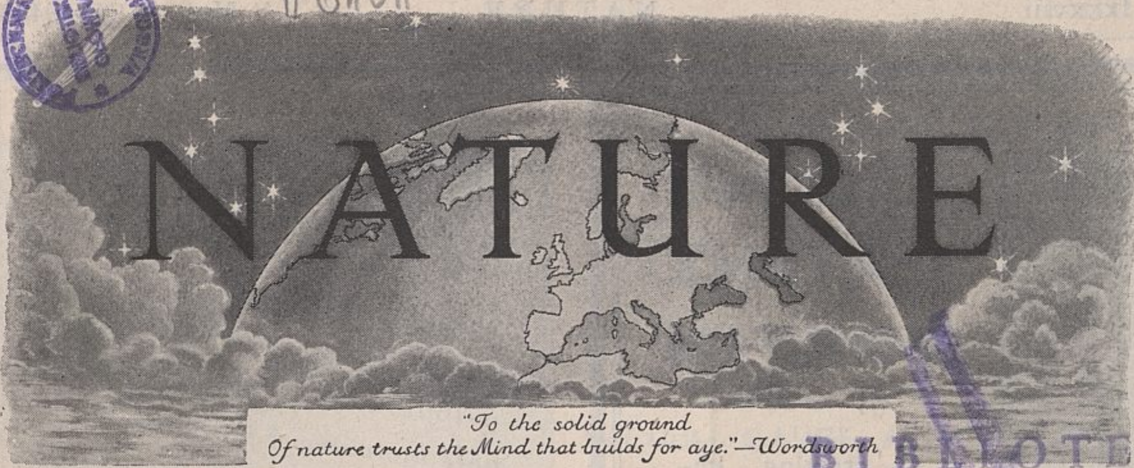

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CONTENTS

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COLONIAL DEVELOPMENT IN THE BRITISH EMPIRE

THE development of British Colonial territories is not least among the problems which are already laying claim to the funds of human energy and economic material resources which will be at our disposal during the reconstruction period. An increasingly keen discussion of Colonial policy, both in Parliamentary and in unofficial circles, has accompanied the recent steps taken by the Government to provide funds and expert personnel to assess the full import of the issues, to estimate the scale of essential needs and to embark without delay on actual projects. The publication of Sir Frank Stockdale's first report of progress in the West Indies is an earnest for the future.

With the Colonial Development and Welfare Act of 1940, the Government has embarked on a long-term scheme of advance in the Colonial territories, with the improvement of standards of living of their peoples through the active development of natural resources as the keynote of policy. The older principle whereby development was confined within the limits of the internal finances of each territory has been abandoned in recognition of the fact that in many cases they "cannot, however efficient their economic administration, finance out of their own resources the research and survey work, the schemes of major capital enterprise, and the expansion of administrative and technical staffs which are necessary for their full and vigorous development" ("Statement of Policy on Colonial Development and Welfare." Cmd. 6195; 1940). This is a sphere in which the scientific world—and particularly those concerned with biological and sociological aspects—can do much to further the declared policy. Both the considered views of men of science at home who can contribute to the framing of policy, and the more direct services of those who will enter the field of Colonial development, will be needed. Hence the importance of the widest appreciation of the social and technical problems involved, and the need for consideration of the ways in which as individuals and through their own institutions men of science can most effectively contribute to wise planning and orderly development.

In the very full debates in the House of Lords during the past year, two particular issues have come to the fore. First is the need for mustering and putting at the service of the British and the Colonial Governments the advice of those who can contribute from their experience and special knowledge. Lord Trenchard has advocated the establishment of a Colonial Board or Council. Originally it seemed that he wished such a body to be comprehensive in its terms of reference and empowered to report regularly and directly to Parliament. The difficulties that might be expected to follow from the existence of two largely separate sources of direction on Colonial policy, the Colonial Office itself and an Advisory Council reporting independently, were emphasized by Lord Cranborne as Secretary of State, but the Government has shown no aversion to the further development of advisory bodies responsible to the Colonial Office itself.

The most fruitful and expeditious direction of advance would indeed appear to be along these lines, and the limitation of a council to the economic field, which Lord Trenchard—apparently by way of concession—suggested in his more recent speech, does not seem to be necessary or desirable. A number of advisory committees have in fact already been set up by the Colonial Office. On them sit experts, members of Parliament and men with long Colonial experience, and they already cover such fields as education, agriculture, labour and welfare. To their number has recently been added the Colonial Research Advisory Committee under the chairmanship of Lord Hailey, which will advise on the further development and organization of scientific research which the Colonial Development Fund has made possible. The next steps would therefore appear to be the completion of the series of advisory committees required to cover the whole field of Colonial problems, including economic policy and administration and, equally important, their integration by means of a central advisory body. With representatives from the component committees sitting together, such a Central Council, itself fully informed of the questions on which its several committees were working, the problems of balanced development, both between and within particular territories and fields of development, would on the advisory side be in the road to solution. At the same time, the parliamentary and other representation on the committees and Council should ensure both the public insight into Colonial problems and the close touch with government policy which Lord Trenchard and others are so anxious to secure. It would also go far to foster public interest and concern in the future of the Colonies without raising a question of constitutional innovation, the discussion of the merits of which might well distract attention from immediate needs and opportunities.

On such a Central Council, as on the existing advisory committee, scientific workers would have an important constructive part to play and an opportunity to pool experience with their colleagues from the administrative and commercial spheres in seeking the most effective means of carrying out the dual mandate—securing both the welfare of the Colonial peoples and benefits for their Western partners.

The second major question concerns recruitment and training for all branches of the Colonial Service. During this War there has been a closer concern than in 1914–18 for provision for the future, and the need for hurried reinforcement of depleted Colonial staffs may not be so acute ; but the fact that development on all fronts is being planned for the Colonial territories will mean that an increased and a more varied personnel and, hence, a considered plan of post-war recruitment and training, will be required.

The Secretary of State, in response to suggestions that the source of recruitment should be widened, has pointed out that the Selection Board for the Colonial Service is not tied to a narrow range of either age or scholastic attainment and itself includes a non-official member. Here, too, the value of scientific training may need affirmation. The maintenance of scientific standards in appointments to the technical services is only part of the question. There remains the need for securing an increasing receptivity and understanding among administrative officials towards the scientific approach which must lie behind so much of the work of those departments. On the other hand, the scientifically trained staffs of the technical departments have to apply their knowledge in a social context not only very different from that of Great Britain itself, but indeed one in which much may depend on their appreciation of the outlooks of the peoples they work among and of their administrative colleagues who are directly responsible for orderly social development.

In the recent suggestions for the establishment of a Colonial Staff College great emphasis has been laid on the need for affording Colonial officials not merely the technical knowledge for their particular spheres, but also an understanding of all the related fields of Colonial development and of the wider economic and other social problems of the world as a whole. The desirability for the greatest community of ideas between the administrative and the scientific staffs of Colonial areas is obvious. There is need for thought on the best ways of making plain the nature and importance of scientific contributions to those whose earlier training and experience may have provided little foundations for such understanding. This in turn raises the question whether a closed service institution would in fact provide the best training ground for those in whom the widest outlook is desired, a point that will become increasingly important as personnel are drawn more and more from the Colonial territories themselves, and the assimilation of Western standards will be part and parcel of training in all fields.

Moreover, the Colonial Services differ from a military or purely administrative system precisely in the very wide range of their activities, which comprise not only administrative and political, but also a number of educational, technical and scientific fields. The training of technicians and scientific workers for a particular service is most economically and comprehensively achieved in institutions where the field of knowledge rather than the particular post is the basis of organization. There is much to be said for this point of view with regard to the training of political officers.

For the existing practice, whereby advantage is taken of facilities in the universities in training for the Colonial Service, considerable success can be claimed, particularly with respect to the generally admitted need for guarding against an excessive insularity of outlook among Colonial officials, many of whom spend long years in remote areas and in very special circumstances. Facilities associated with the universities could without difficulty be extended and where necessary further specialized, and they provide a particularly suitable environment for the frequently advocated supplementary courses which should be taken by men after a number of years of service. The Colonial Service would in this way be able to continue to share in the benefits of that universal framework for more specialized studies which the universities seek to confer. There should, in view of their traditions of freedom and of devolution of authority, be no serious difficulty in developing, in one or more of the universities of the British Empire, in close association with academic departments including special Colonial studies, training schools which, while providing fully the conditions needed for the desired *esprit de corps*, would have the advantages of a continuous outlook on wider horizons.

THE PUBLIC LIBRARY IN RECONSTRUCTION

THE importance of the industrial or scientific library as a tool of research and as a service to the investigator or technical man on a par with the material services such as power supply, light and water, which along with his equipment he is apt to take for granted, is now gaining recognition. This interest must now be extended to include the public library service, for an efficient public library service is highly important as a factor in adult education. The public library service, too, must play an important part in education for citizenship, and in that respect scientific workers themselves might well be glad to avail themselves more freely of its services.

These reasons alone would give public library services an important place in reconstruction. The report on "The Public Library System of Great Britain", prepared by Mr. L. R. McColvin, city librarian of Westminster, for the Library Association, demonstrates beyond dispute the need for drastic overhaul and reorganization. This report, however, has also a close bearing on those questions of regionalism and the relation between national and local control which are encountered almost everywhere when plans for post-war development are being considered. The provision of public library services has hitherto been left entirely to the local authorities, and the quality of their performance affords a fair test of their fitness for full responsibility in others.

The Acts of Parliament by virtue of which public libraries exist are permissive, not compulsory. That does not invalidate the fairness of this test of the fitness of the local authorities, but this survey, with its picture of widely varying performance, leaves an outstanding impression of the unsatisfactory general provision and of a badly organized service which reflects sadly on the competence of the local authorities and stamps permissive legislation in this field as a comparative failure. That is indeed the major interest of the survey itself. On points of detail the scientific worker will note the duplications, deficiencies and glaring disparities which abound, the absence of general standards for salaries and the consequence that many library workers are not properly qualified for their posts, understaffing and inadequate premises, parsimonious expenditure on books and indeed every other item, and the pronouncement that reference library work is the outstanding failure of librarianship in Great Britain.

One point in this survey has direct implications for the scientific worker. Mr. McColvin emphasizes the fact that a poor library does not immediately result in a demand for a better one. The public does not normally ask for a better library service unless it already has experience of a good one. It is only a good library that can demonstrate the advantages and uses of a developed service. Mr. McColvin, in fact, points out that several counties and backward municipalities have been, if not compelled to improve, at least made cognizant of their deficiencies, by evacuated readers who have been accustomed to good libraries in their home towns. Similarly, scientific workers who have at least learnt something of the value and possibilities of a library service owe it to their fellow citizens to play their part in securing for the community as a whole a public library service which adequately meets the purposes set forth in this report.

The basic purpose of the public library, in Mr. McColvin's view, is the utilization of the recorded experience and thought of the men and women of yesterday and to-day to help in the making of citizens better able to contribute to, and benefit from, the constructive life of the community, the nation and the world. Much of that accumulated experience is only available in books, and the society which lacks adequate public libraries is accordingly handicapped by the lack of information and knowledge essential to its material, mental and spiritual development. Books, he urges, are essential to any real democratic conditions of living; they are the tools and the symbols of true freedom.

That conception of an efficient, readily accessible and comprehensive library service, hospitable to all phases of thought, as an essential element in a progressive society, will be endorsed everywhere. The execution of the broad programme outlined in this report and the details of its proposals will rightly be held largely a matter for discussion and decision by the professional librarian in the first place, though even at this stage the scientific worker might well support some of the proposals or observations, such as the adoption of a deliberate national policy of linking up and strengthening existing special libraries, so reducing unnecessary duplication, and gradually extending their range. Moreover, some at least of its observations in regard to stock, purchases, premises and methods are as relevant to the specialist or departmental library as to the general or public library, and well deserve to be carefully weighed.

Mr. McColvin's proposals, however, are worth noting for the further reason which is evident even from a brief summary. An efficient library service may well be an important factor in reconstruction; but, in addition, library reform is an excellent example of the technique required in a democracy for the adjustment of its institutions by consent to serve the purposes of an ever-changing society.

The faults of the present system, on Mr. McColvin's showing, are attributable to the inherent defects of local control. The first task is therefore to create, as the area for each independent local library service, a local unit sufficiently large to facilitate co-ordination and ensure efficiency and economy. These units, of which ninety-two are enumerated, will comprise areas formed for geographical reasons and answering to the distribution of population. Each unit would include an administrative and distributive headquarters with main central library and a radiating system of libraries, branches, distributing centres and travelling library vans, appropriate to the different aggregations of population in the area, the urban and rural services being under a single direction.

Mr. McColvin insists on the management of the unit remaining in local hands and not being placed under the control of the central government or of larger regional authorities. On the other hand, he is emphatic as to the necessity of a central national department responsible for guiding, co-ordinating and encouraging library development, making grants in aid of library services, and supervising their expenditure. He also urges the development of large regional reference libraries assisted by national funds, as well as the fullest possible co-operation between public libraries and all types of other libraries and institutions for research, especially in connexion with specialization and inter-library lending. Efficient management, staffing and an appropriate relation between supply and demand are other points in the proposals.

The National Central Library should be an integral part of the national system and guaranteed a reasonably permanent means of existence and the resources to plan for the future and for whatever developments the national interests might demand. Primarily, it would be a clearing house and centre for the execution of national library projects—cataloguing, bibliography and co-operation. With the development of good library units throughout Great Britain, it should no longer be necessary for the National Central Library to act as a storehouse of reserve stocks, and the units should also decrease the demands on it for work for adult education. Moreover, the removal of the limitations imposed by financial stringency on its present or contemplated work, the supply to library units of specialized books which it is impossible or undesirable for the units to provide themselves, the maintenance of the necessary organization for such inter-lending, the development and maintenance of co-operation between public libraries and others, including the special libraries, its functions as a national centre for bibliographical information, as a central cataloguing department, in organizing international loans and as a centre and clearing house for bibliographical information regarding the literature of other countries, would enable the National Central Library to form the natural keystone of all inter-library co-operation.

With regard to the central authority, Mr. McColvin suggests either a department of a new Ministry of Arts or a Libraries Department of the Board of Education, though he directs attention to the danger of associating a library system too closely with education in the scholastic sense. In addition to the broad duties already indicated, this authority would also be responsible for formulating minimum standards of library service, especially in regard to the supply of books, the availability of services and the qualifications and salaries of those engaged in library work, as well as for the collection of information, conduct of inquiries or issue of reports on the general progress of librarianship and on special aspects thereof. The proposals contemplate an interim period of voluntary reorganization, and the application of compulsion only as a last resource.

It is clear that these proposals touch fundamental issues involved in regionalism and in the re-grouping of local government units. Mr. McColvin recognizes that the civil defence regions of Great Britain may not prove altogether suitable regional units, and that new areas introduced as a result of changes in local government may equally be unsatisfactory and unsuitable for library purposes. He also recognizes that, on the other hand, there may be no considerable reform of local government areas in general for some years. None the less, he urges librarians to place their ideas and ideals at the disposal of all who are concerned with the reconstruction of local government, and to collaborate with them to the fullest possible extent.

In thus urging collaboration and readiness to accept adjustments of the unit system where the adjustments are not such as to prejudice seriously the essential requirements, Mr. McColvin shows the same wisdom and restraint which throughout his report balance his stout defence of the independence and identity of the librarian. It cannot be said of this report, as of some other recent ventures into the field of reconstruction, that the proposals are more concerned to advance the interests of a section than to serve those of the whole community. The fundamental truth that democracy is based on the consent of the governed is firmly upheld throughout.

The report is in fact to be welcomed for its support of those two points, apart altogether from the proposals it advances for reform in a matter which touches closely the mental well-being of the whole nation. It is a stimulus to constructive thinking about some of the issues upon which the existence of our democratic institutions depends. In recognizing the failure of small units, in library service as elsewhere, to function efficiently or even effectively, we should not forget that not only may those units have other contributions to offer, but also that it is of the essence of a democracy that their willing consent should be won to participation in the larger units now necessary. Secondly, it should be recognized, as is implicit in this report, that while it is for the expert and professional worker to submit his proposals, and even to execute them when approved, it is for the community to decide on policy.

There is no graver danger to reconstruction than the tendency to be observed in so many reports from the industrial and business world for sections to attempt to dictate policy and for their plea for self-government or freedom from interference to cloak an attempt to impose an economic system on the community in preservation of sectional interests. Democratic policy, it is true, must be positive, but danger lies in the plea that such questions as the abolition of unemployment, disease and ignorance should be regarded as technical questions and outside politics. In a parliamentary democracy, it is for the electorate to decide whether it is prepared or not to accept whatever restraints on individualism may be necessary to secure these or other objectives. It is then and then only for the expert to frame and execute, under the supervision of parliament, the measures necessary to give effect to the policy adopted by the electorate. Library service may well seem a small matter among the many problems which are the subject of debate for reconstruction to-day, but in this report 'first things' are laid bare with unhesitating precision.

BIOLOGICAL STATISTICS

The Reproductive Capacity of Plants

Studies in Quantitative Biology. By Prof. E. J. Salisbury. Pp. xi+244+7 plates. (London: G. Bell and Sons, Ltd., 1942.) 30*s*. net.

THOSE who are familiar with Prof. Salisbury's earlier applications of statistical methods to structural characters, presumed adaptive, will approach with lively anticipation this quantitative study of reproductive capacity. In his investigation of stomatal distribution he gave precision to the general observations of Zalenski and others, in particular that in dry conditions leaves tend to have more stomata per unit area, whereas the reverse might have been expected. He further demonstrated that, for a given species, the spacing of the stomata is dependent on the size of the epidermal cells and so on the degree of expansion of the leaf during its development. He thus contributed weightily to the replacement of the teleological by the causal point of view in the interpretation of such features.

In the present volume he has collected together measurements, accumulated over a period of fifteen years, of the number of fruits and seeds produced by sample populations of a wide range of species of representative habitats, with the object of examining quantitatively the rough impressions and certain teleological assumptions that have gained currency. The amount of labour and patience required in obtaining so impressive a body of data prompts the thought, *à chacun son métier*.

Among the leading questions propounded is whether the relative abundance and frequency of different species are correlated with their reproductive potentialities. On the other hand, since on the average the number of individuals of different species remains approximately stable, it has been commonly assumed that natural selection has brought about a nice adjustment between seed output and mortality: Is reproductive potentiality in fact proportioned to vulnerability, or is the production of a large progeny rather to be regarded as merely wasteful?

