

NATURE

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SCIENTIFIC METHOD IN GOVERNMENT

THE Riddell Memorial Lectures entitled "The Unknown State"*, delivered before the University of Durham by Lord Eustace Percy, represent a noteworthy plea for the study of government. They are indeed partly addressed to the scientific worker, and were delivered in the belief that a revival of the neglected study of government is the most urgent need of the present day, and that universities have a special responsibility to make it a learned study. Whether that responsibility can rightly be placed upon the universities is a matter of opinion; but no one who has considered Sir Ernest Barker's views on this problem of government, or J. T. MacCurdy's suggestive chapters in "The Structure of Morale" or has noted the difficulties into which the administration is being continually led from the Cabinet level downwards for lack of attention to the fundamental machinery of government, can doubt the need for critical inquiry if not independent research in this field, or that such inquiry should be entrusted to an institution of the independent and academic type. The problem appears to lie outside the field of the National Institute for Social and Economic Research, and there is no obvious independent body to which its study could be entrusted.

At the outset of his first lecture, "The Decay of Political Thought", Lord Eustace Percy challenges the indifference of men of science to this problem. He insists that by neglecting it they imperil that freedom of movement, of entrance, and of experiment which they vigorously claim. Having won freedom, man cannot discard philosophy and remain free. His freedom depends upon the constant re-interpretation, in response to changing circumstances, of three fundamental affirmations: that there exists in any human society an authority entitled to over-ride the will of its individual members; that its individual members have, nevertheless, rights which this authority is not entitled to over-ride; and that both authority and individual have positive duties by the punctual performance of which alone the balance of their respective rights can be preserved. The most characteristic symptom of our intellectual failure during the last twenty-five years in Europe and in America to face the implications of freedom has, Lord Eustace suggests, been our attempt to escape from the study of government into the study of some vaguer entity called 'society'. The assumption that human society is either a self-evident entity like the human body, or has been ascertained to be an entity by investigations of its structure as thorough as those of the astronomer or the physicist, is false. Every science which is concerned with the study of individual man is a social science, in the sense that man is a gregarious animal; but in any other sense, Lord Eustace Percy claims that there is only one social science—political science; he regards 'social' medicine, 'social'

* The Unknown State: a Plea for the Study of Government. By Lord Eustace Percy. (University of Durham: Riddell Memorial Lectures.) Pp. 48. (London: Oxford University Press, 1944.) 2s. 6d. net.

biology, for example, as merely those aspects of medicine or biology of immediate concern to governments.

Political science is the study of human beings living in a particular kind of association, called a State, whereby they regulate some part of their conduct in obedience to rules enforced upon them by persons selected for that purpose, in accordance with procedures laid down beforehand. The distinguishing mark of the citizen is that he is the object of regulated compulsion to social behaviour, while the free citizen is distinguished not only by the acceptance of such compulsion but also by sharing, in greater or less degree, in its exercise. Moreover, while the historian must always remember that manhood and womanhood are more wonderful than citizenship, and that men are greater than their institutions, he must not turn truth into falsehood by supposing that they are more social than their institutions.

Lord Eustace Percy then points out that in studying the State we must face the implications of the moral contrast, because the human law of the State does not coincide with the divine law of love. The difference between Christian and civic duty is one of consistent temper rather than of occasional practice. The central assumption of English-speaking democracy is that the citizen must not only be ready to resist general social disorder; he also must think instinctively, even of offences against himself, not as personal injuries, but as threats to the safety of his neighbours. He is not entitled to forgive; and where this civic temper fails, free government breaks down.

Lord Eustace Percy's analysis up to this point shows clearly how easy is the transition from freedom to anarchy; incessant vigilance, clear thinking and a real attempt to grapple with the philosophical aspects will be imperative in addressing ourselves to the tasks of social reconstruction. The divorce of compulsion from responsibility may yet prove the factor to wreck a social security scheme or a full employment policy. Reformers, as he wisely says, can dispense with a philosophy of government only so long as the citizen feels that he is being reformed by his own consent. Once our old catchword of 'government by consent' ceases to describe the citizen's real feelings, he will turn by instinct and tradition from those who govern him to those who offer to govern him on intelligible principles for definable purposes. These principles and purposes must be religious, based upon a coherent view of what man is, of what constitutes for him a 'good life', and of the means by which it can be attained; and in this second lecture, Lord Eustace Percy outlines a Christian philosophy of government. What matters primarily is the spirit of a government and of its citizens; and the practical difficulties are considered of preserving this spirit in a reforming democracy which is also a great international Power.

The statesman, it is pointed out, must work in the medium of social circumstance. Remembering that his fundamental aim is moral improvement, he must judge the probable moral effect upon his citizens, both of law itself and of the processes by which law is made and enforced, given the character of his citizens, the texture of their social system and

the machinery of government at his command. In governing backward peoples, he must be careful not to distort, by novel constraints, the human nature which he can compel, but cannot suddenly change. Compromise is to the statesman what the scientific method is to the man of science; but in politics this scientific attitude has proved unstable.

Christian positivism, Lord Eustace Percy suggests, needs the thought and teaching of universities; their social surveys at present are providing material for the administrator, not for the statesman, and reflect the contemporary preoccupation with urgent administrative projects, from which emerges no outline of settled law. In his final lecture, he attempts to outline the practical application of his Christian positivism. Here he suggests that under modern conditions of publicity, the tendency of law to create superstitions, and, in its turn, to be itself progressively influenced by such superstitions, has become an imminent danger to the whole system of parliamentary democracy. We need, particularly now, to submit our inherited laws of personal relationships to a criticism as keen, and as closely related to the actual facts, as that which Bentham brought to bear on the inherited legal systems of his day, remembering that virtue is a more important fact than vice. The art of government lies, not in continual accretions to law as circumstances or fashions of thought seem to demand, but in those transformations of essence by which the body of the law is kept sound and is made serviceable to the good citizen.

Lord Eustace Percy refers to the point that the only interest which the law recognizes in the shareholder is that of current profit, and in passing to the problem of fitting policy to the facts, he is equally forthright in his challenge to political invention. He emphasizes the danger which lies in the identification of government with the social services, a belief in the efficacy of taxation, and in the efficiency of pure State administration. After the War, a social service policy must, at least, be one of the priorities, such as housing, and careful selection. But we must remember that a legislative minimum tends to become a social maximum, and Lord Eustace Percy hopes for the recognition of the family rather than the individual, as the unit of social reform, though it involves a reconsideration of law, a reconstruction of administration, and a regeneration of the spirit of State policy.

In conclusion, Lord Eustace Percy refers to the necessity of overcoming that disabling weakness in the local administration of Britain—the growing inability to combine State and voluntary social services. The most urgent duty of government at this time is that of mobilizing all citizens in the tasks of reconstruction. We have, moreover, to find a way of carrying out social reconstruction without turning every general election and every parliamentary debate into a competitive appeal to majority self-interest. The future task of all law and all statesmanship is to convince men of the inevitability of social change and of its inevitable effect on all lives; to draw from them, in that conviction, the 'free-will

offerings' which alone can bring us safely through such change; and to adapt law and administration fearlessly to such change. Government, like marriage, is a great adventure; but, like marriage, an adventure in the normal architecture of a common life whose temper and whose end is peace, and to both of which the temper of crisis is fatal.

It is remarkable how similar is this philosophical approach in some of its conclusions to those reached by Prof. H. J. Laski from an entirely different angle in his pamphlet, "Will Planning Restrict Freedom?"* Prof. Laski argues that planning will be required not merely to renovate the tragedies of war but also to inaugurate that era of scientific research on the threshold of which we stand; and that to give effective expression to the public context in housing and health and nutrition and education, society must plan the use of its resources in peace not less than in war. He examines the argument that in a planned society the citizens must lose that chance to experiment with themselves which is the essence of freedom. Planning, he points out, is simply the exercise of that foresight which adapts the means to the end; but planning evades the dangers of bureaucracy only when the decisions taken by the professional planners are built upon an alert and interested public opinion. A planned society requires from its citizens a higher degree of knowledge, and a far greater continuity of interest than are required in a State where *laissez-faire* obtains, and Prof. Laski quotes the experience of the Tennessee Valley Authority which D. E. Lilienthal brought out so strongly in his recent book.

Prof. Laski is thus on common ground with Lord Eustace Percy in urging that decentralization, participation, and a high level of social understanding are the essential safeguards against the danger that a planned society may degenerate into bureaucracy. Decentralization prevents the impress of uniformity in a world where variety is essential for the realization of any scheme of values; participation enables ordinary men and women to play their part in the civic process, instead of leaving their experience to be inferred by leaders. A high level of social understanding is important, first as preventing the division of any society into a small number of persons who rule and a vast multitude over whom they rule, and, secondly, because those who lack a map of the universe in which they dwell are liable to lose their way.

Our task, as Prof. Laski sees it, is to discover the institutions through which decentralization, participation, and a high level of social understanding are made generally available to ordinary men and women: and he points to three types of experience of which our historic freedom has been the outcome, and which are closely connected with these safeguards against bureaucracy: our emphasis on local self-government; our long experience of ecclesiastical self-government; and, in the last century, our experience in the trade unions and the consumers' co-operative movement. All these point to the existence of a considerable reserve of unused talent, and

it may well be that the joint industrial councils and production committees will provide a potent means of expression in the future which will facilitate that closer integration of industry with the community which is one vital aspect of our problem.

Prof. Laski's approach is more pragmatic than Lord Eustace Percy's; but the trend of thought is strikingly parallel. Prof. Laski emphasizes the necessity, in developing a system of government, of delineating clearly the responsibility for decisions and of avoiding building institutions which provide ministers and officials alike with an excuse for not taking action. Again, he insists on the need for a massive publicity over the whole field of social action, and on the danger in the assumption by a vast majority of the citizens that political responsibility is not a task in which they ought to share: they must be brought to realize that it is, on the contrary, an integral part of their civic function to shape the character of the political process into which they are born. Once again we find the recognition that, important as is high ability in politics, it is only likely to achieve its appointed aim when linked with integrity and courage.

The central issue in planning is that of eliciting the maximum possible participation of the body of citizens in the processes of politics, and reviewing measures and changes required in the transformation to a planned society. A planned society involves the acceptance of a common body of purposes by its members, and an equal response to equal demands. In saying this, Prof. Laski comes closer to Sir Ernest Barker's postulates for democratic government; and to the extent that the totalitarian State represents the spirit and temper of intransigence rather than the spirit of accommodation, Prof. Laski might dispute its claims to be a planned society. But there can be no question that in war-time the most successful administrators have been those who most fully took their subordinates into their confidence and sought both to elicit and to use the experience of those subordinates. Firms which had a tradition of good relations with the trade unions have almost invariably a better record of production than firms with a tradition of bad relations. That experience is highly relevant to the future organization of industry; for in industry as in other fields, it remains true that nothing is so important in a society which seeks to remain democratic as the ability to maintain a high interest in its problems among the body of its citizens; and nothing so promotes that high general interest as the pursuit by the community of great purposes which call for the participation of the common man.

