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SCIENTIFIC AND INDUSTRIAL RESEARCH.—I

WHILE there is no interruption to the flow of reports and papers discussing scientific and industrial research—the statements "A Post-war Policy for Science" issued by the Association of Scientific Workers and "Problems of Scientific and Industrial Research" from Nuffield College are among the more recent—there is some reason to fear that even from the point of view of educating public opinion as to what is required, many of the contributions to this discussion are not so effective as they might be. One of the main reasons is that discussion, not to say opinion, is becoming confused because of the failure to distinguish clearly between tactics and strategy. Admittedly the distinction is not always easy to maintain in practice, but it is all the more important that the effort should be made at a time when the short-term and long-term aspects of these problems may vary considerably in urgency. Unless our broad objectives are clearly seen and defined in terms both of programmes and in respect of the type of men required to serve them, there is grave danger that steps may be taken to meet our short-term needs which may prove serious obstacles to the more fundamental developments which are also required.

There is yet another reason for distinguishing clearly between the tactics and the strategy of research which is well illustrated in the Nuffield College statement. Welcome as may be the large measure of agreement on what are clearly matters of tactics, such as the encouragement of mobility in research workers, on their status and remuneration and general improvement in conditions of service, such matters depend on, and may even determine, the nature of the institutions or organization which we set up for research. Unless, therefore, we have first resolved on the broad lines of our research programmes and on the qualities which they will demand in the personnel responsible for their execution, apart from the corresponding demands for material resources such as equipment, we cannot determine the appropriateness of either institutions or organization to serve our purposes. Attention to tactical questions before strategic objectives have been decided may thus very well create obstacles to the strategy of research which will not easily be overcome.

There is a further reason why the distinction between strategy and tactics is important, and this is well illustrated in the statement from the Association of Scientific Workers. The decline of German science since 1933 is sufficient evidence that science cannot ignore political institutions, that, even from the point of view of the advance of science itself, some regard must be had to the social and political institutions affecting the conditions under which the man of science works. Society has an effect on the course of science which may not be so obvious, but may be as pronounced, as the impact of science on society. Not only are scientific workers increasingly concerned with the social effects of the application of scientific discoveries, with seeing that the knowledge which in such fields as nutrition, for example, has made possible the improvement of health and elimination of disease, is used effectively, but also they are conscious that the structure of social institutions and of industry may markedly assist or impede such processes.

With such considerations increasingly prominent, the difficulty of handling aright the problems which arise out of the interactions of science and society and politics becomes more acute. It is more than ever important, as it becomes more difficult, to draw the line and determine exactly how far and in what manner science should make its representations in political affairs where scientific factors are specially important. Uncertainty of touch or judgment in such matters as, for example, in the statement from the Association of Scientific Workers, is a fatal obstacle to handling these problems wisely and shaping aright the organizations through which may best be expressed the voice of science in the fields where it has a legitimate and imperative right to be heard.

One of the main reasons for failings in this respect is the absence of enough attention to the philosophy of research, and the symposium on the "Organisation, Direction and Support of Research" arranged last autumn by the American Philosophical Society (see p. 263 of this issue) is a notable contribution to the fundamental thinking required, here and on the larger strategy of research, before we can consider in detail those questions of tactics with which much current discussion in Great Britain has been overburdened. The long paper by H. A. Innis on "Political Economy in the Modern State" contributed to that symposium is particularly suggestive in this connexion, and a welcome correction alike to the tendency to align science with any particular political party or system or to those who imagine that science can remain indifferent to the political institutions which determine the limits within which freedom of scientific thought and inquiry are possible. He directs attention to exactly those problems which must be solved in the control of research, whether by the State or by industry, if the creative spirit is to be preserved and if freedom of inquiry is to mean advance in knowledge and not the mere acquisition of information which may or may not be relevant to future intellectual progress or to society's needs.

Recognition that the distinction between fundamental and applied research is merely a convenience which can be overstressed should at least help the consideration of the conditions which are fundamental for fruitful research of either type. In many fields, as the Nuffield College statement points out, the distinction has little meaning. Both methods are constantly being used simultaneously in attacking a problem ; they are interdependent, advance in one constantly affecting the other. No clearer demonstration of this could be found than in the recent offer of the directors of Imperial Chemical Industries, Ltd., to provide eighty fellowships in science at nine universities in Great Britain, in connexion with which Lord McGowan stated, "Nearly three generations of experience of the administration and conduct of research have convinced us that academic and industrial research are interdependent and complementary and that it is useless to expect substantial advances in industry without corresponding advances in academic science". Clearly, therefore, if we can determine and establish the conditions under which fundamental research or investigation concerned purely with the advancement of scientific knowledge is best promoted, we shall have gone far to determine those under which applied research also will flourish, and this irrespective of any particular branch of scientific inquiry. We cannot, however, rest content merely with postulating a free society and freedom of inquiry. The research worker must be free both from intimidation and from control by government ; he must be able to inquire and speculate with as few restraints as possible : but the debate between the protagonists for absolute freedom in science and those who advocate the maximum planning of science will lose some of its value if it fails to emphasize the positive as well as the negative side. We are concerned with factors which stimulate, as well as with avoiding restrictive or repressive conditions. We must seek for conditions which stimulate creative powers, imagination and enthusiasm, and beware of checks on them as well as on the scope or direction of inquiry.

There is yet another point at which conditions of scientific work are affected, if not determined, by the nature of the society in which the man of science works. A totalitarian regime clearly is inconsistent with full freedom of scientific inquiry and ultimately fatal to the advance of knowledge, but other political systems may have their own effects through their influence on the various types of incentive—social as well as economic—which summon the scientific worker to give of his best. Dr. J. B. Conant made a wise point in his address to the American Philosophical Society's symposium when he referred to the importance here of the quality of the appeal to the brilliant and enterprising sons and daughters of the mass of our society. That appeal, he thinks, should be couched neither in utilitarian terms nor in those appropriate to the secluded retreat, but rather that in each area of the entire field of learning the activities under way must be manifestly relevant to the future of our civilization, not only to man's physical and social needs but also to his highest hopes and aspirations.

The relations of science to society and even to industry are in fact more complex than some of the more ardent protagonists of planning care to admit, and Dr. Conant's suggestion of relevance rather than utility as the touchstone to test the vitality and validity of a scholarly enterprise indicates a line of thought to be explored more fully. Again, the limitations of the scientific method as applied to social problems, the looseness with which the term is employed, to which Dr. Conant directs attention, equally merit consideration, as much as the greater emphasis on philosophy for which he calls. It is the absence of an adequate philosophy and consequent failure to develop the capacity for making disciplined and well-informed judgments on all those matters of value which are involved in so many vital human decisions that has been responsible for the weakening of civilization and the growth of barbarism. From no point of view can we be satisfied any longer with a system of education that fails to develop that capacity. It must be one of the prime requirements in future of all our training institutions, both for teaching and research, and we should vigilantly watch to see that no subsequent organization impairs or retards that same capacity of judgment.

Dr. Conant has assuredly put his finger on the weak spots. It is not that high standards of performance as to the technical part of his task are not essential for the scholar whether man of science, mathematician, philosopher or historian. Equally essential, however, are integrity of purpose, a disciplined imagination, and the power of critical analysis of both the problem at hand and the investigator's own contribution. To provide such men and women who come into the court of public opinion with clean hands and a consecrated heart, and to maintain their integrity and consecration and critical and imaginative powers undimmed, should be a first objective of our research strategy. The institutions and organization which can succeed in this will never lack the flow of creative thought and fundamental discovery upon which the advancement of science and of civilization both depend.

There are therefore at least two problems involved here. First re-examination of our whole educational system, not merely at the university level, with respect to the provision of an adequately trained and broadly educated personnel to enter the field of scientific research, and the balancing of the immense needs for technical and scientific training by competent education in the liberal arts and humane studies. The emphasis must be on the balance, for the second problem is that of securing competent direction of research. That is no less vital. It forms the link between the two things which, as the Goodenough Report on Medical Schools points out, a community that wishes to promote research must do. "First and foremost, it must find and train the men who have the ability and impulse for scientific inquiry. Secondly, it must create the most favourable conditions for their work and give them the tools they need."

It may well be that the most valuable result of the establishment of more senior fellowships in science on the lines of the scheme recently initiated by the directors of Imperial Chemical Industries, Ltd., will be the contribution it makes to throwing up men of the requisite outlook and calibre for the direction of research. The wise insistence on some combination of teaching with research under conditions where, as Bruce Truscott notes, compared with industry, the fellows can be sure of time and tranquillity of spirit, may stimulate not merely fruitful research itself but also clear and creative thought about the compartmentalism of science, its effect on training or restraint on effective research. From such thought alone can come the competence and confidence to move surely across boundaries and to handle wisely the attack on the unknown, whether it be in industry or elsewhere, with its calls for team-work as well as initiative and individuality.

The Goodenough Report in its brief reference to research well stresses, in quoting from the evidence submitted by Sir Thomas Lewis, the importance of these last factors. Organization, in fact, must be secondary to the selection of personnel. Unless we can secure an adequate supply of men of the right gifts no organization will ensure the prosecution of effective research, and the essential preoccupation of wise administration is, as Alan Gregg observes, to create and foster the circumstances, the human relationships, in which gifted men will be most productive and prodigal of their gifts. In particular, he points to two dangers which our strategy must frankly recognize and provide against: first, the tendency to waste research ability by diverting it into other channels by the demands of administration and teaching; and secondly, the tendency for the endowment of research to deprive the investigator of his primary right of choosing a subject to be studied, of framing a hypothesis to be tested, of planning and performing some crucial experiment.

It may be noted in passing that Mr. Gregg looks to senior fellowships for research of much the same type as those contemplated in the scheme of Lord McGowan and his fellow directors to meet this need, though he appears to have a slightly higher standard of status and emolument immediately in mind. The basic strategy is clearly the same, and the same close resemblance in the conclusions reached by progressive minds in Great Britain and in the United States may be discerned in the broad objectives of some of the programmes of research. The differences in content are frequently rather in points of detail than in scope, though the emphasis on particular aspects of the programme must obviously vary.

A noteworthy example may be found in the field of agriculture. The research programme recently adumbrated by the Parliamentary and Scientific Committee in its report, "A Scientific Policy for Agriculture", has features in common with the more detailed programme outlined by Dr. E. C. Auchter in his address last autumn to the American Association of Land-grant Colleges and Universities (*Science*, 99, 169, 190; 1944). Whereas the former does no more than indicate that an expenditure of at least three million pounds on agricultural research is required, with the completion of British soil and geological surveys, and intensive and large-scale research into the complex part played by organic matter in our soil, it recognizes that nutrition must play an important part in determining the trend of agricultural research, and like Dr. Auchter again, that agricultural research is linked up with and affected by fundamental research in other fields.

This point, of which the Parliamentary and Scientific Committee has already shown itself aware in its earlier report on coal utilization, is specially well brought out by Dr. Auchter. In addition to nutrition, he points to the value for plant and animal production of a detailed systematic world geography of soils, climatic conditions, varieties of plants and methods of plant and animal production, to the need for research on new immunizing agents, into engineering and electrical and mechanical problems in agriculture and the use of agricultural products, into the utilization of crop residues and to basic research to extend our knowledge of such substances as starch, proteins, lignin, hemicellulose, enzymes, hormones and vitamins. If for a moment we have passed from the consideration of broad objectives to that of detail, it is to demonstrate more conclusively first, the validity of Dr. Conant's criteria of relevance in determining the broad objectives, and secondly, the way in which programmes are interlocked, and work in furtherance of the broad objectives in one field may involve work in quite another field.

Strategical requirements, whether from the point of view of applied or fundamental research, may well thus require us to reconsider the compartmentalism of science and to facilitate both team-work between workers in one or more sciences and the abrogation of the impediments such compartments offer to effective research. Beyond this the broad strategy of research would seem to involve first the provision, on this basis of relevance to social needs, for the organized study of particular and urgent problems, both in the development of natural resources, as of fuel and power supply and agriculture and their effective utilization in the service of the community, and of nutrition and health, including the treatment or control and the prevention of disease. Such organized study must include adequate provision not merely for many lines of industrial research but also for systematic fundamental research, planned at least so as to assist the advance of science on an even front by filling in the gaps left by individual initiative and with special regard to the borderlines of the sciences at once so apt to be neglected and so richly productive when cultivated. Again the conception of relevance must include relevancy to the needs of the Colonial peoples also, and it is worth noting in passing that the first annual report of the Colonial Research Committee contains an admirable discussion of strategy in relation to the organization of Colonial research.

There are yet two further aspects of such broad strategy which should be noted. First, provision for the organized study of particular and urgent problems the social relevance of which is immediately apparent leads us almost imperceptibly, through the consideration of such questions as transport, the utilization of the land, water supply, the planning of town and country and the location of industry, to the study of a whole range of problems in the social sciences the immediate relevance of which may be less apparent. Without adequate attention to social biology and the biological factors in human relations, to population changes and vital statistics, to psychology, and allied subjects, we shall be without the basic knowledge we require for the evolution of a new social order or for the establishment of better human relations either at the industrial or at the international level, as well as without the effective technique for handling and improving such relations. As Roy Glenday points out in a recent book, "The Future of Economic Society", we need to know much more about the principles and rules which will govern the social and economic organization of the groups of human beings of which the new world order will be composed. Even more emphatically, Dr. J. T. MacCurdy in discussing, in "The Structure of Morale", this problem of organization indicates how far we have to go when he says that man can expect to fabricate a social organization that will be adaptable only when he has developed a liaison system comparable in its intricacy with the individual human brain.

The suggestions for research which Dr. MacCurdy has made in this connexion should be considered in framing our broad programme of research, and they bear closely on the second aspect of strategy which remains to be considered. If there were any scientific workers who imagined that research strategy could be considered entirely without reference to politics, they should have been disillusioned by the reception which has been given to the report of the Parliamentary and Scientific Committee on "A Scientific Policy for Agriculture". The suggestion that policy should not be shaped primarily or excessively by sectional interests but should be based on the application of scientific principles has been represented as an attempt to dictate policy by reference to such principles alone.

The attempt to formulate and to apply an adequate strategy of research is clearly liable to like misrepresentation, for such strategy can only be put into operation when it receives the necessary political support. It must be therefore a primary responsibility of scientific workers in endeavouring to think out such a strategy to undertake simultaneously the corresponding and no less essential task of explaining and interpreting that strategy to their fellow citizens. At this point no less than in the application of scientific and industrial research in industry educational work has to be undertaken. That is a task of co-operation as well as education. As Mr. Glenday observes: "Before scientists can claim the right to plan a new world order, they must first plan science itself by organizing its various departments to the point of making possible effective co-operation between them". Such endowments as Lord Kemsley's travelling fellowships, the fellowships in science offered by Imperial Chemical Industries, Ltd., and the trust fund for economic and financial research established by the Bank of England should be taken by scientific workers as a challenge both to fundamental thinking on the strategy of research and to full and resolute co-operation alike in the exposition and interpretation of science and in setting their house in full order. Their training has developed in them the critical and unprejudiced approach to novel problems in their particular fields; they must now apply this faculty in a wider field.

THE HUMAN FOOT

Structure and Function as seen in the Foot
By Prof. Frederic Wood Jones. Pp. iv+329. (London: Baillière, Tindall and Cox, 1944.) *25s.*

PROF. WOOD JONES is a distinguished member of a long line of British anatomists who, from the time of John Hunter, have refused to limit their activities to the dissecting room and to circumscribe their work within the confines dictated by the supposed immediate requirements of surgery. The line includes Owen, Turner, Humphry, Flower, Cunningham, Elliot Smith and, fortunately still with us, Sir Arthur Keith, and Profs. Arthur Robinson, T. H. Bryce and J. T. Wilson. All these professed human anatomy but all were also excellent comparative anatomists, neurologists or embryologists, and the influence of their wide interests on the advance of anatomical knowledge is not adequately realized. Prof. Wood Jones, in continuing this great tradition, has made significant contributions to mammalian comparative anatomy and, in his publications, he has shown great skill in presenting the detail of human anatomy against a background of mammalian structure which enables one to separate most revealingly those human characteristics that can be regarded as primitive from those that are specialized.

In the book under review Prof. Wood Jones gives an excellent account of the structure of the human foot. The account is none the worse for being, from time to time, iconoclastic and even provocative. It takes for granted an introductory knowledge of human anatomy and will be more readily followed if the reader has already studied, as he should have done, the author's "Principles of Anatomy as seen in the Hand", for the two books are complementary. Doubtless every anatomist could find points of detail with which he would not agree, but, in general, the descriptions are clear, succinct and, often, illuminating. The figures, which have been drawn by the author himself, are most helpful in clarifying the descriptions and they possess the added merit of a quite engaging charm. Omissions, too, will be noted by every anatomist, in accordance with individual prejudice. Thus, in the reviewer's opinion, some reference to Wheeler Haines' work on sesamoids and secondary centres of ossification would have been useful, and the absence of reference to the architecture of the bones, and more particularly to Weidenreich's study on the structure of the calcaneum, is surprising.

The interest of the author in comparative anatomy and in the problems of human phylogeny is revealed in every chapter; but he is careful to warn most emphatically against too much reliance on tags of morphology for assumptions, by analogy, as to function. The case against the 'gorilloid' theory of the derivation of the human foot is convincingly presented, though it is, perhaps, too much taken for granted that this theory, in its extreme form, is widely held. Most anatomists are of the opinion that the early hominoid stock was not derived from an anthropoid ape of the degree of specialization of the extant great apes, and most also believe that the separation of the hominoid from the anthropoid stock occurred at an earlier geological stage than has sometimes been held. But, equally, most workers on primate phylogeny cannot overlook the innumerable structural resemblances between the great apes and man. These resemblances are all-pervading. They extend, as Heuser's account of the ten-day chimpanzee 'ovum' shows, to the very early stages of development, and it would be unfortunate if Prof. Wood Jones's demonstration of the unlikelihood of a 'gorilloid' stage in the phylogeny of the human foot was taken to indicate a more remote relationship between man and the anthropoid apes than, in fact, a survey of all the relevant facts appears to warrant. Notwithstanding this caveat, however, Prof. Wood Jones has made his primary phylogenetic point most persuasively, though some of the argument used in establishing it ignores the significance of allometric, or heteroauxetic, growth in producing differences of proportions of bones in quite closely related animals. Those gene changes concerned in the causation of, say, achondroplasia can alter limb proportions most strikingly without leading to the opinion that the resulting dwarfs represent a new species.

On the functional side Prof. Wood Jones's analysis is again often illuminating. This holds especially for the descriptions of muscular activity and the accounts of movements at the different joints of the foot. His insistence on the freedom of movement at the talo-calcaneal joint is noteworthy, since, in spite of the ease with which the facts can be established, the text-book accounts of this joint are unsatisfactory. The account of the arches of the feet emphasizes the importance of the ligaments in the maintenance of the longitudinal bow, as he prefers to call it. Absence of the anterior metatarsal arch is accepted, but there is no reference in this chapter to the views of Morton, Bankart, Lake or Bruce and Walmsley. A little more emphasis on the clinical importance of proper foot function might justifiably have been introduced, especially as some of the opinions expressed have implications for that part of orthopædics which deserves better than to be called, as it is coming to be called in the United States, podiatry.

"Structure and Function" appears in the title of Prof. Wood Jones's book, and the descriptions of isolated structures and functions throughout it are excellent. There is, however, for the reviewer, no satisfactory attempt at integration of the two. That structure is adapted to function is taken for granted, and little stress is laid on structure which may conceivably be non-adaptive. Further, having taken the structural adaptation to function for granted, there is no reference to the importance of the sieve of natural selection in the establishment of the adaptation. Prof. Wood Jones is an unblushing supporter of the theory of the transmission of acquired characters, and inherent in his whole approach to the study of structure there is the restricted teleology of the end in view. The reactions of readers to this approach will doubtless be conditioned by their individual philosophical attitudes. At least one of them, who has, he believes, followed the arguments sympathetically, remains unconvinced by Prof. Wood Jones's examples, and will adhere to the orthodoxy that there is no good evidence for accepting the doctrine of the transmission to offspring of modifications produced in response to functional requirements. Prof. Wood Jones writes: "Every simile that is called upon to explain the ordering and working of structures and organs in the living body is derived from the unliving world of mechanistic physical science. No real understanding of the longitudinal arch of the foot will ever be come by in attempting to assess its character in terms of the triumphs of the architect or the engineer". Ends, not antecedents, satisfy him as they have satisfied many others; most biologists, however, will prefer Boyle's "industrious indagation of efficients" and will find their apologia in the first chapter of Sir D'Arcy Thompson's "Growth and Form".

J. D. BOYD.

RECENT WORK ON MAGNETOCHEMISTRY

Magnetochemistry

By Prof. Pierce W. Selwood. Pp. ix+287. (New York: Interscience Publishers, Inc.; London: Imperia Book Co., 1943.) 5 dollars.

IN hybrid terms for investigations involving the experimental examination or the theoretical consideration of particular physical properties of substances, the words 'chemical' or 'chemistry' are often used where they serve no useful delimiting or other purpose. The author of this book possibly feels the difficulty, and gives an explicit definition of magnetochemistry as "the application of magnetic susceptibilities and of closely related quantities to the solution of chemical problems". This, however, is not a severe limitation, for any problem of structure, whether atomic, molecular, or crystalline, which arises in the consideration of the experimental results, may be regarded as a chemical problem; and in fact the subject-matter of the book is virtually the entire range of results for susceptibilities, and their interpretation.