The complexity of the problems is made apparent from the outset. The author points out, for example, that fluctuation in number of offspring has the effect of countering the danger from predators. Though "mast" years lead ultimately to an increase in number of predators, the inevitable lag enables the sudden abundance to be effective in increasing the number of individuals, at least temporarily, and possibly securing the spread of the species. Another complicating factor is seed size, which is examined and discussed in Chapter 2. It is established that the more advanced the phase of ecological succession the larger are the seeds, on the average, of the species characterizing the vegetation; and the author points out that the smallest seeds are to be found among plants of open habitats, and also among parasites, saprophytes and mycorrhizal plants, which are not dependent for survival on early photosynthesis.

In Chapter 3 it is shown that parental vigour, estimated by the number of fruits borne, has no significant effect on the viability of the seeds set and very little on their size. Apparently, below a certain minimum of food supply an ovule or seed aborts and the effect of starvation is seen in fewer seeds of nearly normal size.

Having defined his terms, of which the most important is reproductive capacity, the product of the average seed output per plant and the average percentage germination, the author proceeds to examine the data for different edaphic and climatic conditions and the effects of competition. He remarks that competition may sometimes be the more important and gives examples of perennials in which the onset of reproduction is delayed for years by competition. Between individuals of the same species, on the other hand, while competition leads to depauperate individuals, it affects the total output but little whether many small or few large plants survive. In Chapter 7 it is established that no correlation exists between number of capsules per plant and number of seeds per capsule.

The remainder of the book is devoted to a comparative study of reproductive capacity over a wide range of examples. The general conclusion frequently emerges that there is no evidence of reproductive capacity being correlated with risk of mortality, but definite evidence of correlation with extent of geographical range (for example, Scilla spp.) and with relative abundance (for example, Hypericum spp., Gentianaceæ). Vegetative spread and multiplication complicate comparisons and receive special discussion in the concluding chapter.

The discussions of special cases are full of interest and are informed throughout with original observations which add greatly to the value of the book. It will provide a mine of information for contributors to the biological Flora, which is being compiled under the auspices of the British Ecological Society.

To the general reader it may be a matter of regret that the statistical data are given *in extenso* throughout the text. The summaries and, still more, the many comments and original observations are in consequence more difficult to pick out. While it is desirable that data so laborious of collection should be permanently preserved and accessible, the value of the book would, in the reviewer's opinion, have been increased had the bulk of the data been segregated. A limited number of examples would have sufficed to illustrate the chief statistical features and the methods of statistical treatment. The results could then have been given in the text mainly in the form of averages with standard deviations.

A minor point to which attention should perhaps be directed is the author's interpretation of probable error when, having obtained an average $A \pm p$, where p is the probable error of the mean, he states that the average would thus be between $A + p$ and $A - p$. The circumlocution adds nothing and might mislead, for the evidence does not suffice to tell on which side of A the mean of an indefinitely large sample would lie, or how far from A. D. T.

QUANTUM STATISTICS, CHEMICAL EQUILIBRIA, AND REACTION KINETICS

Equilibrium and Kinetics of Gas Reactions

An Introduction to the Quantum-Statistical Treatment of Chemical Processes. By Robert N. Pease. Pp. ix+236. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1942.) 22*s*. 6*d*. net.

THE correspondence between the equations of classical statistical mechanics and thermodynamics has been realized for a long time, having been demonstrated by the work of Boltzmann and Gibbs. Nernst and Planck afterwards introduced the concept of absolute entropy, with the statistical implication that the number of alternative states of a system is limited, indicating the necessity of applying quantum restrictions. The introduction of the atomic structure of matter into thermodynamics via statistical mechanics then made possible the calculation of absolute thermodynamic functions, and hence the evaluation of chemical equilibrium constants.

Dr. R. N. Pease has given a clear account of these developments in Part I of his book. The treatment is not absolutely rigorous, but it is doubtful if this can be considered a fault in a book designed as an introduction to the methods of quantum statistics for the student who is not primarily a mathematician, or for "the reader who has been separated from academic work for a number of years, and now wishes to catch up on recent developments in this important field of the interpretation of chemical processes". As would be expected, the selection and critical discussion of experimental material are admirable throughout.

Chapter 1 is largely a summary of elementary thermodynamics after the manner of Lewis and Randall, but contains also a section on the experimental determination of equilibrium constants. Then follows a consideration of the Nernst Heat Theorem, with the method of estimating entropies from specific heat measurements. A number of examples are given of the calculation of equilibrium constants from thermal data. Quantum statistical methods are introduced in Chapter 3, which explains the calculation of absolute entropies, free energies and equilibrium constants from spectroscopic data. This treatment largely utilizes the elegant methods of Giauque. The present position is set out clearly. For simple molecules, partition functions may be calculated precisely, and equilibrium constants derived from them are reliable. In the case of more complex molecules, there is often doubt as to the assignment of normal modes of motion, internal rotations, etc., and the partition functions and equilibrium constants are more likely to be in error. At present the problem of partially restricted rotation limits the usefulness of the statistical method. The normal procedure is the estimation of potential barriers in the molecule by a comparison of the entropy calculated by statistical methods with the thermal entropy, whereas what is really required is to be able to set up theoretical models in terms of which the spectroscopic data may be confidently interpreted.

The second part of the book deals with the kinetics of gas reactions. The application of thermodynamics and statistical mechanics to rate processes has proved a much more difficult problem, and the results are less certain. Modern theories suffer from the disadvantage of having to postulate an underlying equilibrium—between reactants and activated complexes in the case of chemical reactions—which is clearly only an approximation. The activated complex theory of reaction-rate, together with the older collision theory, are discussed at the beginning of the second part of Dr. Pease's book. The former is treated essentially by Eyring's method. There follows an account of what the author calls the four "classical" reactions—decomposition of nitrogen pentoxide, formation of hydrogen iodide, reaction between nitric oxide and oxygen, and formation of hydrogen bromide. In each case, with perhaps the exception of the third, calculations based on a simplified version of Eyring's theory lead to results which are in approximate agreement with experimental data. The author rightly points out that the number of reactions amenable to theoretical treatment in this way is small, either on account of inadequate investigation or uncertainty of interpretation.

Chapter 6 deals with quasi unimolecular reactions, and gives a review of the familiar Lindemann-Hinshelwood theory in the light of experimental data. It is difficult to disagree with the author's conclusion that it is doubtful whether any unambiguous experimental evidence for the validity of the theory has been obtained, except perhaps in the case of the isomerization of cyclopropane.

Chain reactions form the subject of the next two chapters (7 and 8). The main characteristics of these processes are illustrated by reference to a number of well-known reactions, including the hydrogen – chlorine reaction, the thermal decomposition of acetaldehyde (discussed at some length), and the thermal decomposition of ethers. Oxidation reactions, involving branching chains, are also treated.

The book concludes with a chapter on surface reactions in which the usual topics are clearly discussed; in addition, there is an interesting section on the extension of the activated complex theory to surface catalysis due to Laidler, Glasstone and Eyring.

Dr. Pease is to be congratulated on writing a very good book, which includes critical reviews of many different subjects in a comparatively small space, and which should be of great value to teachers and specialists in other branches of chemistry. The experimental side is well to the fore throughout; chemical reactions are generally very complex affairs, and the author has avoided a common tendency to simplify them. He has also abstained from building up complex theories on flimsy experimental bases. Indeed, one of the many pleasing features of the book is that the reader is left with the impression that it is often almost as difficult to measure the rate of a reaction as to calculate it.

C. H. BAMFORD.

FOOD AND PREGNANCY

THE average human baby weighs between 7 lb. and 8 lb. at birth; it contains about 370 gm. of protein, 25 gm. of calcium, 14 gm. of phosphorus and 0·4 gm. of iron. It builds up two thirds or more of these materials during the last three months before birth. All this material must come from the mother. Two questions arise. First, how is the transfer of the necessary material to the fœtus regulated? Secondly, how far does the health of the baby and mother depend on the mother's supply of food? These two questions occupied the English Group of the Nutrition Society at its meeting on February 6.

Food passes from the circulation of the mother to that of the fœtus through the placenta. This passage is not a free diffusion. Sir Joseph Barcroft discussed the placenta as a barrier. New information has been obtained by the use of heavy sodium. The guinea pig fœtus comes within 10 per cent of equilibrium with heavy sodium in the maternal plasma in 5–7 hours; the extracellular fluid of the mother comes within 10 per cent of equilibrium in about 5 minutes. It is possible to calculate the diffusion coefficient of oxygen across the placenta. About 0·1 ml. of oxygen passes from the blood of a ewe to her fœtus per square centimetre per second, when the difference between the pressure of oxygen in the blood of mother and fœtus is 1 mm. of mercury. Across other body barriers the diffusion coefficient is about fifty times as great. As the time of birth approaches, it becomes difficult to keep up a passage of oxygen through the placenta rapid enough to meet the needs of the fœtus.

The placenta may exercise a selective effect. According to Dr. Hoch, who spoke after Sir Joseph, the concentration of vitamin A in the plasma of mother and baby, at birth, is about equal; but the concentration of carotene is much higher in the mother's plasma.

The degree of obstruction by the placenta is reduced by mechanical means. Corrugation increases the area of the surface of interchange and the vessels of the fœtal and maternal circulation run in opposite directions. The hæmoglobin of the fœtus has a higher affinity for oxygen at low tension than has that of the mother. The hydrogen ion concentration of the blood of a pregnant ewe is raised; in consequence, the hæmoglobin of her blood gives up oxygen at abnormally high tensions.

The relative growth-rate of a goat fœtus, at different periods of pregnancy, is related to the rate of transfer of heavy sodium per unit weight of fœtus through the placenta. Hence, the rate of growth of the fœtus may be determined by the rate of passage of food through the placenta, and therefore by the size and vascularity of the placenta.

Dr. John Hammond suggested that the partition of food between fœtus and mother is regulated by the same factors as regulate the partition between different maternal tissues; that is, the fœtus, with a very high metabolic rate, competes with maternal tissues at a level slightly below that of the mother's central nervous system. The rate of growth is limited in some way by the mother. A foal, born of a Shetland pony mare inseminated from a Shire stallion, is smaller at birth and remains small until weaned. It is only when it eats according to appetite that genetic factors cause it to grow faster. The rate of growth, *in utero*, may be determined either by the rate of supply of food through the placenta, as suggested by Barcroft, or by the supply of an internal secretion or a metabolic substance produced by the mother.

The relation of growth to the supply of food to the fœtus becomes important in human pregnancy. The baby of a diabetic mother is fat, owing to the large amount of sugar supplied to it. Mr. Aleck Bourne, discussing fœtal development, stated that a large proportion of deaths *in utero* are due to smallness or ill-development of the placenta, and suggested that lack of vigour after birth may be due to undernutrition of the fœtus before birth.

How much, then, do the health of mother and offspring depend on the food supply of the mother? Lambs may be lost through neglect of the feeding of ewes in the late stages of pregnancy. But species differ, and the human mother is sacrificed to a much greater degree to the welfare of her offspring. Prof. A. St.G. Huggett said that he recognized five degrees of undernutrition of the mother; only in the most severe is the health of the baby affected. At one time the occurrence of fœtal rickets was disputed; however, it is found associated with osteomalacia of the mother, and the fœtus may suffer from keratomalacia if the supply of vitamin A to the mother is grossly inadequate. In the more severe degrees of under-nutrition, it may need four years of supplementary feeding to bring the baby back to normal, or it may never catch up completely.

Such catastrophes are seen only in extreme cases, but it might be expected that the health of the mother would suffer as the result of less severe degrees of undernutrition, even if the baby escapes. Apart from supplying the materials used by the fœtus, she has to provide some 300 gm. of protein for the development of the uterus and other reproductive apparatus; if the protein is not provided by her food, over and above her normal needs, it must come from other tissues. Pregnant women are known to suffer more than others when food is short. They may get osteomalacia, owing to lack of calcium and vitamin D; frank night blindness occurs during pregnancy in Newfoundland, for example, and clears up afterwards; in a large proportion of cases of beriberi in women the disease appears to have been brought on by pregnancy. We have laboratory evidence which appears to show that deficiencies of vitamins A, B, and C are more common among pregnant women eating their customary diets than among other women. For example, Dr. Hoch reported that he has found the levels of vitamin A in the plasma of pregnant women to be unusually low.

We come back to the old question of the intermediate states of deficiency. As Szent-Györgi has put it: How do we know that they are healthy, just because they have no scurvy? McCance and his colleagues collected records of the diets of pregnant women. The standard was so low, on the whole, and deteriorated so strikingly with fall of income, that it might be expected that there would be plenty of evidence of the ill-effects of undernutrition among poorer mothers. Mr. R. M. Titmuss, who discussed the relation of stillbirth and neonatal mortality to various influences, quoted the report of the Registrar General; the death-rate of babies, in the first month after birth, ranges from 22 per 1,000 in Class I to 33 in Class V. However, he showed that this issue is confused by many factors; for example, the degree of antenatal care, and the age of the mother, which is lower, on the average, in the poorer classes.

The frequency of stillbirth in England and Wales has remained practically unchanged since 1927, and mortality in the first month fell by only one quarter during the period from 1906–10 to 1937; whereas the mortality during the remaining eleven months of the first year of life fell by more than 60 per cent during the same period. Dr. I. Leitch, who followed Mr. Titmuss, suggested that, again, the results are complicated by improvement in antenatal care; more subnormal babies now survive to be born subnormal and die during the first month. The final value of any factor can only be assessed from the final results of the whole course of pregnancy and the early months of the baby's life. So many factors are involved that records of the distribution of deaths associated with pregnancy according to class, locality or time are not likely to give clear evidence of the effects of the single factor, nutrition.

There has been much unsound generalization about the effects of diet on the health of the mother. One may quote the instance of ketosis of ewes, which has been ascribed to overfeeding and lack of exercise. Here it was possible to make a clean experiment and Fraser, at the Rowett Institute, showed that ketosis did not occur in overfed sheep, but could be produced by underfeeding and cured by giving more food. Many still ascribe the rarity of eclampsia in Germany during the War of 1914–18 to the reduction of the amount of meat eaten. But the incidence of eclampsia rose immediately after the War ended, while the consumption of meat remained low. It would be more justifiable to give the credit for the reduction to the increased consumption of vitamin B_1, due to the higher extraction of grain during the war years. But it is now claimed that the changes were due to the fall in the number of first pregnancies during the war years. Eclampsia occurs more often in first than in later pregnancies.

There is one clear-cut instance of a deterioration of health of mother and infant due to deficiency of a nutrient in the ordinary diet. This nutrient is iron. In this instance, we have the specific evidence of iron deficiency, anæmia, and the unmistakable improvement when iron is administered. Mr. Aleck Bourne and Prof. Huggett both quoted three recent experimental studies of the effect of improvements of diet in other respects on the health of mother and baby: the Birthday Trust, the People's League of Health and the Toronto experiments. In these experiments the amount and quality of the foods supplied differed widely. In the Birthday Trust experiment, which was reported at this meeting by Lady Balfour, the extra food provided about 7 gm. animal protein, 0·35 gm. calcium, 0·3 gm. iron and, to those who were given yeast or Marmite, some 240 I.U. vitamin B_1. McCance and his colleagues measured the diets of twenty-five of the women who were receiving this extra food; the average amounts eaten per day were 36 gm. animal protein, 0·59 gm. calcium and 11·0 mgm. iron; it appears that the women either did not themselves eat all the extra food allowed to them or ate less of other foods, such as meat, when they were given this extra food. In the People's League of Health experiment the basic diets were probably better; large amounts of iron and moderate amounts of calcium and vitamin B_1 were given and the intake of vitamins A, D and ascorbic acid was raised well above the average. As these supplements appeared in the form of a 'medicine', they were in all probability consumed entirely by the recipient and not distributed among the family. In the Toronto experiment the diet was raised to a satisfactory level in every particular. In the Birthday Trust experiment, as reported by Lady Balfour, the frequency of stillbirths and deaths during the first month of the baby's life was reduced. In the People's League of Health the incidence of toxæmia (precisely defined) and of premature birth were lower in the supplemented than in the control group. In the Toronto experiment the number of subjects was small and the study more detailed; the chief significance of this experiment lies in the improvement of the subjects, as assessed clinically by an observer who did not know which of the subjects received the food supplements, and in the increase in the number who remained free from any complications. Also, the frequency of anæmia, toxæmia, threatened miscarriage, actual miscarriage, premature birth, endometritis, mastitis and breast abscess was less in the supplemented group, and the average duration of labour shorter; but as the numbers were small, the reduction in the frequency of any of these accidents may not be significant.

These three studies illustrate the difficulties that arise in this type of experiment. In the People's League of Health experiment the incidence of toxæmia was considerably higher in first than in later pregnancies. In the Birthday Trust experiment first pregnancies were more common in the control than in the supplemented group. In fact, Lady Balfour's report was largely devoted to the disentanglement of the confusing factors which might vitiate the results. When attention is focused on accidents, which occur in a small proportion only of the subjects, the results are not significant unless large numbers are studied; when large numbers are studied, it is difficult to control the diet and other interfering factors; and these accidents are, probably, not directly due to inadequacy of the diet. It would be better if it were possible to measure some feature that is present in all cases. Mr. Bourne suggested one; he said that obstetricians want to see 'vigorous' babies, and gave the ability to recover birth weight in ten days as one criterion of 'vigour'. This rate of recovery of weight could be measured.

The general well-being of the mother should be considered. According to Mr. Titmuss, one out of every eight pregnancies does not produce a baby alive at the end of one year. The attention of obstetricians is focused on the various catastrophes that happen between conception and the end of the first few months or less of the baby's life. But, socially, it is more important that seven mothers should be happy and feel well than that the eighth baby should survive. Is it impossible to devise some method of assessing well-being? It should at least be possible to compare the physical state of women before pregnancy with that, say, twelve months after delivery. This well-being may be unrelated to nutrition; but we ought to know.