Prof. Laski may be rather too facile in his argument, but his pamphlet stresses the essentials clearly enough, though he does not throw down the same challenge to creative thought as Lord Eustace Percy. Without such creative thought, however, we are unlikely to evolve the machinery necessary to serve the needs and purposes of a society determined to achieve the Four Freedoms, and it can at least be said that this pamphlet, like others in the same series,

* Will Planning Restrict Freedom? By Prof. Harold J. Laski. (The Planning Bogies Series.) Pp. 40. (Cheam: Architectural Press, Ltd., 1944.) 6d.

is a contribution to constructive and unprejudiced thinking about the real issues. The argument, though not the philosophy of Lord Eustace Percy's lectures, has been stated fairly enough often before. It was well put in J. MacMurray's "Constructive Democracy", for example, where not only the necessity of government in a true democracy being under effective control was urged, but also the necessity of achieving industrial democracy in order that political democracy may survive. It may be true that, as MacMurray urges, the exclusion of the economic life from the competence of the political authority does not belong to the essence of democracy. Freedom of culture is, however, of the essence of democracy, and while conferences such as those recently held by the British Association and the Association of Scientific Workers show how men of science have awakened to the social implications of their work and are increasingly ready to recognize their responsibilities as citizens, the challenge to fundamental thought about the institutions of government, untrammelled by party inhibitions or tradition, thrown down directly and by implication in these papers is one which they, no less than others, have yet to meet.

THE FRAGMENTATION OF SCIENCE

Mitosis

The Movements of Chromosomes in Cell Division. By Prof. Franz Schrader. Pp. x+110. (New York: Columbia University Press; London: Oxford University Press, 1944.). 13s. 6d. net.

TWENTY years have passed since the appearance of Wilson's "Cell", that is of the third and all-embracing 1,200-page edition of this work. We may indeed take 1925 as the end of an epoch, the epoch of comprehensive description; always painstaking, usually thorough, and sometimes otiose, description. In the end this method collapsed of its own weight and broke into pieces. Since 1925 we have been busy putting the pieces together. There are many ways of doing this, most of them unprofitable, but some of them have given new structures of a kind not previously known in biology. Such, for example, is the genography based on the union of breeding analysis, X-ray breakage and salivary gland mapping. On the purely cytological side there is also the speculative structure based on a few simple observations of meiosis in polyploid plants, a structure on which we have been able to rest all our knowledge of genetic crossing-over as well as a large part of our knowledge of chromosome mechanics at meiosis and mitosis. Other special theoretical structures are arising, or will arise, from the new experimental methods of ultra-centrifuging, X-ray breakage, ultra-violet absorption spectroscopy, micro-incineration, specific enzyme treatments, and so on.

Such are the circumstances in which Prof. Schrader, Wilson's successor, takes up his pen to continue the work. Prof. Schrader, like his predecessor, is technically equipped for his task by a long and careful study of mitosis in certain Hemiptera. Theoretically he is equipped by his understanding of the change that has come over this field of research. He values highly the power of concentration in attack which the achievements of the last twenty years have

demonstrated. His theme is mitosis, the division of the cell and the nucleus. In treating it he has taken great pains in limiting his objective and avoiding side issues. He has relegated the resting, prophase and telophase nuclei to a chapter of notes at the end of the book. He has likewise excluded the peculiarities of meiosis from his argument; and the evidence from sex-chromosome behaviour, which he himself summarized in 1928, and which a less self-denying critic might have been tempted to consider, is now grown too bulky or too awkward to take into account. The abnormalities of mitosis produced by cancer and by colchicine and X-ray treatments are sacrificed to the same economy. The uniformity of plants and the diversity of Protozoa (and here we may perhaps cavil) find no place. Genetics, chemistry and internal structure are all locked out or, one should say, thrown away, for they surely contain something of value for the study of mitosis.

After this generous clearance there is little left to distract us from the residue. This is simply the mitotic spindle and the centromere by which the chromosome is attached to this body, both of them stripped of their most significant variations. How does Prof. Schrader deal with this residue? Old-fashioned writers, like Wilson, have faced the same problem. They have first said what happened in mitosis, how it varied in Nature and could be changed in experiment, and have then drawn the conclusions and expounded the theories that seemed to combine or clarify these conditions. Schrader's method, however, is a new one. Having established the 'reality' of the spindle fibres as a basic assumption in two pages, he goes straight to general theories. The inevitably *a priori* theories of forty, fifty and sixty years ago occupy most of his attention, but the young ones also get their turn until liquid crystals and tactoids are reached. Throughout the discussion, observations and experiments appear only as the casual commentators, supporters or objectors, called in apparently to rectify the balance where some theory seems to be showing too badly or too well. For Prof. Schrader is utterly impartial. If one theory is obviously useless it is admitted to have helped in its time, and if another theory is obviously sound it is degraded to a truism or a mere exaggerated fact.

With such a tale the end would be foreseen, even if the author had not stated it on the first as well as on the last page. It is that his inquiry after the perfect and ultimate theory has failed. Mitosis is still too complicated, and the assault still too diffuse, for success. He feels "confusion", "humility", "disillusion" and a "despair" tempered only by hope that still further concentration in the attack (or, should he say, fragmentation in the objective?) may yet yield "definite promise of a final solution".

Prof. Schrader's book may seem depressing, and especially to those who know the merit of his purely descriptive work. But it is not entirely without value. It contains the lesson that while specialization in technique and material is necessary and profitable, specialization in theory, an arbitrary restriction of data, is a contradiction in itself. It is like mountaineering in manacles. That is why this book, on an immense subject, peters out into notes and trifles after seventy-five pages. In describing the past, and planning the future, of scientific theories we must consider all things before we choose to adopt or reject any of them; and in order to make that choice we must have a point of view, and perhaps even a theory, of our own. C. D. DARLINGTON.

INDEXING THE HYDROCARBONS

Faraday's Encyclopedia of Hydrocarbon Compounds
Compiled by Dr. Joseph Escott Faraday. Vol. 1:
C₁ to C₆. Pp. xxv+47+92+40+104+103. (Manchester: Chemindex, Ltd., 1945.) £7 10s. 0d.

FOR many years past organic chemists have been making and describing in detail thousands of new organic compounds: it was and is essential that a worker should know what had been done previously to his discoveries. The advent of Beilstein's handbook had a profound influence on progress when it appeared well over sixty years ago, for it enabled quick reference to the literature. Later it was supplemented by Richter, at first a private enterprise, but later taken over by the German Chemical Society, which created a considerable organization to keep it up to date. British chemical journals and *Chemical Abstracts*, like the corresponding American and German publications, have since contained a formula index on the Richter plan. Decennial indexes have been produced. Yet in spite of all, the magnitude of the task is so great that everything is decades out of date: the two long wars have contributed to the chaos. Now Dr. Faraday will make a fresh start—less ambitious, because it confines itself to the hydrocarbons, and presented in loose-leaf form so that an annual issue of new sheets will keep it up to date either by inserting new pages or substituting new matter for old.

The choice of hydrocarbons is both indicated and happy, for they stand to-day in the forefront of chemical interest as bricks for further synthesis. It is sought to give for each both a wide range of physical properties and every known method of preparation.

The first volume deals with compounds containing from one to five atoms of carbon. Its price is £7 10s., which is reasonable in regard to present-day costs, but obviously restricts possession of the book to firms and university libraries. A larger sale than has been estimated would no doubt reduce the cost, and we are inclined to recommend that it be considered an obligation on the part of all firms who make use of hydrocarbons to possess a copy. The time saved by its use can be very considerable, and every chemical unit must carry its share of the burden of producing chemical literature. Up to now this burden has been very unequally distributed and has fallen on the shoulders of far too few loyalists concerned with chemical progress.

Reference to the book is quick and easy; the sheets relating to a particular compound are numbered in order; formula and alternative names are clearly given. Taking C₅H₁₀, trimethylethylene, as an example, eighty-one methods of preparation are given on six sheets, with references to the journal in which each of these is found. The nomenclature adopted naturally follows very closely the International Rules for naming Organic Compounds.

The Germans in the past have used their hold in scientific literature to propagate the doctrine of German supremacy in chemistry which it has proved so hard to destroy, not so much among chemists, who were aware of the falsity of the claim, as among the intelligent public and the financiers in the City of London, who would often accept an invention, however incomplete or spurious, brought them by a foreigner but would rarely listen to a British inventor. These pages of our credulity must be closed for ever; British inventions are best must be our slogan. We must produce and finance our own literature and not

be afraid to proclaim our own achievements. The secrecy imposed by the censorship to-day is a blight on progress, but it is small in comparison to that imposed by firms on their doings. How many know that the first magnesium from sea water was made in Britain and not in America? Surely this was a chance to tell the world of a British achievement.

In our opinion Dr. Faraday has made a start on a project which deserves widespread support; if we fail him, then the chemical industry of Britain deserves to fail also. E. F. ARMSTRONG.

PLANT ROOT DISEASES

Root Disease Fungi

A Treatise on the Epidemiology of Soil-borne Disease in Crop Plants, and a First Exposition of the Principles of Root Disease Control. By S. D. Garrett. (*Annales Cryptogamici et Phytopathologici*, incorporating *Annales Bryologici*, edited by Dr. Frans Verdoorn, Vol. 1.) Pp. xiv+177. (Waltham, Mass.: Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1944.) 4.50 dollars.

TO the plant pathologist, at work on a root disease, there quickly comes a realization of the enormous complexity and essentially dynamic nature of his problem: the soil, its organisms, and their vagaries make a whole world. But it is a world susceptible to the methods of science, and already, in some instances at least, results based on exact observation and carefully controlled experiments have been obtained; in other instances, because of the incompleteness of experience and the insufficiency of precise data, the subject is at a more elementary stage.

As the sub-title indicates, the author has undertaken a not inconsiderable task. The many and varied aspects of root infection and of the spread of fungal pathogens in the soil have been faithfully dealt with; so, too, the effect of temperature, moisture content, texture, organic content and soil reaction upon parasitic activity are considered in detail and clearly set forth. The latter part of the book is devoted to the ascertained facts relating to the control of root-invading fungi. It may be noted that the author has not considered it within the scope of this volume to deal with the related problems of root physiology and ecology.

There can be no doubt that this work represents a close and fair review of the literature, which is extensive. As an up-to-date survey of work in a field in which he has special experience, Mr. Garrett has written a book which should be of very considerable use to all engaged on the investigation of soil-borne diseases.

Due prominence has been given to the specific conceptions of this branch of botany. The author of a work such as this is necessarily limited by the contemporary state of knowledge. Because of the extensiveness of the subject and the relatively restricted number of workers engaged on it, much of the research, on the fungi of tropical soils for example, is still at an early stage of development. Generalizations based on existing knowledge must therefore be accepted with due caution.

Since the work aims at an exposition of principles, and since the subject-matter is by its nature somewhat discursive, brief summaries at suitable points would have added to the usefulness of the book by rendering it more incisive. C. W. WARDLAW.

RELATION OF CRYSTALLOGRAPHY TO CHEMISTRY

By DR. A. F. WELLS

Research Department, Imperial Chemical Industries Limited, Manchester

IN the development of chemistry two phases can be distinguished. First there is a subdivision into more or less self-contained sections, inorganic, organic and physical—a subdivision dictated by the increasing complexity of the subject. Corresponding divisions have taken place in the other natural sciences, and the training of scientific workers has become more and more specialized. In the second phase the gulfs between the different sciences and between the branches of a particular science tend to be bridged by theories and new techniques. For example, the foundations of modern chemistry were laid when physicists investigated the passage of electricity through gases and the emission of radiation from heated bodies, studies which eventually led to the modern theory of the structure of the atom. Just as the quantum theory contributed to the development of chemistry as well as physics, so within chemistry itself the techniques of the physicist and the physical chemist are required by the inorganic and organic chemist. Thus although the various branches of chemistry have separately become more complex, they have now much in common as regards theory and technique.