The author makes graceful acknowledgment to other books on the general field, and does not give detailed references to work prior to 1934. Since then to the end of 1942 he states that more than one thousand papers on magnetochemistry have appeared. The problem of selection seems to have been avoided by referring to all of them, for specific reference is made in the text to some twelve hundred papers indicated in footnotes. The book is thus in the main an extensive survey of the recent literature along lines similar to those followed in the "Annual Reports" of the Chemical Society. It would, therefore, scarcely meet the needs of those seeking an introductory or a general account of magnetochemistry; but to those who already have some familiarity with, and interest in, the subject such a survey can be of immense service, particularly at the present time.

The author's own practical experience is evident in the first chapter, where the most useful methods for determining susceptibilities are briefly but clearly described. Among the general explanatory remarks, however, there are a number of loose or definitely incorrect statements. It is stated, for example, that substances are called dia- or para-magnetic according to whether the "intensity of the field" in the substances is smaller or greater than that in the surrounding space (p. 1); that for ferromagnetics the intensity of magnetization becomes proportional to the field "only at high fields, when the specimen is said to be saturated" (p. 17); that specific magnetization is "given by the slope of the susceptibility plotted against reciprocal field strength" (p. 18). Slips of this kind are fortunately not typical of the whole book.

The main subject-matter is grouped in seven chapters each covering a particular class of substance. The grouping is not explicitly discussed, but from a magnetochemical point of view it is logical and convenient. The chapters deal with atomic and molecular diamagnetism, atomic and molecular paramagnetism, complex compounds, metallic dia- and para-magnetism, and ferromagnetism. A final chapter deals with miscellaneous topics under the general heading of applied magnetometric analysis.

Atomic magnetism is, as usual, taken as a general term covering the magnetism of ionic crystals, in connexion with which experimental work and the quantitative theoretical treatment earliest reached a fairly advanced stage. The survey is mainly of additional data accumulated during the last ten years. The author deliberately refrains from including tables of susceptibilities, on the ground that "Annual Tables" of such data are to be published; but it may be suggested that much of the information included in the continuous narrative could have been conveyed in more convenient form by means of suitably annotated tables. It is surprising to find how incomplete the experimental information still is on the compounds of transition elements other than those of the first and of the rare earth series.

The most valuable parts of the book are the chapters dealing with molecular paramagnetism and complex compounds, on which the experimental work in recent years has been very extensive. It may happen that the susceptibility is determined, with close approximation, by the number of unpaired electron spins in the molecules, the magnetic effect of any orbital moments being negligible; when this is so, and if no searching inquiry is attempted, the magnetic aspect of the problems is often fairly simple. Not so the chemical aspect; for very difficult problems of structure may arise in connexion with, for example, organic free radicals and biradicals, complexes such as those of chromium and manganese, and hæmoglobin and related compounds. Magnetic measurements are proving invaluable as a guide, and it is most useful to have a survey written with so thorough an appreciation of the chemical background.

To many physicists the magnetic properties of metals are now of outstanding interest, partly, perhaps, just because they are beyond the scope of the theory which is adequate for 'normal' dia- and para-magnetics. It is useful to have recent results collected together, but the theory of metallic magnetism is barely mentioned, and without it the significance of the susceptibility data is not brought out. Much the same remark applies to the material surveyed in the chapter on ferromagnetism, though here there is considerable specific value in the systematic survey of the results for the oxides and other ferromagnetic compounds of iron, and of the non-ferrous ferromagnetic compounds, which are often dismissed rather summarily.

The last chapter includes a description of a number of instruments used in metallurgical control, and a rather sketchy survey of magnetic work on the structure of alloys; it closes with some statements about the susceptibility of sea urchin eggs and sperm.

Those who write surveys of scientific literature undertake a thankless task. Omission of reference to some particular piece of work may give offence; completeness of reference, in reasonable space, is possible only at the sacrifice of other desirable qualities in a book. Over most of the field the references here seem all-inclusive, and as a comprehensive digest of the literature the book is beyond reproach. It might have been much more readable if the author had been less conscientious, and had not attempted to cover so wide a range. The book, however, will probably be used mainly for reference, so that the paragraph which states merely that colloidal magnetite has been examined, and the remarks on sea urchin eggs, may fulfil a useful purpose. The author expresses the hope that the book may contribute, however infinitesimally, to the labours of those scientific men who are seeking to parry the blows of an enemy. It may not do that; but it certainly will perform a valuable service in one small region of endeavour in helping to bridge the devastating gap which is being made by the war years.

E. C. STONER.

SURVEYING FOR STUDENTS

Higher Surveying

By Dr. Arthur Lovat Higgins. Pp. viii+463. (London: Macmillan and Co., Ltd., 1944.) 25*s*. net.

THAT Dr. A. L. Higgins is an enthusiast where the subject of surveying is concerned will be evident to readers of his latest book entitled "Higher Surveying". It is written on somewhat unorthodox lines, each section consisting of a number of "Articles" followed by a selection of examples.

Though ostensibly written for students, the book should have a much wider appeal. The articles are well written, and many of them are concise critical essays on appropriate surveying topics: they include many historical references and discuss modern developments. It may be that these scholarly outlines will sometimes be more appreciated by those who already have a good knowledge of surveying than by the student whose horizon is less wide. Even if not fully understood by the student, however, they will give him a broad view of the subject, into which later knowledge can be fitted.

The impression is given that Dr. Higgins had a great deal of trouble in deciding the scope of the book, and in fixing its title. In the first place, he had so much material that he decided to jettison much that was of a more elementary character, and also some details of field technique which the student might be expected to learn in the field. It probably seemed too drastic to carry out this policy rigidly, and opportunities have been taken in the text and examples to incorporate much that is not strictly 'higher surveying', but which completes and rounds off the treatment of other subject matter. Even with these omissions the author's troubles were not ended. He was anxious to include a considerable number of worked examples taken from university examination papers, and also others for the student to solve. Consequently, with the space at his disposal, he had either to omit subject matter he was anxious to include, or deal with it in a less detailed manner than he would have wished. In some cases the examples have been used, not to illustrate the text, but to supplement or even as a substitute for it. In other cases the text is somewhat too concise and condensed for easy reading. The reviewer considers that Dr. Higgins has overcome his difficulties very successfully, and the book cannot fail to be of great value to its readers.

The six main sections of the book deal respectively with (1) instruments, (2) engineering surveys, (3) photogrammetry, (4) field astronomy, (5) geodetical surveys and (6) errors in surveying.

These sub-titles sufficiently define the scope of the book. It is from the section on engineering surveys that much of the elementary work on chain surveying, traversing, levelling, plane-tabling, etc., has been omitted. Section 3 deals with both ground and aerial surveying, and is necessarily selective. The last section, of about sixty pages, dealing with errors of surveying, contains a mass of information, the theoretical work being rather too concisely expressed, but with the applications fully explained by means of numerical examples.

Finally, it may be said that the production is excellent, and the publishers are to be congratulated on presenting so well, in war-time, this most useful and attractive text-book.

W. N. THOMAS.

THE STUDY OF FINE PARTICLES

Determination of Particle Size in Sub-Sieve Range

A Report of Discussions. Pp. 69. (London: British Colliery Owners' Research Association and the British Coal Utilisation Research Association, 1944.)

THE measurement of fine particles is a subject of increasing importance in many industrial processes and in the study of natural phenomena concerning soils and dusts. It is now realized that the influence of very fine particles is so predominant that in many researches measurements would be desirable to a lower limit of one micron in diameter, though it is not often that this degree of accuracy can be attained. The above report contains an account of the activities of two research associations having the object of improving particle size measurements, and they may be complimented on the broad way in which the problem has been treated.

The volume reports two informal conferences held to discuss the subject, with an introductory paper by Drs. Skinner and Boas-Traube and Messrs. Brown and Hawksley. This paper summarizes recent developments in the measurement of fine particles, dealing with microscopical measurement, the dispersion of various powders in liquids, and in considerable detail with the measurement of size distribution by determining the rate of change in optical density of a dilute suspension of the powder in a liquid. This latter method is now being extensively used both for research purposes and for the rapid checking of industrial products as a routine procedure. The report of the second conference expresses the views of research workers from various laboratories of the Department of Scientific and Industrial Research and a wide range of industrial organizations.

From this discussion it is apparent that the problem needing most urgent research is that of effectively dispersing a powder in a liquid, since this procedure is involved in almost all methods of sub-sieve particle-size determination. A large number of peptizing agents have been suggested for various powdered substances, but no general theory has yet been developed that would obviate the present method of proceeding by trial and error. Many processes and designs of apparatus are now available for measuring sub-sieve particles which are satisfactory for comparing the fineness of various powders, but serious discrepancies are shown to exist when the same powder is tested in different designs of apparatus. Thus it is evident that further research is necessary on many details before the absolute size distribution of the finest particles can be determined; but the report is a valuable guide to those engaged on particle-size measurement regarding the choice and most effective way of using such apparatus as is available.

H. HEYWOOD.

Solvents

By Dr. Thos. H. Durrans. (Monographs on Applied Chemistry, Vol. 4.) Fifth edition, revised and enlarged. Pp. xii+202. (London: Chapman and Hall, Ltd., 1944.) 17*s*. 6*d*. net.

WHEN this book was first published in 1930 it was not generally appreciated how useful organic solvents were and how wide their application could be. Since then they have become of prime importance, and their manufacture is an important section of the fine chemical industry. This little book has undoubtedly contributed to their use; it gives just the required amount of information in detail about each of them, as well as a general section about their behaviour in general. Organic solvents have adverse as well as useful properties: they are toxic and have a considerable fire risk. Workers with them risk chronic poisoning, so that guidance in their use is required: the book contains the necessary information including the relevant data regarding critical concentrations. Similar data are given for the explosive limits of the various substances.

There are now so many of these solvents, most of them sold under trade names, that it is hard to know what they are. The appendix giving the trade names and probable composition is therefore especially valuable: it occupies eight pages with some four hundred entries.

A second appendix shows in tabular form the power of the solvents to dissolve twenty-five named substances mostly used by the plastics industry. The work is a mine of information, and its frequent revision enables it to be kept up to date and accurate.

There is no indication of any particular new solvents, though such are continually being added to the list. Dr. Durrans is to be congratulated on his efforts, which are greatly appreciated by all users of solvents.

Aeroplane Flight

By H. F. Browne. Pp. 167. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1944.) 7*s*. 6*d*. net.

THERE is already a flood of books on the elements of aerodynamics purporting to be written in non-technical language for the beginner. Many of these fail to fulfil their authors' intentions simply because the explanations assume a knowledge of mechanics and physics not to be expected of the non-technical reader. Mr. Browne does not commit this mistake. He explains the principles of mechanics as he meets them in very simple language, using homely everyday examples, illustrated by unique sketches of his own preparation. These diagrams are perhaps the most outstanding feature of the book, and they have been made to illustrate the text in a way that photographs or sketches of actual aircraft parts could never equal.

The subject is discussed in chapters each dealing with some part of the theory of flight such as lift, stalling, drag, thrust, control, stability and performance. There is also a discussion on the mathematical units involved, leading up to a chapter on wind tunnels and the interpretation of their results. The explanations of some of the more complex ideas are extremely good. The mechanics of the airscrew, the gyroscope and gyroscopic action, and the meaning of "Reynolds Number" in aerodynamic experimental work, are examples of the way in which the author has succeeded in putting the technical facts into language that is both simple and mathematically true.

While this book is essentially for beginners, its method of presentation of the subject might well be studied by many teachers.

The Annual Register

A Review of Public Events at Home and Abroad for the Year 1943. (New Series.) Edited by Dr. M. Epstein. Pp. xii+176. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1944.) 42*s*. net.

THE new issue of this annual record follows the usual arrangement. The greater part is devoted to a factual and objective story of world history divided into national sections, half of which treat of Great Britain and the Dominions; the British Colonies have no separate section. The record is chronological, which puts the social history into perspective with the history of the War, and so gives an admirable sketch of human interests in the year. Under the headings of various enemy or enemy-occupied countries, there is much social history some of which failed to receive adequate notice in the restricted newspapers of to-day.

The second half of the book has the usual surveys of literature, with reviews of some outstanding books, art, music, drama, science, law and finance. The review of scientific achievements is comprehensive though very condensed and perhaps less readable than some of the other sections. Then follows a record of events, obituary notices and a long and detailed index.

In addition, certain public documents printed in full include the Anglo-Chinese Treaty concerning Extra-Territorial Rights. In spite of the crowded events of the year, the editor has succeeded in producing a balanced volume of the same size as previous issues.

Elements of Radio

By Abraham Marcus and William Marcus. Prepared under the editorship of Ralph E. Horton. Complete edition. Pp. xiii+699. (London: George Allen and Unwin, Ltd., 1943.) 27*s*. 6*d*. net.

THIS book, printed in the United States, is in the nature of an elementary course of instruction in radio technique on very practical lines. The authors state that as a result of many years experience of teaching this subject, they consider it a mistake to require the student to learn a mass of laws and principles of electricity before teaching him radio. The first half of the book deals with the radio receiver, starting with the crystal detector and leading up through valve detectors and amplifiers to the superheterodyne type of receiver. The second half of the book is slightly more advanced, and deals first with the phenomena of direct and alternating current electricity and their applications; and then with the essential characteristics of radio transmitters and auxiliary equipment.

The style throughout is very elementary, with very clear diagrams, and includes a series of questions, problems and practical exercises and demonstrations, all of which are probably very suited to a particular type of instruction designed for a short-period (one year or less) course. Only the simplest of formulæ are included, such as for the calculation of circuit constants; and the technical material is clearly and accurately presented.

MEANING AND SCOPE OF SOCIAL ANTHROPOLOGY

By Prof. A. R. RADCLIFFE-BROWN
University of Oxford

THE name 'social anthropology' came into use some sixty years ago to distinguish the subject from ethnology. The avowed aim has always been to apply the inductive method of the natural sciences to the study of human society, its institutions and its evolution. But it is only gradually that we can learn how to apply the inductive method in a new field. The history of chemistry from the time of Bacon to Lavoisier illustrates this. So social anthropology is not now what it was in 1890. At that time theoretical discussions in social anthropology were largely concerned with speculations about origins (of religion, of totemism, of exogamy, etc.). There are still some social anthropologists who remain faithful to the ideas and methods of 1890. But the work now being done in the subject consists largely of experimental studies, combining observation and analysis, of particular social systems, intended to provide material for the systematic comparison of systems of different types and to test existing hypothetical conceptions. Anyone who wants to know what social anthropology is doing at the present day should read the admirable work of Arensberg and Kimball on "Family and Community in Ireland".

One of the most completely organized departments of anthropology is that of the University of Chicago. The subject is divided into five fields: physical anthropology, archæology, ethnology, linguistics and social anthropology. Students, who must already have the degree of B.A. before entering the department, are required to devote a period of study to all five subjects and pass a comprehensive examination in all of them. Thereafter the student specializes in one of the fields for his degree of Ph.D. A brilliant student can complete this work in four years, but many take longer.

We may consider this combination of subjects from the point of view of each one of them in turn. Physical anthropology proper, as distinct from human biology, is the study of variation in the human family (the Hominidæ) and of human evolution. It includes, therefore, not only the study of existing varieties of *Homo sapiens*, but also human and primate palæontology. A student who aims at being a competent physical anthropologist must first obtain a thorough grounding in biology, comparative morphology (particularly of the primates), human anatomy, histology, embryology and physiology. It seems desirable that he should have some acquaintance with archæology and ethnology. His own special work will in no way be helped by any study of linguistics or social anthropology.

Ethnology, as the name shows, is the study of 'peoples'. Peoples, or ethnic groups, differ from and resemble one another in racial character, in language and in culture. The ethnologist compares and classifies peoples on the bases of these similarities and differences, so that he has to deal with racial, linguistic and cultural classifications. Further, he seeks to discover by various methods something about migrations, interactions and developments of peoples in the past.

It is evident that the competent ethnologist should possess a sound knowledge of physical anthropology, linguistics and social anthropology. Ethnological literature is very heavily overloaded with uncritical speculations. A writer who talks glibly of brachycephaly and dolichocephaly but is completely ignorant of the complexities of structure of the skull will offer us an account of the movements and developments of races from the first appearance of man. One who is ignorant of linguistic science will affirm a connexion of two widely separated languages on the evidence of similarities of a few words selected from imperfect vocabularies. Or one who, by his lack of knowledge of social anthropology, is ignorant of the nature of institutions such as totemism or exogamous moieties, will affirm that these institutions all over the world must have been introduced by Egyptians looking for gold, pearls and cowrie shells.

Prehistoric archæology is really one kind of ethnology (palæo-ethnology), the study of the peoples of the prehistoric past who are known to us only from their remains—their dwelling sites, their bones, the implements they made and used. Since the archæologist recovers no traces of the languages or the social institutions of these vanished peoples he has no need, in the pursuance of his own special studies, for any knowledge of linguistics or social anthropology. On the other hand, he has to know something of geology and surveying. It would seem to be most desirable that ethnology and archæology should keep closely together. They are merely branches of a single study.

Linguistics, the systematic study of language in general, as distinguished from the study of particular languages or groups of languages, is regarded in the United States as one of the fields of anthropology. In England the subject, as a subject, has not yet received recognition except in the School of Oriental Studies, London. A student who intends to specialize in linguistics does not really need to know anything more about physical anthropology or prehistoric archæology than ought to be known by every educated person. But there are important connexions of linguistics with ethnology and social anthropology. For example, the ethnological problem of the Aryan people is a linguistic problem as well as an archæological, racial and cultural problem.

We come finally to social anthropology—the general theoretical study of social institutions—law, religion, political and economic organization, etc. Within his own field of study, the social anthropologist has no use for physical anthropology. If it should ever be proved that racial (that is, biologically inherited) characters influence social institutions or their development, then he would take due note of the fact.

Prehistoric archæology obviously makes no contribution to such branches of social anthropology as comparative religion, the comparative study of law or of kinship or of economic systems. It does not even provide very much help to the study of comparative technology as that is conducted in social anthropology, where what is sought is to determine the mutual interrelations between the system of techniques and the other parts of the total social system. Certainly a social anthropologist should be acquainted with the general results of prehistoric archæology, but the methods of the archæologist and the details of investigation are not his concern as a social anthropologist.

There is often a good deal of confusion about the relation of social anthropology to ethnology. To a certain extent, but only to a certain extent, they deal with the same facts. But they deal with them in quite different ways. A typical problem of ethnology is how and when the ancestors of the American Indians entered the continent of America and how they developed the differences of racial character, language and culture which they exhibited when Europeans first came in contact with them. A typical problem of social anthropology is, "What is the nature of Law ?" An ethnologist and a social anthropologist might both study the same American Indian tribe, but one would be looking for facts relevant to his aim of placing the tribe within his general picture of the peoples of the continent ; the other would be examining the way in which the tribe deals with infractions of custom in its bearing on a general theory of the nature and function of law.

Since both ethnology and social anthropology need field studies, there is an obvious economy of labour if a field worker can provide the material needed by the ethnologist and also that needed by the social anthropologist. In some field studies this has been done. But a field study in social anthropology needs more than description ; it requires theoretical analysis. There are innumerable examples of ethnographic monographs which are admirable for the purposes of ethnology but are extremely unsatisfactory to the social anthropologist who might wish to make use of the data.

Ethnographical field studies are generally confined to the pre-literate peoples. In the last ten years, field studies by social anthropologists have been carried out on a town in Massachusetts, a town in Mississippi, a French Canadian community, County Clare in Ireland, villages in Japan and China. Such studies of communities in 'civilized' countries, carried out by trained investigators, will play an increasingly large part in the social anthropology of the future.

It is now possible to see that what holds the various branches of anthropology together is the central position of ethnology (with archæology) as the geographical, historical and classificatory study of races and peoples, past and present. It is for this reason that ethnology and anthropology are sometimes regarded as being one and the same. It is an interesting fact that the symposium (as it is now commonly called) on the future of anthropology at the centenary meeting of the Royal Anthropological Institute included discussions on physical anthropology, archæology, social anthropology and the study of material culture. There was no one to speak on the future of ethnology. Ethnology takes contributions from physical anthropology and linguistics, but gives little to them in return. Social anthropology as the study of evolution is in bad odour with some ethnologists at present, so that while they give little they also take little.

But what of the relations of the branches of anthropology to subjects that lie outside the field of anthropology ? Physical anthropology has its closest connexion with the biological sciences. There is a tendency to seek to absorb it into a wider study of human biology, which would, presumably, also include what is called social biology. The study of the Bantu languages or the languages of the American Indians is left to the anthropologist, but not the study of the Indo-European and Semitic languages. How (and why) draw a line between prehistoric archæology and the archæology of historic times ? But if no such line is drawn, archæology becomes continuous with history. Ethnology, or some part of it, is claimed as a subdivision of geography—ethnogeography. And where, at the present time, are we to put anthropogeography or human geography, in geography or in anthropology or in both ?

Ethnology deals with the history of peoples. But the rest of history is excluded from anthropology. Yet the closest connexion of social anthropology is with the history of institutions—economic history, the history of religion, of law, of political organization, of science, etc. But to the social anthropologist the history of Europe or of Christianity is of no more interest than the history of India or China, of Islam or Buddhism.

The writer of the article on "The Future of Anthropology" (see *Nature*, Nov. 20, 1943, p. 587), which surveyed the discussion at the centenary meeting of the Royal Anthropological Institute, asks, 'Who is to study the world-wide history and development of social institutions ?" The answer is, in the first place, the historians. The social anthropologist cannot examine for himself the original sources for the economic, political, legal and religious history of ancient Greece and Rome, India, China, Russia, Persia and Turkey. It is unusual for him to be thoroughly competent in even one of these fields. The social anthropologist, for the most part, has to take the facts about institutional history and development from the historians, though, of course, he has to exercise his judgment as to the reliability of a particular historian. What the social anthropologist does with this material is to use it to formulate his general hypotheses about law, religion, economic organization and so on. But these hypotheses need to be verified ; and although some verification is possible by the comparison of different historical societies, the final test lies in actual (experimental) observation of existing social systems.