In any future experiment it would be advisable either to raise the standard of the diet to a satisfactory level in every particular or to raise the intake of one constituent only; blunderbuss administration of a mixture of vitamins and minerals is unlikely to give clear results. Uniform criteria of, for example, prematurity should be adopted, and uniform methods of measurement fixed. At present, however, gigantic dietetic experiments are in progress. Prof. Huggett discussed the changes in diet due to rationing. As pointed out by Prof. J. R. Marrack, the supply of milk free or at a reduced price and the provision of cod liver oil and fruit juice have raised the general level of the diet of pregnant women above the average which existed before the War. Diets are now more uniform. A survey of the nutritional status and health of pregnant women now should give useful information on their reactions to standard conditions, and a comparison with pre-war records would indicate the effects of certain changes in diet.

We need to know more about the physiology of pregnancy. Why is it that a woman appears to need extra supplies of vitamins A, B_1 and C during pregnancy ? What is the purpose of the extra store of protein that is accumulated by a pregnant animal ? Why, as Dr. T. Moore pointed out, has a baby, at birth, such a low stock of vitamin A ? When we can answer these questions, we shall be in a better position to know what clinical evidences of deficiency we should look for and to lay down the food requirements of pregnancy. Prof. Huggett gave personal estimates of the levels to which the diet of a pregnant woman should be raised : 1–1·5 gm. of protein per kgm. of body weight, 1–1·5 of calcium and phosphorus, increased amounts of vitamins, particularly A, B_1 and D ; supplements of iron ; in terms of actual food-stuffs, more cheese, milk, vegetables and fruit. Until we have better knowledge of the physiology of pregnancy and more detailed evidence of the effects of diet on the health of mother and baby, we cannot assess the relative urgency of these demands. But pregnant women form such a small fraction of the total population and their health is of such importance, that they should, for the present, be given the benefit of any doubt and be allowed a prior claim on our food supply.

TRAWLING AND THE STOCKS OF FISH

IN a paper read before the Royal Society of Arts on January 27 on "Trawling and the Stocks of Fish", Dr. E. S. Russell, director of fishery investigations, Ministry of Agriculture and Fisheries, brought out in a convincing manner the problems which will confront us after the War in connexion with the national fish stocks of Great Britain and those of our near neighbours. In a summary of the history of the trawling industry from its beginning rather more than a century ago up to the present day, he traced its gradual growth. The demersal fishery, consisting of those fish living on or near the bottom, such as cod, haddock, hake, plaice and others, began with sailing boats fishing near shore. Then they ventured into the deep waters of the North Sea and, with the advent of the steam trawler and the great spread of fishing, went as far as Iceland and the Faroes, the Barents Sea and Bear Island, south of Spitsbergen. It is a tale of ever-increasing strength in boats and gear, and, running with it, an increase of fish—up to a certain point.

In 1866, a Royal Commission recommended that all restrictions on deep-sea fishing should be swept away and the industry allowed complete freedom of development—a measure which favoured enormously the later expansion of the trawl fisheries. It is a different matter nowadays. During the period of expansion there has been an almost continuous increase in the size and power of the steam trawler and in its fishing quality. It is a case of continued exploitation of the stocks of fish, beginning in a small way on grounds nearest at hand and spreading to all waters within reach, made possible by technical improvements in ships and gear and the building up of the fishing fleets in ever-growing strength.

The stocks of fish are not unlimited. The intense fishing made inroads into these stocks which are shown in the detailed statistics available, some of which were quoted by Dr. Russell. Those from the beginning of the century show a marked increase in the quantity of fish landed from 1886 to 1907; then follows a period of stabilization. With less fishing, landings necessarily fell heavily in the war period during 1914–18, in 1919–20 recovered to a level rather higher than pre-war, and in 1928 were not very different from 1907–13. Then comes a time when there is a sign of over-fishing. The landings fall off notwithstanding improvements in gear, and the average size of the fish is less. In spite of the fact that the war years had made it possible for the fish to recuperate, the very intense fishing which came after had made inroads on the stocks which could not be balanced. The only exception to the diminution of the stock was the cod in the extreme north. Here the fish were so unusually abundant, owing to changed hydrographical conditions, that this fishery itself was obliged to exercise restriction. Apart from the cod, the density of all the important demersal fish was steadily diminishing. Over-fishing was clearly the cause. The fish were not allowed to grow up.

At this point the present War broke out : once again, far fewer vessels are engaged in the fishery, once again the fish have recuperated and have grown to their full size and strength. After the War of 1914–18, enough was not known of the causes of these diminishing stocks. Modern research gives us no such excuse. As Dr. Russell states : "A conclusion of great importance has been reached, namely, that in most fully developed fisheries a state of over-fishing has been reached, a state where the ever-increasing intensity of fishing has resulted, not in an augmentation of the catch but in a diminution". He illustrates this by the haddock statistics, but it is the same story with almost any of the other important demersal fish. He has dealt with the subject fully in his recent book, "The Over-Fishing Problem" (Cambridge, 1942).

There is a grave warning here. Already something has been done by enlarging the mesh of the nets in order that immature fish may escape, but the question of immature fish, important as it is, is not nearly so important as the question of over-fishing. Canada has already so successfully controlled her halibut fishery that it has improved enormously.

With recuperated stocks and fishing fleets greatly reduced by the ravages of war, there are now exceptional opportunities to plan a more rational exploitation of the fisheries of Great Britain, and for this it is evident that international agreement will be needed. The object of such agreement will be to secure from each fishery area the maximum steady yield that the stocks can afford—to draw the interest while leaving the capital untouched. The only cure for over-fishing is to fish less, but with our improved knowledge it is clear that proper control will bring better profit to the industry and will lead to an increase, rather than a decrease, in the amount of fish landed.

ATMOSPHERIC POLLUTION*

By DR. G. M. B. DOBSON, F.R.S., and
DR. A. R. MEETHAM

ONE might think that the trouble of atmospheric pollution was a result of the industrialization of Great Britain during the past hundred and fifty years. It is therefore interesting to turn to John Evelyn, who wrote of London in 1661 :

"And what is all this, but the Hellish & dismal Cloud of SEA-COALE ? which is not onely perpetually imminent over her head ; but so universally mixed with the otherwise wholesome & excellent aer, that her Inhabitants breathe nothing but an impure & thick mist, accompanied with a fuliginous & filthy vapour, which renders them obnoxious to a thousand inconveniences, corrupting the Lungs, & disordering the entire habits of their bodies ; so that Catarrs, Phthisicks, Coughs & Consumptions, rage more in this one City than in the whole earth besides."

Hence the trouble is no new one. However, no major attempt was made to obtain accurate records of the pollution in towns until about 1912, when a small committee under the chairmanship of Sir Napier Shaw designed suitable instruments and arranged for regular observations to be made which have gone on until the present day. Now it may be asked what good has been done by the very great amount of work which has been put into these observations. The answer is that without them there is no means of knowing whether the trouble is getting better or worse ; whether big changes—for example, construction of the great power stations in London—have appreciably affected conditions, and whether legislation designed to reduce the evil has in fact had any effect. It would have been of great interest if John Evelyn could have made even the simplest observations to show the intensity of pollution in his day.

The pollution usually found in towns can be divided into three distinct classes : (1) 'Smoke', which consists of black carbonaceous matter formed by the imperfect combustion of fuel. This is mainly in the form of very small particles which float for a long time in the air, only settling out very slowly. (2) 'Ash' or grit which is thrown out with the flue gases and comes chiefly from industrial plants where the velocity of the flue gases is high. Such ash consists of much larger particles than 'smoke' and therefore settles relatively quickly out of the air in the immediate neighbourhood of the chimney discharging it. (3) Finally, there are the corrosive sulphurous gases. Of these, sulphur dioxide is generally the most important and comes from the sulphur always present in coal to the extent of 1–4 per cent. These gases are removed by being dissolved by clouds and rain or by reacting with stonework and the like.

The instrument which has been longest in use to measure the amount of pollution is the deposit gauge. This consists of a large glass funnel into which rain and impurities fall, to be collected in a bottle below. The object is to measure the amount of pollution settling out of the atmosphere on to buildings, trees and the like. The deposit is collected once a month and weighed and analysed into its chemical constituents. The gauge is not one of the most useful instruments, since it tends to collect material such as dust which is blown up by the wind.

* Being the substance of a Friday evening discourse entitled "The Air We Breathe in Town and Country" at the Royal Institution on February 12. Acknowledgement is made to the Department of Scientific and Industrial Research for permission to refer to unpublished results of the survey of atmospheric pollution at Leicester.

In order to measure the amount of black polluting matter suspended in the air Dr. J. S. Owens designed the automatic filter ; in this, air is drawn through a filter paper which removes the dirt, the amount of which can be estimated from the blackness of the stain produced. The position of the filter paper is changed automatically once or twice an hour so that variations in pollution throughout the day are recorded. The fact that only black matter is shown on the filter paper is no great disadvantage since most of the dirt usually found in the air is black. It has been shown that the greater part of the dirt caught by the filter consists of carbonaceous matter floating as very small particles in the air and may be described as 'smoke', in contrast to the larger inorganic particles of 'ash' which quickly settle out of the air. A filter can be connected in the pipe supplying air to the apparatus for measuring sulphur dioxide and in this case the filter is changed once a day. A variation of this type of filter has been designed which can be weighed before and after exposure, thus determining directly the weight of suspended matter in a given quantity of air.

Smoke is well known to have the effect of reducing the ultra-violet and visible daylight received in towns, and several instruments have been designed to measure this. Two have been used to enable a count to be made of the number of particles floating in the air. The first, designed by Dr. Owens, drives a jet of damp air at a high speed against a glass plate, when many of the particles are deposited on the glass, though some of the smaller ones may escape. The second instrument, designed by Mr. H. L. Green, uses the principle of thermal precipitation by which dust in warm air is deposited on any cold object. In both instruments the particles are counted with the aid of a microscope, and since the number of small particles that can be seen depends both on the illumination and on the magnification used, standard conditions must be employed if comparable results are to be obtained. If we wish to know the total number of particles present in the air down to the very smallest, we must use the Aitken dust counter, which uses the fact that if damp air is rapidly cooled by expansion, water droplets are condensed on each particle. The water drops fall out on to a polished metal surface and can be counted with the aid of a lens, but since there are so many it is usually necessary to dilute the sample of dirty air with a large volume of clean air to get a reasonable number to count. The number of these particles varies greatly, from some ten million per cubic inch in town air to a thousand or so in the cleanest country air. Some of the particles found in country air are produced naturally and are not due to human activities.

Finally, we come to the gaseous pollutions. The total acidity (mainly due to sulphur dioxide) is measured by passing a known quantity of air through a solution of hydrogen peroxide and titrating the resulting acid after 24 hours. We may determine what may be called activity of the sulphur gases by measuring the rate of sulphation of a standard surface of lead peroxide and in this way obtain a figure which will give an indication of the very much slower rate of attack of stonework, etc., by the sulphur gases. The latter apparatus has been found to be very useful since many sets can easily be exposed in different places—usually for a month—and then analysed.

Turning now to the results that have been obtained with these instruments, we take first the deposit gauge. Of the total catch, part is soluble in water and part insoluble. Some of the insoluble matter is dust blown up by the wind, and is often found to increase in dry weather. Much of the remainder comes from the nearest two or three industrial chimneys. The weight of soluble matter is very closely related to the rainfall, and there is little doubt that the rain removes a considerable amount of the sulphur gases in the air. The sulphur dioxide is mainly caught by cloud droplets as they float in the air rather than by the rain falling through the air. This is indicated by the fact that the amount of sulphates, for example, deposited with the rain falls off much more slowly outside a town than the amount of sulphur dioxide in the surface air. The sulphur dioxide at cloud level will be much more uniformly distributed than that in the lower air.

The results from the automatic filter may be used to show how the amount of smoke varies through the day. As might be expected, the air is cleanest in the early morning just before the first fires are lit for the day. A rapid increase of smoke then occurs, reaching a maximum in the middle of the morning. A shallow minimum during the afternoon is partly due to a reduction in the amount of smoke produced at this time and partly to the increased turbulence of the air in the middle of the day, which removes some of the smoke from street level. A second maximum in the late afternoon, which may or may not exceed the morning maximum, is caused partly by cooking the evening meal and partly by the reduced turbulence at this time of day. A remarkable result that comes out of these observations is that even under conditions of very stagnant air which causes a thick smoke haze during the day, the air in the early morning is comparatively clean. Even a thick fog, which in the evening has become a 'pea-souper' by picking up smoke, is found to be a nearly white fog, resembling a country fog, in the early hours of next morning; in other words, yesterday's fog has been removed or deposited during the night and a new clean fog has taken its place only to become as dirty as its predecessor during the coming day.

Although most measurements of acidity in the air take a single sample running for 24 hours and so cannot show the diurnal variation, yet a few hourly measurements have been made. These show a maximum of acidity during the daytime, but since the lighting of fires produces no extra acidity in the way that it produces extra smoke, we should not expect the morning maximum to be so marked. This is what the observations show to be the fact.

Both smoke and acidity show strong annual variations, with a maximum in winter and minimum in summer. This is natural both because more fuel is burnt in winter than in summer and also because the greater turbulence in summer will carry smoke and acidity more rapidly upwards.

The reduction of daylight—and particularly of ultra-violet light—near the centre of a large town by the smoke may be very great, and the proportional reduction is much greater in winter than in summer, although there is more need for ultra-violet in winter. This is partly due to the greater amount of smoke in winter and partly to the fact that the more oblique rays of the sun must travel a longer path through the smoky air. On a bad day in winter in London, nine tenths of the daylight is probably lost because of smoke alone.

In order to study atmospheric pollution in cities throughout Great Britain, the organization started under Sir Napier Shaw is still in existence; nearly sixty municipal authorities co-operate in making measurements of the pollution of the atmosphere within their respective towns, all the results being co-ordinated by a central committee under the Department of Scientific and Industrial Research, which carries out central services for this co-operative scheme. A large amount of information has been collected in this way during the last twenty-five years about the pollution at selected points in a number of cities. This information is very valuable in showing whether the pollution is getting better or worse, but it is usually not possible for any one city to run more than one or two stations, and we should never in this way have found out much about the distribution of pollution in different parts of a town. Again, since it is probable that the instruments set up in different towns will not be in comparable positions, we could say little about the general cleanness of one town as compared with another. What is perhaps more important still, is that we had little information about the 'life-history' of pollution after it left the chimney, and how it was removed from within the town, and how it was finally removed from the atmosphere. For this reason the Atmospheric Pollution Research Committee of the Department of Scientific and Industrial Research recommended that a thorough investigation should be undertaken into the distribution of pollution within one typical town. The city finally chosen was Leicester, since it is a large industrial city and is fairly well removed from other large towns the pollution from which might complicate the results. The authorities of the City of Leicester gave every possible assistance and two full years observations were made there at a dozen different situations in the centre of the city, in the suburbs and in the country surrounding it. Observations of smoke, sulphur, acidity and daylight were made at all these sites. Later, observations were made for a short time at a few other stations to clear up special points.

Curves for smoke and sulphur dioxide or acidity show distributions generally similar; the maximum density of pollution coincides closely with the centre of the city.

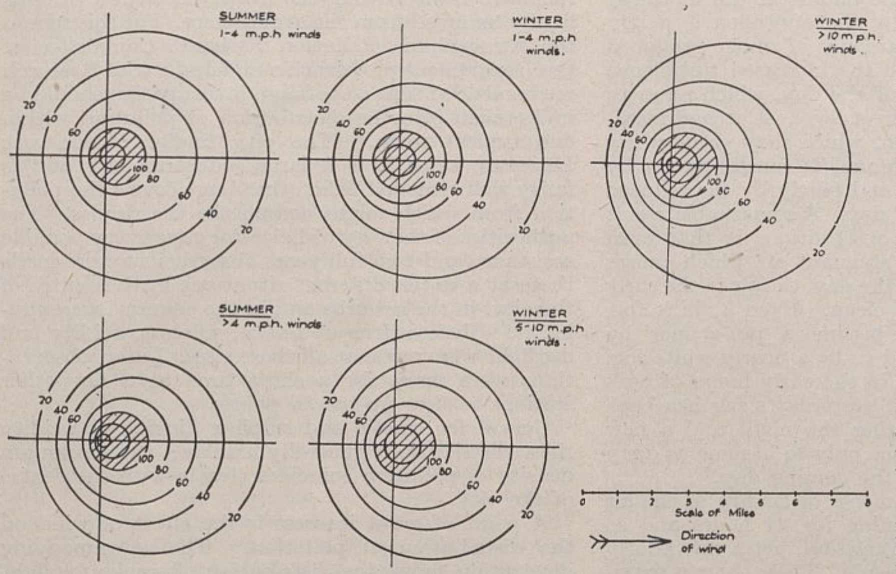
A point of great interest is the effect of wind on the distribution of pollution. The accompanying illustration shows the distribution of smoke for light and moderate winds in summer and for light, moderate and strong winds in winter; the intersections of the straight lines indicate the centre of the city. At first it is very surprising that in all cases the highest pollution is found close to the centre of the city rather than some distance downwind from the centre; and the general distribution—indicated by the circles —is little distorted by the wind, while the pollution added by the large city of Leicester was under most conditions difficult to detect above the general level of pollution in the surrounding country only a few miles downwind from the centre of the city.

In an earlier research the number of particles found by the Owens dust counter was recorded at various distances downwind from the centre of Norwich. Although this work was less detailed than that at Leicester, it again showed that even in strong winds the maximum number of particles was always found very close to the centre of the city and fell off rapidly downwind. It showed also that an increase of wind, by say three times, only resulted in a decrease of the pollution at the centre by about 30 per cent. At distances of more than five miles downwind the number of particles was nearly constant.

From these diagrams it is quite clear that somehow or other smoke is quickly removed from the surface air where the measurements are made. If there were no removal of smoke, the concentration would steadily increase as the air passed across the city—more rapidly when passing over the centre of the city and more slowly as it passed over the outskirts—so that the densest pollution would be somewhere near the leeward edge of the city. It is possible that the removal of this smoke is affected in three ways: by diffusion sideways across the wind direction, by deposition on to the ground and by spreading upwards. Diffusion sideways could not account for the rapid fall in pollution at a distance downwind from the centre which is small compared with the width of the city. The deposit gauge gives no sign that deposition is sufficiently rapid to give the effect, and we are left to conclude that diffusion upwards into the upper air is the really important factor.

