. May 16.

[1] Lovelock, J. E., Lidwell, O. M., and Raymond, W. F., NATURE, 153, 20 (1944).

Role of Manganese in the Biological Synthesis of Ascorbic Acid

I HAVE adduced evidence[1] that manganese has a specific role in the synthesis of ascorbic acid by plants and animals. Until now the evidence of the synthesis of ascorbic acid in presence of manganese has been chemical; that is, by titration with the indophenol reagent. Evidence that the indophenol-reducing substance synthesized is identical with vitamin C has now been obtained.

Phaseolus radiatus seeds were germinated in distilled water and in separate and mixed dilute solutions of sodium chloride, magnesium sulphate and manganous chloride. The grains germinated in solutions containing manganese, within certain minimal concentration, alone showed a largely increased synthesis of ascorbic acid; the other salts had no effect upon the synthesis of ascorbic acid. Young growing guinea pigs were divided into three groups and kept on a scorbutic diet of oatmeal, 63; bran, 10; casein, 20; linseed oil, 2; codliver oil, 2; sodium chloride, 1; calcium phosphate, 2. One group was supplemented daily with 0·5 mgm. of synthetic ascorbic acid. The second group was supplemented with a given amount of *Phaseolus radiatus* germinated in distilled water for one day and calculated to contain 0·5 mgm. of total (reduced and dehydro-) ascorbic acid. The third group was similarly supplemented with a given (smaller) weight of *Phaseolus radiatus* germinated in 0·002 per cent manganese solution for one day and containing 0·5 mgm. of total ascorbic acid. The experiment lasted three weeks.

The results are given in the accompanying table. The two groups supplemented with germinated *Phaseolus radiatus* showed exact parallelism in their growth-rate, and closely agreed with the growth-rate of the group supplemented with synthetic ascorbic acid. This establishes the identity of the increased indophenol-reducing substance synthesized by *Phaseolus radiatus* when germinated in 0·002 per cent manganese solution with vitamin C.

In another set of experiments guinea pigs (120–150 gm. in weight) kept on the above scorbutic diet were divided into two groups. One group was

Substance fed	Ascorbic acid content (av. of 3 weeks) (mgm./gm. original seeds)	Ascorbic acid fed (mgm.)	No. of pigs	Av. initial wt. (gm.)	Av. wt. after 3 weeks (gm.)	Av. increase in wt. after 3 weeks (gm.)
Synthetic ascorbic acid	—	0·5	6	115	181	66
Phaseolus radiatus germinated in distilled water	0·80	0·5	6	116	176	60
Phaseolus radiatus germinated in 0·002% Mn	1·03	0·5	6	106	165·5	59·5

given intraperitoneal injections of 25 mgm. glucose dissolved in ½ ml. of distilled water. The second group similarly received 25 mgm. glucose dissolved in ½ ml. of 0·04 per cent manganese solution. The injections were given daily for 14 days and then the animals were killed, cross-sections of the root of lower incisors taken, the histological structure studied and the degree of protection against scurvy judged according to the Key and Elphick[2] scale. The number of animals employed in each group was five.

The animals in the group injected with glucose alone had a degree of protection of 0, showing that no synthesis of ascorbic acid had taken place in these animals. The animals in the group injected with glucose in manganese solution had, on the other hand, an average degree of protection of about 3. Some animals had complete protection (degree 4) against scurvy (see photograph). This proves that the animals injected with glucose in manganese solution had synthesized ascorbic acid, thus affording themselves partial or complete protection.

The experiments recorded above support my hypothesis that manganese is indispensable for the synthesis of ascorbic acid by animals and plants, and that the non-synthesis of the vitamin in primates and the guinea pig is due to an insufficiency of the metal at the seat (jejunum) of ascorbic acid synthesis. Further investigations are in progress.

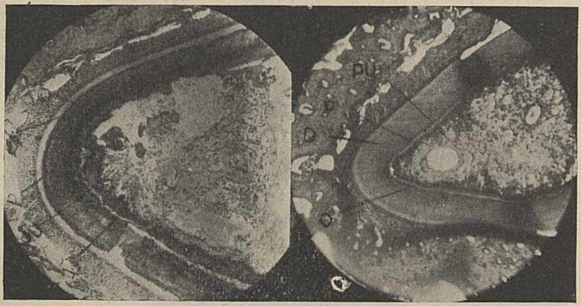


Fig. 1. Fig. 2

Fig. 1. SECTION OF ROOT OF LOWER INCISOR OF GUINEA PIG INJECTED WITH GLUCOSE ONLY.
Degree of protection, 0. Narrow dentine; wide calcified predentine; wide inner dentine; odontoblasts disorganized and migrating into pulp which is also disorganized.

Fig. 2. SECTION OF ROOT OF LOWER INCISOR OF GUINEA PIG INJECTED WITH GLUCOSE IN MANGANESE SOLUTION.
Degree of protection, 4. Wide dentine; narrow uncalcified predentine; inner dentine absent; odontoblasts long and parallel; pulp normal.

D, dentine; *p*, predentine; *I.D.*, inner dentine; *O*, odontoblasts; *pu*, pulp.

I wish to record my grateful acknowledgment to the governing body of the Indian Research Fund Association for placing funds for this investigation at my disposal.

M. N. RUDRA.

Department of Medical Chemistry,
Prince of Wales Medical College,
Patna.
March 24.

[1] NATURE, **141**, 203; **143**, 811; **144**, 868; **151**, 641. *Biochem. Z.*, **301**, 238. *Oesterr. Chem. Z.*, **42**, 315. *J. Indian. Chem. Soc.*, **17**, 705. *Ann. Biochem. Exp. Med.*, **2**, 9.
[2] *Biochem. J.*, **25**, 888.

Dried Potato Products and Nutritional Encephalomalacia in Chicks

THE feeding value of dried potato products has been investigated at the Agricultural Research Institute of Northern Ireland, chiefly from the point of view of their value as substitutes for maize meal and other cereal products in rations for pigs and poultry. Excellent results have been secured with fattening pigs[1,2], in agreement with Woodman's results[3]. Preliminary experience suggests that such products are satisfactory substitutes for maize meal in the rations of laying pullets kept on good grass runs[1].

We have also attempted to replace the maize meal in a practical chick ration by dried potato meal manufactured by drying potato slices in direct contact with flue gases. The control ration consisted of maize meal 51·5 per cent, wheat-feed 20 per cent, fish meal 10 per cent, earthnut cake meal 5 per cent, dried liver meal 5 per cent, cod-liver oil ('controlled mixture') 2 per cent, mineral mixture 1·5 per cent. This ration was based on a successful ration used in assessing the value of dried liver meal produced in Northern Ireland as a riboflavin-rich protein supplement[4].

Replacement of the maize meal of this control ration by the dried potato meal led to serious symptoms of nutritional deficiency and mortality from about the middle of the second week onward. Deficiencies of vitamins A and D were ruled out by the inclusion of adequate cod-liver oil in the rations, the absence of symptoms of rickets and the presence of considerable reserves of vitamin A in the livers *post mortem*; the dried liver meal was known to supply adequate riboflavin[4]; the condition did not respond to dried yeast or to massive doses of thiamin hydrochloride or pyridoxin; and calculation seemed to exonerate pantothenic acid deficiency, especially in view of the absence of dermatitis.