In relation to chemistry the science of crystallography occupies a special position. Classical crystallography was restricted to the study of the external forms of crystals and their physical properties, though the study of crystals naturally led to speculations concerning the fine structure of matter, with the result that much of the space-group theory required in X-ray crystallography was available long before it was possible to use it. With the discovery (by physicists) of the diffraction of X-rays by crystals the whole status of crystallography was altered. From being essentially a descriptive subject, of comparatively little importance to chemistry, it gave rise to a new technique making possible the determination of the spatial arrangement of atoms. Moreover, the new structural crystallography is not limited, as was classical crystallography, to the study of well-developed crystals, for its methods may be applied to powders, to quasi-crystalline materials in which there is only partial ordering of the atoms, and even to glasses and liquids. It has become customary to describe that part of the new knowledge which is of more chemical interest as 'crystal chemistry', while 'crystal physics' embraces the study of the physical properties of crystals and their relation to internal structure. In this article I shall endeavour to show that the subject-matter of crystal chemistry is of such fundamental importance to chemistry that it must be incorporated into chemistry as an integral part of that subject.

The question of the relation of crystallography to chemistry is not only of academic interest. It is intimately concerned with the practical problem of how chemistry should be taught, and the type of training determines the mental outlook of chemists and hence the way in which the subject develops. Certain practical advantages of a knowledge of crystallography are sufficiently evident; for example, the ability to recognize crystalline forms in microchemical

analysis and to identify solid compounds by means of their refractive indexes. The recent publication of a book on the optical properties of organic crystals is a sign of the increasing attention being paid to the use of crystallographic data for such purposes. We still await a systematic compilation of morphological data such as was envisaged many years ago by T. V. Barker. Indexes of optical, morphological and X-ray data represent three ways in which crystallography can be of immediate practical value to chemists. The ability to 'think in three dimensions' and the appreciation of the relative shapes and sizes of groups of atoms are invaluable to those designing molecules of particular shapes required, for example, in modern synthetic polymer research.

We might make two generalizations about chemistry which illustrate the artificiality of separating crystal chemistry from chemistry. The first is that the chemist is chiefly interested in reactions between atoms, ions or molecules of different kinds; and the second is that so far as structural studies are concerned he deals only with finite groups of atoms. These limitations arise from the very nature of chemical methods and illustrate two essential differences between chemical and physical methods of studying a substance. The chemist studies it by changing it into something else; that is, he investigates how it reacts with other substances, the nature of the products, the mechanism of the reaction, and so on. Furthermore, he can deal only with substances in the liquid, dissolved or gaseous states, in which they exist as finite molecules or complex ions. When, therefore, an indefinitely large grouping of atoms has been formed, it can be studied only by breaking it down into smaller fragments which can then be examined by these chemical methods. The physicist, on the other hand, studies the way in which matter interacts with energy in some form or other without, in general, causing any irreversible change in composition.

In certain cases the chemist is interested in the combination of atoms of the same element, for example, when they form a finite molecule (Cl_2 , P_4 , etc.), and the determinations of the numbers of atoms in these molecules were essential to the assignment of correct atomic and molecular weights. The cohesion of such molecules in the solid and liquid states involves only interactions of a feeble sort between the electronic systems of molecules within which the primary chemical valencies of the elements are already satisfied; that is, the crystal is built up of discrete molecules held together by van der Waals bonds. There are, however, other possibilities. For example, an element may form finite molecules in solution or in the vapour state, but further combination, by means of the same kind of bonds, takes place on crystallization, giving infinite arrays of atoms as in crystalline selenium (infinite chains) or black phosphorus (infinite layers). Some elements, indeed, have two crystalline modifications, one of which is built of finite molecules and the other of infinite 'molecules', as in the case of white and black phosphorus. In yet other cases there is no stable finite molecule, as with carbon and silicon. Not only similar atoms, but also similar molecules may join together to form more complex molecules. Where the latter are finite, the reaction comes within the province of chemistry; where infinite, the polymer is a solid. Thus molecules such as Fe_2Cl_6 and Al_2Cl_6 simply represent degrees of molecular complexity intermediate between the molecules AX_3

and the infinite 'molecules' in the solids. The formation of these intermediate molecules is the exception rather than the rule. As an example of another type of combination between similar molecules we may instance the dimeric forms of certain carboxylic acids. Here the two molecules are held together by hydrogen bonds of exactly the same type as hold together the molecules in the crystal. Just as there are two ways of building up an infinite array of molecules of oxalic acid by means of hydrogen bonds (into infinite chains and layers in the two crystalline forms), so in other cases there may be two ways of uniting the molecules, to give on one hand a finite dimeric molecule and on the other the infinite array in the crystal. These examples should suffice to show that the comprehensive study of the interaction between atoms and molecules includes all cases of combination, whether the primary units be atoms or molecules of the same or of different kinds, and whether the product is a finite or an infinite grouping. We must now indicate other ways in which the study of the solid state has enlarged the scope of chemistry and contributed to our understanding of matters essentially chemical.

By enabling us to study atomic arrangement in the infinite arrays of atoms in crystals, X-ray crystallography has greatly extended the range of stereochemistry, a subject which hitherto had been restricted to the study of finite molecules and complex ions. We have already remarked that in order to study a substance by chemical methods it is necessary to use it in solution or in the vapour state, that is, to break down the extended groupings of atoms characteristic of the crystal into finite molecules or ions. Thus the information obtained from the study of the solid state is complementary to that provided by chemical methods, though the stereochemistry of finite molecules may also be studied—and with greater precision—in the crystal, for in molecular crystals the internal structure of the molecule is in general not appreciably affected by the relatively weak intermolecular forces. We may remark here that the physical methods have an important advantage, apart from their greater precision, over the chemical methods, in that they do not depend on deductions concerning the mechanisms of reactions, a complication inherent in the classical methods of studying stereochemistry. The study of crystals has had much less effect on organic than on inorganic chemistry, for a number of reasons. First, the structural units in crystals of the simpler organic compounds are generally the same finite molecules which are studied by the chemist. Second, most organic compounds are built from atoms of a small number of elements (carbon, nitrogen, oxygen, sulphur, hydrogen and the halogens), so that when the approximate disposition of bonds from these elements was known the rough configuration of quite complex molecules could be deduced. The third point is that relatively few complete crystal structure determinations of organic compounds have been made.

Inorganic chemistry, however, presents a very different picture. Not only have we to deal with a very large number of elements, but also there is the additional complication that many of them do not form molecules or complex ions amenable to study by the methods of classical stereochemistry, which required the preparation of molecules or complex ions exhibiting stereoisomerism or optical activity. Whereas, for example, the arrangement of bonds around a silicon atom had to be deduced from the

optical activity of a compound such as $(C_2H_5)(C_3H_7)Si(CH_2C_6H_5)(CH_2C_6H_4SO_3H)$, and whereas the evidence for a particular arrangement of bonds might be only the feeble optical activity of a single compound, the stereochemistry of an element is often established with certainty by the analysis of the crystal structure of a very simple compound or of the element itself. Thus the tetrahedral arrangement of the four bonds from a silicon atom is evident from the structure of the crystalline element, and the planar disposition of the four bonds formed by divalent palladium or platinum is proved by the crystal structures of the chloride ($PdCl_2$) and sulphide (PtS) respectively. Since detailed crystal structure determinations have been made of many more inorganic than organic compounds, the whole aspect of the structural side of inorganic chemistry has been changed.

The effect of studying the spatial arrangement of atoms in crystals has been much greater, however, than simply to extend the subject-matter of stereochemistry and to make its data more precise. The detailed study of bond-lengths and inter-bond angles, together with the similar information gained by the application of other physical methods such as spectroscopy and electron diffraction, has added greatly to our knowledge of the nature of the bonds between atoms. In the realm of inorganic chemistry the study of the solid state has given us knowledge of the constitutions of many large groups of compounds which could not be studied by purely chemical methods. Prior to the development of X-ray crystallography it was not possible to elucidate the structures of such groups of compounds as hydrates, silicates, etc., which exist only in the solid state, and the postulation of whole series of fictitious silicic acids is perhaps the best-known example of the result of making deductions about the constitutions of solids without having any knowledge of the atomic arrangement therein. The knowledge we have acquired of the principles underlying the structures of compounds of many types enables us to appreciate the limitations of empirical formulæ as means of expressing the constitutions of solids. For example, the compounds calcium carbonate ($CaCO_3$), silicate ($CaSiO_3$) and titanate ($CaTiO_3$) have quite different structures, the first containing discrete CO_3^{2-} ions, the second cyclic $Si_3O_6^{6-}$ ions, while the third contains no complex ions. The recognition that not only the satisfying of chemical valencies or the balancing of charges, but also geometrical factors play a part in determining the composition of a solid leads to a fuller understanding of concepts so fundamental to chemistry as the laws of chemical combination. If a substance, whether in the solid, liquid, or gaseous states, consists of stable finite molecules, then we expect to find the law of fixed proportions rigidly obeyed. Also, in the case of an ionic crystal such as sodium chloride ($NaCl$), the requirement of electrical neutrality necessitates the presence of equal numbers of sodium and chlorine ions. Although non-stoichiometric crystals can be prepared by special methods (for example, by heating a crystal of sodium chloride in sodium vapour) the departures from stoichiometric composition are very small. In the case of ferrous sulphide (FeS), however, the sulphur lattice is sufficiently rigid to tolerate the absence of some of the iron atoms, with the result that the 'FeS' phase is stable over the range 50–55.5 atomic per cent sulphur, accounting for formulæ ranging from Fe_8S_7 to $Fe_{11}S_{12}$ assigned to natural specimens of this

material. In this connexion it is interesting that ferrous sulphide is so often quoted in elementary text-books as an example of a chemical compound, and that it figured in the controversy between Proust and Berthollet over the law of fixed proportions. In 1804 Berthollet expressed the view that "the metals can combine with sulphur in very various proportions, and the combinations which are thus formed have very different properties according to their proportions: I am, in this case, again in opposition to the opinion of Proust, who asserts that by the invariable law of proportions sulphur and iron are fixed at 60:100". It would seem fortunate that these early investigators studied the system Fe-S rather than Ni-Te, for example, in which phases with all compositions ranging from NiTe to NiTe₂ are stable. Here, however, we are nearer alloys than chemical compounds; but this only serves to illustrate another point. No definite dividing line can be drawn between alloys and chemical compounds, and alloys—particularly the 'interstitial compounds' (certain hydrides, borides, carbides and nitrides)—are notable for their variable compositions.

So far we have been considering to what extent a knowledge of the arrangement of the atoms in the interior of crystals affects our outlook on chemistry. This knowledge is, however, also essential to an understanding of the properties of the surfaces of the crystal and of processes involving the formation or breakdown of the crystal. Reactions involving a solid phase must start at the surface of the solid, and such reactions are of particular interest both theoretically and practically. The oxidation of a solid metal was one of the first reactions studied quantitatively (the increase in weight of metallic tin on oxidation was recorded by Jean Rey in 1630); but the investigation of the mechanisms of such processes is difficult, and it is only recently that much progress has been made in this field. For example, the results of studying the dependence on oxygen pressure of the semi-conductivity of oxides such as cuprous oxide and zinc oxide, and of the rates of oxidation of the corresponding metals, suggest that these phenomena are closely related. In the case of the oxidation of ferrous oxide (FeO) through Fe₃O₄ to Fe₂O₃, we can now give some sort of physical picture of the process on the atomic scale. The activity of many surfaces is well known and is made use of in a variety of ways. The properties of a surface must be accounted for, not only in terms of the properties of the individual atoms or molecules composing the surface, but also of the atomic structure of the surface, that is, the actual arrangement of atoms in the surface and the difference between the environment of a surface atom and a similar one in the interior of the crystal. The phenomena of crystal growth—the development of different habits from different solvents, the effects of impurities on the habits of crystals and more generally of the form in which a solid separates from solution, whether crystalline or colloidal—all these are associated with the properties of atoms in surfaces and with the way in which the solute interacts with the solvent. The solubility of one substance in another is evidence of interaction between the two substances, and this may be of various kinds. For example, the interaction between molecules of naphthalene and benzene or between stannic iodide and carbon disulphide is quite different from that between, say, resorcinol and water.