Of course, the smoke is finally carried away from the city area by the wind aloft, but it seems that it is the removal of smoke from street level into the air a few hundred feet up that prevents smoke accumulating to a far greater extent than it usually does. That this is really the case is borne out by observations on days when the meteorological conditions are such that upward diffusion is stopped, for we find on these days that a dense smoke haze is quickly formed. The amount of upward diffusion is determined both by the change of temperature of the air with height and by the wind. When there is a cool layer of air near the ground with a warmer layer above, there is little vertical mixing of the air, and these are the conditions when smoke accumulates excessively near the ground. A strong wind will cause a reduction of smokiness, but this is more because it increases the vertical mixing than because it carries smoke away horizontally. This accounts for the observed fact that the reduction in pollution at street level is much smaller than the relative increase in wind velocity.

Although the smoke produced in towns is removed from the street level mainly by diffusion into the air overhead, it must eventually be removed from the area of the town by being carried away by the wind, and it will go to pollute the air over the surrounding country. Since the pollution from towns is dispersed through a great depth of atmosphere by the time it has drifted many miles away, the actual concentration in surface air will be small and may be difficult to detect in the presence of quite small local sources of pollution. On the other hand, the total mass of pollution through the whole thickness of the atmosphere may be great, so that it greatly affects the visibility and the colour of the sky. This makes the study of the pollution in districts far removed from its source rather difficult, and other methods may have to be used than those employed successfully in towns.



Up to the present time, no thorough study of the spread of the smoke over the country has been made, but it is easy to see its effects at great distances from towns. It has been estimated that, during westerly winds, a point some four miles to the east of Leicester receives about 30 per cent of its pollution from Leicester, about 25 per cent from the Birmingham district which is 30–45 miles away, and 45 per cent from elsewhere. North-easterly winds bring the least pollution to the Leicester district from outside since there are no large towns in that direction for many miles. At Oxford, south-westerly and westerly winds generally give very good visibility, but the smoke from the Midlands some sixty miles away produces much haze when the wind is north-westerly or northerly. With moderate or light northerly winds the visibility may be quite good during the morning, but about noon the Midland smoke can be seen arriving while the visibility decreases and the blue sky becomes whitish.

Turning to the effect of pollution on the light received in different parts of Leicester, we find that in summer, when the amount of smoke is generally low, the reduction even at the centre of the city is small, but in winter the decrease is very appreciable and in December the centre of a city may receive less than half that received outside it. The insidious effect of pollution on public health is partly due to this reduction of ultra-violet light, and may be the greatest evil of all.

It may be well at this point to say a few words about the effect of pollution on town fogs. It is probable that the *number* of fogs in a city is not increased above those in the surrounding country; indeed, as is well known, since there is a small increase in air temperature in towns above that of the country outside and since the rain will run off from roofs and streets much quicker than from open ground, one may expect the air in towns to be slightly drier than that outside them. On the other hand, the *character* of any fog which is formed will be greatly changed. Since there are so many more nuclei on which water droplets can form, the fog is likely to be noticeably more opaque and each droplet will catch some of the dirt floating in the air, so that the fog will lose the white character it would have in the country and tend to become a black fog. The number of 'pea-soup' fogs in London seems to have become definitely smaller in recent years, but it is difficult to say exactly why this is so. Unfortunately, the output of pollution does not seem to have decreased in the same ratio, although there was a substantial decrease in the years 1918–23.

One way in which we can get an estimate of the amount of domestic and industrial smoke is to measure the pollution on the different days of the week. On Saturday afternoon and Sunday, a great proportion of the industrial fires, including office heating, will be out or very low. On the other hand, domestic fires will go on as usual or may be slightly increased. It is found that there is a fall on Saturday afternoons and a marked drop on Sundays except in purely residential districts, the percentage drop varying between the residential and industrial parts of a town. On the average, the Sunday pollution in the centres of towns is about half to three quarters of the weekday pollution, and as a very rough estimate we may take the smoke pollution to be two thirds domestic and one third industrial in origin.

There is a greater reduction of sulphur than of smoke at week-ends. This is because a greater proportion of smoke is produced from open fires in houses. In central Leicester on winter weekdays, two thirds of the sulphur is of domestic origin whereas three quarters of the smoke is of domestic origin. This all shows how much more wasteful of fuel we are in the home than in the office or factory. If domestic heating and cooking were done as economically as industrial heating and steam-raising, we should use less coal in houses than industries, not more. These figures refer to peace-time, of course.

It may not be out of place finally to take a look at the problem with a view to the future and see what could reasonably be done to remove the evil. Of the three evils, 'smoke', 'ash' and 'sulphur', it is reasonably easy to prevent the emission of ash from industrial plants without placing too great a financial burden on industry, and one may hope that this will be made compulsory. The ash from domestic fires is probably too small to cause a serious nuisance.

The removal of 'smoke' depends on burning fuel in a proper manner. There seems no reason why most industrial plants should make any great amount of smoke, and even now the best plants are practically smokeless. Smoke means loss of fuel and it should be in the interest of the industries themselves to burn their fuel efficiently. A reduction in domestic smoke is likely to come about through the ever greater use of gas and electricity for cooking and heating, while smokeless fuel may replace some raw coal. If district heating is widely adopted, it should also help very much. Any method of increasing the efficiency of the open grate would improve matters, but short of abolishing open coal-fires altogether, the most effective reform would be to consume the smoke emitted during kindling and refuelling.

From time to time there have been suggestions that 'smokeless zones' should be established in the centre of cities where no coal could be burnt in such a way as to produce smoke. The results of the detailed work at Leicester allow us to make a rough estimate of the effect. While such efforts are greatly to be encouraged, no striking effect is to be expected unless the smokeless zone is large, owing to the smoke from the surroundings which will be carried into it.

To prevent the emission of sulphur dioxide may prove to be the greatest difficulty. However efficiently coal is burnt, the amount of sulphur dioxide formed depends only on the weight of coal consumed and the sulphur content of the coal. Unless some means is provided for absorbing the sulphur before the gases are discharged into the air, little improvement can be obtained, though washing the coal removes some of the sulphur. Some of the great electric power stations have means of absorbing the sulphur gases, but from by far the greatest amount of coal burnt all the sulphur dioxide formed is discharged into the atmosphere. There is some hope that, in the not too distant future, apparatus for absorbing sulphur gases may be practicable for much smaller plants, but it is perhaps too much to hope that such means could be generally adopted for the domestic fire. If communal or district heating were introduced on a wide scale, the central plants might be fitted with sulphur absorbers. The use of coal gas (where almost all the sulphur is removed) or of electricity (provided sulphur-absorbing plant is installed at the power stations) on a very much greater scale than at present may be the final solution.

It is greatly to be hoped that in planning the new Britain all practicable measures to reduce atmospheric pollution will be adopted.

OBITUARIES

Mr. Rollo Appleyard, O.B.E.

Rollo Appleyard, whose death occurred on March 1, was one of those pioneer engineer-physicists who did so much during the last few decades of the nineteenth century to establish British electrical industry on a scientific basis. Born in 1867 and educated at Dulwich, he was fortunate, as a student at the City and Guilds Institute, to come under the influence of that great coalition Profs. Ayrton and Perry. Bedford College and Coopers Hill College in turn welcomed him afterwards on the physics side.

At the age of twenty-five, Appleyard joined the technical staff of the India Rubber and Gutta Percha Company at Silvertown, where he remained for twenty-two years. Among his colleagues at this time was Rymer-Jones, of world-wide submarine cable reputation, and during this period Appleyard devoted a good deal of time and thought to dielectric and conductor problems in submarine cables. He contributed many papers to the *Proceedings of the Physical Society*, the *Phil. Mag.* and to the engineering institutions, as well as articles to the electrical press. These covered a variety of subjects including electrical alloys, network problems, submarine cable testing and apparatus for this purpose, coherers, surface tension and thermometry. He was mostly interested in dielectric theory, and an outstanding example of his practical application of his knowledge of physics was the production of the submarine cable connecting Honolulu and San Francisco, in which he achieved the lowest dielectric constant obtained on any submarine cable to that date.

In the improvement of the conductor for long-distance submarine cables, Appleyard invented the 'conductometer', an instrument for the measurement of electrical conductivity, and his paper on the subject before the Institution of Civil Engineers gained him the Telford Premium in 1903. As evidence of his versatility and long interest in technical matters, it may be recorded that seventeen years later the award was made to him a second time, for a paper on the mathematics of catenaries. While at Silvertown he also devoted considerable thought to the physics and the development of the intricate mechanism involved in the formation of a golf ball core.

During the War of 1914–18, Appleyard worked in the Admiralty and Air Service, where his unique combination of practical engineering knowledge and physics training enabled him to make many contributions to the war effort, for which the O.B.E., as a mark of recognition, was conferred upon him. He introduced improvements in the measurement of height by barometer and the design of instruments used for many different purposes.

Throughout his life, Appleyard showed a marked literary talent which for many years revealed itself in his papers and articles. Towards the end of the War of 1914–18, he produced several valuable confidential reports for Government Departments, and directed for some time the technical history section of the Admiralty. He was a member of the editorial staff of *The Times Engineering Supplement* for some nine years from its establishment in 1905. As one of the abstractors in the early days of *Science Abstracts*, he did useful work, but perhaps he will best be remembered for his delightful biographical works: "Pioneers of Electrical Communications", "A Tribute to Faraday", and others. These, along with his "History of the Institution of Electrical Engineers", will for many years to come remind the members of that body, among whom he counted so many friends, of his engaging character. Mostly perhaps will he be missed in those more intimate circles, the Athenæum, the 25 Club and the Dynamicables, where his grace and charming personality were always a delight to his fellow-members.

P. DUNSHEATH.

WE regret to announce the following deaths:

Sir Sidney Burrard, Bart., K.C.S.I., F.R.S., formerly Surveyor-General of India and superintendent of the Trigonometrical Survey of India, on March 16, aged eighty-two.

Prof. H. G. Denham, dean and professor of chemistry, Canterbury University College, Christchurch, New Zealand, and chairman of the New Zealand Council of Scientific and Industrial Research, aged sixty-two.

Prof. J. Eustice, emeritus professor of engineering at University College, Southampton, on February 24, aged seventy-eight.

Dr. F. G. Parsons, research fellow in anthropology at St. Thomas's Hospital and formerly professor of anatomy, University of London, on March 11.

Mr. H. E. Stilgoe, C.B.E., formerly chief engineer of the Metropolitan Water Board, and a past-president of the Institution of Water Engineers, the Institution of Municipal and County Engineers and the Town Planning Institute, on March 12.

NEWS and VIEWS

Cambridge University Botanic Garden

WHEN Mr. Reginald Cory, a graduate of Trinity College, died in 1934, he bequeathed the residue of his estate to the University Botanic Garden at Cambridge. Mr. Cory, who was himself a great gardener and helped to finance expeditions to China and other countries to collect plants that could be grown in British gardens, was a generous benefactor of the Cambridge Garden during his lifetime. His handsome final bequest has now begun to accrue, and from this time onwards the garden will benefit by £9,000, rising eventually to £13,000, a year. In accordance with the terms of the will, only £1,000 a year of the legacy can be devoted to maintenance, the remainder being available for capital expenditure, including the purchase of land for the extension of the garden. The Cory Fund will be administered by six members of the senate, including the Professor of Botany and the University Treasurer.

The Cambridge Botanic Garden, which is a part of the University Department of Botany, has already a deservedly high reputation, but there are now great possibilities of further enhancement, especially as regards the variety of plants cultivated in it and the general beauty of the Garden. In the past, many important botanical investigations have been carried out there, and in view of the opportunities now available it is anticipated that several branches of botany will be greatly assisted. Of the total area of forty acres, about eighteen have been used as garden allotments for many years. After the War, it may be considered desirable to incorporate these into the Garden proper. An arboretum is a great desideratum, but this may have to be established on a different site as the soil is unsuitable for certain conifers. The Garden at present lacks protection from the north and east, and a good wall against which the more delicate shrubs can be grown is an urgent necessity. Much greater facilities could be usefully provided for growing water-plants as there is a stream contiguous to the Garden. The range of glasshouses could also be advantageously extended, giving additional provision for the cultivation of ferns and bryophytes, and tropical and sub-tropical flowering plants. No doubt all these possibilities will be weighed by the managers of the Cory Fund.

Nature Reserve at Oxford

THE University of Oxford has accepted, as a gift from Mr. and Mrs. H. Spalding, eighteen acres of meadow land on the left bank of the River Cherwell opposite the walk known as Mesopotamia. This land is to be maintained as a nature reserve, to preserve in perpetuity a piece of water meadow, characteristic of the Oxford basin, for the enjoyment of the public, and to afford facilities for observation of the plants and animals inhabiting this type of land. The meadow land includes a small triangular area at its south end which, surrounded by old hedges, might, if suitably planted, develop into a woodland plot tempting to nightingales, which at present are not audible from Mesopotamia. The area is at two levels, that nearer the river being liable to flooding. The blight of suburban extension has already threatened that part farthest from the river with untidy neglected fields and huts, and the preservation of Mr. and Mrs. Spalding's gift will protect Mesopotamia from further spoliation of the river. Administrative control is to be vested in the Curators of the Parks who, in consultation with a committee of naturalists, will manage

None of the Vacancies advertised in these columns relate to a woman between 18 and 41 unless such woman (a) has living with her a child of hers under the age of 14, or (b) is registered under the Blind Persons Act, or (c) has a Ministry of Labour permit to allow her to obtain employment by individual effort.

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The Assistant will be required to work in Exeter for the Summer Term, 1943, and then at the School in London.

Applications, giving particulars of age, qualifications, experience, etc., should be sent to the undersigned as soon as possible.

NANCIE MOLLER,
Warden and Secretary.

Reed Hall, Streatham Drive.
Exeter, Devon.

A junior assistant is required for the Physics Laboratory at Rugby School, to commence May. Applications should be addressed to R. W. Scott, Rugby School Science Laboratories, Barby Road, Rugby.

Ido-English and English-Ido dictionaries, 11s. post free and information on international language, Ido Society, 8 Spareleaze Hill, Loughton, Essex.

ANIMAL DISEASES RESEARCH ASSOCIATION

Applications are invited for the post of Research Assistant on the grade of Scientific Officer, to which the following salary scales apply: Men—£400 by £18 to £454; £454 by £25 to £580 (bar); £580 by £25 to £680. Women—£350 by £18 to £464 (bar); £464 by £25 to £580. The commencing salary will be according to the qualifications of the candidate selected. There is superannuation provision under the scheme of the Federated Superannuation System for Universities.

Candidates should state their experience, if any, of research in animal disease, including any special qualifications in histo-pathology or bacteriology.

Six copies of application and not more than three testimonials should reach the undersigned not later than April 26, 1943.

A. R. MILROY,
Secretary.

Moredun Institute,
Gilmerton, Midlothian.
March, 1943.

HENRY GEORGE PLIMMER FELLOWSHIP

The Governing Body of the Imperial College invite applications for the Henry George Plimmer Fellowship, vacant from September 1, 1943. The Fellowship was founded in memory of Professor Henry George Plimmer, F.R.S., who held the Chair of Comparative Pathology at the College from 1915-18. It is tenable for one or more years at a recognized institution, and is for research which may include Morbid Anatomy, Histological Anatomy, Chemical Pathology, Protozoology, Bacteriology and allied subjects in either Zoology, Medicine or Botany. The annual value is equal to the income from certain War Stock, approximately £217 per annum. The Fellow shall be considered to be attached to one of the Biological Departments of the Imperial College, and shall work under the general supervision of a Professor of that Department.

Applications (by letter only) should be sent before June 1, 1943, to the Rector, Imperial College, Prince Consort Road, London, S.W.7, from whom further particulars can be obtained.

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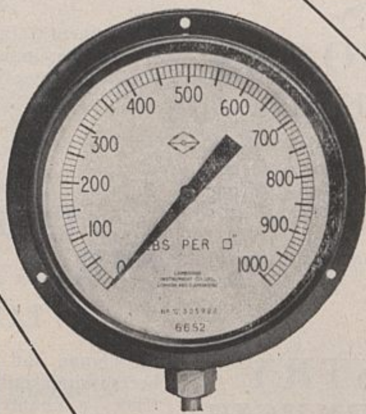

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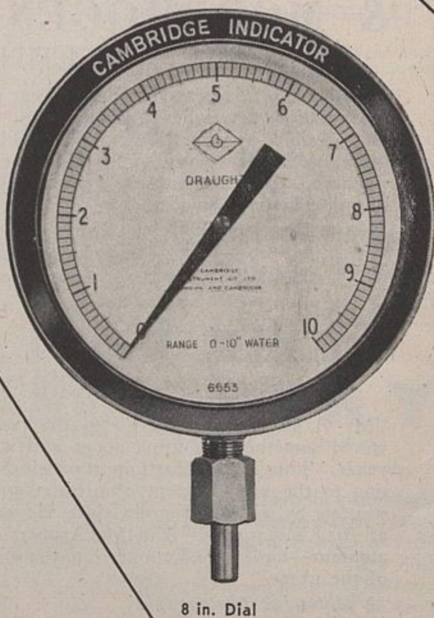

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Scientific and Industrial Research in India

IN its report which appeared during the War of 1914–18, the Indian Industrial Commission, over which Sir Thomas Holland presided, directed attention to the necessity of establishing a system of organized research if Indian industries were to be adequately developed. Unfortunately, in the post-war period little attention was paid to these recommendations, although in 1937 the late Lord Rutherford in the presidential address which he had prepared for the twenty-fifth meeting of the Indian Science Congress Association once more emphasized how greatly India would benefit by the formation of an organization similar to the Department of Industrial and Scientific Research. The present War, combined with the energy and foresight of the Hon. Dewan Bahadur Sir A. Ramaswamy Mudaliar, now a member of the War Cabinet, provided the necessary stimulus, and on April 1, 1940, the Board and Council of Scientific and Industrial Research was formed by the Government of India. Dr. (now Sir) Shanti Bhatnagar was appointed as the first director. The manifold activities and the great achievements of this research organization, due largely to the energy of its director, are little known in Great Britain, and we welcome, therefore, the new publication, *Journal of Scientific and Industrial Research*, issued by the Council, the first number of which has just been received.