Afterwards, Dr. Blakemore, of the Institute of Animal Pathology, Cambridge, directed our attention to Asplin's work[5] on an outbreak of nutritional encephalomalacia in Great Britain. Asplin's clinical description applies in detail to the clinical picture observed by us, except that we have also noted well-marked intermittent tremors, as though the heat regulatory system was impaired. Such tremors, however, are included among the symptoms of 'crazy chick disease' (nutritional encephalomalacia) by Titus[6].

We have now repeated these experiments with rations essentially similar to that described above and have confirmed the diagnosis of nutritional encephalomalacia from the occurrence of the characteristic massive œdema of the cerebellum and pin-point hæmorrhages of its surface in affected chicks;

Prof. J. H. Biggart has very kindly further confirmed the nature of the brain lesions by sectioning.

While our work on this subject is not yet completed, we think it advisable to direct attention to these observations in view of their possible practical significance. It is possible under war-time conditions that potatoes and dried potato products may frequently be regarded as cereal substitutes in chick-rearing rations, which are also likely to contain cod-liver oil. Incorporation of cod-liver oil with cereal products is well known to lead to oxidative destruction of vitamins E, and where the proportion of cereal is low or stale meals are used, nutritional encephalomalacia may be encountered. It is clear that, under war-time conditions, obscure types of leg-weakness other than rickets or curled-toe paralysis (riboflavin deficiency) may be due to nutritional encephalomalacia and should be checked by macroscopic and, where possible, microscopic examination of the cerebellum.

R. H. COMMON.
W. BOLTON.
Ministry of Agriculture for Northern Ireland,
and the Queen's University of Belfast.
May 22.

[1] *16th Ann. Rep. Agric. Res. Inst. N. Ireland*, 16 (1942–43).
[2] Bolton, W., Hale, R. W., and Common, R. H., *Scottish J. Agric.*, **24**, 229 (1944).
[3] Woodman, H. E., and Evans, R. E., *J. Agric. Sci.*, **33**, 1 (1943).
[4] Common, R. H., and Bolton, W., *J. Soc. Chem. Ind.*, **61**, 153 (1942).
[5] Asplin, F. D., *Vet. J.*, **96**, 449 (1940).
[6] Titus, H. W., "Keeping Livestock Healthy", *U.S. Dept. Agric. Year Book* 1942, 1075.

p-Cresol and Œstrone in Urine

THE presence of *p*-cresol in human urine, as well as in the urine of horses, cows and other animals, has been known for a long time. It occurs mainly as a salt of *p*-tolylsulphuric acid. According to Siegfried and Zimmermann[1], the average concentration of *p*-cresol in normal human urine is of the order of 18 mgm. per litre, and in a man with an adrenal tumour a value of 25 mgm. per litre has been reported[2]. In the urine of pregnant mares, Marshall has found that the concentration is 60 mgm. per litre[3].

It is significant that these increases in *p*-cresol are accompanied by corresponding increases in the concentrations of œstrogenic hormones, mainly œstrone, present in the urine, which have been reported as 0·016 mgm., 0·3 mgm. and 10 mgm. per litre respectively in the three cases. The urine of stallions provides an even richer source of œstrone, the concentration reported being of the order of 17 mgm. per litre[4]. We have confirmed this figure for total œstrogen, and in addition have found that the concentration of *p*-cresol in this instance reaches the remarkably high value of 550 mgm. per litre. Approximately 25 gm. of *p*-cresol (benzoate, m.p. 72°; aryloxyacetic acid derivative, m.p. 134°) were isolated from the strong phenolic fraction from 10 gallons of the mixed acid-hydrolysed urine from two stallions. It is also known that the œstrone content of human urine increases progressively during pregnancy, and Falsia[5] has reported that there is a corresponding increase in the *p*-cresol content.

The origin of the phenol and cresols in urine is usually attributed to tyrosine, and in support of this view it has been claimed that the concentration of phenols in urine increases with an increase in protein intake. On the other hand, Fricke[6] has pointed out that the phenolic constituents of urine are most abundant in Herbivora, and has claimed that the quantity in human urine is increased on a vegetable diet. These considerations seem to indicate that tyrosine and intestinal putrefaction may not be the sole source of phenols in urine, and the above correlation between the elimination of œstrone and *p*-cresol suggests the possibility that not only the former but also the latter may be derived from the male hormone or some related steroid. On this basis the *p*-cresol could arise from ring *A* of the steroid molecule, in which the hydroxyl and methyl group are correctly placed. This possible connexion between the natural sex hormone and simple phenols, coupled with the known œstrogenic activity of many phenolic compounds of comparatively simple structure, recalls the suggestion, originally due to Dodds[7], that the true œstrogenic agents may be relatively simple compounds resulting from the breakdown of the cyclopentanopolyhydrophenanthrene system.

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A Search for Endemic Areas of Trichinosis in Great Britain

ALTHOUGH the life-history of *Trichinella spiralis* has been known for nearly a century, we are still very ignorant of the epidemiology of trichinosis in man—a gap in our knowledge which remained unsuspected until Hall[1] discovered the frequent occurrence of sub-clinical human infestation in the United States. A repetition of Hall's work more recently carried out in Great Britain by Van Someren[2] and later by Miss M. Young[3] has revealed that a similarly high incidence of infection is to be found here. Interest in the epidemiology of the infection in Great Britain has been still further stimulated by the outbreaks of clinical trichinosis which occurred during the winter of 1940–41 at Wolverhampton, Penrith and Harpenden[4,5] accentuating the urgency for the discovery of the origin of infection.

In the past, it has been generally supposed that outbreaks of trichinosis in Great Britain are traceable to the importation of infected pork, which occasionally finds its way through the meat inspection; but this now appears to be an inadequate explanation, and it seems more than likely that reservoirs of infection exist among animals in our own country.

Although Leiper[6] was able to demonstrate infection in rats at centres where trichinosis had been diagnosed in man, the general incidence of rat infection throughout Great Britain appears to be very low. The attempted detection of hitherto unrecognized endemic areas through the examination of rat carcases appeared therefore to be an unpromising line of research, and it was thought that the examination of the carcases of rat-eating animals might be more likely to produce a result, as their skeletal muscles would present evidence of trichinosed flesh having been eaten at any time during their whole lives. Some 636 stoats, 78 weasels and 2 polecats were secured for this purpose, through the medium of the pest officers in various counties, and were subjected to a thorough examination. In this process portions of the masseter muscles, intercostal muscles, tongue, muscles of the hind leg and the whole of the diaphragm were examined as crush preparations under the microscope. The rest of the muscle was then cut off the bones and subjected to peptic digestion and afterwards examined, but the whole laborious and malodorous process was carried out without revealing the presence of a single larva of *Trichinella spiralis*.