Political systems, economic systems, and systems of law are studied in social anthropology and also in economics, political science and jurisprudence. But there are very important differences of method. One of these, though by no means the most important, is that in the three studies mentioned attention is usually confined to certain types of society, whereas social anthropology has for its field all human societies and therefore tends to pay most attention to those which are neglected by the social sciences. It is true that at present there is no close connexion of the three social sciences with social anthropology, but this may be expected to develop as the last-named subject itself develops.

As anthropology is at present recognized, psychology lies outside. Yet social anthropology stands in a very close relation to psychology. To make the relationship clear it is necessary to distinguish between two kinds of psychology. Psychology is here taken to mean the study of the mental or psychic systems—if you will, the behaviour systems—of organisms. We may study the behaviour, the external manifestations of the psyche, of earthworms, rats or chimpanzees. General human psychology deals with the mental characteristics which are possessed by all human beings. Social anthropology deals with the characteristics of all human social systems. A social system consists of a certain set of social relations between certain human beings, exhibited to observation in their interactions with one another. It is obvious that one determining factor in the formation of human social systems is that basic human nature which it is the business of the general psychologist to study. Similarly, the nature of multicellular organisms is determined by the nature of the living cell which it is the business of the cytologist, the biochemist and the biophysicist to study. The connexion between social anthropology and general psychology is just as close and of just the same kind as the relation between animal physiology and cytology.

There are also what may conveniently be called 'special psychologies'. These deal, not with the universal characteristics of human beings, with basic human nature, but with the special mental or behaviour characteristics of individuals, types, classes or groups. Psychiatry affords an example of a 'special psychology', as do attempts to define psychological 'types'—extrovert, introvert; schizophrenic, cyclothymic; pycnic, asthenic.

One of the 'special psychologies' consists of the study of the psychical characteristics (that is, characteristics of mind or behaviour) of the members of a defined social group, either a local community or a defined social class within a local community. When we study the 'psychology' of the French or the Germans or the people of the United States, we are dealing with those characteristics of mind or behaviour that result from 'conditioning' by a particular social system. Here the 'special' characteristics with which we are concerned are determined by the social system, while the social system itself is determined by the general characteristics of basic human nature.

It should be evident that there is a two-way connexion between social anthropology and psychology. Human societies are what they are because human beings are what they are. Similarly a human body is what it is because living cells are what they are. But why human beings belonging to a particular society or group exhibit certain characteristic modes of behaviour is because they have been 'conditioned', as the phrase is, by that society. Similarly the cells of a muscle act and react as they do because they are individual members of the muscle.

Prof. F. C. Bartlett (*Nature*, Dec. 18, 1943, p. 700) proposes drastic changes. He would give no place in anthropology to archæology, to linguistics (the general study of language), to ethnology (the geographical and historical study of races and peoples), or to social anthropology (as the comparative study of the forms of association found among human beings or as the study of social evolution). He would retain physical anthropology or anthropometry if it would abandon its present aim of studying evolution, variation and heredity in the human family and would devote itself to measuring physical characters that are correlated with differences of behaviour. He would also admit the study of material culture so long as it was limited to the study of the applications of natural knowledge and their influence on behaviour. He adds two other disciplines. One is the study of the effects of general environmental conditions on behaviour. The other is the study of "a group's psychological possessions, its traditions, beliefs, customs, ideals and of their repercussion upon social conduct". For Prof. Bartlett, anthropology should become a group of special psychologies dealing with the effects on behaviour of anatomical characters, environment, knowledge and the 'psychological possessions' of groups. Anthropologists need not fear, however, that Prof. Bartlett's drastic reforms will be carried out in the near future. Meanwhile, that 'special psychology' which is concerned with the way in which the behaviour of individuals is determined by the 'culture' of the society in which they live is already part of social anthropology. But to say that it should be the whole of it is to deny to social anthropology the right to that study of the nature of social systems and of their evolution which is the *raison d'être* of the science.

Applied social anthropology is not much more than twenty years old. It was developed in South Africa, England and Australia in connexion with problems of Colonial administration. About twelve years ago it secured, despite the opposition of some ethnologists, a footing in the United States, not only in the Indian Bureau but also in the Soil Conservation Bureau and in an investigation of factory efficiency carried out in a large factory under the direction of Prof. Elton Mayo of Harvard. Since the United States came into the War, large numbers of anthropologists have been called to Washington to carry out work which either is, or is supposed to be, applied anthropology.

There is a good deal of misunderstanding about applied anthropology, what it is, what it can do and what it cannot do, but that matter obviously cannot be discussed here. The recognition of applied social anthropology has certain very definite advantages and certain equally definite disadvantages. To mention only one of the latter, theoretical social anthropology is still in the formative stage. The demand on social anthropologists to spend too much of their time on practical problems would inevitably reduce the amount of work that can be given to the development of the theoretical side of the science. But without a sound basis in theory, applied anthropology must deteriorate and become not applied science but merely empirical practice.

What of the future? Social anthropology must claim a position of relative independence. (There are already chairs of social anthropology at Oxford and Cambridge.) This does not mean that it should sever its connexion with ethnology, with which it has always been associated; and its connexion with ethnology connects it indirectly with prehistoric archæology. It should maintain a close connexion with general linguistics, for language is a social institution. (At Oxford the only lectures on general linguistics have been those given in the Institute of Social Anthropology.) It could maintain a closer connexion with human biology than with the narrower subject of physical anthropology.

Outside the field of what is called anthropology, it must maintain or establish connexions with psychology, with history (more particularly economic history, the history of law, of political organization, of religion) and with economics, political science and jurisprudence. The history of culture, in the sense of the history of art, of music, of literature, ought not to be neglected in any complete social anthropology, nor, of course, technological history. In the training of a social authropologist the first essential is a real understanding of the experimental method in scientific investigation, and this is best acquired by a thorough study of the history of science.

One part of social anthropology is the comparative study of economic systems. Surely there ought to be close connexion between this study and economics and economic history. Another part of social anthropology is the comparative study of legal systems, which demands a similar connexion with jurisprudence and the history of law; and so on with other parts of social anthropology. But what part of social anthropology would give a similar close connexion with the study of the somatic differences exhibited by the various races of mankind, or with the study of the date and the affinities of the Solutrean or Capsian culture ? So long as ethnology continues to exist, it will provide a meeting-ground for archæologists, physical anthropologists, students of linguistics, and social anthropologists. Such a meeting-ground has been provided for a century by the Royal Anthropological Institute and will continue to be provided in the future. Any attempt to impose a more rigid artificial unity will be likely to produce exactly the opposite of the result at which it aims.

GENETICS AND KARYOLOGY OF *DROSOPHILA SUBOBSCURA*

By DR. U. PHILIP, J. M. RENDEL, H. SPURWAY and PROF. J. B. S. HALDANE, F.R.S.

MODERN genetical theory is largely based on the study of *Drosophila melanogaster*, which has proved a useful guide to the genetics of other organisms. But there has been a tendency to regard this species as a standard, and any deviations from its genetical behaviour as exceptions.

The genetical study of other species of Drosophila has not merely opened a promising field of comparative genetics; it has also demonstrated that most species show qualitatively novel features. Thus *D. virilis* has a number of labile genes, *D. miranda* has two *X*-chromosomes. In *D. ananassæ* the males are triploid for at least one gene. *D. pseudo-obscura* A, though apparently monotypic, is polymorphic for a number of intra-chromosomal gene orders, each with its characteristic geographical range; and *D. subobscura* has been found to be a structural heterozygote in both sexes. In general the comparison of species suggests that they differ at least as much in the arrangement and proportions of the gene material as with regard to genes themselves.

C. Gordon[1] began the genetical study of *Drosophila subobscura*, and we owe some of our stocks to him. The study was continued by Gordon, Spurway, and Street[2] and Christie[3], and we hope shortly to publish a series of papers on it. The species belongs to the *obscura* group of the subgenus Sophophora (Sturtevant[4]), and its diagnostic characters are given by Gordon (1936) according to Collin (unpublished). It appears to be a native British species, and seems to have a wide distribution in Europe. For in a letter sent just before the outbreak of war with Italy, Buzzati-Traverso and Pomini, of the University of Pavia, informed us that flies of our stocks had given hybrids with flies of a species found in Italy and Germany, on which they had made genetical and cytological studies. Its possible identity with Sokolov and Dubinin's[5] *D. obscura*-3 from the U.S.S.R., is discussed later. The flies can be caught fairly regularly under 'bleeding' elms and oaks. We know little of the several related British species, and have so far not attempted to study their systematics.

At mitotic metaphase there are five pairs of telomitic rod-shaped chromosomes, and one pair of 'dots'. The *X*- and *Y*-chromosomes, which are of equal length, are the longest pair of rods. They can also be distinguished from autosomes in that somatic pairing only occurs at their proximal ends.

The salivary gland nuclei contain one short and five long elements. The *Y*-chromosome is exceptional in including at least 15 euchromatic bands, which have homologues in the *X*. One of the autosomes carries a large swelling similar to the 'Balbiani Ring' of Chironomus. The long chromosomes contain a good deal of heterochromatin. In all other Drosophila species so far described, except *D. busckii*, the heterochromatin of the proximal ends of the chromosomes forms a large darkly staining chromocentre. In *D. subobscura* this heterochromatin consists of large pale granules, and there is no chromocentre (Emmens[6]).

The most interesting feature of the species is the polymorphism of the chromosomes, each of which presumably represents one element in Muller's[7] terminology. Almost all larvæ both from wild parents and laboratory cultures show inversion configurations in one to five of the long chromosomes; no translocations have been found. The different chromosomal orders fall into two groups.

(*a*) Both homozygous forms seem as viable and fertile as the heterozygote. In the four cases of this type so far studied, one order is by far the commoner, and may be taken as the standard, from which the other orders may be said to differ by one or more inversions.

(*b*) In three cases the heterozygote appears to be more viable and fertile than either homozygote. Most larvæ show salivary configurations proving that in at least two of the paired autosomes the homologues differ in respect of a compound inversion. These inversions are an included inversion covering the middle third of one autosome, two adjacent inversions covering three fifths of another, and a pair of overlapping inversions covering the distal quarter of a third autosome. Thus three of the autosomes have two (if not more) equally common isomeric orders. As they differ in respect of compound inversions, these should reduce crossing-over in heterozygotes very efficiently.

From a cross between two structural heterozygotes, or between a heterozygote and a homozygote, we should expect equal numbers of larvæ homozygous and heterozygous for a particular chromosome. In fact, there are significantly fewer homozygotes, though the nature of the selection against them is so far unknown. Its efficiency may be judged from the fact that a line which, before inbreeding, was heterozygous for the three inversions the heterozygosity of which is favoured by selection, is still heterozygous for all of them after fifteen generations of brother–sister mating. This would only be expected in one of 37,000 such lines in the absence of selection. Another similar stock was still heterozygous for all three after ten generations of brother–sister mating; after nineteen generations it was still heterozygous for one, and died out during the twenty-first. Stocks made cytologically homozygous for any two of the three orders tend to die out; however, we have one cytologically homozygous stock derived from a fertilized wild female; but this is extremely difficult to keep alive, though it can easily be crossed with our other stocks.

Thus the species resembles a permanent structural heterozygote such as many Oenothera species, though structural homozygotes are not quite inviable. Sokolov and Dubinin (loc. cit.) reported a similar structural heterozygosity in a species from Ukraine and Caucasia which they referred to as *Drosophila obscura*-3 without giving diagnostic characters. The detailed structure of the inversions seems to be different, and it will be of great interest to determine how close systematically their populations are to ours.

In some vertebrate species, such as mice, pure lines can easily be established. In others, brother–

sister mating leads to low viability or infertility, or else to lines which are not as homogeneous as expected. It is at least possible that in such cases cytological investigations may reveal a condition like that of *D. subobscura*. In any event, a small and rapidly breeding animal species in which inbreeding is harmful is a valuable object of genetical study.

In our present stocks forty-seven loci are marked by visible mutants, several of them by a series of allelomorphs, and forty-four of these loci have been assigned to linkage groups. On the *X*-chromosome we have fourteen loci, apart from lethals. Some of the sex-linked mutants, such as *yellow*, *cut*, *singed* and *bobbed* with a terminal locus and a normal allelomorph in the *Y*, are clearly homologous with those of other species. The homologies of the autosomal mutants are more doubtful. The most striking mutants without obvious homologues in other species are an incompletely recessive *white testis*, with no change in eye colour; *bulge*, a sex-linked recessive hypertrophy of the eyes, which may be folded without disarrangement of the facets; *short costal* vein, a sex-linked recessive abolishing one of the diagnostic characters of the genus; and *six-jointed*, an autosomal recessive giving an extra tarsal segment and rough eyes.

Many of the mutants were obtained by inbreeding the progeny of wild flies. Most of these are autosomal, but three are sex-linked. One of these, *withered* wing, found by Street and Gordon (unpublished), is interesting as being sex-limited, only appearing in homozygous females, and not in hemizygous males. It is therefore, like an autosomal recessive, largely shielded from natural selection. Though located near the proximal end of the *X*, it has no normal allelomorph in the *Y*-chromosome like *bobbed*. The other two, a lethal and a visible *dried wing*, are ordinary sex-linked recessives.

Since each long autosome will ultimately have three maps, one for each homozygous chromosome order, and one for the heterozygote, mapping is a slow process, but it is certain that the maps of all five long chromosomes will be longer than those of *D. melanogaster*. That of the *X* is more than 150 units long, compared with 67 in *D. melanogaster*. The minimal estimates of the length of the long autosomes vary from 80 to 140 units, as compared with 47 to 55 units for the arms in *D. melanogaster*.

The total lengths of the genetical maps of different species of Drosophila are:

Drosophila virilis	788 (Chino)[8]
,, *subobscura*	570 +
,, *pseudoobscura* A	420 (Sturtevant and Tan)[9]
,, *ananassæ*	326 (Kikkawa)[10]
,, *simulans*	311 (Sturtevant)[11]
,, *melanogaster*	280 (Brehme)[12]

Thus *melanogaster* is far from typical of the genus. Since the species do not differ markedly in the numbers of bands in the salivary chromosomes, the differences in map-length are probably due to differences in frequency of chiasma formation within homologous regions.

With such large map distances recombination values reach 50 per cent, and at least one, namely, $50 \cdot 82 \pm 0 \cdot 42$ per cent between *scarlet* and *interrupted* venation, the loci of which are more than 86 units apart, is perhaps above 50 per cent. We have also discovered negative interference in connexion with a large inversion in the *X*-chromosome. The presence of a cross-over in the region immediately proximal to this inversion, so far from diminishing the frequency of cross-overs in the region immediately distal to it, increases it about twenty-fold. Multiple crossing-over is, of course, much more frequent than in *D. melanogaster*, and we possess considerable data concerning it.

The effect of inversions on crossing-over is also quantitatively different from that in *D. melanogaster*. Thus a single inversion covering about a third of the *X*-chromosome and reducing the map-length by at least 80 units gave only one internal double cross-over in 8,000 flies. A single inversion covering about 15 per cent of this chromosome, and lying between loci giving 32 per cent of recombination, did not reduce this percentage. This and other facts suggest that chiasmata are localized.

'Non-disjunction' of the sex chromosomes, causing the production of female pronuclei with two or no *X*-chromosomes, occurs once in about 7,000 oogeneses. But, as in *D. pseudoobscura*, *XXY* females do not give *XX* pronuclei with an appreciably higher frequency than *XX* females.

Meiosis can be observed in male imagines of this and other Drosophila species (Philip[13]). The three sex chromosomes in *XYY* males form a loose trivalent and segregate at random. A male of slightly abnormal phenotype and two normal males were trisomic for one of the long autosomes, a condition which is lethal in *D. melanogaster*.

We have found four flies mosaic for sex-linked genes. One appeared to be wholly female and three gynandromorphs. One of these had two ovaries and two testes, all fairly well developed, but not normal. All the mosaics were 'fore and aft' rather than bilateral, suggesting a pattern of cleavage somewhat different from that of *D. melanogaster*. A sex-linked eye colour which was non-autonomous in two out of three mosaics is probably homologous with *vermilion* in other species.

Unlike all other Drosophila species so far tested, *D. subobscura* will not mate in the dark. Since visual stimuli are essential for mating, several mutant forms with abnormal eye colours, including *white*, which, though phototropic, do not respond to moving contours (Kalmus[14]) are male-sterile. The mutant *yellow*, as in other species, has a cuticle abnormally permeable to water and other substances (Kalmus[15]) and is at a disadvantage in dry environments. In *D. subobscura* it is also at a disadvantage as a male in mating. Normal females generally kick off yellow males which attempt to copulate with them. Yellow females show no preference. But it is possible by selection to obtain a stock in which normal females are comparatively tolerant of yellow males, though the normal body colour is still preferred. Thus we have demonstrated not only sexual selection of a more or less Darwinian type, but also the inheritance of degrees of preference in the female, such as Darwin postulated.

It will be seen that this native European species differs from all animals so far described (if Sokolov and Dubinin's form and our own are conspecific) in being normally a structural heterozygote in both sexes. It is also very favourable material not only for comparative genetics, but for the study of chromosomes with long map distances, of polysomy, of the genetics of behaviour, and many other topics. We hope after the War to compare the British and Continental races. It is also to be hoped that it will be studied in several British centres, in order to investigate whether it possesses geographical races or other adaptations to the different conditions in various parts of Britain.

We acknowledge gratefully a succession of grants from the Rockefeller Foundation which have made this work possible, and the hospitality of Rothamsted Experimental Station, which has allowed it to be continued after 1940.

[1] *J. Genet.*, 33, 25 (1936).
[2] *J. Genet.*, 38, 37 (1939).
[3] *J. Genet.*, 39, 47 (1939).
[4] "Genetics".
[5] Drosophila Information Service, 15, 39 (1941).
[6] *Z. Zellf. u. mikro. Anat.*, 26 (1937).
[7] "The New Systematics", 185 (Oxford: Clarendon Press, 1940).
[8] *Jap. J. Genet.*, 12 (1936).
[9] *J. Genet.*, 34, 415 (1937).
[10] *Genetica*, 20, 458 (1938).
[11] Carnegie Institution of Washington Pub., 399 (1929).
[12] Carnegie Institution of Washington Pub., 552 (1944).
[13] *Nature*, 149, 527 (1942).
[14] *J. Genet.*, 45, 206 (1943).
[15] *Proc. Roy. Soc.*, B, 130, 185 (1941).

HEALTH EDUCATION IN YOUTH SERVICE*

THE Central Council for Health Education, which is recognized by the Government as one of its agencies for health education, has thought it timely to outline the part that it considers health education should play in the youth service of the future.

The general standard of health in the community at present falls so far short of possibilities that there is obviously much room for improvement; and one of the ways in which it can be improved is through health education. Clearly, education alone will not be sufficient—there is needed also an improvement in community conditions (particularly in regard to housing and nutrition). But it is only through education that people can be encouraged to make the best use of conditions as they exist and be made aware of the possibilities of improving them.

Ideally, health education should be a way of living and something that is almost insensibly absorbed in the home, the school, the youth organization and the work place, rather than a formal subject taught in set sessions at set times. It has, however, at least three important aspects—the imparting of knowledge, the inculcation of habits and the encouragement of attitudes. Knowledge will not of itself lead to better health; but it provides the intellectual background to habits already acquired and helps in the development of healthy attitudes. Many of the most important health habits must be inculcated long before the child is capable of assimilating the knowledge which justifies them; but their practice should be reinforced by theoretical understanding as soon as possible. Attitudes are influenced by home environment from the very earliest days, and in particular by the way in which habit-training is carried out, but they also require intellectual understanding for their fullest development. These three aspects of health education are thus closely inter-related.

Knowledge important in health education includes an understanding of the structure and functioning of the body and of the relationship between physical and mental health. Important also is an understanding of how the spread of disease occurs and how it can be prevented or reduced; a grasp of the social factors influencing the health and well-being of the community; and a knowledge of the personal and social measures necessary to enhance health and build up resistance to disease.

* Memorandum by the Central Council for Health Education.

The bodily habits relevant to health education include those consisting essentially of the disciplining of natural functions (for example, eating and voiding) and those others (for example, personal cleanliness) which are essentially habits of civilization. Equally important are the habits of the mind and of behaviour in relation to society.

Among the important attitudes are those of normality towards the body and its functions, deviating neither towards prudish avoidance nor towards prurient curiosity; of regarding health not as a mere absence of disease, but rather as a positive state of joyous well-being; and of feeling a sense of responsibility for the state of personal, family and community health.

Since young people do not enter within the scope of the youth service at the age of fourteen without having been influenced very considerably by their earlier training, any consideration of the type of health education appropriate to the period of adolescence is dependent upon the making of certain assumptions about what will have been achieved before this period is reached. It seems reasonable to assume that by the time children reach the age of fourteen, they will have received in home, school and juvenile organizations, health education along the three lines of imparting of knowledge, inculcation of habits and encouragement of attitudes indicated above, up to levels appropriate to their stage of development. The definition of these levels is in the main a matter for parents and teachers, and those responsible for the youth service will need to continue to build from the levels already reached.

Health Education in Youth Service

The special functions of health education in adolescence would appear to be the reinforcement and widening of earlier education, especially in those directions most affected by the maturing ideals, emotions, experiences and activities of this period. With the statutory raising of the school-leaving age, some of this education will be given in the last year or two at school, and with the establishment of young people's colleges, some will be given during part-time compulsory education. The extra year or two of compulsory education would be most usefully employed in giving systematic instruction in those aspects of health education for which the adolescent is now sufficiently mature—in intellectual and emotional development and in social experience and awareness. For many young people, this will be the last opportunity for systematic instruction, and full advantage should be taken of it.