The Board functions largely through a series of committees, some nineteen in number, which range from a Vegetable Oil Committee to one of Radio Research. At the present time, the research work of these various committees is carried out, under the general control of the director, in various university laboratories and at the Indian Institute of Science, Bangalore, but a National Chemical Laboratory is to be opened at Poona. This has been made possible by a munificent gift of 8 lakhs of rupees from Messrs. Tata Sons and 1 lakh of rupees from Messrs. Indian Wire and Steel Products Limited. Articles in the *Journal* discuss the possibilities of the manufacture in India of calcium carbide and thermionic valves and also the utilization of Bhilawan resin as a base for plastics. Interesting articles deal also with established Indian industries such as the Tata Oil Mills and the Juggilal Kamlapat group of mills. While agriculture must always play a predominant part in Indian economy, with her many resources, she can support also great industries. Doubtless future issues of this journal will furnish us with an account of some of these developed by the new research organization.

Industrial Health Advisory Committee

THE appointment by the Minister of Labour of an Industrial Health Advisory Committee, and the announcement by him of a three-day conference (in April) on industrial health, to which representatives of the Dominions will be invited, as well as representatives of organizations in Great Britain interested in the physical well-being of the working population, indicate a move in the direction of reform long overdue. The rapid mechanization of war, with its consequent emphasis on accurate large-scale factory work, has directed attention to the time lost in factories through petty illnesses and industrial hazards, mostly preventable. Most, if not all, of these hindrances to production existed in peace-time, but only a life-and-death war, with its vast increase in the factory population, has made it obvious that the standard of health of the factory worker is everybody's business—it is, in fact, a political question. True there are Factory Acts, providing a minimum standard of conditions in factories and protection against many industrial hazards, but their enforcement is entrusted to factory inspectors whose numbers—their zeal has never been in question—are wholly inadequate for the work they have to do. Nor is there much provision for research in industrial health, or much apparatus for the implementation of its findings. One of the duties of this new Committee will be to codify knowledge and help to bring it into use.

A comparatively modern development is the realization of the fact that the health of the worker is not merely the province of medical men and factory inspectors, but also of the worker himself. This is reflected in Mr. Bevin's suggestion that trade unions should take an interest in the preservation of health, and in those from other quarters that workers should help in the defence against industrial hazards and the teaching of industrial hygiene. Mr. Bevin hopes that Government, employers, managers and workpeople will co-operate to the full in providing factory conditions that will make work healthier, safer and more pleasant. The Committee will advise him how the Government can do its part. This valuable co-operation, for these honourable ends, must be continued after the end of the War, through the difficult times of transition and on into the era of peace.

British Council: New Institutes in West Africa

PROF. W. M. MACMILLAN, who has been working for the past two years in the Empire Intelligence Section of the British Broadcasting Corporation, has been selected by the British Council to act as its representative in West Africa. He will leave for the West Coast as soon as possible. His appointment follows a survey recently made by Mr. C. A. F. Dundas, the British Council's representative in the Middle East. It is hoped to establish institutes in the four West African Colonies, to serve as intellectual and cultural centres and to demonstrate the progress made in Britain in the fields of science, pure and applied, literature, art, music and drama. The necessary executive staff is now being assembled. Prof. Macmillan, lately professor of history and research fellow at the University of the Witwatersrand, Johannesburg, is a member of the Colonial Office Advisory Committee on Education in the Colonies. He has spent many years in Africa and several of his books are widely known; they include "Warning from the West Indies" (1936), and "Africa Emergent" (1938).

Mortality and Life Assurance Statistics

Sir William P. Elderton and Mr. M. E. Ogborn read a paper before the Royal Statistical Society on March 16 on "The Mortality of Adult Males since the Middle of the Eighteenth Century as shown by the Experience of Life Assurance Companies". Life assurance as we know it began in 1762, when the Society for Equitable Assurances on Lives and Survivorships was founded and, until early in the nineteenth century, this was the only company having a substantial number of lives assured on its books. The lives represent a provident type drawn from the professional and business classes, with a sprinkling of landed gentry on one hand and of clerks and servants on the other. Three mortality experiences were quoted: Arthur Morgan's, 1762–1829; H. W. Manly's, 1863–1893; and a recent experience, 1924–1938. The rates of mortality were light and show a steady decrease up to about age 77. In the most recent experience the rates of mortality are about one fourth of those of the first experience up to age 47, and rather less than one half of those of the second experience. The proportional fall decreases at the older ages until there is little change from age 82 onwards. As regards the general population, the English Life Tables Nos. 3, 5 and 10 were used for comparison as they correspond most nearly in date to the assurance experiences. From No. 3 to No. 5 the mortality decreased by about one quarter at early adult ages and by about one tenth between ages 30 and 40. From then onwards No. 5 shows an increase in mortality over No. 3, and even though the methods of construction and reliability differ it seems probable that mortality actually increased. From No. 5 to No. 10 there was a decrease of about one half in the rates of mortality up to age 47, dropping to one tenth at age 77, and showing on the whole a smaller decrease at the later ages. These changes are similar to those between the two corresponding experiences of the assurance offices, though the general population has, as would be expected, a higher mortality than that of lives assured.

Control of Infectious Diseases

IN a Chadwick Lecture given on March 16 by Dr. Robert Cruickshank, of the L.C.C. Group Laboratory, it was stated that although the mortality from infectious diseases has steadily declined in the past half-century, approximately one out of every five deaths is at present due, directly or remotely, to infection. To assess the effect of past measures and as a guide to new methods of control, the bulk of infectious diseases can best be analysed in four main groups: (1) acute respiratory infections; (2) tuberculosis; (3) intestinal infections; and (4) childhood fevers (whooping cough, measles, diphtheria, scarlet fever, in that order of importance). The pneumonias and bronchitis are pre-eminent as a cause of death among the infections (they are third on the list among deaths from all causes); sulphonamides have failed to produce any striking reductions in the death-rate from these causes. A promising beginning has been made in the control of influenza, but the common cold is still a major public health and economic problem.

The upward trend of tuberculosis in war-time—the causes are hypothetical—has helped to accelerate measures for its better control; the role of artificial vaccination needs fresh consideration in Great Britain. Typhoid fever declined sharply coincidental with the introduction of the water-carriage system of sewage disposal, but paratyphoid, bacterial food-poisoning and bacillary dysentery are now more prevalent than they were. Their control will be closely linked with improved personal hygiene, particularly of food-handlers. The highly fatal gastroenteritis of infancy is an unsolved problem needing urgent attention. Whooping cough is the most serious of childhood infections; it can be prevented or attenuated by prophylactic vaccination. Measles, itself a mild disease, is a menace because of its secondary complications. Diphtheria may not be wholly preventable but should cease to cause death. The means by which improvements in the control of infectious disease can be effected are: (1) administrative regionalization (with the medical officer of health, the practitioner and the bacteriologist as co-operative partners); (2) structural (improved design and equipment of hospital, school and home); (3) educational (of child, parent, nurse, student, medical man); (4) preventive (better feeding, better hygiene, artificial immunization, new methods for the control of air-borne infections).

Mild Winter of 1942–43

THE break in the series of severe war-time winters in Great Britain effected by the mild weather at the end of 1942 and in the early part of 1943 had an interesting effect upon the wild life of the English countryside compared with the previous three winters. Although in Scotland wildfowl and wild geese were reported to have been as numerous as in the previous season, in most parts of England the golden-eye, a characteristically abundant visitor in the previous war winters, was much less numerous. In west Cumberland in the middle of February the hatching of brown trout and sea-trout eggs was reported to be some thirty days in advance of the previous seasons, although in an article on "The Spawning Habits of Salmon" in the *Field* (February 6), G. M. King, clerk to the Dee Fishery Board, contends that in thirty-four years' experience he has failed to find that prevailing weather conditions affect the spawning time of these fish. In other parts of Lakeland there were many plants of red dead nettle, shepherd's purse, red campion, ivy-leaved toadflax, etc., in flower at Christmas. Over England generally the yellow winter jasmine was reported to have given one of the finest flowering displays for many years, and the songs of the song-thrush and skylark commenced several days earlier than usual. The missel-thrush was reported sitting on its nest in North Wales in February, and the song-thrush nest-building in Lancashire on February 6, and sitting on eggs on February 17. In Sussex and most other parts of Great Britain the exceptionally early pairing of partridge was also noted; in Cumberland these birds had paired by Christmas. Another Sussex feature was the early breeding of rabbits. From the Home Counties there were many early reports of hazel flowers, male and female, recorded in the *Times* in January.

Recording Technique in Electro-Biology

AN interesting paper entitled "Amplifying and Recording Technique in Electro-Biology, with Special Reference to the Electrical Activity of the Human Brain" was read by G. Parr and W. Grey Walter at a meeting of the Wireless Section of the Institution of Electrical Engineers on March 3. One of the fundamental properties of the living cell is the production of an electromotive force, which changes when the cell is stimulated into activity. In order to study the nature and magnitude of these biological E.M.F.'s, special amplifying methods and input circuits are required, operating suitable visual, photographic or pen-writing recorders. The paper referred to reviews the standard methods of obtaining records, and the application of these to the recording of the potentials in the human cerebral cortex. The magnitude of the potentials produced by the brain varies from 5 to 1,000 micro-volts ; it is of alternating wave form, of frequencies ranging from 1 to 20 cycles per second, and very irregular. The frequency of the output from an abnormal brain (for example, epileptics and cases of cerebral tumours) differs appreciably from that of the normal, and from this and other indications it is claimed to be possible to diagnose mental diseases and locate with considerable accuracy the sites of tumours.

Although the records in most cases show a wave form of a main predominant frequency, this is frequently interrupted by irregular groups or bursts of waves of other frequencies. These irregularities have a definite clinical significance, and it is therefore of importance to analyse the record accurately to determine the frequencies present. The authors described a tuned reed autographic analyser which has been developed for this purpose, and showed an example of its application. The reading of the paper was accompanied by a demonstration on a human subject, in which the varying effects of permitting the brain to rest and of stimulating it into activity were shown by records on a cathode ray oscillograph.

Golden Gate Bridge

Instruments have recently been installed on the Golden Gate Bridge at San Francisco for accurate recording of movements that occur under wind loads (*Earthquake Notes*, 14, Nos. 1 and 2 ; 1942). These include a wind velocity recorder, a wind directional recorder and a non-sensitive recording seismograph. Vertical and horizontal graduated boards at midspan will facilitate observations with a transit to measure movement in these two planes. The wind vane and anemometer are mounted on a structural steel platform on the west or ocean side of the bridge at midspan. Both these instruments are electrically connected to motor-driven recording units in the east leg of the south tower. At this point a 24-hour continuous record is maintained from the two wind instruments and the seismograph. With these records it is expected that useful information will be obtained as to the various movements caused under different wind conditions ; for example, as in the case of a 72 m.p.h. wind such as was recorded during a storm in 1938.

Earthquakes Registered in New Zealand

During November 1942 ten earthquakes were registered by the seismographs at Auckland, Arapuni, Christchurch, Kaimata, New Plymouth, Tuai and Wellington, according to a seismological report just received (*Prov. Bull.* No. P-129, November 1942, Dominion Observatory, Wellington W.1, New Zealand). The greatest was on November 10 when the trace amplitude on the Z record was 12 mm. This earthquake began recording with P compression at 11h. 53m. 45s. u.t. from an epicentral distance of 82° and from an azimuth south-south-west of Christchurch. The shock of November 3 had a focal depth of 350 km., and the next deepest focus occurred on November 7 (180–200 km.). The most intense of the twenty-six earthquakes felt during the month in New Zealand had intensity 5 on the Rossi-Forel scale. This occurred on November 26 at 1h. 31·6m. u.t. from an epicentre near latitude 41° S., longitude 172·3° E. Masterton was most often affected during the month, and Wellington experienced three small shocks on November 3, 7, and 14.

Activity on Jupiter's South Equatorial Belt

Mr. B. M. Peek, director of the Jupiter Section, British Astronomical Association, reports a remarkable outbreak of activity in Jupiter's South Equatorial Belt. This outbreak commenced at some time between February 7 and 11 in System ii longitude 15° approximately. It is possible that there will be a repetition of the phenomena of 1928–29. The preceding end of the disturbance is advancing rapidly along the north component of the belt in the direction of decreasing System ii longitude : the main features, however, are not rotating so rapidly as System i. In the following portion there are some dark humps on the south component of the belt, the System ii longitude of which is increasing rapidly. Assuming that the rate of drift is maintained, the first of these humps—which is more like a streak than a hump—should reach conjunction with the preceding end of the Red Spot in the first week in April. One important difference between the present outbreak and that of 1928–29 is the appearance of a second centre of disturbance on March 1 about longitude 290°, System ii. Mr. Peek conjectures that the preceding end of the whole disturbed region may soon pass to the north of the Red Spot. If this should occur, it would cause the Red Spot Hollow, which has recently been very faint, to grow darker again.

Variation in δ Ursæ Majoris

A brief notice about the variation in the brightness of this star appeared in Nature of February 6, p. 165. Additional corroborative evidence is afforded by further observations by Mr. N. F. Knight in North Africa, and Mr. F. M. Holborn at Streatham, London. Mr. Knight's latest observation, made on February 2, gives the magnitude 3·5–3·6, and Mr. Holborn had recorded the same magnitude on February 2. Mr. Holborn's most recent observations on February 26 and March 4 show that the star is now practically back to its normal magnitude, 3·4. It may be recalled that Mr. Knight estimated its magnitude as 3·8–3·9 on December 10, and on January 14 and 15, Mr. Holborn's estimate was 3·7.

Announcements

Dr. H. Spencer Jones, Astronomer Royal, has been awarded the Gold Medal of the Royal Astronomical Society for his determination of the solar parallax.

Sir Bennett Melvill Jones, professor of aeronautics in the University of Cambridge, has been appointed chairman of the Aeronautical Research Committee in succession to Sir Henry Tizard.

The University of Sheffield has received a gift of £800 from an anonymous donor to provide equipment for the Department of Geology after the War.

Mr. A. Wright has resigned from his post of lecturer in mining, on his appointment as senior investigator to the Lancashire and Cheshire Safety in Mines Research Committee.

The Director of the Seismological Institute of the University of Chile reports that a new seismograph consisting of both horizontal and vertical components is being installed at the University in Santiago, Chile.

LETTERS TO THE EDITORS

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

The Making of a Research Worker

MANY of the comments made in the editorial article "The Making of a Physicist" in NATURE of August 29, 1942, p. 245, apply generally to British scientific research workers, including those engaged in agricultural research.

The Imperial College of Tropical Agriculture[1] is peculiar in that the primary purpose of its existence is the postgraduate training of the young men who are to become members of the Agricultural Service of the British Colonial Empire. Even the research work of the College, important as it is on its own account, is yet in a large degree ancillary to this prime consideration. The College has been in existence for some twenty years and its present postgraduate course has been gradually evolved during that time. The remarks in the article mentioned above are thus of great interest to the academic staff of the College, and it may be that our views and experience will be of interest to the readers of NATURE.

Our course consists partly of direct lecture-room and laboratory instruction and partly of independent research or experimental work by the student, leading to the preparation of a dissertation—in fact "the apprenticeship in research" described in the NATURE editorial article.

There can be few to-day who would question that the graduate in applied science who aspires to become an investigator or research worker should be given special postgraduate training before he embarks upon his career ; but the apprenticeship in research is by no means the only method that can be conceived for giving such special postgraduate training to the future research worker. It is quite feasible to give him direct instruction in the general principles of research work, in the special mathematics of experimental work, and in the modern technique of research in his own particular subject. Indeed by means of courses of that type it is possible to give the student a more complete equipment of the special technical knowledge he needs than he can gain under the apprenticeship system. In the postgraduate course at this College we deliberately employ both methods, and it would be difficult to say to which we attach the more importance. But it can be said that we certainly do not attach any less importance to the apprenticeship scheme as a result of twenty years experience in the practice of training research workers in agriculture and the various sciences allied thereto.

Before I personally came to this College I had had, in my capacity of a Director of Agriculture, experience of the work of a good many of its 'associates'. I had found them generally very good men at their jobs. None the less, for reasons which need not be detailed here, I had still a very open mind about this apprenticeship in research as a part of their training. Now, after a few years association with the postgraduate training given here, and of watching the development of the young men while they are receiving it, I have become convinced that a real apprenticeship period is an essential part of the ideal training of a research worker—just as essential as the direct formal instruction in the research technique of his subject. The apprenticeship is necessary as a means of educating any gifts of scientific thoroughness, judgment and outlook with which the student has been endowed by Nature ; and working as a junior in a research institute is not the same thing as a proper apprenticeship.

In the NATURE editorial article, it is stressed that the clear objective of this system must be the training of the research worker, not the conducting of research ; and it is rightly pointed out that the temptation must therefore be avoided to use the research student as an observer in other men's research work, that is, the student must not be an extra pair of hands for his tutor. It is also pointed out that the god of 'communications' is a false god whose worship must be avoided ; but no mention is made of what our experience leads us to regard as yet another cult that can be carried too far, namely, that of the dissertation.

The striking difference between the conditions under which a man works while he is a research student and those under which he will work later is that in the former capacity he has perforce to produce his dissertation at a certain fixed date, marking the end of his apprenticeship. He is thus instructed, as it were, to 'publish his results' as early as possible. Yet when he becomes a paid worker he will be, or should be, equally strongly discouraged from anything savouring of premature publication. The preparation of a report or dissertation at the end of the period of training is unquestionably an entirely essential part of the apprenticeship system. But unless special care is taken, it can easily become the chief object of the student's work as an apprentice : whereas his object during that time should be to do good work, and the report or dissertation is but the record of the work he has done.

It should be made clear to the student at the beginning that the gaining of his postgraduate qualification will depend upon his showing his ability to do research work and report his results intelligently. The main function of his dissertation is that of a record : the dissertation is not a sort of glorified examination paper in which the gaining of high marks is the one and only essential for the winning of the postgraduate qualification. Again, it is suggested that for students at this stage it should be an absolute rule that the publication of a dissertation *in extenso* is never permitted. (No doubt for men at a later stage, qualifying for a doctorate, the position is different.) The research student may be permitted to use, in a published paper, the data which he has obtained in the course of his apprenticeship, or his tutor may use the data with due acknowledgement. But the knowledge that his dissertation can never be published entirely *in extenso* will go a long way to stop the student losing his sense of proportion as to the relative importance of the work he does and of the report he writes about it.

It is mentioned that his own mistakes are part of the apprentice's training. I would add that so also should be the mistakes made by earlier students in the same institution, as recorded in the filed dissertations on problems related to his own. The extreme degree of conciseness and elimination of non-essentials that is so desirable in publications nowadays need not be required in a dissertation. This factor seems to make a body of earlier dissertations particularly instructive for students. Each year's students learn by the mistakes of their predecessors, even as they contribute similarly to the education of their successors.