The carcases received for examination came from the following counties: Northumberland 11, Cumberland 74, Westmorland 39, Lancashire 148, Yorkshire 42, Cheshire 6, Lincoln 106, Flint 2, Nottingham 21, Leicester 1, Shropshire 4, Warwick 1, Worcester 15, Rutland 1, Northampton 3, Huntingdon 4, Cambridge 3, Norfolk 29, Suffolk 8, Oxford 8, Hereford 2, Gloucester 26, Berkshire 2, Buckingham 15, Bedford 1, Hertfordshire 2, Surrey 1, Hampshire 17, Wiltshire 5, Dorset 12, Somerset 1, Devon 2, Isle of Wight 2, Caernarvon 52, Montgomery 3, Radnor 3, Pembroke 1, Glamorgan 2 and Carmarthen 5. (The uneven distribution of the animals does not in any way reflect their distribution throughout the country as a whole, but only the facilities at the disposal of the various pest officers.)

Experimental feeding of trichinosed flesh to ferrets, which animals are believed to be domesticated polecats, showed that infection very readily occurred. The mink is also known to be very susceptible, and there is every reason for believing that were trichinosis at all prevalent among the rats in any district from which wild mustelids were examined, the larval parasites would have been found. It is unfortunate that we were unable to secure stoats or weasels from any of the regions in which trichinosis had recently appeared in man; but even in the absence of this positive control to the observations, it is considered that the negative findings in 716 small Carnivora from so many widely distributed parts is a useful indication of the sparse distribution of *Trichinella spiralis* throughout England, and suggests that reservoirs of infection are confined to a few relatively small areas.

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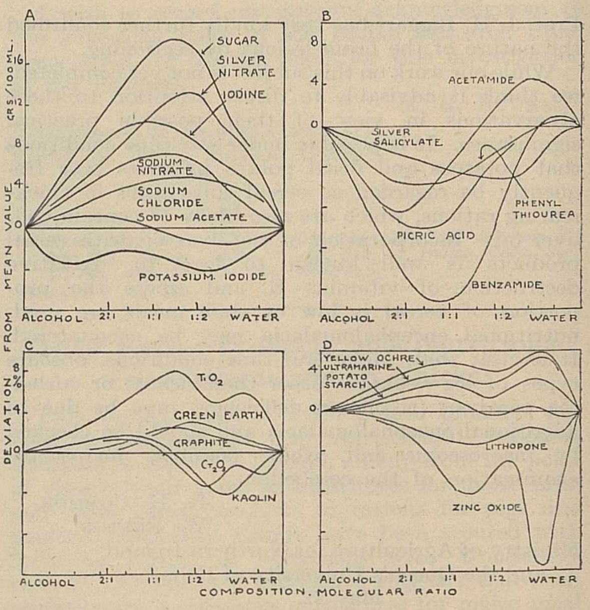
Flocculation in Solutions and Suspensions

Flocculation in suspensions of finely divided solids in liquids can be readily demonstrated either by microscopic examination or by experimental methods; flocculation is mainly the cause of anomalous viscosity behaviour and thixotropy.

Solute particles, whether of sodium chloride, mercuric bromide, soaps or shellac, appear also to be aggregated in some circumstances, and this is demonstrated by comparing the properties of the solutions with those of the suspensions, especially in mixed liquids. The degree of flocculation of a suspension can be gauged by the ultimate sediment volume and rate of sedimentation, flocculation being associated with a large sediment volume and a relatively high rate of sedimentation. In the accompanying graphs



Relation between deviations from mean solubility and sediment volume (ordinates) and molecular composition (abscissæ) for solutions and suspensions in alcohol - water mixtures.

are compared, for solutions and suspensions in ethyl alcohol – water mixtures, the deviation below the mean solubility value of several crystalloids and the deviation above the mean value of sediment volumes of several finely divided pigments. The shapes of the curves are similar, there being a maximum deviation in the neighbourhood of the composition two molecules water, one molecule alcohol.

The specific viscosity of salt solutions, colloidal solutions and suspensions alike varies with the viscosity of the liquid medium, being lower in liquids of low viscosity than in viscous media[1]. The specific viscosity of solutions of mercuric salts, aluminium chloride, sodium chloride, etc., and of suspensions of zinc oxide, titanium oxide, etc., in alcohol increases with addition of water following the increased viscosity of the medium.

The explanation of this behaviour that the higher specific viscosities are due to the longer times of orientation of asymmetric particles in the more viscous liquids can be amplified by assuming the presence of flocks which tend to orientate and break up in the stream of flow. Flocculation, akin to the sol $\rightleftharpoons$ gel transition, is a kinetic process, the solvated particles on collision tending to aggregate momentarily at least. In liquids of higher viscosity the particles moving more slowly and with a kinetic energy less in proportion to the increase in viscosity are less likely to disengage themselves from the cohesive force after collision.

With colloidal solutions of cellulose derivatives, proteins, resins and other large-molecule substances in mixed liquids, it is usually found that above a certain concentration the optimum solvent mixture yields solutions of minimum viscosity, and Palit[2] has shown that these are affected less by temperature than those in other mixtures. With the optimum solvent mixture there is a nearest approach to a solution of single molecules, which is less affected by temperature than mixtures containing higher proportions of flocculated particles. Palit, from his work on shellac, has expressed the view that the explanation of the viscosity behaviour in mixed liquids has its roots in the gelation (flocculation) capacity of the system, and such solutions above the minimum gelation concentration may be regarded in a limited sense as incipient gels. In other words, in solutions of some concentration and in the poorer solvents, such as, for example, in the mixture two molecules water one molecule alcohol, the solute molecules are to a greater or less extent in an aggregated state.

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Singlet Terms in the Spectrum of Molecular Nitrogen

IN recent papers communicated at about the same date, one of us[1] has reported a number of singlet band systems in the absorption spectrum of nitrogen in the extreme ultra-violet, while the other[2] has given details of several singlet systems obtained in emission in the near ultra-violet. These two sets of systems do not have any electronic levels in common as they are of different symmetry, but unfortunately the same letters have been used by both of us in designating some of the electronic states.

To avoid confusion, we suggest that primes be affixed for the upper states *p*, *q*, *r*, *s* and *t* of the new emission systems, while the lower level of the Fifth Positive (van der Ziel) system and of Kaplan's systems be designated *a'* instead of *v*. (*a'* and *a* would then occupy a position roughly analogous to that of *b'* and *b*.) We shall also refer to state *o'* as *o* (without prime), as it is now[1] scarcely necessary to emphasize its distinction from an earlier, but discarded, *o* grouping.

The known singlet states of molecular nitrogen are listed here using the revised notation. For convenience we include an abbreviated table of the most important constants, in which some of the values have been slightly 'rounded'. The vibrational constants of the normal state, and ν_0 for $a^1\Pi$ and $b'^1\Sigma$ are from Birge and Hopfield[3]. The value for B_0 of $X^1\Sigma$ has been discussed previously (ref. 1, footnote 37). Levels *g*, *f* and *h*, which may not all be separate states[1], have been extrapolated from measurements by Watson and Koontz[4]. The constants for *b'* are from Tschulanowsky[5]; for other states designated by primes and for *a*, *w*, *x* and *y*, they are derived from a study of emission systems in the near ultra-violet[2]. Absorption systems in the far ultra-violet provide slightly less accurate data for the remaining states[1]. Values of *B* and ω enclosed in parentheses correspond to the stronger absorption bands of a *v'*-progression for which the (0, 0) band was probably not observed; they are presumed to be associated with levels for which $r'_{\text{min.}} \sim r_0''$. In these cases, estimated potential minima ($\sim \nu_e$) are given[1].