The term 'soluble' is loosely used in various senses in chemistry; for example, when it is said that

sodium chloride is soluble in water, ferric chloride in pyridine, mercuric iodide in a solution of potassium iodide or finally a metal in an acid. Even when no obvious chemical reaction takes place, there may be important alterations in the constitution of the solute. Thus in solid ferric chloride there are infinite groupings of iron and chlorine atoms in which every iron atom is surrounded by six chlorine atoms. If this compound is dissolved in carbon disulphide, it forms molecules of Fe₂Cl₆, as it does in the vapour at temperatures below 750° C., but in solution in pyridine the condensation 2FeCl₃ → Fe₂Cl₆ is prevented by the linking of a pyridine molecule to each iron atom. Thus in these various cases we find that 'ferric chloride' exists in quite different forms with iron atoms bonded to 6, 4 and 3 chlorine atoms respectively.

There is much more to be known about a compound, therefore, than the mode of preparation and its chemical properties. It has a structural chemistry of its own if we include within the province of structural chemistry the relations between the constitution of a substance in different states of aggregation. Finally we may mention the interpretation of data concerning processes which involve the formation or breakdown of crystals. The analysis of data such as heats of fusion, sublimation and crystallization calls for a knowledge of the actual processes taking place when the crystal melts, vapourizes or is built up, in terms of the nature and numbers of bonds broken or formed.

In conclusion, we would suggest that there is no longer any justification for drawing a dividing line between finite and infinite arrangements of atoms, and regarding the study of the former as constituting chemistry and of the latter crystal chemistry. The chemist has concerned himself exclusively with finite groups of atoms because he must break down the infinite groups of atoms in crystals before he can apply his chemical methods to them. The tendency to regard all compounds as existing in the form of finite molecules arose quite naturally from the study of gases, which necessarily exist in this form, and from the intensive study of organic chemistry, which is concerned with substances existing for the most part as finite molecules in all states of aggregation. If the study of atomic arrangement in the solid state had become possible at an earlier stage, the scope of chemistry would not have been limited in the ways we have been discussing. We have seen that as regards inorganic compounds, although it is true that some crystals may be broken down and reformed reversibly (for example, simple salts), while with others the breakdown of the crystal destroys the chemical identity of the compound (as in the case of silicates), yet in all cases there is a wealth of information which can be gained only by studying the infinite arrays of atoms which constitute the solid compounds. Similarly, the fact that the molecules which exist in a crystal of glycine may be studied in solution is no reason for neglecting to study the way in which they are held together in the solid state. In the attack on the structures of substances of increasing complexity, from the large finite molecules such as globular proteins and viruses to the infinite 'molecules' of fibres, natural and synthetic, the chemist must rely more and more on the crystallographer. When building up a chain step by step (for example, 2CH₃I + 2Na → C₂H₆ + 2NaI) the chemist could deduce the constitution of the product. When, however, he polymerizes simple aliphatic compounds to polymers of high molecular weight, for example, ethylene to

polythene, he can no longer determine the structures of his solid products and must rely on the X-ray crystallographer to tell him what he has made. The old chemical methods of synthesis and degradation give only limited information about the structural units, and to discover how they were originally linked together is not always within their power.

COMMENTS ON CHROMOSOME STRUCTURE

By DR. I. MANTON
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WHEN a great physicist takes the trouble to explain in simple language some of his matured thoughts on topics of general interest outside his own subject, it is an event for which one cannot be too grateful. The following remarks have been aroused by the appreciative perusal of Prof. E. Schroedinger's delightful little book "What is Life?"¹

Without attempting to summarize the whole of Prof. Schroedinger's argument, it is valuable to notice the great stress which is laid on the existence of two very different methods of obtaining orderly behaviour of matter in Nature. In the inanimate world 'order from disorder' is said to be the rule; the behaviour of matter in bulk being in most cases the expression of a statistical average of the behaviour of vast numbers of particles (atoms, molecules or the like) which, individually, may be doing the most diverse things under the sole compulsion of a tendency towards increased randomness. In biological systems, on the other hand, 'order from order' is met with. In such a system the most complex sequence of events may be determined and set in motion by the pattern of arrangement in space of a comparatively minute number of individual particles occupying relatively fixed positions with regard to one another. The paramount importance of the pattern of atomic arrangement in the particular case of the genetical material carried by the chromosomes is, in Prof. Schroedinger's view, the most interesting discovery of our time.

Few biologists will probably wish to dispute this in general terms. Cytological comment is, however, aroused by the details of its presentation from the circumstance that Prof. Schroedinger, at various points, is thinking in terms of certain assumptions regarding chromosome structure which are by no means universally held. It may therefore be of interest to inquire what change of view, if any, will be entailed if these assumptions are altered.

Prof. Schroedinger is much impressed by the singleness of the 'code script' in inheritance, by code script meaning the sum of hereditary material carried by a haploid nucleus (in genetical parlance this would be referred to as a genome). That only one chromosome set or genome is actually necessary for development is clearly shown by the existence of haploid organisms, for example, many of the lower plants, or cases of parthenogenesis in both plants and animals; it is therefore quite legitimate to ignore diploidy and polyploidy. Difficulties, however, appear at once if 'singleness' is interpreted literally in a molecular sense, and that this is Prof. Schroedinger's interpretation seems clear from his very interesting discussion of the size of a gene.

It might perhaps be questioned whether the 'size of a gene' is a desirable or legitimate use of words. In its original sense a 'gene' meant nothing more than the physical basis of an externally visible mutation, and if a mutation can be caused, as Prof. Schroedinger suggests, by a change of atomic arrangement, of the nature of a quantum jump, occurring within a molecule, then a gene, strictly speaking, is the changed part of that molecule and nothing else. It is an unfortunate biological practice which Prof. Schroedinger cannot be personally blamed for following, that the word is now often used in so many extended senses that it has little precise meaning left. In discussing the maximum size of a 'gene' from genetical data, the word denotes either the smallest piece of a chromosome which can have a genetically detectable effect, or the shortest distance between two mutations which can be separated by crossing-over; a numerical estimate of either of these by existing genetical or cytological methods may be expected to yield purely subjective values expressing present crudities of technique. In discussing the minimum size of a 'gene' as deduced from induction of mutations by ionizing radiations, the word is apparently equated with the range of influence of the minimum degree of ionization required to induce a mutation. The thing that Prof. Schroedinger really wishes to discuss is the fundamental molecular unit of chromosome structure, which is not necessarily identical with any of these concepts. The use of the word gene for this also may seem particularly unfortunate to a cytologist because some idea of structural discontinuity is almost inevitably implied. Mutations are discontinuous and arranged in linear sequence along a chromosome. Whether the fundamental genetical material in which the mutations occur is or is not also discontinuous (like beads on a string) is quite another question and one which neither cytology nor genetics can yet determine. This linguistic difficulty would perhaps best be met if the word gene were deleted from the vocabulary; one of the most pregnant of Prof. Schroedinger's sentences could then be paraphrased as—"We believe a mutation to be of the nature of a quantum jump and the fundamental unit of chromosome structure—or perhaps the whole chromosome fibre—to be an aperiodic solid".

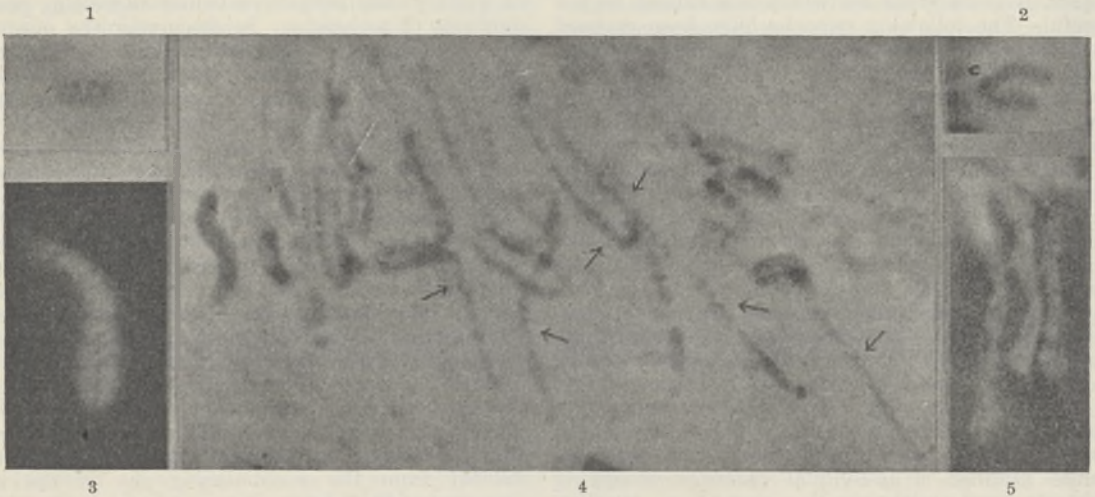
At this point the sense in which the "whole chromosome fibre" can be regarded as a unit becomes of importance. There are at present two extreme views as to this, both supported by some positive evidence. According to the one which Prof. Schroedinger is using, the whole chromosome thread is a single structure at all times, except for a limited period during prophase when it is doubled in preparation for a nuclear division. The strongest piece of evidence in support of this is the differential behaviour of certain nuclear stages to irradiation by X-rays at dosages sufficient to cause gross chromosome fracture. Assuming that the statements in the literature are correct (for example, Riley 1936²) the position appears to be that in some organisms such as *Tradescantia*³, irradiation at prophase can cause fracture of half-chromosomes (chromatid breaks) but at other stages only breakage of whole chromosomes. In interpreting this as meaning that the chromosome thread is single at all stages other than prophase it is not always realized that this singleness could be conferred by spiral structure and is not necessarily based on singleness of the genetical material.

The spiral structure of chromosomes (or perhaps more correctly the helical structure, since the geo-

metrical figure involved would, in mathematics, be termed a helix) is probably not as widely known to scientific workers in general as its importance deserves and it is still far from being fully understood even by cytologists. That the apparent diameter of a fully developed chromosome is that of a helical coil has been known since 1880⁴ for meiotic chromosomes, though owing to technical difficulty the basic facts for mitotic chromosomes have only recently been elucidated. Examples of the structure, as revealed by special treatment or in rare instances spontaneously, are shown in Figs. 1-4 for the different sorts of division in the fern *Osmunda*. Fig. 1 shows an unpaired chromosome at the first meiotic division, with four large coils. At this stage all cytologists are agreed that the genetical material is double in preparation for the second meiotic division and that in a paired chromosome genetical crossing-over between chromatids (half-chromosomes) has taken place; both chromatids, however, share a common spiral path. At

single spiral in certain of the chromosomes is perhaps also an after-effect of the irradiation, but it accords very fully with the other evidence.