From what has been written above, it will be realized that, on the administrative side, there is one factor which is most important in a good training of this kind, namely, a high proportion of 'masters' to 'apprentices'. The number of research students that one senior research worker can handle satisfactorily must obviously vary to some extent with the nature of his subject and the kind of problems he gives to his students; but it is doubtful whether in any circumstances research students can have the best possible guidance if the number of apprentices supervised by one tutor exceeds five. In some subjects the number must not be even so high as that. This means that such postgraduate training of research workers, if it is to be really good, must be expensive. But the men trained should be very valuable material which is being made into something of first-rate importance. It should therefore be worth while to spare nothing that will contribute to the making. It would be hard to conceive of any more interesting and satisfactory duty for a scientific man than the making of a research worker out of a good graduate. In order not to end on a note of pessimism, we must say nothing about the 'master's' feelings on the rare occasions when he suffers from an ill-chosen 'apprentice'.

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[1] See NATURE, 147, 282 (1941).

Behaviour of Thiuram Sulphides, etc., in Spore Germination Tests

SOME seven years ago, in the course of sorting tests of potential organic fungicides, it was noticed that tetramethylthiuram monosulphide sometimes gave irregular results. In certain tests an 'inversion' of toxicity occurred, that is, within a limited range of concentration, toxicity to fungus spores (*Venturia inæqualis*) decreased as the concentration of fungicide increased. When this effect was first observed it was ascribed to some experimental mishap, but it was repeated with sufficient frequency, though not invariably, to convince us that the phenomenon was authentic. It was later seen in the case of tetramethylthiuram disulphide, though not before several tests had been completed without any indication of it, and has been investigated most fully in relation to this compound. Confirmation of the effect has since been provided by the independent observations on the latter substance reported by Dimond *et al.*[1], using spores of *Macrosporium sarcinæforme*.

Substance	Concentration per cent				
	0·1	0·01	0·001	0·0001	0·00001
Thiuram disulphide	*B*	*D*	*D*		
Tetramethylthiuram monosulphide		*A*	*B* (0·0075)	*C* (0·005)	*B* (0·0025)
,, disulphide			*A*	*B*	*D*
Tetraethylthiuram ,,		*A*	*B*	*B*	
Dimethyldiphenylthiuram ,,	*E*	*E*	*E*		
Diethyldiphenylthiuram ,,	*E*	*E*	*E*		
Dicyclohexylthiuram ,,	*D*	*E*	*E*		
Dimorpholylthiuram monosulphide	*C*	*B*	*C*		
,, disulphide	*A*	*B*	*D*		
Dipentamethylenethiuram monosulphide			*C*		
,, disulphide	*A*	*A*	*B*		
,, tetrasulphide			*E*		
,, hexasulphide			*E*		

A, no spores germinated; *B*, mainly ungerminated; *C*, many germinated; *D*, mainly germinated; *E*, all germinated.

We are now able to report that, far from being an isolated occurrence peculiar to the tetramethylthiuram sulphides, this property of 'inversion' of toxicity is shared by some other thiuram sulphides and some dithiocarbamates. It is probable, indeed, that it is a general property of these groups, still unnoticed in some cases because the range of concentration—often a very narrow one—within which it occurs has not yet been located. This is illustrated by the accompanying table giving qualitatively the results of a preliminary survey of some thiuram sulphides.

Only in the case of tetramethyl- and dimorpholylthiuram monosulphides was 'inversion' apparent. When, however, a more critical comparison was made with the view of obtaining quantitative data on the relation of molecular constitution to toxicity, narrower ranges of concentration were examined and 'inversion' was established in the following cases.

Tetramethylthiuram monosulphide
,, disulphide
Dimorpholylthiuram monosulphide
Dipentamethylenethiuram monosulphide
,, disulphide

as well as in the case of

Sodium diethyldithiocarbamate
,, morpholyldithiocarbamate
Zinc ,,
Sodium pentamethylenedithiocarbamate
Piperidine ,,

A variety of hypotheses could be advanced to explain this behaviour on biological, physical, or chemical grounds, but thus far little positive evidence in support of any is forthcoming. Certain considerations can, however, be put forward. The occurrence of the phenomenon in relation to two organisms as different in character as *V. inæqualis* and *M. sarcinæforme* suggests that a biological peculiarity in the response of the organism is not a probable explanation. Again, an explanation on purely physical grounds, such as changes of solubility relationships or in particle size or structure on dilution, seems to be inadequate since the substances cover a range from the very freely soluble to the almost insoluble, and include both the crystalline and the amorphous. It is likely, therefore, that explanation must be sought primarily in the chemical reactions of these notoriously labile substances, and experiments with this objective are now in progress.

H. B. S. MONTGOMERY.
H. SHAW.
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East Malling,
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Feb. 22.

[1] Dimond, Horsfall, Heuberger and Stoddard, Conn. (New Haven) Agric. Exp. Sta. Bull. 451 (1941).

A Middle Pleistocene Discovery in the Anglo-Egyptian Sudan

Andrew's and Arkel's important discoveries of Chellean-type and Acheulean-type artefacts in the 5 m. ironstone gravels of the Khor Abu Anga, and elsewhere near the confluence of the Blue and White Niles[1], is consistent with results obtained in the Lake Plateau Basin of the Nile farther south, where it is plain that erosion levels were not very different from those of to-day, first in "pre-Chellean" and, later, in "Chelleo-Acheulean" times. There is, moreover, striking evidence of "post-Acheulean" sedimentation to higher levels and the consequent deep burial of "Chelleo-Acheulean" and afterwards of "late Acheulean" land surfaces (flats) which had been brought into existence by temporary but relatively long-sustained low levels of Lake Victoria (Victoria Nyanza), and of other open waters.

Perhaps I might be permitted to record here that, before the War, I discovered in the Victoria Basin some of these buried surfaces which are rich not only in implements but also in fossil remains. The latter still await specialist identification and study. One day, after the War has ended, a memoir on these and closely allied matters, much overdue and long ago started by Prof. van Riet Lowe and myself, will, we hope, be completed and published. Meanwhile, these Sudan discoveries are most welcome. They are, we may be sure, the forerunners of others no less important; and in this connexion, and with all due deference to Messrs. Andrew and Arkel, I would like to suggest that the terrace deposits and erosion surfaces near Sarsareib, on the Atbara river, might well repay careful study—especially, perhaps, with regard to very early cultures.

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[1] NATURE, 151, 226 (1943).

Production of Potent Toxins by *Shigella dysenteriae* (Shiga) in a Synthetic Medium

ACCORDING to Doerr[1], *Sh. dysenteriæ* fails to produce toxin in a synthetic medium, but regains its toxicity if transferred from the synthetic medium into alkaline broth. Braun and Cahn-Bronner[2] showed that certain dysentery strains can utilize ammonium as source of nitrogen, and that they produce a weak toxin on media containing lactate as source of carbon, and ammonium as source of nitrogen. From a medium with this composition Wichmann[3] produced a toxin with a minimal lethal dose of 1·0–2·0 c.c. on rabbits of about 1,000 gm. weight.

In the experiments described below, *Sh. dysenteriæ*, Bukarest strains (*R* and *S*) kindly provided by Prof. Boivin, were employed. The base medium contained (expressed in percentages) sodium sulphate 0·5, magnesium chloride 0·01, phosphate (KH_2PO_4 0·05 and Na_2HPO_4 0·45), asparagin 0·05, *l*-cystin 0·05, glutamic acid 0·05, tryptophane 0·05, nicotinic acid 0·001, arginin carbonate 0·05 and pyruvic acid 0·5 (*p*H 7·4). Under these conditions the bacteria were capable of excellent growth for more than five generations both at 30° and 37° C. 300–400 millions of bacteria were counted in 1 c.c. within the first days of growth.

At the beginning of growth, acid was produced, but after 3–5 days the reaction turned alkaline. When 0·05 per cent of sodium nitrate was added, the reaction turned alkaline after two days. Addition of 0·1 per cent of glucose enhanced the amount of acid produced and lessened the toxicity. 10 c.c. of the base medium was autoclaved in ordinary size test tubes. For better aeration, the test tubes were maintained during incubation in a nearly horizontal position. After incubation for ten days at 30° C. the bacteria were removed by sharp centrifugation and the clear supernatant fluid left overnight in the ice box after an addition of 0·5 per cent of phenol. On the following day the sterile fluids were injected intravenously into rabbits of 850–950 gm. weight. The results were as follows:

Quantity of toxin injected (c.c.)	*R*-strain		*S*-strain	
	Total number	Died	Total number	Died
1·0	4	4	4	4
0·5	3	2	3	3
0·4	5	2	5	5
0·3	5	3	5	5
0·2	9	3	9	4

The *R*-strain produced only neurotoxin; the *S*-strain produced in addition enterotoxin, as observed by Boivin and Mesrobeanu. It caused a higher mortality.

Gildemeister and Grillo[4] and Takita[5] obtained unusually potent broth toxins when the dysentery bacteria were grown in 'Cellophane' sacks suspended in a large volume of medium. Similar results were obtained with the synthetic medium described above. A 'Cellophane' sac containing 2 c.c. of the medium was suspended in a vessel containing 40 c.c. of the same fluid. After an incubation time of ten days, 30,000–50,000 millions of bacteria were counted in 1 c.c., and the minimal lethal dose was 0·005 c.c. for the *S*- and 0·025 c.c. for the *R*-strain.

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Feb. 3.

[1] Doerr, R., "Handbuch der Technik und Methodik der Immunitaetsforschung", edited by R. Kraus and C. Levaditi (G. Fischer, Jena, 1908), p. 1,150.
[2] Braun, H., and Cahn-Bronner, C. E., *Biochem. Z.*, 131, 3 (1922).
[3] Wichmann, F. W., *Arbeiten aus dem Staatsinstitut fuer experimentelle Therapie und dem Georg Speyer Hause zu Frankfurt a.M.*, 21, 362 (1928).
[4] Gildemeister, E., and Grillo, J., *Zentralbl. f. Bakt., I. Abt., Orig.*, 133, 201 (1934).
[5] Takita, J., *Kitasato Archiv. Exp. Med.*, 16, 174 (1939).

Laboratory Synthesis of Diamond

IN 1928 an article entitled "The Problem of the Artificial Production of Diamond" appeared in NATURE[1], in which, after a careful analysis of the existing evidence, the writer stated: "The conclusion seems inevitable that diamonds have not yet been produced in the laboratory, and that investigators have been misled into regarding as diamond various transparent, singly-refracting minerals which happen to be very resistant to chemical reagents".

We have recently examined, by various X-ray methods, twelve minute 'artificial diamonds' prepared by J. B. Hannay[2] in 1879–80, and now in the British Museum (Mineral Department) collection. We find that some are pure diamond, others are diamond plus a small amount of impurity, and only one is not diamond at all. One of the specimens has been photographed using the powerful 5 kW. X-ray tube at the Davy Faraday Laboratory, and it has been conclusively proved that this diamond, at least, is of the rare (type II) variety, which gives only primary diffuse spots and none of the more detailed secondary effects[3]. Not only this crystal, but also several of the other diamonds which were not submitted to such a rigorous X-ray examination, show the highly laminated condition which has been mentioned by Robertson, Fox and Martin as especially typical of type II diamonds. Careful inquiry has convinced us that J. B. Hannay did in fact succeed in synthesizing diamond, although in very small quantity, and we feel that he should receive the long overdue credit for his patience and perseverance in this research. We think also that it is a noteworthy fact that the method he used is capable of producing the rare type of diamond, which only occurs to the extent of perhaps 1 per cent or less among natural diamond single crystals. An account of our investigation is being published elsewhere[4].

It would also, of course, have been most interesting to take X-ray photographs of the crystals which resulted from other attempts to synthesize diamond, particularly those of the late Sir Charles Parsons[5], but we have not been able to trace any of his specimens, in spite of the help given to us by his family and by the firm associated with his name. We would be grateful for any information that might lead to the recovery of these crystals; it would be most unfortunate if they should prove to have disappeared as completely as did the crystals prepared by Prof. Moisson during an earlier investigation of the same kind.

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[1] NATURE, 121, 799 (1928).

[2] Hannay, J. B., NATURE, 22, 255 (1880); *Proc. Roy. Soc.*, A, 30, 188, 450 (1880); A, 32, 407 (1882); *Chem. News*, 41, 106 (1880); 86, 173 (1902). N. Story-Maskelyne, *The Times*, Feb. 20 (1880); *Chem. News*, 41, 97 (1880).

[3] Robertson, R., Fox, J. J., and Martin, A. E., *Phil. Trans. Roy. Soc.*, A, 232, 463 (1934). Lonsdale, K., and Smith, H., NATURE, 148, 112, 257 (1941). Lonsdale, K., *Proc. Roy. Soc.*, A, 179, 315 (1942).

[4] Bannister, F. A., and Lonsdale, K., *Mineralog. Mag.* (in the Press).

[5] Parsons, C. A., *Phil. Trans. Roy. Soc.*, A, 220, 67 (1920).

Hydro-Electric Development in Great Britain

THE two articles on this subject in NATURE of February 13 are welcome for directing attention to the proposals in the Bill presented to Parliament, but the subject requires much more critical attention from the scientific, technological and economic side than it has so far received.

It is surely incorrect to assert that "it is considered beyond controversy that there is only one possible zone . . . and that is in northern Scotland" for siting the electro-chemical and electro-metallurgical industries. We have no vested interest whatever in this question, but have been concerned with it closely, and jointly we have reported rather fully upon it in a series of articles in *Engineering*, May–June 1939. Cheap and abundant electric energy is undoubtedly one of the important factors, but perhaps even more important are favourable location for the transport of raw materials and finished products, and a good supply of labour of the right types.

The inquiry upon which these new proposals are brought forward appears to have been far too limited to weigh up and balance all the important factors involved, and all we now urge is that the scheme should be subjected to more thorough consideration by economists, metallurgists, chemists and both water- and steam-power engineers.

On the face of it, the economics of even the hydro-electric side of the question look to us doubtful (in comparison with steam-power). It is noted that the estimates require the harnessing of seventy individual schemes for developing the relatively small supply of 450,000 kW. and that this demands a national subsidy of £30 million. By comparison, the capital cost of the new Canadian hydro-electric aluminium plant on the Saquenay River, the war-time development of which has just been exposed, is said to amount to only £26½ million for 1,125,000 kW.

We are keenly desirous of fostering the rapid development of the electro-chemical and electro-metallurgical industries in Great Britain, but it is vitally important that they should be established on a sound foundation and not be supported or opposed for reasons which do not concern them.

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Nature of Entropy

THE engineer has no difficulty in understanding entropy. The boilerman says: "I give you steam with so much heat energy and entropy, and you want to know how much work your engine will get out of it. I can't tell you as I don't know your condenser temperature, or how bad your engine is. Multiply your condenser temperature by my entropy and you know how much of the energy is not available in my steam. Your engine will increase entropy by heat conduction, or by wasteful expansion, if a turbine; but that is your look out."

The physics student can get the idea by taking a bottle of highly compressed air. By working a small engine slowly, all at room temperature, he can get a certain amount of work. If he first expands his air into a big vessel, his engine will give much less work. The air in both cases has the same heat content, but the expansion measures its increase of entropy. The increase of entropy means that the heat energy, which remains constant, was made less available by the wasteful expansion.

Forty years ago, I offered the Physical Society a paper on the factors of heat. The factors in the case of a perfect gas, for example, are speed of the nice molecules we had in those days, and their momentum. The paper was refused.

Entropy is inconvenient in being infinite in any quantity of matter (or radiation); so that in integrating you must add a fiducial constant, or be vague.

The conception of entropy is vital in chemistry. The late Lord Rayleigh, in 1875 (or Horstman), laid the foundation of energetics by pointing out that all chemical actions went so as to increase entropy. I do not know which was first, neither did Lord Rayleigh.

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Density of Crabs and Lobsters

Recently the densities of a large male crab, *Cancer pagurus* L., and a large male lobster, *Homarus vulgaris* Milne-Edwards, were found at Plymouth using the *displacement method*, and since—to use a popular phrase—these are the heaviest animals which move freely in sea-water the results may be of general interest. Both specimens were known to be in the late inter-moult stage. The density of the crab with a width of carapace 25 cm. was found to be 1·2784 at a temperature of 8·0° C., which gives a sinking factor of 1243. The density of the lobster 39·5 cm. long was found to be 1·1871 at the same temperature, which gives a sinking factor of 1155. Thus the crab is considerably the denser.

The crab weighed practically 6½ lb., while the lobster weighed about 5¼ lb. This is not by any means a record size for either animal, but both were fairly large specimens.

The technique for weighing these large animals is straightforward, but it requires care and preparation. Thus in this particular case it involved the procuring of an accurate balance capable of taking a load of 25 kilos, and a standard flask holding 20 litres. Finally, a density bottle had to be made and standardized, holding 10 litres.

Conditions are too precarious at present to think of carrying out a full investigation of the density of crabs and lobsters, since it would mean keeping a number of specimens of both sexes over a period of four or five years, but from the data already obtained it is possible to make the following generalizations :

(1) The density of the crab is greater than that of the lobster.

(2) The density of the male crab is definitely greater than that of the female.

(3) The density of a large crab is only very slightly greater than that of a small one. (The density of a male crab with a width of carapace of only 6·8 cm. was found to be 1·2648, which compares closely with the specimen given above with a width of carapace of 25 cm. and a density of 1·2784.)

(4) In lobsters the density of the male seldom exceeds that of the female.

(5) The density of a large lobster is considerably greater than that of the smaller.

It is not difficult to account for the differences outlined above when it is remembered that in the lobster the size of the abdomen is comparable to that of the cephalothorax, while in the crab it is greatly reduced, and again a large part of the underside of the abdomen of the lobster is covered with thin chitin only. In the male lobster the claws are greatly enlarged but the abdomen is narrower. Considering the great increase in the size of the claws of the male crab it is not easy to understand the very slight increase in density, since one would look to heterogonic growth to cause a considerable increase.

A. G. Lowndes.
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'White' Bread

Mr. Massingham[1] accuses millers and bakers of producing "faked" bread, basing his charge on the fact that pre-war flour was germ-free. He also states that eighteenth century white bread was never wheat-germless, and that at this period the process of "extraction" had not been invented.