The apparent absence of absorption to levels *x* and *y* makes it likely that these states are of *g* symmetry. State *a'* would then be of type $^1\Sigma_u^-$, and would probably correspond to one of this character predicted on theoretical grounds, namely, by addition of a $\sigma_g 2p$ (that is, anti-bonding $v\pi$) electron to the low-lying $^2\Pi_u$ state[6] of N_2^+. Level *a'* would then be metastable, irrespective of whether it lies above or below $a^1\Pi_u$, and may thus be of importance in the formation of active nitrogen.

State		ν_0 ($\sim\nu_e$)	B_0 (B_v)	$\omega_{1/2}$(ω_v)
v	$?_u$	(119,000) ?	($\lesssim$1·9)	(925)
u	$^1\Sigma_u^+$	(116,000)	(1·07)	(530)
t	$?_u$	(115,000) ?	(1·04)	(460)
s	$?_u$	(113,000) ?	(1·06)	(500)
t'	$^1\Sigma_g^-$	112,774	1·63	
h	$?_u$	112,770	$\lesssim$1·9	
s'	$^1\Sigma_g^-$	110,662	$1{\cdot}58_5$	
f	$?_u$	110,190 *E*	$\lesssim$1·9	
g	$?_u$	108,950 *E*	<1·99	
o	$?_u$	107,655 *H**	$\lesssim$1·8	1918
r	$^1\Sigma_u^+$	(107,000)	(1·06)	(630)
y	$^1\Pi_g$ (or $^1\Pi_u$)	*a'* + 46,420	1·80	1705 ?
r'	$^1\Sigma_g^-$	106,373	1·67	
x	$^1\Sigma_g^-$ (or $^1\Sigma_u^+$)	*a'* + 45,463	$1{\cdot}73_5$	1869
q'	$^1\Pi_g$	05,351	$1{\cdot}36_5$	
q	$^1\Pi_u$	(105,000)	(1·09)	(670)
p'	$^1\Sigma_g$	104,328	1·93	
c	$^1\Pi_u$	104,316 *H*	1·92	2180
p	$^1\Pi_u$	(104,000)	(1·21)	(730)
b'	$^{1-+}$	103,678 *E*	1·144	741·3
m	$^1\Sigma_u^+$ (or $^1\Pi_u$)	(103,000)	(1·35)	(760)
b	$^1\Pi_u$	101,454 *H*	1·41	698
w	$?_g$ (or $?_u$)	*a'* + 40,914	>1·47	1711 ?
j	$^1\Sigma_u^+$	(99,000) ?	(1·45)	
i	$?_u$	(97,000) ?	($\sim$1·5) ?	(670)
a	$^1\Pi_u$	68,956	1·61	1666·7
a'	$^1\Sigma_u^-$ (or $^1\Sigma_g^+$)	$\sim$ 60,000	1·47	1504
X	$^1\Sigma_g^+$	0	$1{\cdot}99_5$	2330·7

H, observed head of (0,0) band. *E*, extrapolated head of (0,0) band.

* or $\nu_0 = 105{,}693$, $\omega_{1/2} = 1962$.

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The Black Redstart

IN his interesting article on the black redstart in NATURE of May 27, Mr. Fitter says that it "was not known to breed anywhere in the British Isles before 1923". It is well over forty years ago that I watched a pair of these birds throughout their nesting activities at Bush Hill Park, near Enfield in Middlesex. I regret that in the end I took the clutch of four eggs. These eggs were sold at Stevens' auction on July 16, 1918 (Sale No. 12,981, Lot 53) on my leaving England and after this interval I can give no more precise data.

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RADIOCHEMISTRY OF AQUEOUS SOLUTIONS

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IN a recent review of radiochemical reactions, that is, reactions induced by α-particles and particularly by X-rays, Allsopp[1] affirms the conclusion that in gaseous systems there is a great similarity between radiochemical and ordinary photochemical processes, and that their mechanisms are essentially the same. In solutions, however, where radiochemical reactions are of far greater biological importance, the situation is still rather obscure and is dominated by the very indefinite 'activated solvent' hypothesis. In view of the more recent work of Dale[2] on the effect of X-rays on enzymes and biologically active substances in solution, the subject has become of renewed interest.

An attempt is made here to show that the above-mentioned parallelism can be extended to solutions, and furthermore that all the known facts on the radiochemistry of aqueous solutions can be interpreted on the basis of known photochemical or chemical reactions in solutions.

It is clear from the outset that the same general principles must apply to solutions as to gases, and consequently the same conclusions are reached: namely, that dissociation processes (in general preceded by excitation) are the direct and chemically most important result of the irradiation[3]. The only important difference lies in the fact that in solutions the active radiation is to a very large extent absorbed by the solvent.

Let us first examine briefly the radiochemical changes produced in water, for which the 'activated solvent' hypothesis was first developed by Risse[4] and later adopted by Fricke[5].

Water is composed of hydrogen ions and hydroxyl ions and does not absorb in the quartz ultra-violet region of the spectrum. The strong absorption in the region between 1800 and 2000 A. is due to the OH^- ions[6]. It is well known from the photochemistry of ions in solutions[7,15] that the photochemical primary processes consist in the detachment of an electron and its subsequent transfer from the ion to one of the neighbouring molecules or ions (electron affinity spectrum). In the absorption of radiation by the OH^- ion it loses its electron, which will be transferred to a neighbouring H^+ ion, so that the radiochemical primary process for pure water is represented by:

$$(HO)^-H^+ + \text{radiation} \rightarrow HO + H \quad . \; . \; . \; (1)$$

or similarly:

$$(HO)^-\ H_2O + \text{radiation} \rightarrow HO + H + OH^- \quad . \; . \; . \; (1a)$$

Although there is this primary splitting into hydrogen atoms and hydroxyl radicals, in general, no appreciable decomposition of the water will be observed. The reason is that the radiochemical primary process (reaction 1) is always followed by the recombination of the decomposition products according to*:

$$H + OH = H_2O \quad . \; . \; . \; . \; . \; (2)$$

thus restoring the initial state.

* For well-known reasons this and all the following bimolecular association reactions require the presence of a third collision partner. However, this fact is of no particular importance for the present discussion.

Recombination processes of this type are specially favoured in solutions because the dissociation products primarily formed are held together by the surrounding solvent molecules[8]. Actual decomposition of pure water can only occur in so far as the subsequent reactions, namely:

$$\text{(Hydrogen formation)} \quad 2H = H_2 \quad . \; . \; . \; . \; (3)$$

and

$$\text{(Oxygen formation)} \quad 2OH = H_2O + O \quad . \; (4)$$
$$2O = O_2$$

can compete with the reverse reaction (2).