The other extreme view of chromosome structure, which is becoming increasingly accepted in the U.S.S.R. and the U.S.A. and (before the War) in Japan, though in Great Britain it has been somewhat opposed, is that a chromosome is fundamentally many-stranded at all stages. If the physical basis of unitary behaviour of chromosome or chromatid can in part at least be interpreted in terms of helical structure rather than molecular structure then perhaps the chief objection to this view has been removed. An example of the type of observational evidence on which the view is based is contained in Fig. 5⁶. The specimen here is at a later stage of anaphase than that of Fig. 4 and had not been subjected to X-rays. Instead it had been given the normal pretreatment with ammoniated alcohol which is generally necessary to make the spiral appear.



- Fig. 1. Unpaired chromosome of *Osmunda* at the first meiotic division after ammonia treatment for spiral structure. Acetocarmine preparation photographed in clove oil by visual light. ($\times 2000$.)
- Fig. 2. Split chromosome at the second meiotic division in *Osmunda* after ammonia treatment for spiral structure, the two chromatids are attached only at the centromere (c). Acetocarmine preparation, ultra-violet photograph. ($\times 2000$.)
- Fig. 3. Split chromosome at metaphase of the third spore division in *Osmunda* showing spiral structure without special treatment. Acetocarmine preparation, ultra-violet photograph ($\times 4000$) negative print (the positive of this and others in Manton and Smiles, 1943⁶).
- Fig. 4. Anaphase of the first spore division in *Osmunda* fixed 30 hours after irradiation of the uninucleate spore with X-rays at 2,500 r. showing fractures, fusions and abnormally clear spiral structure. Acetocarmine preparation, visual light photograph. ($\times 1000$.)
- Fig. 5. Anaphase of the third spore division in *Todea* after ammonia treatment, showing lateral separation of component strands. Acetocarmine preparation, ultra-violet photograph ($\times 4000$), negative print (the positive of this and other chromosomes in Manton, 1945⁶).

the second meiotic division, Fig. 2, the two chromatids diverge so widely that they are only in contact at the region known as the centromere (marked c in the figure). A new spiral, differing in diameter and in number of coils from that at the previous division, affects each chromatid. At a somatic division, Fig. 3, the number of coils is increased still further but the two chromatids lie close together. It is, however, certain that the spiral in each has been independently formed for, in the case figured, direction of coiling was determined in corresponding parts of the sister chromatids and found to be opposite⁵. There must therefore be two separate spirals during prophase and it is possibly this which is detected by the X-ray breakages. At anaphase one of the two spirals passes to each pole, and that the helical coil at anaphase is indeed single seems to follow from the unusually clear case of Fig. 4. This differs from the preceding in that it had been subjected to X-rays some hours previously and many types of fusion and fracture are displayed. The unusual clarity of the undoubtedly

The plant concerned is, however, not *Osmunda* but the closely related fern *Todea*, and the pretreatment and method of mounting acting together have in this case produced a remarkable lateral separation of longitudinally running strands. No less than four strands per chromosome are unmistakably present, most clearly countable, in the original print, in the left-most chromosome. With the detection of quarter-chromosomes the limit of optical resolution has been reached, even with light of short wave-length; but it is by no means impossible that further subdivision would be found to be present if resolution could be extended.

It is not easy to determine the diameter of an object near the limit of visibility, but the fact that quarter-chromosomes are visible at all suggests that their thickness is likely to be of the same order as the wave-length of the light used ($275 \mu\mu$). In round numbers and for the sake of argument this may be put as approximately 3000 A. Now if Prof. Schroedinger's figures for the 'size of a gene' be utilized,

some simple arithmetic will provide a rough estimate of the possible limits of many-strandedness assuming this to exist. The higher limit for the 'size of a gene' is given as 300 A. and there would therefore be room in a quarter chromosome of *Todea* for some 75 threads of this width. The lower limit of size is given as 'ten atomic distances cubed' which, for a protein molecule, might perhaps be put as of the order of 50 A. cubed. There is room in a quarter chromosome of *Todea* for nearly three thousand threads of diameter 50 A. The real unit of chromosome structure is likely to lie in between these two extremes and it is probable that allowance must also be made for some empty spaces between the strands. Nevertheless the figures, rough as they are, indicate at least the possibility that in a whole chromosome, not one but between 300 and 12,000 duplicate versions of the genetical material may be present.

This is not quite the same as the unique phenomenon visualized by Prof. Schrodinger, though it is no doubt sufficiently close to it still to come under the general heading of 'order from order' rather than 'order from disorder'. The importance attributed to atomic arrangement in the 'aperiodic solid' of the unit fibre is almost certainly correct, and this property is shared by many other protoplasmic structures besides the chromosomes, notably by enzymes. If the view of chromosome structure put forward above be correct, however, a chromosome may be found to owe some of its peculiar powers not to the aperiodic fibre as such but to the fact that bundles of these are co-ordinated together in a manner recalling, though not necessarily exactly resembling, the periodic crystals. The 'whole chromosome fibre' may in fact have to be visualized as an aperiodic solid in its longitudinal dimension but as periodic in its transverse dimension.

The recognition of an element of periodic structure in one dimension of the genetical material would perhaps be a minor emendation in the general philosophic view of a chromosome. The issues raised are, however, of immediate importance in cytology, and I trust that Prof. Schrodinger will forgive me if I have used his very interesting little book as an occasion for directing attention to them.

¹ Schrodinger, E., "What is Life? The Physical Aspects of the Living Cell" (Cambridge, 1944).

² Riley, H. P., *Cytologia*, 7, 139 (1930).

³ Catcheside, D. G., *Biol. Rev.*, 20, 14 (1945) (a recent summary received since the above was written differs somewhat).

⁴ Baranetzky, J., *Bot. Zeit.*, 38, 241 (1880).

⁵ Manton, I., and Smiles, J., *Ann. Bot.*, New Series, 7, 195 (1943).

⁶ Manton, I., *Amer. J. Bot.*, in the press (1945).

ALESSANDRO VOLTA, 1745-1827

By ENG.-CAPT. EDGAR C. SMITH, O.B.E.

TO few men of science has more homage been paid than to the Italian physicist Alessandro Volta. In his life-time he was received into the highest scientific circles, and the centenary of his most important discovery and the centenary of his death were the occasions of great international gatherings in the land of his birth. Since then, through the munificence of Signor Somani, Como, where Volta was born and where he died, has been enriched with a beautiful Volta Temple, a finely designed circular hall surmounted by a dome. This interesting building stands in the public gardens near

the edge of a lake in Como, from which can be seen the waters, the fields and woods and the mountains amidst which Volta grew up, a student and a sportsman. For centuries the family from which he sprang had been associated with the district, and its coat-of-arms consisted of a vault (in Italian, *volta*) of a silver gate on a blue background.

Volta was born on February 18, two hundred years ago, being the son of Philip and Madeleine, descendants of the family of the Counts Inzaghi. Well educated under the supervision of an uncle, Volta began experimenting in electricity as a youth, and electricity remained his one and only love. Thanks to the invention of friction electric machines and the Leyden jar, and to Franklin's epoch-making discoveries, there were scores of devotees to the study of electricity, and during the eighteenth century thousands of new experiments were performed and a mass of observations full of promise was accumulated. In the last year of the century, it fell to Volta to make one of the most fruitful inventions in the history of science. As a young man, he corresponded with such able experimenters as Giovanni Battista Beccaria (1716-81) and the Abbé Nollet (1700-70), and in 1769, at the age of twenty-four, published his first paper. In 1774 he became superintendent of schools in Como, in 1776 professor of physics there, and in 1778 professor of experimental physics in the University of Pavia, which remained his headquarters for the rest of his active career. Those early years had been marked by the invention of his electrophorus, and the suggestion of a method of long-distance signalling by electricity. But more important in his own development were his travels, during which he made a host of friends and acquaintances, and, especially in Great Britain, became familiar with the leaders in scientific thought. In 1777 his journeys took him to Germany and Switzerland, during which he met a kindred spirit in de Saussure; in 1781 he went as far afield as Belgium, Holland, France and England; and in 1782 he was in England again, and then went to Austria. In England he admired the pavements of London, the steam engines in Shropshire, and the mills at Manchester; at Portsmouth he visited the fleet under Admiral Howe. He became known to Franklin, Watt, Priestley, Laplace, Lavoisier, Van Marum and many other famous leaders in science.

Living in London at that time was Volta's countryman Tiberias Cavallo, who had come here to follow a commercial career but had succumbed to the fascination of sparks and discharges, and had published "A Complete Treatise of Electricity". To Cavallo, Volta in 1793 addressed two letters which appeared in the *Philosophical Transactions* under the heading "Account of Some Discoveries made by Mr. Galvani of Bologna, with Experiments and Observations on Them". Behind this title lay a long series of trials with metals and the nerves of not only frogs, but also of quadrupeds, birds, fishes, reptiles and amphibia. Desiring to experiment on the human body, he used a piece of tinfoil and a silver spoon separated by his tongue, thus introducing an experiment which untold numbers have repeated.

In 1791 he had been made a foreign member of the Royal Society, and the Society now proceeded to honour him with the Copley Medal, Sir Joseph Banks in his address remarking, "The experiments of Professor Galvani, until commented upon by Professor Volta, had too much astonished, and perhaps, in some degree, perplexed many of the learned in various parts

of Europe. To Professor Volta was reserved the merit of bringing his countryman's experiments to the test of sound reasoning and accurate investigation. . . .” Just at that time Europe was in the early throes of one of her periodical upheavals, and it was partly this which had led Volta to send his memoir to London.

Seven years later came a much more important paper in the form of a letter of 8,500 words in French to Sir Joseph Banks, which ultimately appeared in the *Philosophical Transactions* under the title “On the Electricity Excited by the Mere Contact of Conducting Substances of Different Kinds”. The effect of this communication was as startling as the announcement of Röntgen's discovery of fifty years ago. The whole scientific world became agog with galvanic piles, batteries, ‘crowns of cups’ and so forth. For the first time electricity could be obtained in steady and continuous currents, and so was marked an era in electrical science. The fellows of the Royal Society having been enlightened, the members of the Royal Institution, just founded, of course had to be told; but unfortunately Dr. Garnett, not long engaged as ‘lecturer and scientific secretary and Editor of the Journals’, made a slip and ascribed the invention of the pile to the French; Rumford heard of this, and on May 29, 1800, wrote to Banks: “I knew nothing of the matter until it was too late to prevent a mistake. I have, however, insisted on its being rectified as far as it is possible in some future lecture. . . .” Next day he wrote again that Dr. Garnett is perfectly ready to atone for his lapse and will make this declaration: “Having by mistake on Wednesday, in the course of my public lecture, ascribed to the French philosophers a new and important discovery relative to galvanism, which on inquiry I find belongs to Professor Volta of Milan, I feel it my duty . . .”

The old records are eloquent of the enthusiasm about the new apparatus, and fifty years later J. D. Forbes wrote: “The invention of the pile may in many respects be placed on a par with that of the steam engine. The results of the former were indeed more interesting immediately to pure science, the latter to the arts of life and the needs of civilization. Yet after half a century, this distinction can hardly be drawn with severity. The rapid pace of steam is insufficient for our needs. The electric wire conveys to its destination, ere the locomotive has time to start on its journey, tidings of joy and sorrow—life and death—of victories won, and kingdoms lost.”