A great deal, however, will still remain as the special function of voluntary instructional classes and youth organizations.

The whole spirit of health education in youth service should be such as to encourage the development in adolescents of an appreciation of the possibilities of reaching a high standard of personal and community health and the growth of a sense of individual responsibility for reaching this standard. Certainly importance should be attached to the measures which are required from the State, the local authorities, etc.; but it needs emphasizing that increasing social provision should be accompanied by greater individual effort.

Adolescents particularly need help in meeting the peculiar problems of the period through which they are passing: in physical problems such as the coping with the bodily changes of adolescence; emotional problems such as those arising from the development of sexual interests and urges; and social problems such as those of the relations between the young people and their parents, between young men and young women, and between the individual and society.

The age-range covered by youth service is one in which young people are very interested in the development of physical fitness, strength, agility and grace; and any plans for health education should take full advantage of this interest. The keen desire to make oneself attractive to other people provides a very valuable opportunity for education in the care of the body generally and perhaps particularly in the attainment of grace and poise and in the care of the hair and complexion.

The period of adolescence is also one in which it is essential to give some training for approaching maturity. Examples of such training are marriage preparation, parentcraft, home economics, and instruction in the measures needed for the maintenance in full health of the individual, the family and the community.

It is clear that in most youth organizations very little will be possible in the way of systematic courses of instruction. Young people in their leisure hours wish for recreation, and lectures should be arranged mainly in response to demands made by the members themselves. The skilful teacher will be able to stimulate such demands—often as a result of informal discussions which make clear the need for further information on specific topics—and lectures which have been requested by the members are likely to be given much more attention than would have been the case had they been forced on the members by the leader.

But while it is true that the atmosphere and practice of the educational system will be a vital part of health education throughout, this is pre-eminently true of the youth organizations. The whole routine of the club—activities, toilet arrangements, concern for the cleanliness of premises and equipment, insistence that habits acquired in the organization are for everyday use and not 'for club night only', personal relationships between leaders and members and between one member and another—is of the utmost importance. Thus the encouragement of camping, rambling, youth hostels, etc., as well as the more formal type of physical recreation, is an essential part of health education.

The extent to which health education will be carried out in youth organizations will depend largely upon the degree to which the leaders are themselves educated, able to colour the whole life of their organization, and able and ready to stimulate and respond to demands for information. In addition, therefore, to those qualities of personality which are essential to any successful youth work, all leaders should be alive to the need for and the possibilities of health education, should themselves have a positive attitude to health and should have that necessary minimum of basic factual knowledge which will enable them to plan their programmes in the best way.

Moreover, each club or group of clubs should have at least one leader specially qualified in health education. This person might in many cases be the physical recreation instructor, in other cases the instructor in first aid and home nursing or allied subjects.

Ideally, too, each club would have a medical adviser—who would be available to advise the youth leaders and the young people upon matters within his province. It must be recognized, however, that this ideal will not be attained for a long time ahead, and it is therefore all the more important that meanwhile there should be a corps of fairly highly trained youth leaders (each of whom might serve a group of clubs) who, while naturally not attempting to carry out the work of a medical practitioner, would nevertheless be able to give the organizations covered by them skilled help and advice on the principles of healthy living. The Central Council for Health Education is able to give local authorities help in training youth leaders to carry out this work.

No amount of training will make good leaders out of poor material; but native abilities and aptitudes may be reinforced by courses of instruction. In the organization of such courses the Central Council for Health Education again can give considerable help, and indeed, regards the training of youth leaders as one of its most important tasks. It has already held many such courses and is developing co-operation with the Central Council of Physical Recreation so that theory and practice may march together.

In this connexion, it is worth considering the institution of a certificate in health education along lines somewhat similar to that in physical recreation, awarded at present by the Central Council of Physical Recreation. Youth leaders, like other students, are the more likely to give serious study to a matter when they are working for a test, and have a natural desire for some documentary evidence of the standard they have attained. The Central Council for Health Education hopes to discuss with the Board of Education and its Youth Advisory Council the desirability of such a certificate and the terms upon which it might be awarded to persons judged suitable from other points of view.

While it is true that the best youth leaders can do excellent work even in a very poor environment, it is equally true that a general high standard of achievement depends upon the availability of adequate accommodation and equipment. Club premises which, with proper cloakroom, lavatory and toilet accommodation, will reinforce, not contradict, health teaching; physical recreation apparatus, playing fields, camping sites, swimming pool, youth hostels—these are the basic material requirements. There is also particular need for a permanent residential school, with attached model club, in which, throughout the year, youth leaders from all parts of the country may gather for training and refresher courses, of which the theory and practice of health education should form an important part.

THE PHILOSOPHY OF RESEARCH

THE American Philosophical Society arranged a symposium on the "Organisation, Direction and Support of Research" for its autumn meeting, held during November 19–20, 1943, and the papers presented have now been published (*Proc. Amer. Phil. Soc.*, 87, No. 4, January 29, 1944). Together they constitute a notable contribution to the philosophy of research, dealing on the whole with strategy rather than with tactics, and though concerned primarily with American conditions, they are highly relevant to the present discussions in Great Britain on the organization of research, the functions of the universities, the relations between teaching and research and like problems.

The first paper, Dr. J. B. Conant's Franklin Medal Lecture on "The Advancement of Learning in the United States in the Post-war World", well illustrates the general validity of the symposium. Free inquiry, he points out, is the necessary condition for the advancement of learning in any age, but while welcoming the debate between the schools of Bernal and Polanyi on the planning of science, Dr. Conant urges that relevance, not utility, should be the touchstone : in each area of the entire field of learning, the activities under way must be manifestly relevant to the future of our civilization. Following the argument of Francis Bacon, he reminds us that we must not mistake the mere acquisition of information for an advance in knowledge, and strikes a note of caution about our understanding of the scientific method and its limitations which recurs frequently in the symposium. Only in situations where value judgments can be eliminated from the frame of reference are methods comparable to those used in the advancement of knowledge really applicable, and yet the difference between disciplined and well-informed judgments, involving values on one hand and on the other extravagant and ignorant opinion, marks the boundary between civilization and barbarism. Developing this distinction between accumulative knowledge and philosophy, Dr. Conant refers to the confusion between what is social science and what is social philosophy. He believes that, like the service of social science and the practice of the arts of democratic government, they are vocations which cannot be combined. A major share in both advancing learning and fostering philosophy will be the responsibility of the universities, though research institutes will play an important part, and whether or not professional education is combined with research, it is essential that our intellectual leaders be in close contact with the most promising youths of the oncoming generation. We need not organize institutions of higher education into a hierarchy ; but we must make it an ambition of the people to foster the spirit of free inquiry. The unity of the world of pure learning is based, not on a common method, but on a common dedication.

Prof. H. S. Taylor's paper on "The Organisation, Direction and Support of Research in the Physical Sciences" covers more the problems considered in such reports as those of the Parliamentary and Scientific Committee on "Scientific Research and the Universities". After reviewing briefly the research structure in the United States, in Great Britain and in the U.S.S.R. and commenting on the relation between research and education—the immense needs for technological and scientific training must be balanced by competent education in the liberal arts and humane studies—he asserts that the problem of direction of research is a problem of personnel and is resolved when a competent director is found. The body responsible for such selection should consist primarily of scientific men, and breadth of interest within that body should help to promote wisdom of choice. In regard to the support of research, he points out that research workers and directors have local responsibilities which, if recognized, might well broaden the bases from which private support of research might come. As regards the support of fundamental research by industry, he looks to the prosecution of fundamental studies in research institutes, co-operatively supported, and concerned also with the dissemination of research information and the training in methods of research of specially selected personnel at the graduate student level for future positions of responsibility within the industry. Speaking of State and Government support of fundamental research, Prof. Taylor insists that scientific men must be masters in their own households ; the processes of mutual co-operation and assistance among the individual sciences must be multiplied, and the isolation of one science from another must progressively diminish.

In his paper "The Discovery and Interpretation of Biological Phenomena", Dr. W. Bronk, like Dr. Conant, and Marjorie H. Nicholson in her subsequent paper on "Merchants of Light : Scholarship in Arts and Letters", draws fresh inspiration from Bacon, and discusses more particularly the influence of scientific societies and institutes on teaching and research. He stresses the need in our teaching for more concern with the generalizations and relationships of science, more attention to the analytical processes, and less to the description of phenomena, particularly in training biological investigators, and pleads for clear thinking about the impediments which certain of our scientific compartments offer to effective research, and the limitations they impose on the character of the training we give our future investigators.

No summary could do justice to this suggestive address, which is practical rather than philosophical, and much the same must be said of Alan Gregg's "A Critique of Medical Research". This is somewhat more philosophical and is concerned primarily with the strategy of medical research. Commenting on an important point made, for example, in the last annual report of the Carnegie Corporation of New York, that research funds are increasingly earmarked for specific purposes by the donors, so that experience in selecting research problems and projects is on the whole too infrequent in the medical schools, he insists that the right of choosing the subject to be studied, of planning and performing some crucial experiment, belongs not to the donor or the administrator but to the investigator himself. The essential pre-occupation of wise administrators is to create and to foster the circumstances, the human relationships, in which gifted men will be most productive and prodigal of their gifts ; and besides the creation of fluid research funds Dr. Gregg suggests that the creation of readerships, or posts of equal pay and tenure to professorships, but without the traditions or connotation thereof, is urgently needed to correct that characteristic of American research in which ability in research is neutralized, sterilized or otherwise wasted by the existing demands of administration and teaching. As to probable directions and characteristics of medical research in the next few decades, he instances the study of the effect of differences of environment on genetically similar organisms, genetics, biophysics and chemotherapy.

Dr. K. K. Darrow, in much the shortest paper, contributes a few crisp comments including a defence of the present system ; while much the longest paper is that by H. A. Innis on "Political Economy in the Modern State". This is a major contribution to the debate to which Prof. F. Hayek's "The Road to Serfdom" has recently contributed in Great Britain, and Mr. Innis's extensive quotations from Mark Pattison may well set the contestants searching that writer anew. This sound philosophical paper has its place also in the discussion on the place of the universities and their functions, and in Roy F. Nichol's paper on "War and Research in Social Science", Prof. R. L. Schuyler's paper on "War and Historiography" and Marjorie Nicholson's paper, there are stimulating comments and contributions to the fundamental thinking and philosophy on which alone the wise organization and direction of scientific research can be based.

OBITUARIES

Prof. W. E. H. Berwick

WILLIAM EDWARD HODGSON BERWICK, who died at Bangor on May 13, 1944, was professor of mathematics in the University College of North Wales from 1926 until his retirement, due to ill-health, in 1941. The title of emeritus professor was then conferred upon him by the University of Wales.

Berwick was born at Bradford on March 11, 1888, and was educated at Bradford Grammar School and at Clare College, Cambridge, of which he was a scholar from 1906 until 1910. He was bracketed Fourth Wrangler with C. G. Darwin and G. H. Livens in the Tripos of 1909 (the last year of the order of merit). In 1910 he was placed in the first class of Part II of the Tripos, and he was a Smith's Prizeman in 1911. His mathematical distinction was later recognized by a fellowship at his old College (1921–24) and by a Cambridge Sc.D. in 1925.

After two years as assistant lecturer at Bristol, Berwick went to Bangor as assistant lecturer and afterwards lecturer. Here he remained until 1920, except for two years spent in the anti-aircraft experimental section of the Munitions Inventions Department. At Bangor he had a congenial colleague in G. B. Mathews, who for many years had been almost the only worker on number-theory in England. From Bangor, Berwick went to Leeds, as lecturer and afterwards reader in mathematical analysis. He was appointed to the chair at Bangor in 1926. Shortly after this, his health began to deteriorate, but he struggled with great courage and fortitude, against increasing disabilities, to continue his teaching work and research.

Berwick's mathematical activity was concerned entirely with number-theory, the theory of equations, and topics arising out of them. His main publication was a Cambridge tract, "Integral Bases", in which he developed methods for determining an integral basis for any algebraic number-field. In particular, such a basis is determined for the field defined by $\sqrt[n]{a}$. This required the discussion of twenty-three separate cases, depending on the nature of the common factors of n and a. The tract is a substantial contribution to algebraic number-theory, and it exhibits Berwick's interest in, and remarkable talent for, difficult enumerations and calculations. This talent was also shown in his calculations dealing with the complex multiplication of the elliptic functions.

Berwick also edited a second edition of Mathews' tract on "Algebraic Equations", to which he added appreciably. He published a number of original papers on complex multiplication and on the resolvents of quintic and sextic equations. He gave a good exposition of the latter subject in a lecture to the London Mathematical Society (printed in the *Journal*, 3; 1928).

Prof. Berwick leaves a widow, to whom all sympathy is due. H. DAVENPORT.

We regret to announce the following deaths:

Lieut.-Colonel L. F. Goodwin, professor of industrial chemistry and chemical engineering in the Queen's University, Kingston, Ontario, on August 15.

Prof. G. F. Stout, during 1903–36 professor of logic and metaphysics in the University of St. Andrews, on August 18, aged eighty-four.

NEWS and VIEWS

Mathematics at Bedford College, London: Retirement of Prof. Harold Simpson

PROF. HAROLD SIMPSON retires from the chair of mathematics at Bedford College, University of London, at the end of the present session. After a distinguished career at Oxford and a short period at Bangor, North Wales, he became head of the Mathematics Department at Bedford College in 1907 and was appointed professor there in 1912. Prof. Simpson has contributed many important articles on various topics to mathematical and scientific periodicals; in addition, he has written four valuable books. (These have appeared under the name Hilton, which Prof. Simpson gave up in 1939.) The first of these, on "Mathematical Crystallography", appeared in 1903, and his interest in this application of mathematics continues; he has served on the council of the Mineralogical Society on various occasions since 1908 and often attended the meetings of the Geology Section of the British Association. His next books, on "Finite Groups" (1907) and "Homogeneous Linear Substitutions" (1914), are in certain respects an almost essential complement to his first, having regard to the state of algebraic knowledge in Britain at the time. His other book, "Algebraic Plane Curves" (1920, 1932), is well known both to teachers and to students. Prof. Simpson has served on the council of the London Mathematical Society since 1915 and has been librarian since 1925.

Prof. Simpson played a very active and useful part in the affairs of the University of London. In particular, his colleagues will remember the skill and patience which he exercised in dealing with the business of the various committees with which he was concerned. Many hundreds of students of Bedford College will remember with gratitude his exceptional ability as a teacher; his sympathetic and understanding nature was particularly apparent to those students not so gifted in his subject, but all regard him with affection. Outside his own subject and in addition to his interest in geology, Prof. Simpson was deeply interested in architecture and in music. Students at Bedford College will remember the excursions he organized for them to various centres of architectural interest and his activities with them in the College Musical Society.

Appointment of Dr. W. N. Bailey

DR. W. N. BAILEY, Richardson lecturer in pure mathematics in the University of Manchester, has been appointed to the University chair of mathematics at Bedford College, London. He is perhaps best known for his work on the theory of generalized hypergeometric series; much of this was incorporated in his Cambridge 'tract' on this subject, an excellent booklet which makes pleasant reading. To him are due two new methods of obtaining transformations of such series; one is algebraic and the other uses contour integrals of Barnes' type. These methods led to various generalizations in the theory, and applications were made to Bessel functions and Legendre functions. Some of his most important work in this field concerned infinite integrals in which the integrand involved the product of three Bessel functions. The argument used an earlier result of his, that Appells' hypergeometric function of two variables could in a particular case be expressed as a product of two ordinary hypergeometric functions. This case has since been of use to other writers and has led to new researches. His most recent work, which is in process of publication, is on the problem of finding transformations of hypergeometric series of both the ordinary and the basic type. Previously, no general method of obtaining transformations of basic series had been given. His new point of view has led to new transformations of basic series, thrown further light upon them and has also led to numerous identities of the Rogers–Ramanujan type.

Science and Industry at Manchester

THE Manchester Chamber of Commerce has done well to issue in pamphlet form (Pp. 63. 1*s*. 6*d*.) the addresses given at the four meetings on "Science and Industry" in March and April last. The pamphlet contains not only the addresses of Lord Riverdale, Dr. A. P. M. Fleming, Dr. Andrew McCance and Sir Edward Appleton, which have already been noted in these columns, but also other addresses given at the meetings, such as those of Sir Raymond Streat, Mr. A. H. S. Hinchcliffe, announcing the formation of a Joint Standing Council of the Chamber and of the University of Manchester, Mr. C. C. Renold and Mr. R. H. Dobson. Mr. C. C. Renold, following Dr. Fleming's address on "Research Workers: their Education and their Place in Industry", referred particularly to the traditional industries where the application of science should involve challenging the traditions themselves, not merely tuning them up or their further evolution. The emphasis should be on the application of what is already known rather than the extension of the boundaries of knowledge, and Mr. Renold suggested that for the medium-sized traditional concern the key move is the appointment of a scientific liaison officer with broad and general rather than specialized scientific qualifications. His job should be to recognize the problems and indicate lines worthy of investigation, and to help the practical men to apply the answers. With this fairly high-ranking appointment in the management, a re-casting of management structure might also be necessary to separate those functions of management which lend themselves to contact with the scientific liaison officer and thereby provide a convenient channel for his influence to become effective. Some re-casting of the accepted curricula of teaching may be required to provide men of the necessary breadth of scientific appreciation. Mr. R. H. Dobson, following Dr. McCance's paper on the application of research, referred to the bearing of fundamental research on the export trade of Britain, and to the necessity of creating a liaison and a free interchange of ideas and work between technical assistants and the people on the shop floors.

Looting of Simeis Observatory

A TELEGRAM received at the Royal Observatory, Greenwich, from G. A. Shajn, member of the Academy of Sciences of the U.S.S.R., gives an account of the fate suffered at the hands of the enemy by the Simeis Observatory in the Crimea. A week or two before the Germans occupied the southern part of the Crimea, the staff of the Observatory was evacuated, the workers taking with them the object glasses of the two astrographs and part of the laboratory equipment. In May 1944, after the Crimea had been liberated by the Red Army, the Academy of Sciences sent Dr. Shajn to inspect the remains of the Observatory. He established the following facts. During September and October 1943 German specialists dismantled all the Observatory's instruments and moved them in thirty or more trucks to Simferopol, whence they were dispatched to Germany. The equipment stolen was the 40-in. reflecting telescope, the double astrograph, a new astrograph for zonal observations, a photoheliograph, three stellar spectrographs, a large cœlostat, a long-screw measuring machine, a Repsold machine, a microphotometer and two astronomical clocks.

In addition to this, much other laboratory equipment and the whole library collection of more than nine thousand negatives, and the equipment of the power station and workshop were all taken away. The wooden parts of three observatory domes were destroyed, and one of them was used as a stable. The wooden building which housed the spectrohelioscope was also destroyed, as were a number of other pavilions. On January 18, 1944, the main building of the Observatory, where a Rumanian army unit was quartered, caught fire. It continued to burn for two days, but the commander of the unit did not call out the fire brigade nor did he take any steps to extinguish the flames. British men of science will sympathize with Russian astronomers in the looting and wanton destruction of this famous Observatory.

Tropical Diseases Investigation in New York

A RECENT article in *Nature* (May 9, 1944, p. 625) referred to the part played by parasitic diseases in war and to the realization by American physicians that these diseases constitute a grave danger to their troops overseas. Prof. H. W. Stunkard (*Ann. New York Acad. Sci.*, 44, Art. 3, 189; 1943) has referred to the absence of adequate instruction in tropical medicine or of any institution devoted primarily to work on parasitic diseases in the United States. Nuttall, Brumpt and Fülleborn, he states, thought that New York should provide the financial support for such an institution, because it is the principal shipping and commercial centre in the United States. In time of war, Prof. Stunkard points out, it is one of the chief ports of embarkation and disembarkation, so that there is acute need there for diagnostic, therapeutic and research work. The Columbia University Department of Public Information now announces that plans are being formulated which will, if they are carried out, make New York City a world centre of teaching and research in tropical medicine. Dr. H. S. Mustard, director of the DeLamar Institute of Public Health, Columbia University School of Medicine, states that a substantial beginning has been made, thanks to a temporary grant from the Macy Foundation. An additional grant from the John and Mary H. Markle

Foundation has been received for research on filariasis. Instruction in tropical medicine for medical students has been increased at the Institute, and its laboratories are now available to officers of the armed services and to others who need to go to the tropics. Intensive courses for graduates are also being provided and it is expected that very soon a full year's course will be available. There is hope that new buildings will be possible soon after the War.

Dr. Mustard echoes Prof. Stunkard's words when he says that ". . . the very business of war depends upon a successful combating of tropical diseases". Not only is the health of the fighting forces concerned, but also that of local populations in the tropics who are required for getting raw materials, building airfields and general labour. Alliances, treaties and national and trade interests are more than ever taking United States Government officials, business men and others to the tropics by ship and aeroplane, and these men, ships and aeroplanes may bring back tropical diseases and their vectors. "The universities of the United States cannot remain aloof from the realities of this situation," says Dr. Mustard. Only a few United States universities, he states, will be able to offer courses in tropical medicine, the number being limited by their position and resources. A university giving such courses should be in a great city which is a great centre of rail, sea and air transit, especially transit to and from the tropics; and it should be a recognized cultural, educational and medical centre and have international prestige and an outstanding school of medicine. Columbia University in New York City, with its unique relation with the School of Tropical Medicine at Puerto Rico and with the College of Physicians and Surgeons, would certainly seem, as Dr. Mustard suggests, to be well fitted to undertake this vitally important work.