It is conceivable that a very small decomposition of pure water into hydrogen and oxygen molecules can occur under certain conditions; for example, if the hydrogen and hydroxyl fragments are formed with a very high kinetic energy and thus quickly removed from each other's sphere of action.

However, the situation is radically changed if there are present in the water substances which can interact chemically with the hydrogen atoms and hydroxyl radical primarily formed.

Both the hydrogen atoms, as free atoms, and the hydroxyl free radical are extremely reactive. The hydroxyl radical is a strong oxidizing agent which by accepting an electron is transformed into the OH^- ion, whereas the hydrogen atoms are powerful reducing agents. There are, therefore, scarcely any substances which, if dissolved in the water, will not be attacked by these powerful reagents and will thus act as acceptors towards one or the other of the radicals formed by the irradiation. The 'acceptor action' of different solutes is now a chemical matter and it will be discussed in the following for a few cases which have been investigated experimentally.

Molecular oxygen.

$$\text{Acceptor action:} \quad H + O_2 = HO_2 \quad . \; . \; . \; . \; (5)$$

followed by

$$\text{hydrogen peroxide formation} \quad 2HO_2 = H_2O_2 + O_2 \quad . \; . \; (6)$$

Reactions (1) and (2) account for the fact that water is not decomposed by X-rays in the absence of dissolved oxygen. While in the presence of the latter, one gets hydrogen peroxide simply because the hydrogen atoms are removed from the solution by reacting with oxygen molecules according to the well-known reaction (5)[9], which eventually leads to the formation of hydrogen peroxide, reaction (6). The remaining hydroxyl radicals from reaction (1) will then give molecular oxygen (reaction 4), which also enters into the process.

Hydrogen peroxide. Hydrogen peroxide—either formed from molecular oxygen, or starting with a solution of hydrogen peroxide in water—is not stable under these conditions because it can itself act as an acceptor for hydrogen atoms and hydroxyl radicals, as is well known from the thermal (catalytic) and photochemical decomposition of hydrogen peroxide[10]. These reactions are:

$$H_2O_2 + H = H_2O + OH \quad . \; . \; . \; . \; . \; . \; (7)$$
$$H_2O_2 + OH = HO_2 + H_2O \quad . \; . \; . \; . \; . \; . \; (8)$$
$$H_2O_2 + O_2^- = O_2 + OH + OH^- \quad . \; . \; . \; (9)$$

where reactions (8) and (9) represent the well-known chain reactions[10]. It is clear that the interplay of the radicals H, OH, HO_2 (reactions 7, 8 and 9) will eventually lead to a stationary (maximum) concentration of hydrogen peroxide in the solution. This maximum concentration, because of reaction (9)—where the anion O_2^- of HO_2 enters—

will depend on the pH, alkaline pH favouring a lower stationary H_2O_2 concentration[11].

Iodine or bromine ions[12].

Acceptor action : $I^- + OH = I + OH^-$ (10)

Reaction (10), by eliminating the hydroxyl radicals, frees the hydrogen atoms, which will give molecular hydrogen. The iodine (or bromine) atoms combine to give molecular iodine (or bromine)

according to : $2I = I_2$ . . . . (11)

Reaction products : hydrogen, iodine (or bromine).

At alkaline pH, molecular bromine and iodine are to some extent converted into their oxy-acids. These oxy-acids are oxidizing agents and will act as acceptors towards the hydrogen atoms. In this way the hydroxyl radicals will become free and this will result in the formation of molecular oxygen according to reactions (4).

Ferrous salts[13].

Acceptor action : $Fe^{2+} + OH = Fe^{3+} + OH^-$ . . (12)

Reaction (12) frees the hydrogen atoms formed in the radiochemical primary process, which will then give molecular hydrogen (reaction 3). Reaction products : ferric salt, hydrogen.

Ceric salts[14].

Acceptor action : $Ce^{4+} + H = Ce^{3+} + H^+$ (13)

This frees the hydroxyl radicals, which will give rise to the formation of molecular oxygen (reactions 4).

Reaction products : cerous salt, oxygen.

It is clear that this can be extended also to any other substance. In general, if the solute has oxidizing qualities (for example, potassium permanganate, etc.), it will react with the hydrogen atoms and leave the hydroxyl radicals to form molecular oxygen[12,14] ; on the other hand, if the solute has reducing properties, it will be oxidized by the hydroxyl, and the hydrogen atoms will give molecular hydrogen.

In the case of more complex organic molecules (for example, tyrosin enzymes, proteins) there will always be a reaction of the solute with the hydroxyl radicals (possibly also with hydrogen atoms) which will lead to its decomposition and deactivation. If no hydrogen or oxygen gas is evolved, one has to assume that both the radicals primarily formed have reacted with the solute.

Some quantitative relationships can be derived from the mechanism proposed above. In the simplest case, the radiochemical primary process (reaction 1) is followed by either recombination (reaction 2), or by an acceptor reaction of the general type :

$$S + OH \xrightarrow{k_S} \text{reaction products} \quad . . . . (14)$$

where S represents a general solute acceptor molecule or ion. The rate of disappearance of the solute for the stationary state $\left(\frac{d\,[OH]}{dt} = 0\right)$ is then given by the equation :

$$-\frac{d(S)}{dt} = \frac{\varkappa\, k_S\, R_{abs.}\,[S]}{k_2[H]+k_S[S]}, \quad . . . . . . (15)$$

where k_2 and k_S are the rate constants of reactions (2) and (14), and $R_{abs.}$ denotes the total radiation absorbed per unit of time ($\varkappa$ proportionality factor ; brackets represent, as usual, concentrations in gm. mols per litre).

If $k_2[H] < k_S\,[S]$, ... (16)

that is, if the reaction with the substrate is rapid compared with the reverse process (2), this simplifies to :

$$-\frac{d(S)}{dt} = \varkappa R_{abs.} \quad . . . . (17)$$

and

$$\Delta(S) = \int_0^t \varkappa\, R_{abs.}\, dt = \varkappa\, R_{abs.}\, t. \quad . . . (17a)$$

If relation (16) holds (which is probably usually the case) the total amount of solute changed $\Delta(S)$ is independent of its concentration and proportional to the total radiation dose ($R_{abs.}$) as seen from equation (17*a*). Whereas the latter is practically always true, the independence of the concentration depends on whether equation (16) is fulfilled.

The above result is in agreement with the experimental evidence[1], and in particular with Dale's 'dilution effect', that is, the radiochemical deactivation of enzymes is independent of their concentration.

If there are two solutes present, for example, in addition to a substrate S an enzyme E, the primarily formed OH hydroxyl radicals will also react with the latter in a reaction of the same type, namely :

$$E + OH \xrightarrow{k_E} \underset{\text{(deactivation)}}{\text{decomposition products}} \quad . . (18)$$

From this, the rate of deactivation of E (for the stationary state) is given by :

$$-\frac{d(E)}{dt} = \frac{\varkappa\, R_{abs.}}{1 + k_S[S]/k_E\,[E]}; \quad . . . . (19)$$

that is, the rate of deactivation is *decreased* with increase of the ratio of the concentrations $[S]/[E]$. This corresponds to Dale's 'protection effect'[2].