In the last year of the dying century, Volta was at the height of his career, a conqueror of Nature. In his native land was another conqueror, Napoleon, who in June won the battle of Marengo and so became master of northern Italy. Next year the two met in Paris. On November 11, 1801, Count Rumford wrote to Sir Joseph Banks, “At the last meeting of the mathematical and physical class [of the National Institute] the First Consul came in. . . . He stayed about an hour—till the meeting was over. Volta read a paper on Galvanism and explained his theory of the action of the voltaic pile or battery. . . . After Volta had finished his memoir the First Consul demanded leave from the President to speak, which being granted, he proposed to the meeting to reward M. Volta with a gold medal, and to appoint a committee to confer with M. Volta on the subject of his experiments and investigations respecting galvanism, and to make such new experiments as may bid fair to lead to further discoveries. He delivered his sentiments with great perspicacity and

displayed a degree of eloquence which surprised me. . . .” Volta eventually got his medal and also a sum of money, and was elected a member of the Institute. Later, he became a senator of the Kingdom of Lombardy and a Count, but the world of science was enriched by no more discoveries by him.

Volta continued to work quietly at Pavia until 1819, when after acting as director of the Philosophical Faculty of the University for four years, he retired to his beloved Como, where he died on March 5, 1827, at the age of eighty-two. Up to the age of forty-nine he had remained a bachelor; then he married Teresa Pellegrini, by whom he had three sons. His grave and monument are at Como, where at the great Exhibition held in honour of his memory in 1899 a fire destroyed a great deal of his original apparatus.

One of the best recent accounts of Volta and his work is contained in illustrated articles by Mr. Frank Walker in *Engineering* of January 1938.

CORROSION OF METALS IN SOIL

THE corrosion of metals buried underground is a problem of very considerable importance; it is one also of great complexity. In 1922 experiments were initiated by the U.S. National Bureau of Standards to determine the effects of various soils on materials in general use for pipes buried in the ground. From time to time reports have been issued summarizing the results obtained as the work progressed; a report has now appeared dealing with an investigation begun in 1932 to study the corrosion-resistance of both ferrous and non-ferrous materials and the effect of applying improved protective coatings*.

No attempt was made to obtain series of specimens differing step-wise from each other. Manufacturers were invited to submit specimens which they believed or hoped would be resistant. Hence the various samples differed in so many ways that co-ordination of the results is a matter of extreme difficulty. The authors have themselves realized this, and deal with their data in a thoroughly sound and logical manner. They give warning that the results must be interpreted with care partly in consequence of the difficulty of obtaining satisfactory ‘repeat’ results, and also because the experimental conditions were not identical with those to which pipes would probably be subjected in practice. This latter point is particularly true when protective coatings are applied, because small laboratory specimens can be more carefully coated and handled with greater care than is possible in practice. As a result, when the authors attempt to arrive at a general conclusion of importance, it is so whittled down with exceptions and provisos as to be of disappointingly limited value. Although the detailed results will be of great value to the manufacturers who supplied the materials and upon whose behalf the research was, of course, mainly carried out, it is obviously the general conclusions that will appeal most to European readers.

Fifteen different soils were chosen, including several clays and loams, peat, muck and cinders.

* Soil-Corrosion Studies, 1941: Ferrous and Non-Ferrous Corrosion-Resistant Materials and Non-bituminous Coatings. By Kirk H. Logan and Melvin Romanoff. *Journal of Research*, Nat. Bur. Stand., 33, No. 3 (1944).

Important factors mentioned are the texture of the soils, their retentiveness of water, pH values and water-soluble contents. The pH values of the soils chosen ranged from 2.6 in Rifle peat to 9.4 in Merced silt loam, thus covering the ambit of soils in general.

The reasons why pipes in some soils corrode more rapidly than in others have not as yet been fully determined. Soil solutions are often too weak to account directly for the observed corrosion, but the electric conductivity of soils containing soluble salts is important. Soil bacteria may also play a part. Differences of potential between various points on the surface of the material are a fruitful source of trouble; these may be due to many causes, including the presence of scale, segregations and variations in the soil itself in contact with the material in different places.

Eight cast irons were tested, including one high-alloy cast iron with 2.61 per cent chromium and 15.0 per cent nickel. The results of exposures for two, five, seven and nine years are compared, and the superiority of the high-alloy metal demonstrated both as regards loss in weight and depth of pitting. The plain and low-alloy cast irons (c. 0.5 per cent copper) with silicon ranging from 0.95 to 2.50 per cent behaved very much alike.

An interesting experiment consisted in embedding two different plain cast irons in contact in very wet Docas clay, the water-soluble material of which was almost entirely sodium chloride. At first one of the cast irons was cathodic to the other; but after considerable drying of the soil a reversal took place, the cathodic metal now becoming anodic. This illustrates the importance of such factors as soil aeration and water-retentiveness, as also the difficulty of forecasting results in practice in view of seasonal variations in rainfall and drought.

For many years attempts have been made to increase the resistance of steel to corrosion by alloying with different elements such as chromium, nickel and copper. In the present research, cleaned 5 per cent chromium steel, after various periods of exposure up to nine years in ten different soils, lost less in weight than ordinary steel but was more deeply pitted. Many investigators have already directed attention to this behaviour of chromium steels under quite other conditions of corrosion. The authors attribute it to formation of a protective superficial oxide film which breaks down locally, setting up potential differences leading to localized corrosion. This is a generally accepted view. On the other hand, cleaned nickel-copper steel (2.47 per cent nickel, 1.08 per cent copper) proved superior to ordinary steel both as judged by loss in weight and depth of pitting, whereas the same steels exposed with adherent scale showed no advantage after four years.

Turning now to the non-ferrous metals, a useful table is given summarizing the losses in weight sustained by nine copper alloys relatively to that of tough pitch copper taken as 100. This latter metal was very resistant to corrosion, as was also red brass (14.8 per cent zinc) and copper-nickel alloy (5 per cent zinc, 20.0 per cent nickel). The zinc content of the brasses included in this set ranged from 14.8 to 39.6 per cent (Muntz metal), and the apparent losses in weight rose steadily with the zinc content. It is pointed out, however, that in some cases the observed losses do not accurately indicate the extent of corrosion, since part of the zinc had been removed by selective corrosion which weakened the material. The observed depth of pitting also

might be misleading as in some soils dezincification occurred, the depth of which was not known. The addition of 0.08 per cent arsenic to Muntz metal did not prevent dezincification, but the authors suggest that more arsenic might yield better results.

It was noted that, in general, soils that are severely corrosive to iron may be non-corrosive to lead, the exceptions being highly organic soils. This is attributed in part to the formation on the metal surface of insoluble salts, such as sulphate, chloride or carbonate, which protect the underlying metal from attack. Organic salts, on the other hand, are usually soluble. The addition of 5 per cent antimony did not materially improve the resistance of the lead.

Copper tubes coated with a thin layer of tin appeared to receive a temporary protection, but in the course of four years much of the tin disappeared. Reversal of potential is suggested as a cause of failure, the tin being anodic and protecting the copper just as zinc protects galvanized iron. But reversal might be caused by the presence of tin-copper alloys which are cathodic.

Experiments with lead-coated steel pipes were not encouraging; the authors doubt if a lead coat of any reasonable thickness can be satisfactory in corrosive soils. On the other hand, zinc applied by the hot-dip method to the extent of some 3 oz. per sq. ft. increased resistance to corrosion; it is concluded, however, that it would not add more than four years to the life of the pipe.

Vitreous enamel, rubber coatings, a thick moulded coating of China wood oil with mica, and a baked-on 'Bakelite' coating were each found to reduce corrosion substantially over periods of from four to nine years.

It is impossible in a brief article to do full justice to the mass of data contained in the report. The foregoing is an attempt to lay before the reader the salient features of the research.

J. NEWTON FRIEND.

OBITUARY

President Roosevelt

NOT since Abraham Lincoln was assassinated at the moment of victory eighty years ago has the death of an American president shocked the world like the passing of Franklin Delano Roosevelt on April 12, at the age of sixty-three.

Over the success and achievements of the New Deal policy which Mr. Roosevelt initiated when he entered on his first term of office as president in 1933 there is still much controversy. The policy had its faults; but, comprising economies in the public service, plans for unemployment relief, public works enterprise on a large scale, and schemes for the rehabilitation of agriculture, with the accompanying National Industrial Recovery Act, which authorized the President to frame a code of regulations for each industry, and the further legislation passed during 1934 and the first part of 1935 dealing with currency, tariff, public utilities and taxation questions, and the Social Security Act in which, for the first time, the United States accepted the principle of national unemployment insurance and old-age pensions, it nevertheless was a landmark in American history.

The full extent of Mr. Roosevelt's contribution in the New Deal policy cannot perhaps be accurately assessed as yet, though the bitterness of the personal attacks on the President made by its opponents and the determination with which he himself supported

it in the face of the judgment of the Supreme Court in May 1935 invalidating the Industrial Recovery Act and later decisions which similarly declared unconstitutional several minor but important features of the New Deal indicate that the policy owed much to the impress of his forward-looking mind. Already in the achievements of the Tennessee Valley Authority that outlook has been vindicated, and the possibility of a new and more positive conception of government demonstrated to the world. That experiment was not only a social venture but also, in a true sense, a scientific approach to the problem of the conservation and development of national resources, and the integration of local and regional administration with central government. It is an approach of exactly the same order as that which characterizes the report of the Committee on Administrative Management with which Mr. Roosevelt's name is also associated. That great State paper and the Tennessee Valley Authority are sufficient evidence of Mr. Roosevelt's appreciation of the importance of a scientific approach to the problems of government and planning, and when the dust of controversy settles down it may well be found that scientific workers have a special reason to hold Mr. Roosevelt's name in remembrance for the way in which his determination and vision made possible a more effective contribution of science to the service of mankind, while at the same time his sense of human values never allowed that contribution to be overstressed.

While his well-known physical disability may well have increased Roosevelt's sympathy for and understanding of the less privileged people of his country, his forward-looking mind led him to seek further ways of overcoming it. In his 'fireside talks' he utilized the new technique of broadcasting with skill and success and was able not only to overcome the obstruction of Congress to measures which he regarded as essential and urgent but also to win a place in the mind of the ordinary citizen of all lands as the moral champion of freedom and human rights against tyranny and aggression. He was one of the earliest, even amid his preoccupation with the New Deal, to sense and give expression to the seriousness of that challenge to liberty, and the skill with which he used his broadcasting technique and endeavoured to express rather than lead public opinion during the first few months of the War was an important factor in securing endorsement of such successive acts in support of Great Britain and the cause for which the United Nations now stand as the setting up of a permanent joint board to consider plans for the defence of the United States and Canada, the transfer of over-age American destroyers to the Royal Navy and the lease of naval and air bases in British North America to the United States, and his great personal triumph in re-election for a third time in November 1940.

In the following year down to the Japanese attack on Pearl Harbour, Mr. Roosevelt's genius for timing was even more strikingly manifested, and the British people, and indeed the United Nations, can never forget the consummate skill with which he handled such matters as Lend-Lease, the establishment of air bases in Greenland, the dispatch of American forces to Iceland, and the amendment of the Neutrality Act. Much, no doubt, was due to the skill with which the President in his broadcast addresses and speeches voiced the aspirations of the common man and showed the way in which his policy tended to satisfy them. Even before the Atlantic Charter was drafted,

Mr. Roosevelt had showed a gift for the right and effective phrase which put some of his speeches, like those on the four freedoms and on the arsenal of democracy, alongside the Gettysburg speech of Lincoln in the literature of democracy.

On Roosevelt as a war leader the time for judgment has not yet come. Imagination has seized on the way in which this crippled leader has flown across the world to attend one conference after another. Within these years, moreover, he saw the establishment not merely of such joint agencies as the Anglo-American Combined Raw Materials Board and the corresponding Food Board, the Middle East Supply Centre, the Anglo-American Caribbean Commission, the post-war implications of which the President was one of the first to see, but also the inauguration of such definite organizations to deal with post-war problems as U.N.R.R.A. and the Food and Agricultural Organization.