Solar Research in Belgium during 1942

A NOTE on this subject by Swings (*Astrophys. J.*, 99, 118; 1944) reports that the University of Liège still continues its programme of astronomical infra-red spectroscopy, and that in June 1942 a new self-recording high-dispersion spectrograph was installed in the constant-temperature basement of the solar tower. This instrument utilizes four plane echelette gratings with 15,000, 3,600, 2,400 and 1,200 lines per inch respectively, the whole spectrum from 1 μ to 20 μ being covered with a resolving power which will separate lines 1 cm.$^{-1}$ apart. A preliminary paper by Migeotte gives a general account of the results obtained from recordings of the solar spectrum in the region near 1·5 μ. Here absorption lines only 1·5 A. apart can be separated, and the distinction between solar and telluric lines is relatively simple. A study of the water-vapour spectrum in this region is nearing completion, and the new instrument is now in continuous operation.

Research in the Caribbean

PROF. J. L. SIMONSEN, director of research of the Colonial Products Research Council, Sir Robert Robinson, Waynflete professor of chemistry in the University of Oxford, and a member of the Council, are now on a visit to the Caribbean area, where they are discussing fundamental problems of research on new uses for Colonial raw materials, with specific reference to the co-ordination of the work of the Colonial Products Research Council with that of the Caribbean Research Council.

Biography of the late Lord Cadman, F.R.S.

MR. IVOR EVANS has been entrusted with the writing of the biography of the late Lord Cadman. Readers of *Nature* possessing letters, etc., likely to be of interest are asked to forward them to Mr. Evans, c/o Mr. James Cadman, Walton Hall, Eccleshall, Staffs.

Night Sky in September

FULL moon occurs on Sept. 2d. 20h. 21m. U.T. and new moon on Sept. 17d. 12h. 37m. The following conjunctions with the moon take place: Sept. 11d. 06h., Saturn 0·7° N.; Sept. 16d. 01h., Mercury 5° S.; Sept. 16d. 08h., Jupiter 3° S.; Sept. 19d. 00h., Mars 5° S.; Sept. 19d. 11h., Venus 5° S. In addition to the above, the following planetary conjunctions also take place: Sept. 10d. 02h., Venus in conjunction with Mars, Venus 0·5° N.; Sept. 23d. 16h., Mercury in conjunction with Jupiter, Mercury 0·1° N. Mercury is in inferior conjunction on Sept. 6, stationary on Sept. 15, and attains its greatest western elongation on Sept. 22. The times of rising of the planet at the beginning, middle and end of the month are 6h. 31m., 4h. 15m., and 4h. 32m. respectively. Venus sets at 19h. 29m., 18h. 48m., and 18h. 23m. at the beginning, middle and end of the month, and is not very well placed for observation. Mars and Jupiter are too near the sun for favourable observation. Saturn can be seen late at night or in the early morning hours; at the end of September the planet rises at 22h. The autumn equinox commences on Sept. 23d. 04h.

Announcements

MR. C. T. GIMINGHAM has been promoted to the post of director of the Plant Pathology Laboratory of the Ministry of Agriculture and Fisheries at Harpenden, to succeed Mr. J. C. F. Fryer, who has been appointed secretary to the Agricultural Research Council.

THE Council of the Institution of Electrical Engineers has decided to continue for the present session the scheme for the admission of non-members of the Institution to any technical meeting of the Institution. Anyone who considers that his technical experience and educational attainments do not suffice to admit him to any form of Institution membership, but who nevertheless wishes to attend meetings of the Institution, can obtain from the secretary an application form, on the completion of which and on payment of a fee of 10*s*. to cover administrative costs, he will receive notices of meetings and an invitation card which will serve as a title of admission.

DR. G. LAPAGE writes: "May I correct an error in my abstract, entitled 'A Flatworm Parasite of Freshwater Trout', of the paper by J. B. Duguid and E. M. Sheppard, printed in *Nature* of Aug. 5 (p. 185). My abstract implied that Duguid and Sheppard concluded from material sent to them by Dr. Peterson, of Yell, that *Diphyllobothrium latum* is endemic in freshwater trout in the Shetlands. What these authors actually say is that 'from material kindly sent to us by Dr. Peterson of Yell, we gather that a species of Diphyllobothrium is endemic among freshwater trout in certain of the Shetland Islands'. This is, of course, very different from the statement which I attributed to them and would refer, presumably, to the larval stages".

LETTERS TO THE EDITORS

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

Penicillin-like Antibiotics from Various Species of Moulds

SINCE the demonstration of the biological and chemical properties of penicillin, an antibiotic produced by *Penicillium notatum*[1,2,3,4,5], certain other species of moulds have been shown to produce similar substances—*Aspergillus flavus*[6,7,8,9], *A. giganteus* Wehm[10], and *A. parasiticus*[11].

In the course of an investigation of moulds that have been shown by Wilkins and Harris[12,13,14] to produce antibiotics, we have found that in addition to the above-mentioned species penicillin-like substances are produced by the following :

	National collection of type cultures No.
P. fluorescens	6621
P. rubens Biourge	6643
P. avellaneum Thom and Turesson	3751
P. baculatum Westl.	3956
P. turbatum Westl.	6523

Of these, *P. baculatum* and *P. rubens* are morphologically similar to, and therefore possibly related to, the *chrysogenum-notatum* group, but the others are quite widely separated morphologically from that group and from each other (personal communication from Dr. W. H. Wilkins).

The antibacterial activity developed in a variety of media, including in each instance modified Czapek Dox[2], with and without corn steep liquor.

The penicillin-like nature of the antibiotic was established by the following biological and chemical properties : active against *St. aureus*, not against *B. coli* ; extracted into organic solvents at *p*H 2 and re-extracted with water at *p*H 7 ; inactivated by acid and alkali ; partially inactivated by heating at 100° C. at *p*H 7 for 15 minutes ; completely inactivated by penicillinase and by copper ions ; all except the product of *P. turbatum*, which was not tested, were inactivated by methyl alcohol. (Some of the inactivation tests on the product of *P. baculatum* were carried out by Dr. E. Chain. We are indebted to Dr. E. S. Duthie for preparations of penicillinase.)

Thus it is becoming apparent that many species of moulds produce penicillin-like substances.

H. W. FLOREY.
N. G. HEATLEY.
M. A. JENNINGS.
T. I. WILLIAMS.
Sir William Dunn School of Pathology,
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July 28.

[1] Fleming, A., *Brit. J. Exp. Path.*, 10, 226 (1929).
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Organic Accelerators for Enzyme Systems

IN order to determine the part played by yeast extracts in the stimulation of the respiration of various cells[1], a study was made on the possible antagonism between this respiratory stimulant and several well-known respiratory depressants. The poisons, potassium cyanide, sodium azide, amyl alcohol and urethane, react reversibly or irreversibly with particular enzyme systems of the respiratory chain. Potassium cyanide and sodium azide depress the activity of the iron oxidation catalysts, while amyl alcohol and urethane react with the dehydrogenating system.

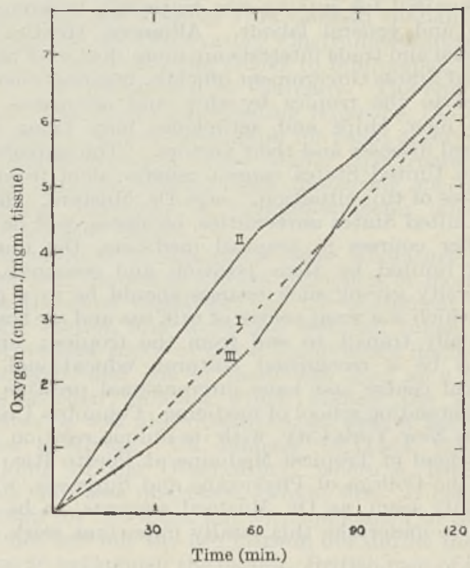

Fig. 1. EFFECTS OF YEAST EXTRACT AND SODIUM AZIDE ON RAT LIVER RESPIRATION
Curve I, control. Curve II, yeast extract initially present and sodium azide added at 60 min. Curve III, sodium azide initially present and yeast extract added at 60 min.

In Fig. 1 is shown the antagonism between yeast extract (6 mgm./ml.) and $M/1{,}050$ sodium azide on rat liver respiration. The oxygen uptake was determined in Ringer-phosphate glucose solution at a temperature of 37·5° C.[1]. In one set of experiments, 1 ml. of yeast extract (18 mgm./ml.) dissolved in Ringer-phosphate glucose was placed in the flask at the beginning of the experiment. Addition after 60 minutes of 1 ml. of $M/350$ sodium azide in Ringer-phosphate glucose offset the stimulation caused by the extract and brought the rate of oxygen uptake back to that of the control. In the other set of experiments, the depression of respiration due to sodium azide was offset completely when 1 ml. of yeast extract was added from the side arm. Qualitatively similar results were obtained with potassium cyanide. No antagonism could be found between the yeast extract and poisons such as amyl alcohol and urethane. We suggest, therefore, that the yeast extract stimulation occurs at the same part of the chain blocked by cyanide and azide, namely, cytochrome oxidase. Yeast and rat skin have behaved in a manner qualitatively similar to liver.

Since cytochrome oxidase is known to be an iron porphyrin enzyme containing a hæmin-like prosthetic group, it was thought desirable to study more closely the activity of the yeast extracts on simpler systems containing such iron enzymes as horse radish root peroxidase and liver catalase. In the accompanying table is given the results of the sodium azide–yeast extract antagonism on the oxidation of pyrogallol by peroxidase.

ANTAGONISTIC EFFECTS OF SODIUM AZIDE AND YEAST EXTRACT ON PEROXIDASE ACTIVITY.

Flask	Total purpurogallin produced (mgm.)	P.N.
I. Control	16·0 16·2	 0·21
II. Control, yeast extract (1·5 gm.) ..	20·5	0·27
III. Control, 1 ml. sodium azide (0·50 *M*)	10·2	0·13
IV. Control, yeast extract, sodium azide	14·5	0·19

The method used in determining peroxidase activity was that of Willstätter modified by Bancroft and Elliott[2]. The yeast extract partially offset the sodium azide depression and accelerated the purpurogallin production approximately 26 per cent above control. The extract was much more effective against potassium cyanide. The depression caused by lower concentrations of both poisons could be offset completely by the extract. The extract exerted a slight but definite peroxidase action in the absence of added enzyme.

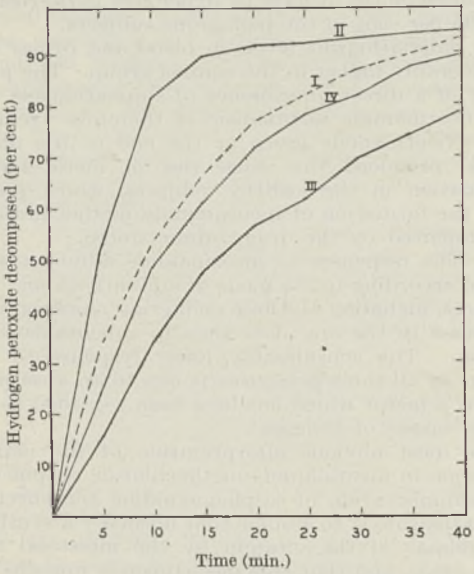

Fig. 2. EFFECTS OF YEAST EXTRACT AND POTASSIUM CYANIDE ON DECOMPOSITION OF HYDROGEN PEROXIDE BY CATALASE.
Curve I, control. Curve II, control + yeast extract. Curve III, control + potassium cyanide. Curve IV, control + potassium cyanide + yeast extract.

In Fig. 2 is shown the stimulation of hydrogen peroxide decomposition by catalase in the presence of the extract, and also the ability of the extract to antagonize the potassium cyanide depression. The method employed for the calculation of catalase activity was that of Euler and Josephson[3]. Concentrations of yeast extract and potassium cyanide were 1 mgm./ml. and $2 \cdot 5 \times 10^{-3}$ *M*., respectively. The yeast extract did not decompose hydrogen peroxide in the absence of catalase.

The experiments on peroxidase and catalase indicate that the yeast extract did not function as substrate for the enzymes. It did not possess catalase activity in itself and showed but a very slight peroxidase activity. Significantly increased activities were observed only in the presence of the enzymes. The yeast extract may be considered to contain organic accelerators for iron porphyrin enzymes. It is suggested that the extract contains organic iron compounds the molecular size of which lies somewhere between iron sulphate and hæmin, and which can function as additional prosthetic groups for the protein of the enzyme (apoenzyme). This possibility is being investigated.

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SISTER M. ST. AGATHA SUTER, *I.H.M.*
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Effect of Caramelized Fructose on the Stability of *l*-Ascorbic Acid

THE investigation of the effect of caramelized fructose on the stability of *l*-ascorbic acid was suggested by the demonstration that caramelization of lemonade powders at high storage temperatures was due to fructose which was formed from sucrose by hydrolysis, made possible by the liberation of water of crystallization of citric acid[1]; and also by the fact that a darkening of colour and a loss of ascorbic acid are associated changes in orange juice concentrate, although the relationship between the two processes is by no means clear.

That this matter may be important in relation to the deterioration of foodstuffs in warm climates is indicated by the fact that, at 98° F. (36·7° C.) and higher temperatures, pure fructose (both solid and aqueous solution) caramelizes spontaneously. As circumstances will not allow of the completion of this work for some time, it was deemed of sufficient interest and possible importance to merit a short statement.

A sample of B.D.H. fructose which had caramelized on keeping was used for the tests carried out under aerobic conditions reported below. A 1 per cent aqueous solution gave a galvanometer reading of 81 with an Evelyn photo-electric colorimeter. Tests—chiefly under anaerobic conditions—were also carried out with samples of Kahlbaum and of Baird and Tatlock fructose which had likewise caramelized on keeping. 1 per cent solutions gave galvanometer readings of 75 and 23 respectively. Pure fructose was prepared by recrystallizing from an alcoholic solution which had been treated with Merck pulverized animal charcoal until all traces of colour had been removed.

Ascorbic acid was estimated by titrating with 2 : 6-dichlorophenolindophenol, which was not reduced by the samples of caramelized fructose used. This is in contrast to the products of caramelization brought about by the action of alkali[2].

Glassware and materials were sterilized except for ascorbic acid and fructose. This was necessary owing to the liability to bacterial and fungal infection, especially in the solutions containing pure fructose and ascorbic acid.

10 per cent solutions of pure and of caramelized fructose were made up to contain 50 mgm. ascorbic acid per 100 c.c. solution. About 24 c.c. solution was put into 50 c.c. stoppered containers. Thus the available oxygen was much in excess of the amount

needed to oxidize the 13 mgm. ascorbic acid present, since complete oxidation would need less than 1 c.c. of oxygen. Also the containers were opened up at intervals for titration.

In most of the tests the solutions were stored at 50° F. (10° C.). The rate of loss of ascorbic acid was found to be too rapid for convenience at 85° F. (29·4° C.).

The accompanying table summarizes the results of a number of experiments. It is clear that there is a greater loss of ascorbic acid in solutions of caramelized fructose than in solutions of pure fructose. The contrast is emphasized by the direct comparisons for the second, tenth and seventeenth day intervals.

Per cent loss of ascorbic acid under aerobic conditions at 50° F. (10° C.).

Days	Pure fructose	Caramelized fructose
2	3·1	32·9
5	—	46·6
7	12·3	—
8	—	68·5
10	18·65	75·2
14	20·3	—
17	31·0	100·0

The question naturally arises as to whether caramelized fructose has a destructive effect on ascorbic acid under anaerobic conditions. Tests, using various techniques, were carried out with the three samples of caramelized fructose mentioned above. The results so far obtained are not sufficiently precise to merit detailed statement; taken by and large, however, there can be little doubt of a destructive effect, but it is also clear that the rate of destruction is very much slower. The destructive effect under anaerobic conditions is also indicated by the decided differences in rate of loss of ascorbic acid brought about by the different samples of caramelized fructose under anaerobic conditions.

Wm. Edwyn Isaac.

Low Temperature Research Laboratory,
Cape Town. May 16.

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Production and Release of Nicotinamide by the Intestinal Flora in Man

An investigation into the daily elimination of nicotinamide methochloride in healthy human beings[1] revealed a considerable discrepancy between this elimination and the daily intake of nicotinamide on current diets, as calculated from assays by Williams[2] in the United States and Kodicek[3] in Great Britain. Najjar and Holt[4] have shown that aneurin can be produced by the intestinal flora, which is thus capable of influencing the aneurin household of the body in a decisive manner. These findings suggested a similar mechanism for the production of that part of the nicotinamide which cannot be accounted for from the daily food intake.

This possibility was examined in a preliminary experiment by 'sterilizing' the alimentary tract of two persons with sulphaguanidine. The elimination of nicotinamide methochloride was estimated before, during and after the dosing period. A considerable drop in the nicotinamide methochloride elimination occurred during the dosage. We then proceeded to investigate this effect on a larger scale with eight volunteers. Five persons (three healthy and two chronic pellagrins) were given succinyl-sulphathiazole, while three persons (two healthy and one chronic pellagrin) received sulphathiazole to serve as a control. Diet and environmental conditions were uniform throughout the whole experimental period. The daily nicotinamide methochloride output was estimated before, during and after the treatment, blood and urinary levels of sulphathiazole were determined and test doses of nicotinamide were given twice to each subject, at the end of the dosing period and a week later, once orally and once parenterally.

The following points emerge from these experiments:

(*a*) There was a sharp drop of nicotinamide methochloride elimination during dosage with succinylsulphathiazole from the first day of dosing onwards, while the control group on sulphathiazole showed no significant change. The extent of the decrease in the nicotinamide methochloride output varied individually between 50 and 100 per cent, probably with the degree of sterilization of the intestines. The reduction in methochloride output was greater with succinylsulphathiazole than with sulphaguanidine and amounted on the average to 70 per cent in the healthy and 95 per cent in the pellagrous subjects.

(*b*) Sulphathiazole levels in blood and urines were considerably higher in the control group. The possibility of a direct interference of sulphathiazole with the nicotinamide metabolism is therefore excluded.

(*c*) Nicotinamide given at the end of the dosing period produced the usual rise in methochloride elimination in the healthy subjects, which proved that the formation of nicotinamide methochloride is not impaired by the drugs administered.

(*d*) The responses to nicotinamide administration varied according to the mode of administration; five subjects, including all three pellagrins, showing lower responses to the oral dose than to subcutaneous injection. The considerably lower response to oral dosage in all three pellagrins points to an absorption defect, a factor which has long been regarded as one of the causes of pellagra[5].

The most obvious interpretation of the marked reduction in nicotinamide methochloride output during administration of sulphaguanidine and succinylsulphathiazole is to assume that normally a synthesis and release of the vitamin by the intestinal flora takes place, and that this mechanism is impaired by the bacteriostatic action of the drugs. It is improbable that the drop in nicotinamide methochloride elimination could have been due to greater utilization of nicotinamide, since more sulphathiazole was circulating in the subjects receiving sulphathiazole, who showed no decrease in methochloride output, than in those receiving succinyl-sulphathiazole.

The gap between the dietary intake of nicotinamide and the elimination of nicotinamide methochloride referred to above appears, therefore, to be filled by the nicotinamide produced and released by the intestinal flora. Furthermore, it seems from present and previous work[1] that the quantity thus provided for human utilization can amount to as much as 80 per cent of the daily uptake.

This new factor is capable of explaining a number of previously reported inconsistencies in the etiology and therapy of nicotinamide deficiency diseases, particularly of pellagra. Roussel[6] and later Goldberger[7] and many others have insisted on the pellagra-preventive action of milk and milk products, which are notoriously poor in nicotinic acid[8]. Conversely, maize, which is the staple food of many districts where pellagra is endemic, is not more deficient in nicotinic acid than wheat[8]. These paradoxes could easily be explained by assuming a primary effect of these foods on the intestinal flora. Thus, taking the case of milk, the following mechanisms may be involved.

(1) Milk protein provides the necessary building-stones for the bacterial synthesis of nicotinamide. This would appear possible in view of the work of Bovarnick[9], who demonstrated that mixtures of certain amino-acids and organic amides, which are present in significant amounts in milk protein, yield nicotinamide when heated.

(2) Milk as such provides a favourable nutritional medium for some types of intestinal bacteria, with a consequent increase in their general activity, including vitamin synthesis.

(3) Milk, by influencing certain physico-chemical factors, such as *p*H, favours the development of some particular strains of the intestinal flora responsible for the production of nicotinamide.

Maize, on the other hand, might produce the opposite effect on the intestinal micro-organisms.

Regarding nicotinamide deficiencies other than classical pellagra, particularly the acute confusional states described by Cleckley, Sydenstricker and Geeslin[10] in America and Gottlieb[11] in Great Britain, the suggestion by one of us (R. B.[12]) that confusional complications following sulphaguanidine therapy might have been due to a temporary aneurin deficiency should now be implemented by postulating an even more likely occurrence of an acute nicotinamide deficiency.

The literature contains numerous references to rashes following sulphaguanidine and succinylsulphathiazole therapy. While most of them have undoubtedly an allergic basis, a number have been put down to other causes and have even been likened to pellagrous dermatitis[13].

On the basis of our findings we would also like to endorse Najjar and Holt's[4] suggestion that the use of sterilizing sulphonamide drugs requires careful attention to the vitamin B status of the patient.

A detailed report of these experiments will be published elsewhere.

We are indebted to Dr. W. A. Caldwell for permission to carry out the larger experiment at West Park Hospital, Epsom, and Dr. S. W. Hardwick for the clinical care of the subjects under investigation.

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Epsom. June 30.