This treatment can easily be extended to the case of several solutes : the reactivity of any particular substance being expressed by the rate constant of its acceptor reaction.

If the hydrogen atoms react instead of the hydroxyl radicals, the situation is obviously quite similar.

Apart from this indirect action of the solute as acceptor towards the radiation products hydrogen atoms or hydroxyl radical, there is, of course, also the possibility of a direct absorption of the radiation by the solute itself followed by some chemical change.

Any photochemical or chemical primary process in solution consists in either the removal or the transfer of an electron, and these processes constitute the two general types of chemical elementary processes (oxidation and reduction). Whether these processes are induced directly by the radiation or through reactions with hydroxyl radicals (oxidizing, electron acceptor) or hydrogen atoms (reducing, electron donor) makes no difference for the final result.

This conclusion is fully borne out by a consideration of those solutes of which the photochemistry is fully known, as is the case, for example, for the simple inorganic ions[15] which have been discussed above. A closer study shows that in these cases it would make no difference for the end effect whether the radiation acts directly on the solute or indirectly through the primary decomposition products of the water. It is obvious that this fact alone would make the radiochemical change independent of the concentration in the case of one solute.

In aqueous solutions it may be said that, in general, whether the action of the radiation on the solute is either direct or indirect, there will be no appreciable difference in the qualitative result of the radio-chemical process. However, the difference in the quantitative result may be of great importance from a biological point of view*. Furthermore, it is clear that the general principles outlined above can also be applied to non-aqueous solutions.

* This was very kindly pointed out to me by Dr. W. M. Dale.

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[9] cf. Weiss, *Trans. Faraday Soc.*, **31**, 668 (1935).
[10] Haber and Weiss, *Proc. Roy. Soc.*, A, **147**, 332 (1934). Weiss, *Trans. Faraday Soc.*, **31**, 1547 (1935).
[11] Kailan, *Z. physik. Chem.*, **98**, 474 (1921).
[12] Lanning and Lind, *J. Phys. Chem.*, **42**, 1229 (1938).
[13] Fricke and Hart, *J. Chem. Phys.*, **3**, 60 (1935).
[14] Clark and Coe, *J. Chem. Phys.*, **5**, 97 (1937).
[15] cf. Weiss, *Trans. Faraday Soc.*, **37**, 463 (1941).

FREEDOM FROM WANT OF FOOD

A PUBLIC conference on "Freedom from Want of Food" was organized by the Watford branch of the Association of Scientific Workers and other local bodies on May 20 to discuss the findings of the United Nations Conference on Food and Agriculture held at Hot Springs, Virginia, last year.

Sir Jack Drummond, of the Ministry of Food, who was one of Great Britain's delegates to Hot Springs, described that meeting as the first conference of the peace. It was concerned with the international planning of the production and distribution of food. Forty-four nations were represented and there were scarcely any conflicting views among the delegates. Scientific men considered how their knowledge of nutrition could be applied to the vast problem of malnutrition; agriculturalists considered how best to produce the vast quantities of food the world requires for the adequate nutrition of all; economists considered how the world's trade could be planned to facilitate the most efficient production and distribution of food. Finally, the findings of these several groups was co-ordinated into the United Nations plan for securing 'Freedom from Want'. By international agreement and planning the nations were to produce and distribute food on the basis of physiological requirements.

The problem, Sir Jack said, is terrifying in its magnitude. For example, in culturally backward countries, better nutrition would result in a vastly better survival-rate of children. Hence populations already numerous would only add to their number and thus aggravate the already terrible problem of adequate food supply. In Britain we have made a start in the rationalization of food distribution. Milk was in short supply in the winter now not because it is being produced in lower quantities than before the War. Actually far more milk is being produced, but it is being allocated to those who need it most —nursing mothers and children. Food—the right kind of food—is now regarded as a very important part of preventive medicine. Medical men are becoming more and more interested in how to prevent disease rather than merely how to cure it. Nutritious food is a great preventative of illness.

Mr. P. Lamartine Yates said that four things are necessary in order that practical results should come out of the deliberations at Hot Springs. First, there must be constant surveys into the state of the nutrition of the people and inquiry into what foods are being eaten. Since the War, the Ministry of Food has made surveys and so has its opposite number in the United States. As a result, a great deal of information on diet and nutrition has become available. These surveys must continue after the War if malnutrition is to be avoided. Secondly, propaganda such as that started by the Ministry of Food to show people what they ought to eat and how they can get the best out of their food should be continued and extended. Thirdly, there must be a stable relationship between wages and the cost of food. Poverty is the basis of malnutrition and at present food prices are being kept down by means of a Government subsidy of £200 million a year; this is at 2*s*. a person a week. While Mr. Yates is not in favour of the continuance of such vast subsidies after the War, he thinks that wages and food prices should fluctuate together.

Finally, Mr. Yates urged that someone must be responsible for looking after all this. The United Nations are setting up a permanent international committee in Washington; but on a national scale Mr. Yates believes that a Ministry of Food will still be necessary. We are in for a grim time after the War. Shipping is short and because labour all over the world is engaged in war production there is a world food shortage. Only with difficulty will the United Nations obtain sufficient food to alleviate the worst sufferings of a battered and starving Europe. We must be prepared to put up with rationing of our basic food for a year or two after the War.

There followed a lively discussion and several important points were raised from the floor.

The Conference unanimously adopted a resolution urging that similar conferences should be organized in other parts of Britain to make known to the public the resolutions passed at the Hot Springs Conference. The necessity was accepted for continued rationing of food in Great Britain until such time as the population of Europe is ensured of adequate nourishment, and it was resolved that the administration of relief to enemy occupied countries should not be used either directly or indirectly as a means of exerting political pressure upon the populations concerned.

FOOD PRODUCTION IN INDIA

IN his presidential address to the Section of Agriculture at the thirty-first Indian Science Congress, Ras Bahadur Dr. D. V. Bal presented certain aspects of the present and post-war food production in India.

One of the paramount needs of India at the present time is to lessen the gap between the food produced in the country and the amount required to feed the population adequately. Before the War, home production fell far short of requirements and 2–2·6 million tons were imported annually. The population of India is now much larger than it was a few years ago, but the increase in the area under food crops and normal yields have not been proportionate to the increase in population. The resultant food shortage and occasional famines indicate the urgency of the need to make India self-sufficient for food, instead of relying more and more upon imports.

To effect this, many factors require consideration, and State aid in various directions is essential. Water shortage can be mitigated by irrigation facilities and by the construction of wells in certain areas. Low yields are often due to the selection of unsuitable types of soil for certain crops. Surveys need to be undertaken to adjust this problem, and to determine where poor arable land would be more profitable if it were laid down to pasture or trees. Soil fertility can be improved by raising the organic matter status by encouraging the preparation of composts from farm wastes, town refuse and night soil. Rotation of crops, including the cultivation of legumes, would serve the double purpose of providing valuable essential foodstuffs and raising the nitrogen content of the soil. The available amount of protein for human consumption is definitely inadequate, and the deficiency can only be made good by extensive growth of leguminous crops.