It was these perhaps and the tentative scheme worked out at Dumbarton Oaks, considered further at Yalta, and now to be discussed at the San Francisco Conference that lay nearest his heart. While he did not live to see the moment of complete victory, he lived long enough to see it close at hand and to know that so far as such victory, complete, comparatively cheap, and dramatic could justify his choice of commanders, his judgment and courage have been fully vindicated. But if Mr. Roosevelt was an organizer of victory it is as one of the great architects of human liberty that he will be best remembered. We cannot measure yet what his passing may mean in inspiration and authority just as the foundations of the new world order he has done so much to plan are to be laid. Among the makers of America he will rank with Washington, Jefferson, Jackson, Lincoln and Wilson. But more almost than any of his predecessors he had the confidence of the common man, and the common man, looking back, while endorsing the verdict of the man of science that he gave science a wider opportunity to serve mankind, may well come to regard him above all as the architect of a world order in which the four freedoms are at last enshrined. Roosevelt himself would ask no more of his countrymen or of the United Nations than that they should continue to accomplish thoroughly this task to which he—and they—have set their hands. Gratitude to Britain's friend in her finest and darkest hour demands no less. "We have learnt," said Mr. Roosevelt in his Fourth Inaugural, "that we cannot live alone, at peace; that our own well-being is dependent on the well-being of other nations—far away. . . . We have learnt to be citizens of the world, members of the human community." His infinite patience and tact and the inexorable march of events have committed the people of the United States overwhelmingly to joining some form of world organization. In a true sense he has given the world the tools and the opportunity to build again. There can be no more fitting tribute to his memory than to finish the job and to secure that the structure is adequate to the purpose to which it is dedicated.

But no tribute to President Roosevelt would be complete without reference to the help he received throughout his career from his wife, whom he married in 1905, Anna Eleanor Roosevelt, a niece of Theodore Roosevelt. To her and her four sons and daughter will be extended the heartfelt sympathy of the British people, many of whom have reason to know how nobly Mrs. Roosevelt seconded the President's efforts to aid them when they stood almost alone.



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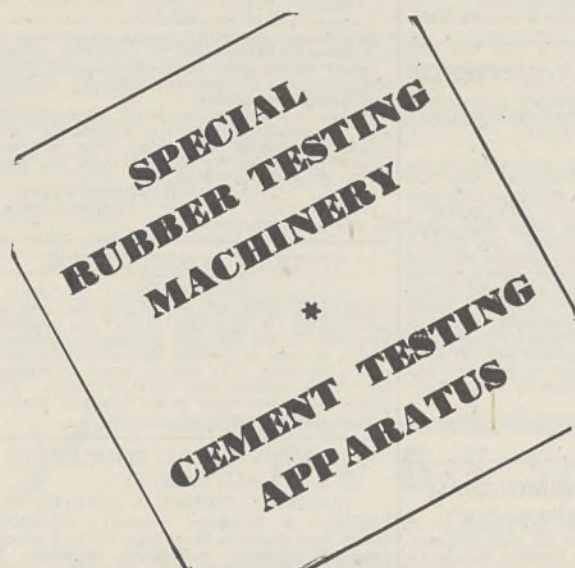
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COMMONWEALTH OF AUSTRALIA

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

APPOINTMENT OF PHYSICIST FOR ELECTRON TUBE RESEARCH

Applications are invited for a position of RESEARCH PHYSICIST on the staff of the DIVISION OF RADIOPHYSICS, SYDNEY, AUSTRALIA.

Duties: Advanced experimental work in connection with Division's programme of electron tube research and development.

Qualifications: Highest qualifications as a Physicist—combined with considerable research experience in modern electron tube work, thermionics and vacuum techniques.

Salary: Dependent on qualifications and experience, commencing salary will be within the range of either Principal Research Officer (£A796-£A940 p.a. actual), or Senior Research Officer (£A665-£A790 p.a. actual), or Research Officer (£A560-£A640 p.a. actual).

Subject to satisfactory medical examination, successful applicant will be appointed initially on probation for a period of twelve months and thereafter, if confirmed in the appointment as an officer of the Council, will be eligible to contribute to and receive benefits from, either the Commonwealth Superannuation Fund or the Commonwealth Provident Account. The probationary period may be waived in the case of a sufficiently senior man.

Applications in writing, stating date of birth, nationality, present employment and particulars of qualifications and experience, accompanied by copies of not more than four testimonials, should reach the Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, London, W.C.2, not later than May 11, 1945.

G. A. COOK,

Secretary.

Council for Scientific and Industrial Research, MELBOURNE, AUSTRALIA.

COMMONWEALTH OF AUSTRALIA

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

APPOINTMENT OF OFFICER FOR MICROWAVE CRYSTAL DEVELOPMENT

Applications are invited for a position on the DIVISION OF RADIOPHYSICS, SYDNEY, AUSTRALIA, for MICROWAVE CRYSTAL DEVELOPMENT WORK.

Duties: Experimental work in connection with Division's programme of microwave crystal receiver research and development.

Qualifications: University degree in Metallurgy, or in Science with physics as a major subject and training in chemistry and/or metallurgy; and also research experience in modern radio or crystal rectifier techniques.

Salary: Dependent on qualifications and experience, commencing salary will be in range of either Research Officer (£A560-£A640 p.a. actual) or Assistant Research Officer (£A390-£A540 p.a. actual).

Subject to a satisfactory medical examination, the successful applicant will be appointed initially on probation for a period of 12 months, but thereafter, if confirmed in his appointment as an officer of the Council, will be eligible to contribute to, and receive benefits from, either the Commonwealth Superannuation Fund or the Commonwealth Provident Fund.

Applications, in writing, stating date of birth, nationality, present employment and particulars of qualifications and experience, accompanied by copies of not more than four testimonials, should reach the Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, London, W.C.2, not later than May 11, 1945.

G. A. COOK,

Secretary.

Council for Scientific and Industrial Research, MELBOURNE, AUSTRALIA.

ROYAL HOLLOWAY COLLEGE

(University of London)

APPOINTMENT OF A SENIOR LECTURER IN APPLIED MATHEMATICS

The Governors invite applications for the above post, which is resident and open to women only. Applications are required not later than May 8, 1945. Full particulars may be obtained from the Principal, Royal Holloway College, Englefield Green, Surrey.

VETERINARY EDUCATIONAL TRUST

ELECTION TO A WELLCOME RESEARCH FELLOWSHIP

Applications are invited for the appointment to the above Fellowship from any person who on October 1, 1945 is under 36 years of age and has taken the Membership Diploma of the Royal College of Veterinary Surgeons or a degree in any Faculty in any University in the British Empire; or who, if a female, has passed an examination which would have entitled her if a male to take any such Degree.

The Fellowship, to the value of £450 per annum (liable to Income Tax) is tenable for one year and for a subsequent period of two years at the discretion of the Advisory Committee. The basis of annual remuneration may be increased under special circumstances. The Election will be made in June to take effect as from October 1, 1945.

Applications must be received on or before May 14, 1945.

Forms of application are obtainable from Dr. W. R. Wooldridge, M.Sc., M.R.C.V.S., Honorary Secretary, Wellcome Research Fellowships for Veterinary Research, 40 Westminster Palace Gardens, Westminster, London, S.W.1.

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE

The Governing Body invites applications for the post of HEAD OF THE CHEMISTRY DEPARTMENT, rendered vacant by the appointment of Dr. J. F. J. Dippy, D.Sc., Ph.D., F.R.I.C., to another post. Duties will commence on September 1, 1945.

Candidates should possess (a) high academic qualifications, (b) industrial experience, and (c) teaching experience (preferably in a Technical College or University). The salary scale at present is £540-£20-£660+£52 bonus, but the scale is subject to review under the terms of the new Burnham Report.

Further particulars and application form will be sent by the undersigned on receipt of a stamped, addressed, foolscap envelope. Applications should be sent in as soon as possible and in any case not later than May 1, 1945.

J. F. S. ROSS,

Principal and Clerk to the Governing Body.

COIMISIÚN NA STÁT-SHEIRBHÍSE

POSITION VACANT: ASSISTANT INSPECTOR OF FISHERIES (Male) IN THE DEPARTMENT OF AGRICULTURE

Application forms for and particulars of the above-named post may be obtained from the Secretary of the Commission, 45 Upper O'Connell Street, Dublin. *Salary Scale:* £150-£15-£350 a year, plus bonus. A higher initial salary may in certain circumstances be allowed. *Age Limits:* 25-40 years on April 1, 1945, except in the case of persons with certain specified service in the Defence Forces or such Auxiliary Defence Services as may be determined. *Essential Qualifications:* (i) a recognized University degree in Science, including the subjects Botany and Zoology or an equivalent qualification, (ii) satisfactory postgraduate experience of practical field work in connection with Marine or Fresh Water Biology.

Latest time for accepting completed application forms: 5.15 p.m., May 18, 1945.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF GEOGRAPHY

Applications are invited for the post of Assistant Lecturer (Grade III) or Lecturer (Grade II) in Geography. Stipend and period of probation will depend on qualifications and experience. The Minimum salary in Grade III is £350, and of Grade II, £450. Duties will begin on Oct. 1, 1945.

Candidates must have special qualifications on the science side of the subject, preferably in meteorology and climatology. Four copies of application, with names of three referees, must be sent on or before June 2, 1945, to the undersigned, from whom further particulars may be obtained.

C. G. BURTON,

Secretary.

The University, Edmund Street, Birmingham, 8.

EDINBURGH & EAST OF SCOTLAND COLLEGE OF AGRICULTURE

Applications are invited for the post of SOIL CHEMIST on a salary range of £400-£600 per annum, plus existing war bonus. Candidates should be in possession of an Honours Degree in Science and should have several years' experience in Agricultural Chemistry with particular reference to soil analysis.

Applications stating age, qualifications and experience, together with copies of three recent testimonials should be lodged not later than 7th May with the undersigned from whom further particulars may be obtained.

THOMAS BLACKBURN,

Secretary.

13 George Square, Edinburgh, 8.

SURREY COUNTY COUNCIL

WARREN ROAD HOSPITAL, GUILDFORD DEEP X-RAY THERAPY AND RADIUM CENTRE

Applications are invited for the appointment of full-time ASST. PHYSICIST to the above Radiotherapy Centre. Commencing salary according to experience on grade £950 by £25-£400 p.a., plus War Bonus 19/- p.w. male, 15/6 p.w. female. The appointment is temporary and is subject to one month's notice on either side. Apply to Dr. H. Canwarden, Medical Superintendent at the Hospital.

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(UNIVERSITY OF LONDON)

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

Applications are invited from men and women holding degrees in Physiology or Medicine for the post of DEMONSTRATOR IN THE PHYSIOLOGY DEPARTMENT, from October 1, 1945, at an initial salary of not less than £900 per annum, with superannuation benefits.

Further particulars may be obtained from the Warden and Secretary, to whom applications should be sent by May 19, 1945.

BRIGHTON TECHNICAL COLLEGE

Principal: Gordon E. Watts, M.A., Ph.D., B.Sc., F.R.I.C.

Applications are invited for the appointment of a Lecturer in Mathematics in the above college. A Salary according to Burnham Technical Scale, with allowances for approved industrial, research, and teaching experience.

Further particulars and forms of application may be obtained from the undersigned, and will be returned, with copies of at least two recent testimonials, by Monday, April 30, 1945, to the Principal of the College.