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Production of a Soluble Pectinase in a Simple Medium by certain Plant-Pathogenic Bacteria belonging to the Genus Pseudomonas

IT has generally been assumed that plant-pathogenic bacteria are able to decompose pectin[1]. Thaysen and Bunker[2], however, limit themselves to the following statement: "to the aerobic pectin decomposers belong some of the many plant-pathogenic bacteria . . . In most of their biochemical reactions they resemble the *Pseudomonas fluorescens* group or those *Bacterium coli* forms which are regularly found in grass and hay". Although many plant pathogens do in fact belong to the genus Pseudomonas[3], including organisms responsible for soft rot[4] as well as necrotic lesions, yet no detailed study of the pectin-degrading powers of these green-fluorescent bacteria seems to have been made, nor has it been shown that they resemble the soft-rot organisms of the Bacterium group (for example, *B. carotovorum*) in producing an exo-cellular pectinase[5,6].

Pseudomonads have the simplest of growth requirements, and the pectin-ammonium salt medium devised by Coles[7], with one slight modification, is quite suitable for the demonstration of their pectin-degrading powers. The modification, following Waksman and Allen[8], lies in the substitution of pectic acid for pectin, partly for the reason that it is more easily recognized through its characteristic, gelatinous and insoluble calcium salt, and partly because only one enzyme, pectinase, instead of two, is concerned in its immediate breakdown. Waksman and Allen used a commercial polygalacturonic acid preparation as substrate. This material is not available here, but a suitable pectate medium can easily be prepared from B.D.H. citrus pectin in the following way: a 0·4 per cent solution of pectin in decinormal sodium hydroxide is left overnight at 20° in order that the methyl ester groups may be hydrolysed[9]. Sodium ammonium hydrogen phosphate (0·05 per cent) is then added and the medium brought to *p*H 7·0[10] by the careful addition of $2N$ hydrochloric acid. Finally, after addition of potassium chloride (0·02 per cent), magnesium sulphate (0·02 per cent) and a trace of ferrous sulphate the medium is tubed and sterilized by steaming.

All the pseudomonads tested grew readily in this medium at 24°, even from a small inoculum, and could be maintained in serial cultivation in it without production of either acid or gas, the *p*H remaining between 6·5 and 8. But good growth did not necessarily mean extensive degradation of soluble pectate, for out of thirty-five strains so tested, most of which were reputedly pathogenic and also fluorescent, only six actually degraded the pectic acid in a reasonable time. After three weeks incubation following a heavy inoculation, the metabolism solutions from these strains, after removal of bacteria by centrifuging, gave no appreciable precipitate with acetic acid and calcium acetate, whereas the metabolism solutions from the other strains still gave a copious gelatinous precipitate of calcium pectate. The six active strains were distributed as follows: *Ps. mors-prunorum* Wormald[11] (one out of eight strains); *Ps. syringæ* derived from pear (two out of eight); *Ps. marginalis*[4], *Ps. cerasi* and *Ps. tabaci* (one out of one in each instance). In addition to these six active and thirteen inactive strains the following were also inactive: *Ps. prunicola* (two strains); *Ps. syringæ* derived from sources other than pear (three); *Ps. phaseolicola* (one); *B. tumefaciens* (two); *X. pruni* (one); ordinary saprophytic strains of *Ps. fluorescens* (seven).

Of the six active strains, three were outstanding, namely, *Ps. marginalis*, *Ps. cerasi* and one *Ps. syringæ* strain derived from pear, but *Ps. marginalis*, the only soft-rot organism tested, was the only strain which would grow from a small inoculum and simultaneously completely degrade all the pectate in the medium. Several strains of *Ps. mors-prunorum*, unlike the saprophytic strains, did, however, produce an appreciable degradation of pectate in thirty days when growing from a small inoculum. It would seem, therefore, that the soft-rot organism is more efficient in the degradation of pectate than even the more active of the strains responsible for necrotic lesions, which in turn are more active than any of the saprophytic strains here studied, all this being quite in accordance with legitimate expectation.

Each of the three active strains mentioned above produced an exo-cellular pectinase which could be precipitated by alcohol when all the pectate had been decomposed and the bacteria then removed by centrifuging. The simple medium here used, which contains no organic source of nitrogen, has obvious advantages over the complex media previously used in attempts to isolate soluble bacterial pectinase[5,12,13]. It is of interest that the Pseudomonas pectinase is active at *p*H 7–8, whereas mould pectinase acts best under much more acid conditions[8,14]. A further study of the bacterial enzyme is being made.

I wish to thank Mrs. D. H. Oxford, a special research officer of the Agricultural Research Council, lately affiliated to the East Malling Research Station, for most of the cultures used in the above study. Some were isolated by her and others by Drs. H. Wormald and H. B. S. Montgomery of the Station, to whom I also offer my thanks. The cultures of *Ps. marginalis*, *Ps. cerasi*, *Ps. tabaci* and *Ps. phaseolicola* were received from Dr. W. J. Dowson through Dr. Montgomery. It should be added that the generic names Bacterium, Pseudomonas and Xanthomonas are used in this communication in the sense advocated by Dowson in 1939 [3].

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[1] Buchanan, R. E., and Fulmer, E. I., "Physiology and Biochemistry of Bacteria" (London, 1930), 3, 82, quoting Kruse, W., "Allgemeine Mikrobiologie" (Leipzig, 1910).
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[13] Thornberry, H. H., *Phytopath.*, **28**, 202 (1938).
[14] Ehrlich, F., *Biochem. Z.*, **250**, 525 (1932).

Reaction of Formaldehyde with Keratin

AN earlier communication[1] described the reaction of keratin fibres with boiling solutions of formaldehyde *p*H 2–10. For reasons connected with other work, buffer solutions one tenth the concentration described by Britton[2] were used, and since adequate buffering action could not be obtained at *p*H 1 under these conditions, no results were published for highly acid solutions of formaldehyde. The action upon keratin fibres of formaldehyde buffered to *p*H 1·0, 5·0 and 10·5 with full strength buffers is now described.

(1) *Normal Keratin.* Purified human hair fibres from the sample used in earlier experiments were boiled under reflux for 1 hour in solutions of 2 per cent formaldehyde *p*H 1·0, 5·0, 10·5. Full strength Walpole (*p*H 1·0, 5·0) and Ringer (*p*H 10·5) buffers were used[2], excess reagent being removed from the treated fibres by a 40 hours wash. The supercontraction of the fibres in boiling 5 per cent sodium metabisulphite was then measured in the standard way, three fibres being used for each *p*H value. Results, together with those for fibres boiled in buffer solutions alone, are given in Table 1.

TABLE 1.

*p*H	1·0	5·0	10·5
% Supercontraction :			
Formaldehyde treated	2·0	25·0	1·0
Buffer treated	25·0	21·0	1·0

Supercontraction of untreated hair = 26·0 ± 1·0 per cent.

It is obvious, therefore, that new linkages resistant to boiling metabisulphite were present in hair which had been boiled for 1 hour in 2 per cent formaldehyde at *p*H 1 or 10·5. The low supercontraction of fibres boiled in buffer solution at *p*H 10·5 is due to the presence of new linkages formed by secondary reactions of the sulphenic acid groups of hydrolysed disulphide linkages[1,3].

(2) *Deaminated Keratin.* Human hair fibres were completely deaminated in van Slyke's reagent[4]. The fibres were then treated with formaldehyde as in (1), except that in this case the reaction occurred in the presence of molar sodium sulphate. Table 2 gives the supercontractions of these fibres.

TABLE 2.

*p*H	1·0	5·0	10·5
% Supercontraction :			
Formaldehyde treated	15·0	33·0	5·0
Buffer treated	36·0	33·0	Fibre destroyed

Linkages resistant to boiling 5 per cent sodium metabisulphite, therefore, are formed in deaminated fibres on boiling in 2 per cent formaldehyde at *p*H 1 or 10·5.

The load/extension curves of fibres were determined[1] before and after deamination, and it was found that the reduction in the work required to stretch fibres 30 per cent of their original length was 31·0 ± 1·0 per cent. After standing overnight in distilled water, the fibres were boiled for 1 hour in 2 per cent formaldehyde at *p*H 1·0, 5·0, 10·5 in the presence of molar sodium sulphate, washed for 40 hours and then restretched. The further changes in work of formaldehyde and buffer treated fibres appear in Table 3.

TABLE 3.

pH	1·0	5·0	10·5
% Change in work:			
Formaldehyde treated	+11·0	+6·0	—58·0
Buffer treated	+1·0	—1·0	—61·0

On comparing these results with those in Table 2, it will be seen that no simple relationship exists between the effect of new linkage formation on the resistance of fibres to extension and on the supercontraction of fibres in boiling solutions of sodium metabisulphite.

J. L. STOVES.

University,
Leeds.
July 12.

[1] Stoves, J. L., *Trans. Faraday Soc.*, 39, 294 (1943).
[2] Britton, H. T. S., "Hydrogen Ions", 217–223 (London, 1932).
[3] Stoves, J. L., *Trans. Faraday Soc.*, 38, 254 (1942).
[4] Speakman, J. B., *J. Soc. Dyers and Col.*, 50, 341 (1934).

The Concept of Force

MR. JOSHUA C. GREGORY's statement[1] "When a motor-car turns sharply round a corner the passenger feels as if he were shoved but not as if a thing shoved him" suggests that he has not clearly analysed the experience. The main sensations (other than visual) are of contact and pressure on the side of the body on the outside of the curve; in other words, of a force as ordinarily experienced acting towards the centre, in the same direction as the acceleration. The sensations are exactly similar to those felt in the back when a car accelerates rapidly. If there is no contact there is no sensation and no force, and the passenger continues in his previous uniform motion in accordance with Newton's First Law. In the same way, with high acceleration the head and shoulders which are not in contact with the back of the seat move relatively backwards over the top of this and experience no sensation of force.

W. B. YAPP.

Manchester Grammar School,
Manchester, 13.

[1] *Nature*, 154, 24 (1944).

MR. JOSHUA C. GREGORY's letter under this title[1] seems to me misleading. A "notion of force" without a "notion of matter" appears to me a contradiction. Without matter there can be no motion and therefore no acceleration; and without acceleration there can be no force since force denotes a mass-acceleration product.

When I go round a sharp corner in a motor-car I definitely experience the sensation of being shoved by the seat.

To describe forces as "immortal" or "imperceptible" strikes me as idealist nonsense. A force lasts just as long as the matter with which it is associated has acceleration; the force associated with the retardation of a hammer on one's thumb is perceptible enough. "Disembodied force" is as meaningless as "matterless motion". Let us keep these anthropomorphic and idealist notions of force out of physics; force would exist in a lifeless universe.

JOHN CASE.

Clearbrook,
Nr. Yelverton,
S. Devon.

[1] *Nature*, 154, 24 (1944).

THE description of force, gathered from the "Hermetica" into my communication in *Nature* of July 1, p. 24, does not, as such, ask Mr. John Case to believe in "immortal" and "imperceptible" forces, or to adopt any "anthropomorphic and idealist notions". In 1864 Colding connected immaterial and imperishable forces with the perpetuity of energy which had been clear to him since 1840, and there is at least a hint at the modern conservation of energy in the immortal forces of the "Hermetica". Those who still refuse to reduce causal *efficacies* to mere regular routine can sympathize with the *working* of the Hermetical forces. The letter, however, only suggests that the Hermetical concept of force embodies a recognizable distinction in sensory experience. The concept can do this however violently modern thought disclaims it in other respects.

Muscular sensations themselves, the suggestion runs, only produce a sense of what Prof. Price calls "pure force, disembodied force as it were". This corresponds to the incorporeal nature of the Hermetical force. Sensations of contact are essential to complete the sense of the resistant or propulsive material thing. The Hermetical forces only work in bodies; this corresponds to the very usual combination of muscular and contact sensations. Cut out a man's contact sensations, leave all his other sensations in, he will then, according to the suggestion, have only a sense of "disembodied force" and have no sense of material things. If this sense of pure or disembodied force is actually felt in the centrifugal experience, as Price suggests, the phrase "disembodied force" is not "meaningless", as Mr. Case asserts.

Mr. W. B. Yapp concentrates on a denial of this sense of pure force when a motor-car corners rapidly or accelerates sharply. When a motor-car turns quickly, a passenger on the back seat is thrown somewhat laterally and *feels*, or may feel, as if an immaterial force throws him, as if he is shoved without being shoved by a material shover. This is the experience of the writer and presumably of Prof. Price. Some people stress unexpectedness—they have this sense of pure force when the car takes them unawares as it corners quickly. They have a similar experience during a sharp acceleration backwards or forwards. There seem also to be analogous aeroplane experiences. When I am 'centrifuged' in a motor-car I do not "definitely experience the sensation of being shoved by the seat", as Mr. Case does, nor do I sense a contact push on my free side when I am pressed against the resistant side of the car, as Mr. Yapp seems to do.

Some people at least confess to a momentary feeling of "what on earth is happening!" and an evanescent whiff of uncanniness sometimes rushes through me. Mr. Case and Mr. Yapp may dissent because the inveterate tendency to connect pushes or pulls with contacts predisposes them against a recognition of the actual, though usually momentary, experience. Many 'centrifuged' passengers do seem to glimpse, if only for a moment, the sense of disembodied forces that might be habitual if there were no contact sensations. The experience seems to occur, however the somewhat elusive concept of force is finally assessed.

Prof. Price, of course, though he gave me a cue, is not responsible for the use made of it.

JOSHUA C. GREGORY.

Mount Hotel, Clarendon Road.
Leeds, 2.

Fatigue in Selenium Rectifier Cells

THE effect described by Mr. J. S. Preston in his letter in *Nature* of June 3[1] may be connected with the increased departure from linearity of response which Dr. W. R. G. Atkins and I[2] found to occur in a number of these cells when illuminated by light of wave-length greater than about 0·66 μ. We were interested in the use of these cells to measure daylight, especially under water, where very large changes of illumination occur and optical methods of varying the exposure of the cell are very inconvenient. Long range and large maximum illumination were therefore essential, and the photometer bench used gave a range of 1 to 725. A filament lamp behind a water cell 4·4 cm. thick gave a maximum illumination estimated at some 15,000 lux when no colour filter was used. Schott *BG* 12, *RG* 1 and *RG* 5, Corning Green and Zeiss 966/8 filters, singly or combined, enabled different spectral regions to be tested. Fatigue effects were reduced to the utmost by keeping the cell in the dark except for the few seconds needed to balance the Campbell-Freeth circuit by which the current was measured. The comparative steadiness of the balance seemed to show that in this case fatigue was unimportant. We did not notice enhanced fatigue in red light, possibly because we expected a small fatigue effect due to the warming of the cell circuit by the comparatively intense deep red and near infra-red radiation transmitted by the red filters.

Under these conditions we found that for a Weston cell and light of wave-length below about 0·66 μ, the sensitivity, as measured by the Campbell-Freeth zero resistance circuit, was nearly constant up to about 100 μamp., showing, in fact, a small rise with current up to a few microamperes, as found for some cells by other workers. For wave-lengths above 0·66 μ, however, the sensitivity commenced to fall at about 1 μamp., and had fallen by 15 per cent at 100 μamp. Another Weston cell showed a similar effect, and eight electro cells each showed it to an enhanced degree.

Adding to the resistance of the circuit of course increases the departure from linearity, but we were somewhat surprised to find that for each cell tested the inclusion of 1,000 ohms in the circuit produced a fall in current depending only on the initial current, and not at all on the colour of the light to which it was due. We accordingly suggested that the red light effect was of a primary nature, and due to the existence in the selenium cells of a photo-electric threshold near 0·66 μ, causing a tendency to saturation in the current produced by intense illumination of longer wave-lengths.

The increase in the transparency of selenium near 0·64 μ may be connected with a reduction in the number of photo-sensitive and hence light-absorbing electrons as we passed through that spectral limit. This limit, as found by Mr. Preston for the fatigue effects, is so close to our approximate limit for the curvature effect that it seems probable that the two effects are closely connected.

H. H. POOLE.

Royal Dublin Society. June 16.

[1] *Nature*, 153, 680 (1944).
[2] *Sci. Proc. Roy. Dub. Soc.*, 22, 393 (1941).

THE results to which Dr. Poole refers seem certainly to be related to the fatigue effects which we have noticed. During a recent visit to this Laboratory, Dr. Atkins directed our attention to these results and we discussed them in some detail.

Taken in conjunction with our own, they point to a close correlation between various properties of the cells, as Dr. Poole suggests, and there now seems good reason to believe that the basic common factor is the existence of a photo-electric, and an associated transparency, threshold in the neighbourhood of 0·66 μ or 0·64 μ. The way in which this factor enters into the action of the cell is certainly of practical interest and may be of fundamental importance. Our suggestion that the comparatively deep penetration of red light into the selenium results in a kind of space-charge retarding the emission of electrons from the deeper layers is, of course, only tentative; but such a mechanism would provide for both the non-linearity and the fatigue effects together, provided the space-charge is not built up instantaneously. This supposition recalls also the kind of fatigue exhibited by the older resistance type of cell.

The subject of fatigue merits careful investigation and we hope to carry out further work upon it.

J. S. PRESTON.

Light Division, National Physical Laboratory.
July 4.

Relation between Dissonance and Context

IN an attempt to meet some of the criticisms made of our previous work on the effect of musical context on dissonance[1] a new experiment has been carried out.

A single 'dissonant' chord, the seventh on the sub-dominant (when in *C* Major), second inversion ($c_0\ a_0\ f'\ e''$, according to the tone nomenclature given by Myers[2]), was used throughout as the chord to be investigated, and will be called the 'test chord'. Mr. C. G. Gray suggested this chord, and offered several contexts for it. A number of other passages in which it appeared were found in well-known works, with an additional passage composed by Mr. Gray and slightly altered by the writers. Altogether there were fourteen passages: two by Chopin, one by Weinberger, nine by Greig, one from a traditional air and one by Mr. Gray. The test chord, though, of course, it was not always in *C* Major, did always consist of the same four identical notes.

The passages were played on the piano to fifty students (43 women and 7 men). The aim of the experiment was explained beforehand, and the subjects were asked to avoid judgments of liking and disliking and to concentrate upon consonance and dissonance. As each passage was played by one of the experimenters (P. A. D. G.), the other (R. W. P.) raised his hand when the test chord was sounded and then immediately lowered it again. Each passage was played over in this way often enough for all the subjects to be satisfied that they had identified the test chord and rated it on a scale +3, +2, +1, 0, −1, −2, −3, from very consonant to very dissonant.

The subjects had all received instruction in the psychology of sound and had done the Oregon and other music tests. They also filled in a questionnaire on degree of musical interest. Their average score for on the Oregon test was 77/96, and the scores of this test correlated +0·576 ($p<0{\cdot}01$) with the questionnaire results converted into a quantitative form. These points show that the musical ability of the group was high. The subjects were astonished when told afterwards that they had rated the same chord throughout.

The ratings of the test chord were tabulated and their frequencies are shown in the accompanying table:

Rating	..	+3	+2	+1	0	−1	−2	−3
Frequency	..	62	119	101	52	164	124	78

This distribution of frequencies is quite incompatible with the possible hypothesis that the test chord was of constant or even of approximately constant dissonance-level. They are significantly different from a purely chance distribution of the total of 720 ratings into the seven classes, and show that the chord was most often considered moderately dissonant.

Analysis of variance of the table of ratings showed that the variance due to differences between contexts outweighed the error variance by an amount of which the probability was less than 1 in 1,000. This result is very strong evidence that the dissonance-level of the test chord varied with its musical setting. The variance due to differences between individual subjects was significantly greater than the error variance, and significantly lower than the variance due to differences between contexts. This is evidence that the musical standards, opinions or preferences of the subjects were factors in determining dissonance level, but of far less importance than the effects of varying the musical context.

It may be suggested that 'dissonance-level' is a *Gestalt* phenomenon. It is determined by several factors, of which the chief are (*a*) the physical composition of the chord, (*b*) the 'schemata' in our minds which arise from experience and depend on musical ability, on training and on tradition, and (*c*) the musical effect, import or intention of the passage as a whole. The latter was the outstanding influence in this experiment, and it has been dealt with in a letter to us by Mr. John L. Dunk. This is too long for quotation, but in it he has given passages from Beethoven, Elgar and Wagner, showing that sometimes a chord 'theoretically' correct may be excessively harsh in relation to the musical import of the context; whereas in other passages a dissonance which could scarcely be defended in theory, at least at the period when it was composed, may be completely appropriate from the point of view of the import of the passage as a whole.

We are indebted to Mr. Joseph F. Simpson for his help with the calculations.

P. A. D. GARDNER.
R. W. PICKFORD.

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University, Glasgow.

[1] *Nature*, 152, 358 (1943); 152, 570 (1943); 153, 85 (1944).
[2] Myers, C. S., "Experimental Psychology", Part I, 26–27.

Science and the Fisheries

IN his admirable discourse at the Royal Institution[1] Michael Graham declares with good reason that "the Great Law of Fishing is that unlimited fisheries become unprofitable", and he deduces that "the only adequate measure to conserve the fishery is to set some limit to the amount of fishing". Fishery legislation, with its restrictions upon fishing areas, upon the mesh of nets, upon the size of fish landed and so on, has not succeeded in staying the downward drift, and more restriction is necessary. The Great Law of fishery legislation, based upon sound scientific advice as things stand, is restriction.

Now an outstanding lesson of the United States contribution to the International Fisheries Exhibition of 1883 and its Conferences, to which Graham refers, was, so far at any rate as freshwater fisheries are concerned, the reverse of restriction. The United States Fish Commission realized that "were the governmental policy directed towards preventing the people from catching the few [fishes] left after generations of improvidence, the expense would be enormous, while such laws would be evaded constantly, and almost with impunity"[2]. The Commission therefore dropped a negative for a positive policy and decided "to expend a comparatively small amount of the public money in making fish so abundant in the rivers and lakes that the public itself may fully and freely enjoy the result"[2]. That was the ideal.