It is calculated that improvement in the quality of the seed sown would result in an increase of 10–20 per cent of crop, and a great extension of seed farms is called for to produce and distribute improved seeds of various crops. The breaking up of fallow land to increase the arable acreage is not always practicable, owing to the need for maintaining adequate pasturage for cattle, which in India are so important as beasts of burden as well as for milk production. Serious attempts are being made to improve the cattle by better methods of breeding, and a necessary corollary to this is a stepping-up of the amount and quality of the available feed. As it is, the existing supplies of fodder and the area under pasture are inadequate, and to avoid the inevitable competition between the utilization of land for human and for cattle food, it is essential for better methods of cultivation and manuring to be adopted in both cases. If this were done, an increase of 25–33 per cent of human food could be produced from the area at present under the plough, while adequate manuring and appropriate systems of grazing would bring about a corresponding improvement in the supplies for cattle.

Very considerable losses occur in stored grain from weevil attack, at least 1·3 million tons a year being damaged by insects. Rats and spoilage by weather cause further loss, and provision is needed for more adequate storage facilities.

If maximum crop production is to be obtained, it will be necessary for the State to play a part by subsidizing the cultivators, in order to encourage them to use modern methods without the fear of financial loss. The more adequate food supplies thus obtained would so improve the health and strength of the workers as to raise the standard of industrial manufacture as well as that of agriculture.

In order to stabilize the production in India of various crops in general, and food crops in particular, it is essential to consider the long-range problems and prepare a co-ordinated plan to make the country a self-sufficient unit. Experiments are necessary to determine the maximum crop-yielding capacities of soils, special attention being given to the organic matter and nitrogen status of the soils. The standard experiments finally fixed should be conducted simultaneously at various places with different soils and climatic conditions. For this purpose an efficiently trained body of workers is essential, partly to carry out the fundamental research and partly to act as propagandists in making the results known to the agriculturists. After the return of personnel and machinery from war purposes, many men can be used to colonize selected areas and to carry out organized campaigns against diseases and pests of crops, involving the use of specialized machinery, insecticides and fungicides. Many war vehicles could likewise be adapted for power work on the farm for many purposes.

Finally, it is realized that a suitable wage system must be evolved, ensuring a basic wage to the agricultural labourers, rising in accordance with increased costs of living. Such a system, together with certain subsidies to the cultivators, would make for financial stability in the agricultural world.

BIOLOGY OF THE PRAWN LEANDER

LITTLE is known in detail of the habits of the prawns of the genus Leander, and Dr. H. Höglund's monograph* fills a distinct gap. It is an excellent work and a model for those dealing with the biology and life-history of a single species of prawn. *Leander squilla* together with the more important *Leander adspersus* forms a fishery on the west coast of Sweden. The researches have been carried out, partly as field investigations in order to study *Leander squilla* as a member of a stock, its habits, propagation, growth, etc., under natural conditions in the sea, partly as aquarium experiments in order to study such individual processes as mating, spawning, hatching and moulting.

During the winter, the prawns inhabit deep water. When the water in the upper layers has become warmed in the spring, they begin to appear on the shores, and breeding takes place throughout the summer. Temperature is shown to be all-important to migration, breeding and growth, and the time of arrival of the prawns on the shores varies in different seasons according to conditions. In the autumn they return to deep water. Unlike *Leander adspersus*, which, according to Mortensen (1897), migrates to deeper and colder water to hatch out the larvæ, *Leander squilla* apparently remains close to shore in shallow water. The newly hatched larvæ occur in the plankton. It is specially to be noted that the larvæ of both the Leander species occupy the upper layers, whereas all the other carid larvæ of the district frequent the deeper water from 15 to 25 metres.

Both males and females become mature during their second summer, when about a year old. Females may produce two broods in one summer. Larger and older prawns are scarce, but these avoid the nets much more successfully and there is evidence that they may live for three years.

Striking film photographs are given of the pairing, moulting and spawning processes taken in aquaria. The armature of the female thorax and pleopods in the breeding season ("the breeding dress") is very fully investigated and the exact function of each batch of setæ is determined. Most of these setæ are for use only when the eggs are extruded, appearing at the moult preceding spawning and disappearing after the last batch of eggs has hatched out, when another moult takes place.

* "On the Biology and Larval Development of *Leander squilla* (L.) forma *typica* de Man." By Hans Höglund. *Svenska Hydrografisk-Biologiska Kommissionens Skrifter*, Ny Serie, Biologi, 2, No. 6 (Stockholm, 1943).

The larvæ of *Leander squilla* forma *typica* are described in detail and closely resemble those of *L. adspersus*, although the colour is quite different. Five or six larval stages are recognized, the last stage changing to post-larva. The larval characters of the two species are compared in a table. The whole planktonic larval period lasts for about four weeks, after which the post-larvæ make their way to the shores. This they do very quickly, often before another moult takes place, and the young prawns appear on the shores in enormous quantities.

The illustrations throughout are very good, including clear outline figures in text and plates. The photographic film figures are very illuminating.

FORTHCOMING EVENTS

Saturday, June 17

BIOCHEMICAL SOCIETY (in the Physiology Department, University College, Dundee), at 2 p.m.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS (at Neville Hall, Newcastle-upon-Tyne), at 2 p.m.—Mr. H. R. Wheeler: "American System of Coal Mining"; Messrs. R. Williams, W. Jeffery and A. Taylor: "Outbursts of Gas from the Floor of Coal Seams", Part 1.

Monday, June 19

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting.

ASSOCIATION OF AUSTRIAN ENGINEERS, CHEMISTS AND SCIENTIFIC WORKERS IN GREAT BRITAIN (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 7.15 p.m. —Prof. P. H. Gross: "Planning and Education for Technical Research".

Tuesday, June 20

SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION (at the Waldorf Hotel, Aldwych, London, W.C.2), at 1 p.m.—Luncheon Meeting. Mr. J. Chuter Ede, D.L., M.P.: "Technical Education".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. R. J. E. Silvey: "Listener Research".

Wednesday, June 21

ROYAL SOCIETY OF MEDICINE (joint meeting of the SECTION OF COMPARATIVE MEDICINE with the INSTITUTE FOR THE STUDY OF ANIMAL BEHAVIOUR) (at 1 Wimpole Street, London, W.1), at 2.30 p.m. —Dr. C. S. Myers, F.R.S.: "Instinct"; Dr. W. H. Thorpe: "Learning Processes in Animals"; Prof. D. B. Johnstone-Wallace: "Grazing Habits of Beef Cattle"; Dr. Arthur Walton: "Comparative Sexual Behaviour in the Male".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 3 p.m.—Scientific Papers.

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 4.30 p.m.—Mr. N. Carruthers: "A Simple Periodoscope for Meteorological Data". Dr. T. E. Allibone: "Multiple Lightning Strokes".

ZOOLOGICAL SOCIETY OF LONDON (at Regent's Park, London, N.W.8), at 4.30 p.m.—Exhibition of a Cinematograph Film of some Animals taken in the Society's Gardens, with Commentary by Dr. Edward Hindle, F.R.S.; Mr. Michael Pease: "The Cambridge Auto-sexing Poultry Breeds".