Rich[2] has published figures showing the working of a typical flour mill that operated from 1786 until 1791. Far from "extraction" not having then been invented, "Fine Household Flour" consisted of 55·3 per cent only of the wheat berry, and from this flour was made the white bread then in general consumption in London. Another source from the same period gives 69 per cent for the 'extraction' of this type of flour.

It is probably true, however, that this flour was higher in vitamin B_1 than modern pre-war white flours, as Schultz, Atkin and Frey[3] have found 1·5 I.U./gm. B_1 in 54–62 per cent extraction stone-ground flours, made in as similar a manner as possible to the methods known to be in use a century ago.

The modern roller milling system is the result of much scientific research and produces the type of flour that, rightly or wrongly, people have striven for. When the War ends, the public in Great Britain will most probably demand white bread, as its appearance, eating and keeping properties, in their opinion, outweigh any nutritional advantages that our present bread may have.

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[1] Nature, 5, 254 (1943).
[2] *J. Soc. Chem. Ind.*, 60, 612 (1941).
[3] *Cer. Chem.*, 19, 529 (1942).

Mechanical Lighters

When about a year ago we found it difficult to get matches I thought of a plan for producing a light especially of value where gas is available, which if brought into use would mean economy in chlorate of potash and elimination of match-sticks and match-boxes—surely a desirable end. But then the definition of a mechanical lighter in the 1928 Act of Parliament was shown to me, which would impose a 2*s.* 6*d.* duty on an article which otherwise could be sold for a penny. I concluded, and the recent Bow Street Police Court tinder box case has shown that I was right, that the Excise would not hesitate to impose the duty on any lighter however advantageous it might be.

My plan was to make a paste of chlorate of potash with so much diluted silicate of soda as would, when dry, make a firm button which could be glued at the end of a rod and used to strike a spark against a safety match-box, or against a sheath coated with the same red phosphorus mixture. Hung up by a gas-burner, it would light the gas with the expenditure of perhaps one tenth or one twentieth of the chlorate in a safety match head. To my surprise, I found it would light a methylated spirit lamp the only time I ever tried.

C. V. Boys.
St. Marybourne,
Andover.

RESEARCH ITEMS

Transmission of Leprosy by Ticks

ACCORDING to the *Journal of the American Medical Association* of November 28, Dr. H. Souza Aranjo, of the Oswaldo Cruz Institute, has carried out experiments showing that leprosy can be transmitted by the bite of common ticks. After repeating Max Rudolf's experiment showing that pupæ of *Amblyomma cayennense* show live bacilli in their intestine thirteen days after the last bite of leprosy patients, he described a new experiment with a cattle tick, *Boophilus microplus*, which was fed for a few days on patients in a leprosarium. Seven days after the last meal of blood the intestines of the ticks showed strongly positive acid-fast bacilli.

Vitamin C in the Protozoa

ALTHOUGH the occurrence of vitamin C in the cells of higher plants is well known, the same cannot be said with regard to unicellular organisms, and G. Roskin and O. Nastiukova provide data on the subject (*C.R. Acad. Sci. U.R.S.S.*, 33, No. 8; 1941). No vitamin C has been found in free-living Infusoria, paramecia and Stentor, or in the parasitic Opalina and Nictoterus. When vitamin C was introduced into paramecia with food, it was not stored in the plasma but was liable to disintegration in the digestive vacuoles. On the other hand, vitamin C was found in the protoplasm of *Trypanosoma brucei*, where it was present in the shape of variously distributed granules. Observations on the changes in the quantity of vitamin C during the different stages in the development of infection of guinea pigs by the trypanosome have merely shown that such changes occur but more definite relations could not be established. When guinea pigs were injected with 0·01 per cent ascorbic acid, there was a sharp increase in the vitamin content of their trypanosomes. Thus, the trypanosomes may seriously disturb the vitamin balance of their hosts by consuming vitamins.

Crayfishes of Florida

HORTON H. HOBBS, JUN., has published an important monograph on these freshwater decapods (University of Florida Publications, 3, No. 2; Nov. 1942. Biological Science Series). Its chief value lies in the fact that he has himself collected nearly all the species in the field and gives detailed notes on their habits, habitat and distribution. Apparently the migration of crayfish into and within the State must have taken place largely subsequent to early Pleistocene and is still in progress. The Florida crayfish all belong to the subfamily Cambarinæ in the family Astacidæ, and there are many groups and subgroups showing numerous adaptations to a wide range of ecological conditions. Their natural relationships are described in detail. Forty-two species and subspecies are described, twenty-five of which are, so far as is known, endemic to the State. Among those of greatest interest are some cavernicolous forms. *Troglocambaris maclanei*, a new species belonging to a new genus, is peculiar in living, ventral side up, clinging to the ceilings of wholly submerged portions of underground waterways. The burrowing species are altogether the most numerous. The first pleopods of the male and the shape of the annulus ventralis of the female are the most important organs for taxonomic work. There are many plates illustrating these. Two forms of adult male are recognized, associated with the reproductive cycle. Seasonal data of some of the species are given with records of eggs and young, but there are no descriptions of the young themselves, which presumably, as in all known Astacidæ, cling to the pleopods of their parents by means of the first chela. With so many variations in the parents, one would like to know if the young show any important modifications.

Mammalian Fauna of the Duchesne River

A PAPER on this subject was read by William B. Scott at the autumn general meeting of the American Philosophical Society during November 20–21. The Duchesne River formation has been known for a long time and was supposed to be merely the upper position of the Uinta, in which fossils are exceedingly rare. The Carnegie Museum of Pittsburgh has kept parties in the field collecting fossils from these beds. They have gradually accumulated a remarkable fauna which is of especial interest and importance as being intermediate in time and in character between the Uinta and the White River. The fossils are for the most part very fragmentary, but there are enough excellently preserved specimens to make clear the character of the fauna as a whole. Carnivora are rare and fragmentary, but there is one very interesting specimen which appears to belong to the sabre-tooth cats, and is thus the most ancient American example of this family, or sub-family, which persisted in the Americas until the end of the Pleistocene. The hoofed animals include horses, rhinoceroses, true camels, oreodonts and agriochœrids. These latter families, so characteristic of North America and long extinct, are transitional between Uinta and White River forms. We have also the first of the White River type of brontotheres. The genus Teleodus is common to the White River in its lowest members. Other White River genera are the cursorial rhinoceroses *Hyracodon Hyænodon.* The important feature of the Duchesne River fauna is this transitional character between Upper Eocene and Lower Oligocene.

Cytoplasmic Inclusions in Virus-infected Plants

B. Kassanis and F. M. L. Sheffield (*Ann. Appl. Biol.*, 28, 4, 360; Nov. 1941) report new results from their studies upon the inclusions associated with virus-infected host plants. Striate material, amœboid X-bodies and raphides are the usual inclusions, and these workers have reached the important conclusion that the type of extraneous material formed depends largely upon the amounts of light and heat available to the host. The warm, sunny summer of 1940 brought the appearance of spike-like bodies which had not been seen for some years previously, and several new fibre-like and amorphous forms were also found. All the new types arose either directly or from pre-existing inclusions of the kinds already known. Tobacco mosaic, aucuba mosaic and enation mosaic viruses were used, and it was established that the variation of inclusion bodies was not due to mutation of the virus. A further point substantiating the discovery of inclusions in meristematic cells has been elucidated by Sheffield (*Ann. Appl. Biol.*, 29, 1, 16; Feb. 1942). She has demonstrated the presence of virus in growing points of stem and root by the successful inoculation of specially dissected primordia of tomato and tobacco infected with tobacco mosaic, and tomato with aucuba mosaic. Severe etch virus did not appear to enter the apical meristems of the tomato plant, for inoculation of tobacco with such primordia gave only negative results.

Progress with Indian Fossil Plants

THE fossil Azolla is known from material showing both the organization of the plant body and the characteristic reproductive organs. A recent paper describes a new specimen of remarkable beauty ("Indian Silicified Plants—(1) *Azolla intertrappea*", Sahni and H. S. Rao. By B. Sahni, *Proc. Ind. Acad. Sci.*, 14, 489; 1941). It is a megaspore seen in longitudinal section showing the frothy floats round its upper part, while below, the spore wall is covered by filamentous appendages to which a couple of the microspore massulæ are anchored by perfectly preserved hooks. The whole preparation looks as distinct as an ordinary slide of recent material. *A. intertrappea* is considered a typical member of the sub-genus Euazolla, but distinguished from the living species by details of the massula hooks. Its age is probably Eocene, and it is the oldest, as well as most fully known, fossil member of the genus.

Formation of Nicotine in Plants Grafted on Tobacco

SOME interesting experiments, throwing some light on the problem of the synthesis of alkaloids in plants, have been carried out by A. Shmuck, A. Smirnov and G. Ilyin (*C.R. Acad. Sci. U.R.S.S.*, 32, No. 5; 1941). When nightshade (*Solanum nigrum*) was grafted on tobacco, the scions developed well, came to flower and formed fruit; the nicotine content of the scions was considerable, though somewhat less than in normal tobacco plants. Tomato plants grafted on tobacco stocks deprived of their leaves developed into large plants, often more vigorous than the control tomato plants, and their nicotine content reached about 0·8 per cent of dry leaves. Even higher nicotine content, 1·5–2·2 per cent, was found in *Datura stramonium* grafted on tobacco stock. When, however, tobacco was grafted on nightshade, tomato or Datura stock, nicotine disappeared entirely from the resulting plant, which otherwise developed normally. The same happened in the case of tobacco grafted on tomato stock. These results show that the formation of nicotine by tobacco depends in some way on the root system and on the stem, and when both these organs are present, nicotine can be synthesized even by plants normally unable to do so.

Effects of Altitude on the Chemical Composition of Cultivated Plants

EXPERIMENTAL sowings of various cultivated plants at altitudes ranging from 1,520 m. to 2,400 m., made by S. O. Grebinsky in the Alma-Ata district of Kazakhstan, produced somewhat unexpected results (*C.R. Acad. Sci. U.R.S.S.*, 32, No. 4; 1941). In the case of sugar beet cultivated at 2,000 m., there was more sucrose and less of the undesirable non-protein nitrogen than in the roots grown at 848 m. In peas, there was an increase in monosaccharides from 1·98 to 3·63, in sucrose from 2·65 to 5·56, and a reduction in ash from 6·77 to 3·45 per cent, when plants grown at 848 m. and 2,000 m. were compared. Tobacco (*Nicotiana rustica*) grown at 2,000 m. had 5·44 per cent nicotine, as compared with 3·58 per cent for tobacco produced at 800 m. Barley has shown a doubling of the average seed weight at high altitudes, while the grains contained less protein and more carbohydrates, which should improve the malting quality. The experiments suggest that many plants do better at higher altitudes, and provide a basis for large-scale tests which may make it possible to utilize high mountainous regions of Middle Asia for agriculture.

Effect of Irradiation on Tradescantia

A COMPREHENSIVE quantitative analysis has been made of the effect of X-ray and neutron irradiation of chromosomes in microspores of Tradescantia by D. E. Lea and D. G. Catcheside (*J. Genetics*, 44, 216–245; 1942). Several important conclusions are drawn. Whenever a densely ionizing particle such as a proton passes through a chromatid, the latter is broken. A fast electron is unable to break a chromatid except by the tail of the track, which is highly ionized and may cause a break. About seventeen ionizations are necessary to cause a break. Between 40 and 100 per cent of isochromatid breaks (simultaneous breaks in sister chromatids at the same locus) persist in the cell, while only 10–15 per cent of the primary chromatid and 5 per cent of the primary chromosome breaks remain as such. Breaks which rejoin in the original form do so within 3½ minutes. Simultaneous breaks which may rejoin to form interchanges may be 1 μ–2 μ apart. Predictions can be made as to the effect of X-rays of different wave-lengths.

Incompatibility in Solanum

PUSHKARNATH (*Ind. J. Genet. and Plant Breed.*, 2, 11; 1942) provides convincing evidence of oppositional factors for incompatibility in different species of Solanum which are closely related to the potato. All the diploid species examined were self-incompatible, whereas higher polyploids were self-compatible. Self- and cross-incompatibility in *S. Caldasii*, *S. Chacoense*, and *S. subtilius* is genetically controlled by five allelomorphs. Of the ten possible combinations of these five factors, eight groups have so far been identified and search is being made for the missing S_3S_4 and S_3S_5 groups of individuals.

Shape of Pebbles

WHEN natural pebbles are used as an aid to geological history there is no means of knowing by what stages the individual pebble has reached its present shape. Under experimental conditions the changing shapes of one particular pebble can be examined as attrition proceeds under controlled conditions. Lord Rayleigh reports a series of such experiments (*Roy. Soc. Proc.*, A, 181, 107; 1942). Chalk pebbles, initially shaped as prolate or oblate spheroids, were subject to the abrasive action of steel nuts, nails ('tintacks') and small shot. In general the axes tend to approach equality, but not rapidly enough for the spherical form to be reached before the pebble has disappeared. The form, initially spheroidal, becomes flattened at the poles just like the natural flint pebbles, and may become concave, as flints sometimes do. The abrasion is not merely a function of the local specific curvature, as the figure at other points is involved.

Determination of Half-Value Periods

A NEW method of determining half-value periods between 10^{-4} sec. and 1 sec., using a single Geiger counter, has been described by A. G. Ward (*Proc. Roy. Soc.*, A, 181, 183; 1942). Using the arrangement the following half-value periods were obtained: actinium A $(1 \cdot 83 \pm 0 \cdot 04) \times 10^{-3}$ sec., thorium A $(1 \cdot 58 \pm 0 \cdot 08) \times 10^{-1}$ sec. and radium C′ $(1 \cdot 48 \pm 0 \cdot 06) \times 10^{-4}$ sec. The work had to be terminated abruptly in April 1940 and the paper has been edited by N. Feather, who gives references to two other papers describing similar circuits developed independently.

THEORY OF DIELECTRIC BREAKDOWN*

By DR. H. FRÖHLICH

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A NUMBER of years ago, a general theory of electronic motion in metals was developed by F. Bloch[1] and others, using the methods of quantum mechanics. Many of the results of this general theory can be applied to non-metals, and we shall see that in ionic crystals a quantitative calculation of the mean free path is possible, which is more than was achieved for metals where one was restricted to an estimate of the order of magnitude. I should like to demonstrate this electron theory of solids by applying it to dielectric breakdown in solids, for which a quantitative understanding has been reached in recent years[2].

The insulation of an ionic crystal breaks down if an electrical field higher than a critical field F is applied. Up to a critical temperature T_0, which is of the order of 100° C., F is a specific property of the dielectric and is called intrinsic electric strength. Above T_0, breakdown usually occurs through thermal instability. We are here interested in intrinsic strength only.

Before the theory described below was developed, von Hippel[3] carried out an experiment which strongly influenced the theoretical development. He showed that the intrinsic electric strength of mixed crystals such as potassium-rubidium chloride is always higher than that of their components. In metals, a similar result is found for the electrical resistance and is known to be due to a decrease of the mean free path[4]. This suggests that the intrinsic electric strength, supposed to be an electronic process, depends on the mean free path of the electrons in a similar way as does the resistance of metals, and furthermore that the velocity of the electrons is in both cases of the same order, corresponding to an energy of several electron volts. This latter conclusion is of importance, because the analogy probably would not apply to electrons with thermal energy.

Let us now consider the mean free path of electrons in ionic crystals. Such crystals are normally insulators, but it is known that in strong fields of the order of 10^6 volts/cm. (but below the breakdown strength), electrons are raised into the conduction band of energy levels. In such strong fields the probability of finding electrons with an energy of several electron volts is very much larger than it would be for a Maxwell distribution[5]. We are, however, not interested in the details of the energy distribution. The mean free path l is connected with the time of relaxation τ by $l = \tau v$, v being the electronic velocity. In the absence of an electric field, the average $\bar{v}$ of v over a time, large compared to τ, vanishes, but $\bar{v} = eF\tau/m$ in a field F, giving rise to a current $i = e\bar{v}$. τ can be calculated from the probability P per second that the electron makes a collision and from the angle of scattering δ by $1/\tau = P(1-\cos\delta)$, thus giving collisions a weight, which increases with δ.

It would be wrong to assume that an electron is scattered by the ions in a similar way as in gases. On the contrary, the most important part of Bloch's general theory states that an electron moves without being scattered through a periodic field of force. Thus in a perfect crystal, neglecting the temperature motion of the ions, an electron is not scattered at all. Scattering is due to the deviations from strict periodicity. In general these may be of two types: deviations due to the temperature motion, and those due to foreign ions (in the case of mixed crystals). Thus the scattering probability is composed of a temperature scattering P_T and a scattering due to foreign ions, P_c, where c represents the concentration of foreign ions. Similarly:

$$\frac{1}{\tau} = \frac{1}{\tau_T} + \frac{1}{\tau_c}, \quad \frac{1}{l} = \frac{1}{l_T} + \frac{1}{l_c}.$$

A quantitative calculation of the temperature-dependent mean free path l_T is not difficult. This is due to the fact that the displacement of an ion gives rise to a well-known polarization quite in contrast to the displacement of an atom in a non-polar crystal (or in a metal) where the induced field of force depends on details of the atomic field. The most general displacement of the ions can be developed into a Fourier series, thus giving rise to waves which we shall call polarization waves. If ν is their frequency, their energy U is quantized:

$$U = (n+1/2)h\nu, \quad n = 0, 1, 2, \ldots,$$

$h\nu/2$ is the so-called zero point energy. The average value of n is, according to Planck's law, given by:

$$\bar{n} = \frac{1}{e^{h\nu/kT}-1}$$

As seems reasonable, the scattering probability P_T depends on u^2, u being the amplitude of the polarization waves. Since $u^2 \sim U$,

$$P_T \sim (\bar{n} + 1/2)\, h\nu = \left(\frac{1}{e^{h\nu/kT}-1} + \tfrac{1}{2}\right) h\nu = \frac{h\nu}{2}\,\phi(T).$$

Besides depending on temperature, l_T also depends on the energy E of the electron ($\sim E^2$). Both P_T and $(1 - \cos\delta)$ decrease with increasing energy. The latter can be deduced in the following way. The scattering of an electron by the polarization waves can be considered as either absorption or emission of a polarization wave quantum $h\nu$. Since we are considering electrons with an energy of several electron volts, the scattering is nearly elastic because $h\nu$ is only about 0·1 eV. On the other hand, the momentum of a wave with wave-length λ is $h/2\pi\lambda$. The shortest waves are of the order of the lattice distance. Their momentum is the same as that of electrons with an energy of about 1 eV. Thus the scattering angle δ is not small. For elastic scattering by waves of a given momentum, $(1 - \cos\delta) \sim 1/E$ follows immediately from the momentum law.