May we not look to the same sort of positive policy in regard to sea fisheries, instead of accepting as axiomatic that restriction of fishing is the only adequate means of keeping up the fish population? Scientific workers know enough about the fundamental relations between the chemistry and physics of the sea and the organisms that live in it to attempt some control of these for the benefit of the fisheries. On a small scale the success of such control, by the addition of chemical nutrients, has been indicated by the work on oyster culture in Norway, and by the limited and still incomplete but developing experiments of Dr. Gross and his colleagues in Loch Sween in Argyllshire. In fresh waters, where the basic problem is similar, I am told by the chief of the Biology Division of the United States Department of Agriculture, Edward H. Graham, that it has been encouraging farmers to add chemical nutrients to ponds for the purpose of increasing growth of selected species of fishes, and thus increasing the war-time supply of food.

If the Loch Sween experiments in their wider range are successful, they will point to the possibility of improving sea fisheries instead of curtailing them. If they are not successful, other experiments with the same end in view should be considered. My plea is that scientific workers in fishery matters should turn more attention to the progressive and productive, rather than to the restrictive, possibilities. There is one important point, however, which must be borne in mind. In his paper on the fishery industries of the United States, read at the Conference associated with the International Fisheries Exhibition of 1883, Prof. G. Brown Goode pointed out that "public fish culture is only useful when conducted upon a gigantic scale—its statistical tables must be footed up in tens of millions" [of fishes, not dollars]. In the sea the scale must be vastly greater, it must be international; so that we may be allowed to speculate upon a day, perhaps not many years hence, when the International Fisheries Commission of the nations bordering the North Sea may discuss, along with its programme of researches, the allocation of the sums to be contributed by each nation for chemical nutrients, in the assurance that these will support a larger fish population and an increased fishing fleet in the North Sea.

JAMES RITCHIE.

Department of Zoology,
University of Edinburgh.

Aug. 1.

[1] *Nature*, 154, 105 (1944).
[2] Whymper, F., in "The Fisheries of the World: an illustrated and descriptive Record of the International Fisheries Exhibition of 1883 [1884]", 251.

RESEARCH ITEMS

Inheritance of Tuberculosis

IT has been difficult in the past to evaluate correctly the evidence for the inheritance of tuberculosis or of tendencies which might facilitate infection. Obviously twins provide material which might give valuable evidence on this matter. The analysis of twins has been developed by F. J. Kallmann and D. Reisner (*J. Hered.*, 34, 293; 1943), with highly significant results. 616 twins, 930 sibs, 74 half-sibs and 668 parents in 308 complete families containing twins have been statistically analysed regarding the incidence of tuberculosis. The chance of contracting the disease increases in strict proportion to the degree of consanguinity to a tuberculous patient. The fact that monozygous twins exhibit 16 times as much similarity in resistance as compared with dizygous twins when all criteria are considered indicates that heredity, probably of a multifactorial nature, influences resistance. The authors point out that resistance to the invasion of the bacillus may be different from the factors of resistance to the spread of the established disease. This is supported by the fact that while there is a difference of 1 : 16 between resistance to progressive disease, there is only a difference of 1 : 3·5 in resistance to any form of clinical tuberculosis in monozygous and dizygous twins. The authors are proceeding further with this important analysis.

Freshwater Bryozoa

MARY D. ROGICK, in her "Studies of Fresh-water Bryozoa. XIV. The Occurrence of *Stolella indica* in North America" (*Ann. New York Acad. Sci.*, 45; 1943), records *Stolella indica* Annandale from North America for the first time. The genus was known hitherto only from Asia and South America. This freshwater bryozoon was collected in a pond in Westtown, Chester County, Pennsylvania, where it was fairly abundant on submerged twigs. The pond is fed from a spring passing through a meadow and contains much submerged pond-weed and some lily pads. Filamentous algæ were abundant on the submerged twigs, logs and other objects. In a larger pond nearby, four other species of freshwater Bryozoa occurred. A note on statoblasts in general suggests a simplification in nomenclature, and the terms floatoblasts, sessoblasts and spinoblasts are used for floating, sessile and spiny statoblasts respectively.

Biotin Content of Enzymes

AMONG the members of the vitamin B complex, thiamin, riboflavin, and nicotinic acid occur in combination with a protein, that is, as the prosthetic groups of enzymes involved in respiration. The other members have been assigned no definite role in cellular metabolism. Several of these, notably biotin and *para*-aminobenzoic acid, occur in tissue in a bound form and are liberated only on strong hydrolysis. It might be expected that they also function as prosthetic groups of enzymes. D. R. Miller, J. O. Lampen and W. H. Peterson (*J. Amer. Chem. Soc.*, 65, 2369; 1943) find, however, that the biotin and *para*-aminobenzoic acid contents of six crystalline and three non-crystalline enzyme preparations, and one crystalline protein not an enzyme, lead to minimum molecular weights far in excess of the figures assigned to these enzymes. It is assumed, therefore, that the biotin and the acid are more probably contained as impurities in the crystalline proteins rather than forming an integral part of the enzyme.

Physiology of Pollen

D. LEWIS (*J. Genetics*, 45, 117 and 261; 1943–44) has published further results of his work on the physiology of pollen, which is having far-reaching scientific as well as practical results. He shows that autotetraploidy weakens the inhibition of incompatible pollen. By suitable crosses in synthetic polyploids of *Oenothera organensis*, he has shown that the reduction of the inhibition is due solely to the diploidy of the pollen and not to the tetraploidy of the style. Pollen grains with two different *S* allelomorphs have been used on styles with one or both genes. In some cases there was a difference in compatibility, in others the result was indifferent. These results are considered in relation to the hypothesis that the *S* allelomorphs are competing for an antigenic substance similar to the antigen-antibody reaction in animals. Among many details of importance the author indicates that the effect of one *S* allelomorph of one pollen grain may sometimes be influenced by an association with another *S* allelomorph before pollen-grain formation. In the second paper, the author shows how the discovery of the weakened inhibition to diploid pollen may be used in the production of useful polyploid economic plants. By treating the pollen-mother cells with heat shocks, pollen grains with the unreduced number of chromosomes may be produced. If these pollen grains are heterozygous for the *S* allelomorphs, they will function on a diploid style, whereas the haploid pollen grain will be inhibited by the normal incompatible mechanism. By this method, triploid pears have been produced, and results in plums, cherries and apples indicate that much use should be made of Lewis's method in the future.

Inheritance of Tristyly in *Lythrum Salicaria*

THE historic work of C. Darwin and Lady Barlow upon the inheritance of long-, mid- and short-styled plants of the loosestrife raised several unsolved problems. East published a hypothesis of lethal mid-genes to attempt to explain the results of crossing. This hypothesis left a number of unaccounted exceptions. R. A. Fisher and K. Mather (*Ann. Eugenics*, 12, 1; 1943) have followed their letter in *Nature* (150, 430; 1942) on this subject with extended results. They show that East's theory that the mid-gene was lethal when homozygous is wrong. By special methods of open pollination and statistics they have analysed large progenies and infer that the inheritance of long, mid and short is polysomic in type. Whether the inheritance is tetrasomic or hexasomic is unknown, but experiments are in progress. The authors have grown an open-pollinated population at Chelsea Physic Garden, and find that the mids have reduced fertility both in seed and pollen. This is different from that discovered by Darwin, and they suggest, therefore, that the experiment might be repeated at Down House, where the original work was performed.

Iron Hill Igneous Complex, Colorado

THE detailed report by E. S. Larsen on the rocks and minerals of the Iron Hill stock in south-west Colorado (*U.S. Geol. Surv., Prof. Paper* 197 A; 1942) is an important and long-awaited contribution to descriptive petrology. The stock has an area of twelve square miles ; it is emplaced in Pre-Cambrian granites and is overlain by late Jurassic sandstones. The sequence of rocks in the complex is as follows : (*a*) A mass of dolomitic marble which forms an isolated hill a mile across, as well as several small inclusions within the later rocks. From the evidence of bodies of similar marble in the neighbourhood it is believed that the main mass is of hydrothermal origin, though it may have been intruded as a carbonate magma. (*b*) A coarse-grained melilite rock known as uncompahgrite. (*c*) A pyroxenitic suite which makes up about 70 per cent of the area and ranges from diopside-rock to types composed of biotite, perovskite-magnetite and apatite-perovskite, with varieties containing felspar, nepheline and sphene. (*d*) Ijolite composed of pyroxene, garnet and nepheline. In places nepheline appears to have 'soaked' into the pyroxenites. (*e*) Soda-syenite, commonly banded and associated with (*f*) a later nepheline-syenite ; both (*e*) and (*f*) tend to occur near the borders of the stock. (*g*) A series of dykes of either nepheline-gabbro or quartz-gabbro, or in some cases both. Hydrothermal solutions were active throughout the history of the stock. To explain the origin of the complex the author postulates crystal differentiation of a basaltic magma modified by assimilation of marble in depth, but he himself points out one serious weakness in this conventional hypothesis, namely, its failure to account for the very high TiO_2 and P_2O_5 which characterize most of the rocks.

Magnetic Susceptibility of Iron Tetracarbonyl

IRON tetracarbonyl, which has a molecular weight roughly corresponding with the formula $[Fe(CO)_4]_3$ is, like the other metal carbonyls, diamagnetic. The susceptibility values reported vary rather widely, and the value has been redetermined by H. G. Cutforth and P. W. Selwood (*J. Amer. Chem. Soc.*, 65, 2414 ; 1943). A well-crystallized material was prepared by way of the carbonyl $Fe_2(CO)_9$ from $Fe(CO)_5$. The actual material was found to be paramagnetic, suggesting para- or ferro-magnetic impurities. Measurements over a range of field strength showed that the susceptibility depended on the field. By plotting susceptibility against the reciprocal of field strength, extrapolating to infinite field strength gave a susceptibility of $- 0{\cdot}07 \times 10^{-6}$, which is of the order expected, though rather small.

Electric Arc between Solid Carbons and Graphite Electrodes

IN a paper by J. T. MacGregor-Morris (*J. Inst. Elec. Eng.*, 91, Pt. 1, No. 41 ; May 1944) entitled "Experiments on the Candle-Power and Brightness of the Positive Crater of the Electric Arc, using Solid Carbons and Graphite Electrodes", a critical examination is made of the ways in which a standard of high-intensity light could be developed using the positive crater of an electric arc between carbon electrodes in air, and an account is given of much hitherto unpublished experimental work bearing on this problem. A three-electrode arc was adopted in the researches, and a physical photometer was used in which a galvanometer deflexion automatically gave a measure of the light output of the arc. The accuracy of the method exceeds that possible with visual photometry, and rapid variations of candle-power can be observed. Graphite electrodes and a wide range of uncored soot electrodes were used. For a standard, either the candle-power of the positive crater measured along the axis of the anode might be used, or the brightness of a small portion of the crater near the centre. Measurements are given of the effect on candle-power and brightness of many factors including diameter, resistivity and purity of the anode, arc current, negative electrodes, atmospheric pressure and absorption due to arc flame. Special attention is given to the elimination of a phenomenon the existence of which is generally not obvious, namely, the rapid rotation of the arc stream, which is accompanied by a reduction of candle-power and brightness of uncertain amount. A critical comparison is made with other published work, especially work in other countries, and it is concluded that a standard can best be developed utilizing brightness, an accuracy of 1 per cent being so far attained.

The Starch-Iodine Complex

THE nature of the blue material formed by the action of iodine on starch has been much discussed. In a series of papers by R. E. Rundle and co-workers (*J. Amer. Chem. Soc.*, 65, 554, 558, 1707, 2200 ; 1943 ; 66, 111, 130 ; 1944) evidence is presented for the view that the starch molecules are helical chains with a helix diameter of about 13·7 A., a length per turn of about 8 A., and about six glucose residues per turn, and in the starch-iodine complex the iodine molecules occupy the interior of the helices. Absorption spectra are said to confirm the existence of amylose and amylopectin as two components in whole starch. The amount of iodine bound in complex formation with amylose increases as the concentration of iodide decreases, becoming one iodine molecule for six glucose residues for infinitely dilute iodide solutions.

New Methods in Stellar Dynamics

S. CHANDRASEKHAR (*Ann. New York Acad. Sci.*, 45, Art. 3, 131 ; 1943) has prepared an abridged version of new methods developed by him for the investigation of the dynamics of stellar systems. An outline of the general principles of a statistical theory of stellar dynamics is provided in the paper. An interesting point is mentioned in dealing with the statistics of a gravitational field which arises from a random distribution of stars. The acceleration which a star suffers during a certain interval can be formally expressed as the sum of two terms : (1) a systematic term due to the action of the gravitational field of the smoothed out distribution ; (2) a stochastic term representing the influence of the near neighbours. There is a similarity between the problem presented by stellar dynamics, as stated in the above fashion, and the problems which occur in the modern theories of Brownian motion. Part 3 of the paper deals with the rate of escape of stars from clusters and the evidence for the operation of dynamical friction ; the Pleiades cluster is considered in relation to the results obtained. When dynamical friction is ignored, a half-life for the Pleiades of 5×10^7 years is predicted ; but if it is taken into consideration, the half-life is 3×10^9 years, and there is little doubt but that dynamical friction provides the principal mechanism for the continued existence of the galactic clusters like the Pleiades for times of the order 3×10^9 years. Allowing for dynamical friction, however, will not account for half-lives of the order 10^{10} years for such clusters, and this provides support for the now currently adopted 'short time-scale' of the order 3×10^9 years.

APPLICATIONS OF SPECTROSCOPY

A CONFERENCE on the applications of spectroscopy to industrial and other problems was held, under the auspices of the London and Home Counties Branch of the Institute of Physics, at the Imperial College of Science and Technology on July 1; Dr. S. Whitehead presided.

The introductory address was given by Prof. H. Dingle, of the Imperial College, who opened with a short historical account of the development of spectroscopy. The pioneer work of Newton and, later, Fraunhofer, found no immediate practical application, and it was not until the middle of the nineteenth century that the subject began to acquire a general significance. Under the name of spectrum analysis, it was then regarded as a department of chemistry, and its discovery of new elements, coupled with the realization that a new and rapid method of chemical analysis had become possible, aroused hopes that a process of great practical value had been brought to light. These hopes were quenched, however, by the apparent capriciousness of the method, arising from causes which, in the existing state of physical and chemical knowledge, it was impossible to understand, and chemists soon abandoned it almost entirely. For the next few decades spectroscopy was kept alive, and in some degree developed, by astronomers, for whom no other means of astrophysical investigation was available, and in spite of some unavoidable errors, their contribution was an essential preliminary to the great revival which came with Bohr's theory of the hydrogen atom in 1913. For some dozen years thereafter, spectroscopy stood in the forefront of atomic physics, and the picture of the outer structure of atoms which eventually emerged was constructed *pari passu* with the explanation of the successive details of spectra.

This work, so far as atoms are concerned, is now almost complete, and one of its consequences is the rebirth of *applied* spectroscopy. Two main causes have been responsible for this. First, the requirements of physicists, in their enthusiasm to penetrate the secrets of atomic structure, impelled scientific instrument makers to turn their attention to the mass production of spectrographic apparatus, and this is now available in large quantity. Secondly, the newly acquired knowledge of the processes of production of spectra has made it possible to understand the vagaries which alienated the interest of earlier workers, and the spectrum has become a safe index to both the chemical composition and physical condition of the source of light. Prof. Dingle stated that the problem of qualitative spectrum analysis can now be regarded as solved; but considerable experience—not always possessed by the authors of published analyses—is necessary for trustworthy results. No general process of quantitative spectrum analysis, however, has so far been devised, although in certain special problems the method has been successfully used. He presented an analysis showing the various factors contributing to the strength of a photographed spectrum line, and described work which has been done at the Imperial College—and will be resumed as soon as conditions allow—directed towards the control of all of them except the amount of the corresponding element in the mixture to be analysed. The work of Mr. E. W. Foster, already published*, will, it is hoped, provide a basis for a process of quantitative spectrum analysis of great generality.

* *Proc. Phys. Soc.*, 53, 594 (1941).

Mr. F. Twyman, managing director of Messrs. Adam Hilger, Ltd., followed with a description of certain spectroscopic instruments now available. He confined his remarks chiefly to those which seem of most immediate importance—namely, instruments for analysis by emission spectra and those for identification and estimation of liquids or vapours by absorption in the visible, ultra-violet and infra-red regions. The number of spectrographic analyses of minerals and alloys in Great Britain alone must run into millions every year, while absorption spectra, particularly in the infra-red, have lately assumed great importance in problems of molecular structure of interest to the biochemist and the industrial chemist. The commonest instrument for the production of emission spectra is still the quartz spectrograph; but gratings, largely through the advocacy of G. R. Harrison in America, have recently come into more general use, and experience must decide which is to be preferred for practical purposes. In quantitative work an estimate of the strength of spectrum lines must be made, and for this purpose microphotometers, or micro-densitometers, are available. Attempts have been made to measure intensities directly by photo-electric cells, but there is little doubt that for a long time to come the spectrum will be recorded photographically and the strength of the lines measured by the blackening of the plate. Mr. Twyman next discussed improvements in sparking circuits, and concluded his remarks on instruments for emission spectra by a brief reference to the identification of chemical compounds by X-ray crystal analysis.

The most characteristic feature of apparatus for absorption spectra in the visible and ultra-violet regions is the photometric device, of which the first example was the sector spectro-photometer. The principle of this instrument is common to all subsequent photographic spectro-photometers, except very recent ones still in the experimental stage; but certain improvements in detail have been introduced, which are exemplified in the Spekker photo-electric absorptiometer. In the infra-red, where absorption spectra give important information bearing on the structure of organic molecules, the original Hilger instrument designed in 1909 is, with a few improvements, still in use to-day. Prisms of quartz, fluorite, rock-salt and sylvine are available, making investigation of the infra-red region possible up to at least 21 μ. The radiation is detected by a thermopile, and a recording form of the instrument has been devised.

The next speaker was Mr. D. M. Smith, of the Research Department of the British Non-Ferrous Metals Research Association. He discussed chiefly the difficulties met with in the spectrographic analysis of non-ferrous metals and alloys. In this work the chief problem is the quantitative determination of traces of impurities, and the methods adopted usually involve microphotometric measurements of arc and spark spectrograms, especially the latter. Important sources of error lie in the lack of precise specification of sparking conditions, lack of complete understanding of the effect of small differences between the samples to be analysed and those used to provide standards for comparison, and uncertainties in plate calibration arising from imperfect design in certain types of microphotometer. The British Non-Ferrous Metals Research Association has for some time been collaborating with its members in attempting to improve the accuracy of spectrographic methods, four panels of the Research Sub-Committee having been formed.

In addition to reports from the Photographic, Aluminium and Lead panels (the fourth panel deals with problems common to all the methods), further papers on specific applications are shortly to be published in book form under the title "Collected Papers on Metallurgical Analysis by the Spectrograph".

It is generally agreed that the standard alloys used for comparison should be closely similar in bulk composition and metallurgical history to the samples for analysis, and some pre-sparking is generally regarded as desirable in non-ferrous analysis, although in the analysis of steels it appears to be unnecessary. The 'direct comparison' method, due to A. Walsh, in which no internal standards are used, has proved successful in certain problems, but it is very susceptible to errors from incomplete control of the spark discharge. The reproducibility of spectrographic determinations is most concisely expressed by the standard deviation derived from an adequate number of repeat tests on the same sample, although the calibration of the plate by the use of standard alloys is a possible source of systematic error. In general, methods of compensation, based either on empirical relationships or on considerations of source temperature, are less satisfactory than improvements in the source of excitation as regards increasing analytical accuracy.

Dr. W. A. Roach, of the East Malling Research Station, then addressed the Conference on applications of spectroscopy to biological problems. Lundegardh (1928) and Ramage (1929), he said, were two of the earliest workers to use emission spectroscopy for studying the biological importance of minerals. Ramage burnt the dried and powdered material, rolled in a filter paper, in front of the slit of a spectrograph. Lundegardh sprayed a solution of the ash into an oxy-coal gas flame. The arc method has been used by Webb and Fearon (1937) to make a survey of elements occurring in living tissues, and by Lewis, who found that serious trouble in young animals on 'teart' pastures in the west of England was caused by an excess of molybdenum. Mitchell used Goldschmidt's cathode layer method of soil analysis for studying a serious trouble in sheep called 'pining', which was traced to a deficiency of cobalt. These and absorptiometer methods are now in routine use in a number of biological laboratories.

Similar methods, as well as others, are being used at the East Malling Research Station for the diagnosis of mineral deficiencies and excesses in plants. The limitations of plant analysis when employed alone are illustrated by facts first discovered by Passy (1910) when seeking the cause of widespread chlorosis (absence of chlorophyll) in an orchard. The trouble was cured by injecting an iron salt into the chlorotic trees; yet the percentage content of iron was highest in chlorotic foliage, lower in certain green branches and trees found in the orchard, and lowest in the trees injected with iron salt. The iron in the chlorotic leaves must have been in a form useless to the plant. When iron in a useful form was injected, the leaves grew in proportion to the injected iron, which 'diluted' the useless iron obtained naturally. This type of faulty mineral uptake is known as 'lime-induced chlorosis', since it is common on soils containing excess of calcium carbonate.

A system of diagnosis is being built up by studying the mineral composition of plants in relation to their performance, supplemented when necessary by testing how far performance is improved by injecting more of any selected element into the plant. Healthy plants tend to have a characteristic composition, and a deficiency of any essential element can be diagnosed by analysis alone. When calcium occurs in excess, however, the normal content of any of the trace elements (iron, manganese, zinc, boron, copper, etc.) may prove inadequate because it may be in a state useless to the plant. Supplementary methods, such as plant injection and a study of plant symptoms which are often characteristic of mineral deficiencies, must then be employed.