Saturday, June 24

ASSOCIATION FOR SCIENTIFIC PHOTOGRAPHY (joint meeting with the SCIENTIFIC FILMS ASSOCIATION) (at the Large Theatre, Ministry of Information, Malet Street, London, W.C.1), at 3 p.m.—Discussion on "The Construction and Presentation of Scientific Films". (Mr. Arthur Elton: "The Scope and Distribution of Scientific Films"; Mr. Geoffrey Bell: "Shooting Scientific Films"; Dr. J. Yule Bogue: "The Production of Scientific Films for Medical and Biological Purposes".)

APPOINTMENTS VACANT

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

LECTURER IN ENGINEERING in West Africa—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. E.836A) (June 21).

PHYSICIST for essential War work (work would include experience in various research departments of a North London firm specializing in optical instruments for scientific and industrial research and control)—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. A.518XA) (June 21).

LECTURER (woman, resident) in BIOLOGY at the Cheshire County Training College, Crewe (for Women students)—The Director of Education, County Education Offices, City Road, Chester (June 22).

GRADUATE LECTURER IN GENERAL SCIENCE—The Principal, Derby Technical College, Normanton Road, Derby (June 23).

LECTURER IN ELECTRICAL MACHINERY in the Department of Electrical Engineering—The Registrar, King's College, Newcastle-upon-Tyne 2 (June 24).

TEACHER (full-time) OF GENERAL SCIENCE with qualifications in PHYSICS and CHEMISTRY, in the Junior Technical School of Oldham Municipal Technical College—The Director of Education, Education Offices, Oldham (June 24).

ASSISTANT MASTER to take ENGINEERING SUBJECTS (Mechanical or Electrical), with subsidiary Mathematics or Drawing, an ASSISTANT MASTER to take PRODUCTION ENGINEERING Subjects, with Workshop Practice, and an ASSISTANT MASTER to take MATHEMATICS and SCIENCE, with subsidiary Drawing—The Principal, Enfield Technical College, Queensway, Enfield, Middlesex (June 24).

MASTER or MISTRESS to teach MATHEMATICS in the Mid-Essex Technical College—Mr. E. W. Alston, Education Office, Mid-Essex Technical College, Chelmsford (June 24).

PSYCHIATRIC SOCIAL WORKER with qualifications in SOCIAL SCIENCE and MENTAL HEALTH—The Director of Education, Education Offices, Middlesbrough (June 24).

EDUCATIONAL PSYCHOLOGIST (man or woman)—The Director of Education, Education Offices, Wolverhampton (June 24).

AGRICULTURAL CHEMIST—The Director of Agriculture, School of Agriculture, Houghall, Durham (June 24).

HORTICULTURAL ASSISTANT (temporary, male or female)—The Clerk to the County Council, County Offices, Sleaford, Lincs. (June 24).

LECTURER IN MECHANICAL ENGINEERING, and a LECTURER IN MATHEMATICS, in the Denbighshire Technical College—The Director of Education, Education Offices, Ruthin, Denbighshire (June 26).

LECTURER (temporary) IN MATHEMATICS—The Registrar, King's College, Newcastle-upon-Tyne 2 (June 26).

ENGINEER AND WORKS MANAGER of the Great Berkhamsted Waterworks Undertaking—The Acting Secretary, Great Berkhamsted Waterworks Co., 166 High Street, Berkhamsted (June 30).

SENIOR LECTURER IN SCIENCE with Graduate or equivalent qualifications in PHYSICS and CHEMISTRY, in the Ipswich School of Technology —The Secretary for Education, 17 Tower Street, Ipswich (June 30).

COMBUSTION AND RESEARCH ENGINEER by large organization, with headquarters at Glasgow—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. C.2031XA) (July 1).

ASSISTANT LECTURER IN ENGINEERING—The Registrar, The University, Manchester 13 (July 1).

MECHANICAL ENGINEER (with general experience and good Degree) for Research and Development in Steel Tube Industry (Midlands)—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. C.2162XA) (July 3).

SENIOR ASSISTANT DRAINAGE AND IRRIGATION ENGINEER (Reference No. E.902A), and a JUNIOR ASSISTANT DRAINAGE AND IRRIGATION ENGINEER (Reference No. E. 903A), by the Sierra Leone Government —The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting appropriate Reference No.) (July 5).

EXECUTIVE ENGINEER by the Sierra Leone Government—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. E.1011A) (July 5).

TECHNICAL CHEMIST (Reference No. F.2012XA) and a LABORATORY ASSISTANT (Reference No. F.2503XA), by London Paint Manufacturers —The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting appropriate Reference No.) (July 8).

ASSISTANT SECRETARY to the Oxford and Cambridge Schools Examination Board—The Chairman of the Oxford Delegacy, St. Catherine's Building, St. Aldate's, Oxford (July 31).

READERSHIP IN PHYSICAL ANTHROPOLOGY—The Registrar, University Registry, Oxford (August 31).

ASSISTANT LECTURER (Grade III) IN THE DEPARTMENT OF ORGANIC CHEMISTRY—The Registrar, The University, Liverpool.

PSYCHIATRIC SOCIAL WORKER (full-time)—The Secretary, Education Office, Trinity Street, Colchester.

TEACHER OF MATHEMATICS AND PHYSICS in the Handsworth Technical College and Junior Technical School—The Principal, Handsworth Technical College, Golds Hill Road, Birmingham 21.

TEACHER OF SCIENCE (particularly CHEMISTRY) AND MATHEMATICS, and a TEACHER OF MATHEMATICS AND ENGINEERING SUBJECTS, in the Slough Junior Technical and Commercial School—The Secretary for Education, County Offices, Aylesbury, Bucks.

GRADUATE LECTURER IN SCIENCE AND MATHEMATICS—The Clerk to the Governors, Technical College, Chesterfield.

TEACHER (temporary) OF CHEMISTRY and/or PHYSICS, with subsidiary MATHEMATICS, in the Swansea Technical College—The Director of Education, Education Department, Guildhall, Swansea.

GRADUATE IN PHYSICS, a GRADUATE to teach ELEMENTARY MATHEMATICS and SCIENCE, mainly for work in the Day Technical School for Boys and part-time Day Classes, and a GRADUATE to teach SCIENCE, mainly BIOLOGY, mainly for work in the Day Technical School for Girls, of the Maidstone Technical Institute—The District Secretary of the Kent Education Committee, Mr. A. W. Peacock, 13 Tonbridge Road, Maidstone.

PSYCHIATRIC SOCIAL WORKER (full-time)—The School Medical Officer, Public Health Department, County Hall, Maidstone.

RESEARCH PROFESSORSHIP IN ANIMAL HEALTH—The Principal, University College of Wales, Aberystwyth.

Printed in Great Britain by FISHER, KNIGHT & Co., LTD., The Gainsborough Press, St. Albans, and published by MACMILLAN & Co., LIMITED, at St. Martin's Street, London, W.C.2, and THE MACMILLAN Co., 60 Fifth Avenue, New York 11, N.Y., U.S.A.—Saturday, June 17, 1944.