We have thus explained qualitatively the dependence of l_T on T and on E. The exact expression for a crystal of the sodium chloride type is

$$l_T = v\tau_T = \frac{l_0}{\phi(T)}, \quad l_0 = \frac{16}{2^{2/3}\pi^2}\,\frac{a^2 E^2}{(\varepsilon-\varepsilon_0)\, e^2 h\nu},$$

$$I > E > E_0 = \frac{2^{2/3}h^2}{32ma^2}.$$

ε and ε_0 are the static and the high-frequency dielectric constants, a is the lattice distance. If E is several electron volts, l_T is of the order of 10^{-6} cm., that is, about a hundred lattice distances. Our considerations hold, however, only if E is smaller than I, the smallest energy required to excite or ionize an ion of the lattice. The mean free path for this latter process is only of the order of one lattice distance,

* Opening paper of a discussion on "Dielectric Breakdown and other Electronic Processes in Solids" at the meeting of the Electronics Group of the Institute of Physics, held on February 3.

so that nearly all electrons with an energy E greater than I will carry out such inelastic collisions.

Taking the average over many collisions, the energy

$$A = iF = \frac{e^2F^2\tau}{m} \sim F^2E^{3/2}, \qquad E < I$$

is transferred per second from the field to the electron. An equilibrium is possible only if this energy can be transferred from the electrons to the lattice vibrations. Let B be this latter energy per second. B is independent of the temperature because, as for light quanta, the probabilities for emission and absorption of a quantum, $h\nu$, are $1 + n$ and n respectively, so that $B \sim (1-n) + n = 1$ is independent of n, the only quantity dependent on T. The scattering by foreign atoms does not lead to any energy loss (if E is less than I). An exact analysis shows that

$$B \sim \frac{h\nu}{\tau_0}\frac{E}{E_0} \sim \frac{1}{\sqrt{E}}, \quad E < I, \; \tau_0 = \tau_T\,\phi(T).$$

Thus B decreases and A increases with increasing E. Therefore there exists always an energy E' where $A = B$. For $E > E'$, more energy is taken up by an electron from the field than it can transfer to the lattice.

Thus if we omit the restriction $E < I$ in the expressions for A and B, equilibrium would be impossible in the presence of an external field. Considering, however, $E < I$, equilibrium becomes impossible only if E' is less than or equal to I. While B is independent of the field F, A increases proportionally to F^2. Thus E' decreases proportionally to $1/F$. Hence equilibrium is possible for weak fields (E' greater than I), but impossible for strong fields (E' less than I). The critical field where equilibrium begins to become impossible has thus to be determined from $E' = I$. We identify this critical field with the intrinsic electric strength F. From this condition, we find at once that

$$F^2 \sim \frac{1}{\tau\,\tau_0} = \frac{1}{\tau_0}\left(\frac{1}{\tau_T} + \frac{1}{\tau_c}\right).$$

Let $F(T,c)$ be the intrinsic strength at the temperature T and with a concentration c of a given kind of foreign ions. For small c, $1/\tau_c$ is proportional to c and hence $D = \{F^2(T,c) - F^2(T,0)\}/c$ must be independent of c and of T. This result is independent of the exact value of τ, and of details of its calculation. It contains only the fact that $1/\tau = 1/\tau_T + 1/\tau_c$ (as in metals), together with the general condition for breakdown. The result is fairly well confirmed by experiments on sodium chloride crystals with silver chloride as admixture[6], where the experimental value of D is a constant within 50 per cent while $F^2(T,c)$ varies by more than a factor of 10.

The complete theoretical formula for the intrinsic electric strength of pure crystals of the sodium chloride type is

$$F = \frac{\pi^2(\varepsilon - \varepsilon_0)\,e(mh)^{1/2}\,\nu^{3/2}}{2^{2/3}\,a\,I}\left(\log\frac{4\sqrt{IE_0}}{h\nu}\right)^{1/2}\phi^{1/2}(T).$$

Without the use of any arbitrary constants, it yields values for F which are in good agreement with the experimental values. A characteristic consequence of the theory is the increase of F with increasing temperature T, due to the factor $\phi(T)$ in the above formula. When this theory was first developed, no experiments on the dependence on temperature of the intrinsic electric strength of ionic crystals were available. On the other hand, experiments on amorphous substances showed a decrease with increasing temperature, and experimental physicists expressed some doubt whether this consequence of the theory could be correct. Subsequent experiments[7,8,9], however, proved this consequence of the theory, at least in a qualitative way.

According to theory, the smaller the frequency ν of the oscillations of the ions the greater should be the increase of intrinsic electric strength. Mica, with its small values for ν, should show scarcely any increase with F, and actually it was found[7] that the experimental value of F at 400° absolute is the same as at 100°. For potassium bromide, on the other hand, the intrinsic electric strength should increase by a factor 2 in the same temperature interval. Various experiments[7,8,9] actually show a large increase by a factor between 2 and 3. At present, however, there is not complete agreement between the various experiments, but all indicate an even larger increase than the theoretical one, although the order of magnitude is correct.

A further consequence of the theory is the dependence of the dielectric strength on thickness. As the thickness of the dielectric approaches the dimensions of the mean free path, the dielectric strength should increase. This effect, too, has been found experimentally with mica[7], where layers of 2×10^{-5} cm. in thickness showed an increase of 50 per cent in the breakdown strength.

In conclusion, it can be said that the intrinsic strength of ionic crystals is well understood. A similar theory should apply to non-polar crystals, although quantitative calculations would be much more difficult. As regards amorphous substances, however, it is not known with certainty whether such an application is admissible.

[1] Bloch, *Z. Phys.*, **52**, 555 (1928).

[2] Fröhlich, *Proc. Roy. Soc.*, A, **160**, 230 (1937); **172**, 94 (1939); **178**, 493 (1941). *Phys. Rev.*, **56**, 349 (1939); **61**, 200 (1942).

[3] von Hippel, *Ergebn. exakt. Naturw.*, **14**, 79 (1935).

[4] Nordheim, *Ann. Phys. Lpz.*, **9**, 607 (1931).

[5] Landau and Kompanejez, *Z. Phys. Soviet Union*, **6**, 163 (1934).

[6] von Hippel, A., and Lee, G. M., *Phys. Rev.*, **59**, 824 (1941).

[7] Austen and Hackett, NATURE, **143**, 637 (1939). Austen and Whitehead, *Proc. Roy. Soc.*, A, **176**, 33 (1940).

[8] Buehl and von Hippel, *Phys. Rev.*, **56**, 941 (1939).

[9] von Hippel and Maurer, *Phys. Rev.*, **59**, 820 (1941).

TRAINING FOR INDUSTRIAL MANAGEMENT

THE paper on part-time courses in education for industrial management presented by H. W. Broadbent at the Conference on Training for Industrial Management, arranged in London by the Institute of Industrial Administration during March 5–7, emphasized that education is a continuous process and demands a review of the whole field if any real meaning is to be given to a planned reconstruction after the War. The minimum age at which any attempt should be made to provide preliminary education for ultimate posts of responsibility is eighteen, and even then the subjects to be included would rightly be described as background subjects. Mr. Broadbent considers that the majority of young people could still be exempted from full-time attendance at school at fifteen or sixteen, so long as they are provided with a carefully planned part-time education on a sandwich system. Normally, such a system should be applied in its integrated form on a weekly basis, where the working hours of the week are divided between education (formal instruction) and training (during their occupation or employment in commerce or industry). Up to the age of eighteen the adolescent should be regarded as a ward of the community, and his welfare, education and training should be supervised and directed by the education department, together with representative bodies of employers and professional institutes, on a regional basis.

Day continuation schools, he urged, offer a great opportunity for experiment and research, but in regard to types of training he merely differentiated between technical (in its widest sense) and administrative training for all executive positions. Up to the 18–19 age-group training during work- or office-time should be strictly vocational, and further development should have as its object the interpretation of experience in the exercise of responsibility, and the crystallization of personality and character. In regard to supervisors, foremen and forewomen, it would be necessary during the transition period to train the supervisors of some years standing in industry. This is a special problem, and Mr. Broadbent suggested that half a day per week devoted to an abridged version of the Institute of Industrial Administration certificate course in foremanship and works supervision, and weekly or fortnightly lectures organized by a staff association, local centre or professional institution would meet the need. For the prospective supervisor, besides the half-day a week devoted to the same course, periods of about three months spent in the various departments of the business or factory were suggested, and promising trainees should be encouraged to continue study in the ordinary certificate course of the Institute.

For the executive groups Mr. Broadbent suggested the two years intermediate and two years final grade course laid down by the Confederation of Management Associations, involving two half-days per week in the first two years and one half-day per week in the second. For the higher executive groups he suggested that the Institute of Industrial Administration should give a lead with regard to lecturers. In addition to regular meetings, where the Case method could be employed, special intensive courses or week-end conferences might be arranged for districts. Executives themselves should be encouraged to lecture and to lead discussions, and selected executives sent to the staff college for specialized training.

Mr. Broadbent also said that he considers that there should be a break of at least a year between the school and university, and if this time was spent in commerce or industry under appropriate conditions, many criticisms of the graduate going down from the university would be met. Towards the end of his course, the graduate should take a special series of lectures covering the administrative field generally and he would then on entering employment come within the scope of the executive courses already discussed. While training in management should not form part of a normal full-time university course, special departments of the universities could with advantage form part of the staff colleges which should be set up in all important centres under the direction of a central staff college, where special sandwich courses would be available for all those recommended to them. A further use of these colleges would be the training of teachers for management and the conduct of research in this field.

Machinery is already in existence which could deal with the regional development of education and training in management, and some of the professional schemes in operation should be incorporated, and the courses indicated should be embodied in national certificate and diploma schemes in industrial administration and management. As consultant body Mr. Broadbent suggested that the British Management Council, with some professional body acting jointly with the Board of Education and the Institute of Industrial Administration, is well qualified to act as central authority for the Council in this matter of examinations. Experience in administration and management should be obtained concurrently with education and training in its broadest sense, and Mr. Broadbent laid down as a general principle that all such training is the responsibility of commercial and industrial firms and should be provided in normal working hours, the cost also being borne by them.

Dr. J. A. Bowie surveyed American developments in industrial management. He urged the importance of Anglo-American understanding in this field. Referring to difficulties in the supply of lecturers and the unsatisfactory results of allowing such lecturers to retain active business connexions—a point on which there was general agreement—he said that the main developments in American business education seem to be a trend away from undue specialization and a return to more general subjects, with less emphasis on detail, routine and technique. Regional specialization in education for management has commenced with a trend towards fewer courses, insistence on better pedagogy, a growing belief that in all matters of business and its teaching the analytical methods of the man of science would alone bear real fruit, increasing distrust of departmental lines, and a growing recognition of the importance of research. The world-wide economic depression has revealed the necessity of providing elementary instruction in economic and general business affairs for all citizens in a democracy, and with the increasing advocacy of business education in Great Britain the lessons of American experience should be of great value.

Mr. A. Sanders surveyed the position in regard to training supervising staff for management. He pointed out that the workmen obtain their conception of the firm's policy from the supervisory staff in the larger works. Including in the term 'supervisory staff' all grades of staff from foremen up to and including departmental heads or superintendents, Mr. Sanders puts character, leadership, co-ordination and co-operation as among the principal requirements in such staff, and their training must include education in the structure of the organization and in the principles of supervision, as well as training and experience in a particular profession or craft.

After discussing briefly the education, training and experience required for various types of supervisory staff, including foremen, departmental superintendents in chemical or metallurgical works, employment and welfare officers, clerical supervisors, and senior cost clerks, Mr. Sanders discussed more particularly education and training in the elements of industrial administration so far as it applies to the supervisory grade of staff. In modern industry it is essential that the staff should have some knowledge of the principles of management, and that changes in organization should be clearly explained to staff if good working is to result. With such training and careful and correct selection of staff, we should not be troubled with the suggestion that a supervisor is born not made.

Commending the Institute's two years course in foremanship, he urged that a more advanced course is desirable for the higher grades of supervisory staff. All supervisory staff should have a minimum training in general principles of administration, production and planning, labour management, and costing and remuneration, and Mr. Sanders referred to the possibilities of a course of internal lectures based on the Institute's full syllabus for the Ministry of Labour course. Such courses should be combined with instruction in the company's own procedure and problems. In many ways foremen present a distinct problem, and are themselves of at least three types requiring varying treatment. Interchange of staff, external conferences, works councils, works magazines can all play an important part in such training, and library provision in any works is essential. Such library facilities should be available for all staff.

Mr. Meigh's paper was concerned with training executives for industrial management. He referred particularly to the increasing need of trained executives and therefore of adequate means of training, paying tribute to the pioneers who have been responsible for noteworthy triumphs of skilful management in British industry. Industrial conditions of to-day, he said, require leadership of a type and in such volume that can only come from systematic training. Such training should follow on a knowledge of the products or processes of manufacture, and he emphasized the value of a broad and liberal outlook on the social functions of industry in attracting candidates for training. For those executives already engaged in industry, the idea of a 'Sabbatical year', visits to similar industrial establishments abroad, contact with other executives in the same industry and participation in the work of manufacturers' associations or federations, joint industrial councils and the like confer a wider outlook and a fresh perspective. Systematic reading of the literature bearing on their work is another means for executives to continue the discipline of education and training; only by the establishment of a high standard of scientific and practical training, based on methods generally agreed after adequate experience, can we hope to enter an industrial era in which management will be universally recognized as a profession. Mr. Meigh submitted a rough outline programme of practical and educational training for junior executives as a basis for discussion.

FORTHCOMING EVENTS

(Meetings marked with an asterisk are open to the public)

Saturday, March 20

BRITISH PSYCHOLOGICAL SOCIETY (at Tavistock House, Tavistock Square, London, W.C.1), at 2.30 p.m.—Margaret Lowenfeld, Kathleen Todd and Sylvia Payne: "The Methods of Training Child Psychologists at the Institute of Child Psychology".

Saturday, March 20—Sunday, March 21

BRITISH ASSOCIATION (DIVISION FOR THE SOCIAL AND INTERNATIONAL RELATIONS OF SCIENCE) (at the Royal Institution, 21 Albemarle Street, Piccadilly, London, W.1).—Conference on "Science and the Citizen—the Public Understanding of Science".*

Saturday, March 20

10 a.m.—"The Exposition of Science".
(Chairman: Sir Henry Dale, G.B.E., P.R.S.).

2.15 p.m.—"Radio and the Cinema".
(Chairman: Sir Allan Powell).

Sunday, March 21

10 a.m.—"Science as a Humanity".
(Chairman: Prof. J. L. Myres).

2.15 p.m.—"Science and the Press".
(Chairman: Sir Richard Gregory, Bart., F.R.S.).

Tuesday, March 23

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 1.30 p.m.—Prof. J. L. Myres: "Ancient Tripoli and Cyrenaica".

ROYAL INSTITUTION (at 21 Albemarle Street, Piccadilly, London, W.1), at 3 p.m.—Sir Henry Dale, G.B.E., P.R.S.: "Chemistry in Modern Medicinal Treatment" (ii) "Imitating Nature".

Wednesday, March 24

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Dr. F. Yates: "Agriculture To-day and To-morrow", 7: "Methods and Purposes of Agricultural Surveys".

Thursday, March 25

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 11.30 a.m.—Annual General Meeting; at 2.30 p.m.—"Stereochemistry of Labile Compounds" (Presidential Address).

UNION DES INGENIEURS ET TECHNICIENS DE LA FRANCE COMBATTANTE (in the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 5 p.m.—Lieut. R. Drilhon: "Aperçus sur la Réorganisation rationnelle de l'Agriculture française" (Future of Farming).*

INSTITUTION OF ELECTRICAL ENGINEERS (JOINT MEETING WITH THE INSTITUTION OF CIVIL ENGINEERS AND THE INSTITUTION OF MECHANICAL ENGINEERS) (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Sir Frank Gill, K.C.M.G.: "Engineering Economics".

Friday, March 26

ASSOCIATION OF APPLIED BIOLOGISTS (in the Metallurgical Lecture Theatre of the Imperial College of Science and Technology (Royal School of Mines), Prince Consort Road, South Kensington, London, S.W.7), at 11 a.m.—Prof. J. Bayley Butler: "Some Aspects of Applied Biology in Eire".*

ROYAL INSTITUTION (at 21 Albemarle Street, Piccadilly, London, W.1), at 5 p.m.—Sir James Jeans, O.M., F.R.S.: "Astronomical Problems of To-day".

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Newcastle-upon-Tyne), at 6 p.m.—Dr. Ezer Griffiths, F.R.S., and Mr. M. J. Hickman: "Modern Heat Insulating and Decking Materials".

Saturday, March 27

BIOCHEMICAL SOCIETY (at the Courtauld Institute of Biochemistry, Middlesex Hospital, London, W.1), at 2 p.m.—Annual General Meeting.

Sunday, March 28

SOUTH PLACE ETHICAL SOCIETY (at Conway Hall, Red Lion Square, London, W.C.1), at 11 a.m.—Sir Richard Gregory, Bart., F.R.S.: "Education in World Ethics and Science" (Conway Memorial Lecture).

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

From Light to "Heavy". By H. Fox. Pp. 28. (Skegness: C. H. Major and Co., Ltd.) 1*s*. [12

Ministry of Agriculture and Fisheries. Farmers' Income Tax. Pp. 28. (London: H.M. Stationery Office.) 3*d*. net. [42

British Electrical and Allied Industries Research Association. Twenty-second Annual Report, October 1st, 1941, to September 30th, 1942. Pp. 132. (London: British Electrical and Allied Industries Research Association.) [82

Other Countries

Commonwealth of Australia: Council for Scientific and Industrial Research. Industrial Chemistry Circular No. 1: Some Technical Aspects of Foundry Cores. By H. A. Stephens. Pp. 19. (Melbourne: Government Printer.) [291

Proceedings of the United States National Museum. Vol. 92, No. 3151: New Neotropical Insects of the Apterygotan Family Japygidae. By H. E. Ewing and Irving Fox. Pp. 291–300 + plates 33–34. (Washington, D.C.: Government Printing Office.) [52

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