The final address was given by Dr. R. W. B. Pearse, of the Imperial College, who spoke on applications of the band spectra of molecules. These fall into two classes: first, those in which direct use is made of the spectrum, and secondly, those in which the spectrum is analysed in order to determine the structure of the corresponding molecule. In applications of the first class, a band system, and not an individual band, is to be taken as the molecular analogue of a single line in the spectrum of an atom. By means of such systems the scope of analysis can be extended in several ways. Thus, inaccessible sources of light, such as comets for example, sometimes show the presence of many of their constituents by bands and not lines. Secondly, certain elements which give no line spectra in the ordinary regions of observation when subjected to arc or spark conditions readily show bands if suitable elements are present with which they can combine. Thus, fluorine and chlorine can often be detected by bands of CaF and CuCl; nitrogen and oxygen in the atmosphere of a copper arc show a spectrum of NO; and the spectrum of a hydrogen flame shows S_2 bands when sulphur is present. Thirdly, glow discharges in vacuum tubes often show bands which indicate the nature and purity of the gases present, and give a clue to the origin of unwanted residual gases, for example, leakage from the air, presence of moisture, degassing of walls, decomposition of grease, etc. Fourthly, absorption spectra have enabled certain complex molecules to be identified, and indicated changes in the constitution of such molecules by corresponding changes in the spectrum. Tables of data are now available for the identification of molecular spectra, and their use could be greatly extended.

Applications of the second class require a much more detailed study of the spectrum. The spectra of diatomic molecules can be analysed into bands and branches, and energy-level diagrams constructed. Molecular constants representing the levels give the separation of the constituent atoms, the moment of inertia of the molecule, its frequency of vibration and electronic energy in various states, and the law of force between the atoms. If the observations are sufficiently extensive, the energies of dissociation for the various states can be obtained. This knowledge can be used, with the co-operation of the mathematician and the physical chemist, to throw light on many chemical problems. The determination of temperature and detection of isotopes are further possible products of the analysis of molecular spectra.

A short discussion was held at the conclusion of the meeting, at which it was proposed by Dr. J. Convey, and seconded by Dr. H. Lowery, that in view of the great importance which applied spectroscopy has acquired in various fields, the Board of the Institute of Physics should be asked to arrange for the formation of a group for the study of the subject. The proposal met with general agreement, and is to be submitted to the Board.

CONTROL OF CROSS-INFECTION BY BACTERIA

The Medical Research Council's War Memorandum, No. 11, entitled "The Control of Cross-Infection in Hospitals" (London: H.M. Stationery Office, 1944. 6*d*. net) epitomizes a great deal of research on this important question. Cross-infection, says Sir Wilson Jameson in his introduction, is most apparent and dangerous among infantile and juvenile patients in hospitals, so that this memorandum deals mainly with the risks in children's wards; but it is pointed out that the risks exist also among children at home and wherever else they assemble. Nor are adults by any means free from them. The risks are naturally greatest where infectious diseases are being treated, but they exist in every hospital ward; and, when a cross-infection occurs, the cost of it may be so high that any measures taken to prevent it are in the long run economical, even if these include, as they often must, building alterations.

The commonest types of cross-infection are the respiratory ones, such as tonsillitis, middle ear disease, 'colds in the head' and pneumonia. "If tonsillitis due to hæmolytic streptococci is accompanied by a rash, it is known as scarlet fever." Some thirty serological types of hæmolytic streptococci have been identified, and one and the same type may cause different effects in different patients. The tracking down of these types may be a very complex undertaking. Diphtheria, measles, chicken-pox, whooping cough, German measles, mumps and that disease about which much has been written recently, infective hepatitis, are other important infections which gain entrance by the respiratory tract. Gastro-intestinal infection may be a serious cause of death among infants in hospital. Epidemic diarrhœa, bacillary dysentery and diseases of the typhoid group may also occur. Wounds and burns may become infected, and abscesses, erysipelas, cellulitis and septicæmia may follow. Hæmolytic streptococci and staphylococci are the commonest causes of cross-infection of wounds. There are also the skin infections, impetigo, ringworm, scabies and pediculosis and infections of infants which may cause inflammations of the mother's breast. Nor should we concentrate all our attention on cross-infection of the patients. The nurses and other personnel need protection from it. Dr. Joyce Wright (*Brit. Med. J.*, 585, April 29, 1944), in her study of the sickness records of nurses in University College Hospital between 1936 and 1938, discusses this problem and emphasizes the need for further work on it. Although smallpox is outside the scope of the Medical Research Council's memorandum, it is interesting to note in passing that the theory that smallpox may spread from smallpox hospitals to the surrounding population by way of the air has been revived and supported by Dr. C. K. Millard (*Brit. Med. J.*, 629, May 6, 1944).

Infection in a hospital may be either from a clinical case, from a case which has not been recognized or is in its incubation period, or from a 'carrier' who is either a convalescent or harbours the organisms concerned without showing any symptoms. From any or all of these, infection spreads by way of the secretions or discharges or from the skin or from wounds. It can spread by contact with the patient or with his clothes or belongings, or by means of food or living vectors. But of special interest nowadays are infection by dust and by droplets of moisture, which can be projected 3–6 ft. through the air by talking, coughing or sneezing. Such infection may fall either on another person or on to bedclothes, utensils, food or on to the floor. Small droplets may evaporate and leave in the air minute droplet nuclei which are infected and may carry infection for considerable distances. The diagrams printed in this memorandum indicate that bacterial counts of the air show considerable increases when bed-making or floor-sweeping raises the dust. Dry floor-sweeping does this especially, and the dust settles on bedclothes, on the furniture, on food, toys, utensils, and so on. Pathogenic bacteria can live in floor dust for weeks or even months, and may be numerous there. Large numbers of virulent diphtheria bacilli have been isolated from the floor dust of diphtheria wards. It has been estimated that the floor sweepings of one ward in an ear, throat and nose hospital contained 100 million hæmolytic streptococci; and tubercle bacilli and pneumococci have also been obtained from floor dust. The bacteria of ward dust come mainly from bedclothes; and even the straightening of the clothes of one bed can raise the bacterial count of the surrounding air 100 times. The scales of skin, and hair and finger-nail cuttings found in dust also may carry pathogenic bacteria.

Surrounded by this multitude of enemies, what are we to do? War Memorandum No. 11 referred to above gives detailed directions. Among administrative measures are the abolition of the large open ward and encouragement of the modern tendency to build smaller units. About half the beds in a children's hospital should be in small isolated rooms, so that patients may be isolated if necessary, and so that those suffering from the same disease can be grouped in small wards. Patients should be grouped according to medical risks rather than according to age. Nurses' duties should be so allocated that risks of cross-infection are avoided. This applies especially to those engaged in the kitchens, on the preparation of feeding bottles or on toilet duties. Nurses should receive training in the risks of cross-infection and in hygiene and bacteriology. Similar rules should apply to visitors and to walking patients who may be helping the staff. Immunization and chemo-prophylaxis are also helpful. Labour-saving methods are also discussed. The use of trolleys, for example, in the serving of meals considerably reduced the 7½ miles walked by the staff of one hospital when they served one meal. The control of contact infection is discussed under the headings, handwashing, laundry, cleanliness of kitchens and food stores, the reduction of flies and other insect pests and, in children's hospitals, breast and artificial feeding.

The control of droplet infection is effected by adequate ventilation at all times and all the year round, by placing beds not less than 12 ft. apart, by the use of efficient face masks (which should not be carried in pockets and should only be used once), by the use of antiseptic aerosols insufflated into the air. R. J. V. Pulvertaft (*J. Hyg., Camb.*, 43, 352; 1944) gives a valuable summary of recent work on these aerosols, and the same journal contains in earlier issues other accounts of research done on them. Prof. S. Mudd, of the University of Pennsylvania, has given us recently (*Brit. Med. J.*, 67, July 15, 1944) an American view of progress in the sterilization of the air. Ultra-violet irradiation is also helpful. Prof. L. P. Garrod (*Brit. Med. J.*, 245, Feb. 19, 1944) claims that his study of hospital dust shows that "ordinary, diffuse daylight even on a cloudy day and even in winter in England, can be lethal to bacteria, and that glass is no absolute bar to this effect".

Dust-borne infection has received much attention recently. The interesting work quoted in this War Memorandum No. 11 shows that bedclothes should be handled gently and should not be allowed to touch the floor. The number of bacteria scattered from them is much reduced if they are impregnated with 'technical white oil'. Similarly, the treatment of wooden and linoleum-covered floors with spindle oil reduces the risk of scattering bacteria during sweeping. A striking diagram of results of bacterial counts of the air before and after oiling of floors illustrates this. Floors made of rubber, concrete or composition should be washed, vacuum-cleaned or sprinkled with damp sawdust before sweeping. For the same reasons dusting with dry dusters is banned. Food, sterile materials and so on should, of course, be protected from dust, and any article which falls on to the floor should be regarded as being contaminated. A recent paper by F. C. Harwood, J. Powney and C. W. Edwards, of the British Launderers' Association Laboratories (*Brit. Med. J.*, 615, May 6, 1944) describes a new technique for oiling bedclothes which incorporates the use of dilute water-in-oil emulsions. P. H. R. Anderson, J. A. Buchanan and J. J. MacPartland, in the same issue of that journal (p. 616), record their successful lowering of the rate of respiratory infections in a military barracks by the oiling of the floors with spindle oil. Joyce Wright, R. Cruickshank and W. Gunn, in the same issue (p. 611), have shown that oiling of the floors would not by itself be enough to control the spread of dust-borne hæmolytic streptococci in measles wards, but that oiling of all the bedclothes in addition to oiling of the floors did control this. The infection cycle is, they say, respiratory tract—droplets and discharges—bedclothes and garments—ward air during bed-making—ward dust—ward air during sweeping. Oiling floors thus attacks only the final links in this cycle, and oiling of the bedclothes and linen attacks the earlier ones.

The Medical Research Council memorandum gives in its appendixes lists of disinfectants and instructions for their use and rules for sterilization, isolation, and the application of dressings. The special requirements of maternity wards are also considered, and rules are given for the procedure to be followed when an infection does occur in a ward. G. LAPAGE.

SAP-STAINS OF WOOD

SCHEFFER and Lindgren[1] present a summary of approximately ten years of field and laboratory work on sap-stains of wood. They state that market demands for wood products are becoming more exacting, making stained wood more difficult to dispose of. Losses from degradation are in general decreasing because of improved methods in controlling stain. Chemical, mechanical, and fungus stains are described and discussed as to symptoms, cause, timber species involved, effect on various wood properties, and control, the major emphasis being on blue stains caused by fungi. In the United States blue sap stains are of greater importance in the south than in any other region, although locally and seasonally important also on the west coast and in northern Idaho and contiguous regions. The chief factors influencing the development of fungus blue stains in sapwood lumber and other wood products are temperature, oxygen, and water. No correlation was found between wood density and susceptibility to stain. Flat-grained lumber was slightly more susceptible to stain than edge-grained, due to the greater number of rays exposed and the larger proportion of sapwood. Wood once seasoned and remoistened was less susceptible than unseasoned wood, but not significantly so. No difference was found in susceptibility to stain between winter-cut and summer-cut timber.

The fungi causing blue stain are disseminated by air, ips beetles, mites and possibly to some extent by the saws which cut the logs into lumber. Toughness (ability to stand loads applied quickly) of stained wood was significantly reduced as compared with unstained wood; but other mechanical properties were not significantly affected. Creosote under pressure penetrated considerably deeper into stained pine bolts than into matched unstained bolts. The presence of stain did not affect the yield or strength of paper made from the wood, nor did it affect the glueing and other properties of the wood. The commercial aspects of stain control in the southern United States are discussed, including the advantages and disadvantages of end-racking, end-piling, crib-piling, steaming, kiln drying, and chemical treatments. The chemicals most used at present are 'Lignasan' (ethyl mercury chloride plus inerts), 'Dowicide P.' (mixture in equal parts of sodium tetrachlorophenolate and sodium 2-chloro-*o*-phenylphenolate plus excess alkali) and 'Dowicide H.' (sodium tetrachlorophenolate plus excess alkali). The phenolates are more persistent on the lumber and more toxic to moulds. In poor seasoning weather, the control sometimes is erratic. It is estimated that three billion feet of pine and hardwood lumber was dipped or sprayed in 1936. Not only lumber but also other products, such as posts, barrel staves, shingles, lath, and exterior millwork now are treated to control stain.

One of the problems of commercial stain control is that treatments generally successful in preventing the development of sap-stain in lumber occasionally fail. As one of the basic approaches to the solution of this problem, Verrall[2] studied the relative importance and seasonal prevalence of wood-staining fungi in the southern United States. The studies were made in 1937 and 1938 in Louisiana, Mississippi, and Georgia. More than a thousand isolations were made from both logs and lumber of twelve species of trees, among which long-leaf pine (*Pinus palustris* Mill) and red gum (*Liquidambar styraciflua* L.) predominated. Blocks were inoculated with the isolated fungi to test their staining ability. The staining floras of both logs and lumber were very nearly alike. Those most important in pines were: *Ceratostomella pilifera*, *C. ips*, *Diplodia natalensis*, and other *D.* sp.; on hardwoods: *Endoconidiophora coerulescens*, *Ceratostomella pluriannulata*, *Diplodia natalensis*, and *Graphium rigidum* *Diplodia natalensis* is of prime importance only in the summer months, *Endoconidiophora coerulescens* is of low incidence in the summer months, and *Ceratostomella pilifera* is relatively more frequent in winter than in summer, although of importance the year around. *C. ips*, *Diplodia sp.*, *C. pluriannulata* and Graphium fluctuate very little with season. *Diplodia natalensis* isolated from stained wood is identical with that isolated from cotton and other common agricultural plants in the region. Its prevalence in summer is thought to be due to a combination of ability to grow at high temperature, and abundance of inoculum produced during this season on cotton and other plants.

Verrall[3] also identified the fungi associated with stain in green lumber treated with Lignasan and with Dowicide P. He found no special staining flora on the treated wood, and no evidence of a build-up of stains resistant to the treating chemicals. Some stain was obtained on most treated pieces of pine lumber under the severe conditions of the tests. *Endoconidiophora coerulescens* is probably the most important staining fungus on hardwoods, and treatments were less effective against this fungus than against other species. However, no difficulty was experienced in getting hardwood lumber to remain stain-free after treatment. *Graphium rigidum* and *Ceratostomella pluriannulata* were isolated in relatively greater numbers from Lignasan-treated than from Dowicide-treated wood. *Diplodia natalensis* was not isolated from treated wood. The greater part of the occasional severe staining of treated wood is attributed to poor handling practice, not to failure of the treatments themselves. CLYDE M. CHRISTENSEN.

[1] U.S. Dept. Agric., Tech. Bull. 714 (1940).
[2] *Phytopath.*, 29, 1031 (1939).
[3] *Phytopath.*, 31, 270 (1941).

FORTHCOMING EVENTS

Tuesday, August 29

BRITISH PSYCHOLOGICAL SOCIETY (INDUSTRIAL SECTION) (at the National Institute of Industrial Psychology, Aldwych House, Aldwych, London, W.C.2), at 12.30 p.m.—Dr. K. J. W. Craik: "Proposed Work of the Medical Research Council's Unit of Applied Psychology at Cambridge".

APPOINTMENTS VACANT

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

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

SECRETARY to the Editorial Board of the 'Transactions' (must hold a Degree in Physics, Metallurgy or Engineering of a British University, or an equivalent technical qualification)—The Secretary, Institute of Welding, 2 Buckingham Palace Gardens, London, S.W.1 (August 31).

CHIEF ELECTRICAL ENGINEER AND MANAGER—The Town Clerk, Town Hall, Chichester (August 31).

PRINCIPAL ENGINEERING ASSISTANT on the permanent staff of the Buildings Department—The Clerk to the Kent County Council, County Hall, Maidstone (marked 'Principal Engineering Assistant') (August 31).

BOROUGH ELECTRICAL ENGINEER AND MANAGER—The Town Clerk, 4 Woodville Terrace, Gravesend, Kent (September 1).

ASSISTANT MASTER to teach BUILDING CONSTRUCTION, MATHEMATICS, TECHNICAL DRAWING AND MECHANICS at the Junior Building School, Cowes—The Director of Education, Education Offices, County Hall, Newport, I. of W. (September 1).

LECTURERS (two, full-time) IN PHYSICS—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex (September 2).

UNIVERSITY CHAIR OF STATISTICS tenable at the London School of Economics—The Academic Registrar, University of London, South Kensington, London, S.W.7 (September 4).

CHIEF STEAM TURBINE DESIGNER for a firm in the Midlands—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. C.2249.XA) (September 4).

GRADUATE ASSISTANT (full-time, temporary) to teach MATHEMATICS AND SCIENCE—The Principal, Twickenham Technical College, Egerton Road, Twickenham, Middx. (September 5).

ASSISTANT LECTURER IN ZOOLOGY, and a DEMONSTRATOR IN ZOOLOGY—The Acting Registrar, The University, Leeds 2 (September 8).

ADVISORY OFFICER IN THE ECONOMICS DEPARTMENT—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow (September 8).

CURATOR OF THE CITY MUSEUMS—The Town Clerk, Room 57, Civic Hall, Leeds 1 (endorsed 'Curator of the City Museums') (September 9).

LECTURER (full-time) IN BIOLOGY, and HEAD OF THE SCHOOL OF CHEMISTRY—The Principal, Leicester College of Technology and Commerce, Leicester (September 9).

ENGINEER (Water Supplies) by the Gold Coast Government Public Works Department—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. E.1094.A) (September 11).

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

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

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

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

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

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

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

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

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

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

TECHNICAL ASSISTANT (female, non-resident) for Clinical Laboratory Work—The General Superintendent, Royal Infirmary, Manchester.

TEACHER mainly for MATHEMATICS AND ENGINEERING SCIENCE in the Junior Technical School and in Senior Day and Evening Classes—The Principal, County Technical College, Gainsborough, Lincs.

LECTURER IN ELECTRICAL ENGINEERING with special reference to Design of Electrical Machinery—The Principal, Faraday House Electrical Engineering College, 62–70 Southampton Row, London, W.C.1.

TEACHER OF ENGINEERING DRAWING AND MECHANICS in the Junior Technical School for Boys—The Principal, Wimbledon Technical College, Gladstone Road, London, S.W.19.

TEACHER (full-time, temporary) OF MECHANICAL ENGINEERING SUBJECTS in the Technical College and Junior Technical School—The Principal, Technical College, Talbot Road, Stretford, Lancs.

DEMONSTRATOR IN ANATOMY—The Secretary, University College, Gower Street, London, W.C.1.

PRINCIPAL of Natal University College—The Secretary, Universities Bureau of the British Empire, c/o University College, Gower Street, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Ministry of Agriculture and Fisheries. Bulletin No. 85: Rotations. By Dr. H. G. Sanders. Pp. 18. (London: H.M. Stationery Office.) 4*d*. net. [317

Tractor Ploughing. (N.I.A.E. Publication No. 503/44.) Pp. 40+iv. (York: National Institute of Agricultural Engineering.) 9*d*. [28

Annual Report of the Council of the Yorkshire Philosophical Society for the Year 1943. Pp. 28. (York: Yorkshire Museum.) [28

University of Bristol. Annual Report of the Agricultural and Horticultural Research Station (the National Fruit and Cider Institute), Long Ashton, Bristol, 1943. Pp. 172. (Bristol: The University.) [38

Ministry of Health: Nurses Salaries Committee. Report of the Mental Nurses Sub-Committee. (Cmd. 6542.) Pp. 45. (London: H.M. Stationery Office.) 9*d*. net. [48

Science in the Universities. Report submitted to the University Grants Committee of the Treasury. Pp. 44. (London: Association of Scientific Workers.) 1*s*.

Other Countries

Proceedings of the United States National Museum. Vol. 94, No. 3171: Catalog of Human Crania in the United States National Museum Collections—Non-Eskimo People of the Northwest Coast, Alaska and Siberia. By Aleš Hrdlička. Pp. 172. (Washington, D.C.: Government Printing Office.) [257

National Research Council: American Geophysical Union. Transactions of 1942. Part 1: Reports and Papers, Joint Regional Meetings, Section of Hydrology (a) Dallas, Texas, (b) Pasadena, California. Pp. 172. 1.25 dollars. Part 2: Twenty-third Annual Meeting, April 3 and 4, 1942, Washington, D.C., Reports and Papers, General Assemblies and Sections of Geodesy, Seismology, Meteorology, Terrestrial Magnetism and Electricity, Oceanography, Volcanology, Hydrology and Tectonophysics. Pp. 173–740. 4.50 dollars. Transactions of 1943. Part 1: Twenty-fourth Annual Meeting, April 23 and 24, 1943, Washington, D.C., Reports and Papers, General Assembly and Sections of Geodesy, Seismology, Meteorology, Terrestrial Magnetism and Electricity, Oceanography, Volcanology and Tectonophysics. Pp. 332. 3.50 dollars. Part 2: Twenty-fourth Annual Meeting, April 23 and 24, 1943, Washington, D.C., Reports and Papers, Section of Hydrology. Pp. 333–784. 4 dollars. Part 3: Reports and Papers, Joint Regional Meeting, Section of Hydrology, Western Snow-Conference, Corvallis, Oregon, June 16, 1943. Pp. 102. 1 dollar. (Washington, D.C.: National Academy of Sciences.) [257

Catalogues

X-Ray Darkroom Practice. Pp. 32. Ilford Lead Screens for Industrial Radiography. Pp. 6. (Ilford: Ilford, Ltd.)

Iodatol in Hysterosalpingography. Pp. 8+4 plates. Dienoestrol B.D.H. Pp. 2. Thiouracil B.D.H. (2-Thio-6-oxypyrimidine). Pp. 2. (London: British Drug Houses, Ltd.)