F. HERBERT TOYNE,

Education Officer.

54 Old Steine, Brighton, 1.

STUDLEY AGRICULTURAL COLLEGE

APPLICATIONS are invited for the post of LECTURER in BACTERIOLOGY to students preparing for the National Diploma in Dairying. Ability to assist in teaching elementary Chemistry also is desirable. The post is vacant in September. It is resident and open to women. For further particulars apply to the Principal, Studley College, Warwickshire.

COVENTRY LOCAL EDUCATION AUTHORITY

COVENTRY TECHNICAL COLLEGE

Lecturer in Metallurgy required. Candidates should have degree in Metallurgy, teaching experience and industrial or research experience in Metallurgy. Salary—Burnham (Technical) Scale. Forms of application from:

FRANK H. HARROD,

Director of Education, Council House, Coventry.

UNIVERSITY OF BRISTOL

Wanted a HISTOLOGICAL TECHNICIAN for the Department of Anatomy, experience in laboratory work desirable. Salary £900 p.a. Applications should reach the undersigned, from whom further particulars may be obtained, on or before May 4, 1945.

WINIFRED SHAPLAND,

Secretary and Registrar.

LINEN INDUSTRY RESEARCH ASSOCIATION

The Association has a vacancy for a biochemist, preferably with some experience of industrial bacteriology. The salary is on the scale for a Senior Research Assistant, £875-25-£600 per annum, plus war bonus which at present amounts to £60 per annum; initial salary according to qualifications and experience. Applications should be sent to The Director of Research, The Research Institute, Lambeg, Co. Antrim, Northern Ireland.

HERIOT-WATT COLLEGE EDINBURGH

Lectureship in Mechanical Engineering

The Governors invite applications from British Subjects for Lectureship in Mechanical Engineering. Laboratory and Workshop experience are essential. Candidates will be placed on salary scale according to qualifications and experience.

Applications must be made, on forms to be obtained with full particulars from the College, not later than May 14th.

J. CAMERON SMAIL,

Principal.

H.M. Colonial Service, Nigeria.

Two Entomologists required for Medical Department, to carry out general entomological investigation and research, particularly in connection with control measures against sleeping sickness in Northern Nigeria, and such other duties within their competence as are demanded by the Director of Medical Services.

Candidates, who should preferably be under 35 years of age, must be British subjects and fully trained entomologists. Degree in Zoology and at least two years practical experience necessary.

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Applicants should write quoting F898A to the Ministry of Labour and National Service, Central (T. and S.) Register, Room 5/17, Sardinia Street, Kingsway, London, W.C.2, for the necessary forms which should be returned completed on or before May 1, 1945.

H.M. Colonial Service, Uganda.

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Research Department, Great West Road, Brentford, Middlesex, invites applications for the post of Library Assistant. Candidates should hold a recognized qualification in Librarianship and have had experience in classification and cataloguing, preferably in a technical library. Initial salary £800-£350 per annum, according to qualifications. Superannuation provision under the Federated Superannuation System of Universities.

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research and development department. Age 25-30, salary £350-£450 p.a. Graduate of a recognized University, some knowledge of surface chemistry and nature of films would be an advantage. Write Box 345, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Biochemist, 39, British, reserved, M.Sc.,

Ph.D., F.R.S.E., experienced in Research, in physiological and medical chemistry, bacteriology, microrespirometry, and in staff control, desires post, research or otherwise, in public health hospital or industry. Write Box P.103, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

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"The Value of Early Diagnosis" will be held at the London School of Hygiene and Tropical Medicine on Saturday and Sunday, May 12 and 13, 1945. Details of the programme and application forms may be obtained from the Secretary of the School, Keppel Street, Gower Street, London, W.C.1. The fee is £1. 1s. 0d. with an additional 2s. 6d. for lunch on Sunday.

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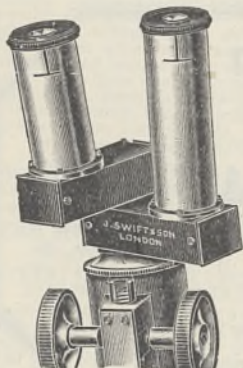
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NEWS and VIEWS

Forest Products Research Laboratory

Mr. W. A. Robertson

MR. W. A. ROBERTSON retired on March 31 from the position of director of forest products research (Department of Scientific and Industrial Research). He took over charge of the Laboratory at Princes Risborough in 1933, the earlier part of his career having been spent in the Indian Forest Service, mainly in Burma. Mr. Robertson has thus been responsible for the direction of timber research in Great Britain during a period of important development which would undoubtedly have been greater but for the restrictions caused by the War. In 1941, when the Secretary of State for the Colonies decided to appoint a forest adviser, Mr. Robertson was selected for this responsible post on a part-time basis. He will now be enabled to devote his entire attention to the problems confronting the Colonial Office in its reorganization of the Colonial Forest Service. In view of his wide experience, it may be considered fortunate that Mr. Robertson's services will continue to be available in this capacity.

Dr. F. Y. Henderson

DR. F. Y. HENDERSON, who has taken up the post of director of forest products research on Mr. Robertson's retirement, joined the staff of the Imperial College of Science and Technology in 1921 as plant physiologist. He devoted much of his time to research, and took an active part in teaching, and organizing the practical teaching in plant physiology. He was also for many years director of biological studies at the John Cass Institute, and superintendent of examinations for the Pharmaceutical Society of Great Britain. In 1931 Dr. Henderson took over the work of Prof. Percy Groom as timber technologist, and did much teaching in this field as well as research on the biological changes in felled timber.

Research in Animal Health at Aberystwyth

THE research professorship in animal health endowed by the generosity of Lord Milford at University College of Wales, Aberystwyth, has been filled by the appointment of Mr. Alastair N. Worden. Mr. Worden, who is twenty-eight, was educated at Queen Elizabeth's School, Barnet, the Royal Veterinary College, London, and St. John's College, Cambridge. After experience of veterinary practice for more than two years with Mr. J. Pickup, of Barnet, Mr. Worden was awarded in 1938 a Ministry of Agriculture studentship in animal health, spending the first year of his tenure of this studentship in the Division of Nutrition of the Lister Institute, the second in the Bacteriological and Biochemical Departments of the Ministry of Agriculture's Veterinary Laboratory at Weybridge and the third in the Department of Agriculture at the University of Cambridge. He also spent some time at the Rowett Research Institute, Aberdeen. In 1941 he was appointed to the Biochemical Department of the Institute of Animal Pathology, University of Cambridge. His research has dealt mainly with human and animal nutrition and with the relation of nutrition to infectious diseases. He is a member of the Parliamentary and Scientific Committee on which he represents the Universities Federation for Animal Welfare and he is secretary of the Institute of Animal Behaviour.

Prof. Worden starts with the great assets of youth, energy and the breadth of outlook which his training has given him. He goes to a centre already made famous by the work done by Sir George Stapledon and Dr. T. J. Jenkin at the Welsh Plant Breeding Station at University College, Aberystwyth. Everyone will wish him success in a field which has become, as one result of the War, of great moment, not only to Britain, but also to the world in general.

Educating the Citizen

THE central problem of the planned society is, as Prof. H. J. Laski has pointed out, to make the issues at stake intelligible and to bring out in individuals the interest that compels action; in "Planning Our Country", J. F. Adburgham and Elizabeth Halton well maintain the standard set by earlier pamphlets in this "Unless We Plan Now" Series (English Univ. Press, Ltd. 4d. net). The main aspects of the problems involved in town and country planning are simply but adequately explained and in a way which should conduce to discussion. There is a short but adequate bibliography, and the pamphlet should fulfil its avowed purpose of bringing home to the ordinary citizen the exact meaning of planning and of how much depends on his contribution and interest if effect is to be given to such proposals as are to be found in the Barlow, Uthwatt and Scott reports.

Much the same can be said of the pamphlet "The Struggle for Democracy", by W. E. Brown, in the "Changing Britain" Series (Univ. of London Press. 1s. net). This is even more elementary, and the appeal is largely pictorial. The graphic presentation shows vividly how the development of the British system of government reflects the efforts and strivings of the individuals in the community. The pamphlet indicates not merely how immense has been the broadening of the basis of government and of the sphere of government action in the last century, but also, and more important still, that government is not to be thought of as something apart from the ordinary citizen: it is a matter of 'we', not of 'they', and the interest or inertia of the ordinary citizen, what he does, as well as how he votes, that ultimately shapes our institutions.

Rose-bay Willow-herb and Honey Bees

IN the *Bee World* of January, A. Norman Handley discusses the status of the rose-bay willow-herb (*Epilobium angustifolium*). He mentions that the Press has joined forces with the farmers in condemning this plant as a noxious weed. The author believes that it is very questionable whether the plant could establish itself in properly cultivated ground. The roots appear to thrive best on waste lands where the soil is firm and undisturbed. The beekeeper, however, appreciates this herb because it yields valuable nectar and pollen especially during periods of scarcity from about early July until mid-August. In 1944, which was a notoriously bad year for bees, many hives managed to build up and even store surplus nectar from the rose-bay willow-herb. This plant also provides humble bees with food at a time when the next year's queens are being reared. The value of these insects as a general aid in pollination and a particular help in the case of red clover is, of course, well known. Now that the author has brought up this subject it would appear desirable that the true status of this kind of willow-herb should be determined. Much more information is needed before it

will be possible to account for the sudden appearance of the plant in land that has been ploughed or cleared and whether it is due to buried seeds or to other causes.

Mme. Lepaute : an Eighteenth Century Computer

ELIZABETH CONNOR, Mount Wilson Observatory, Carnegie Institution of Washington, has written (Leaf. 189, Astro. Soc. Pac., Nov. 1944) a short account of the astronomical work of Mme. Lepaute, whom Lalande considered "the only woman in France who had genuine knowledge of astronomy". As a child she was a voracious reader, and it was generally recognized by those who met her that she had a brilliant mind. When Lalande and Lepaute, to whom Mme. Lepaute (*née* Nicole-Reine Étable de la Brière) was married in 1748, collaborated in a treatise on clock-making, Mme. Lepaute calculated a table for the book containing a number of oscillations for pendulums of different lengths and the lengths of pendulums corresponding to a given number of vibrations. Her great work was the assistance that she rendered in the computations of the perturbations of Halley's Comet, and Lalande pays her a tribute when he affirms that without her help Clairaut and he would scarcely have undertaken this enormous task. In 1759, Lalande was placed in charge of the *Connaissance des Temps*, and Mme. Lepaute became one of his assistants. When this work was given to someone else in 1774, they concentrated their attention on volume 7 of the "Ephémérides", and Mme. Lepaute made all the calculations for the sun, moon and planets for both volumes 7 and 8, covering the period 1774-93. In addition to this, she devoted much time to eclipses, computing a table of parallax angles which was useful in eclipse work. She also made computations for the observation of the transit of Venus in 1761, and wrote a memoir on the subject for the Academy at Béziers. For twenty-five years she was engaged continuously in astronomical work; but her eyesight was finally affected and during the last years of her life she was unable to apply herself closely to the subject.

A 1,000-g Centrifuge

In connexion with recent development work, the Bell Laboratories have designed a centrifuge for the purpose of subjecting objects to high accelerations under conditions permitting the effects of the acceleration to be studied. The machine is described and illustrated by R. M. Pease in an article in the *Bell Laboratories Record* (22, No. 16; Dec. 1944). Machines of this general type have been built before; but there was none available that would develop high enough accelerations. For the required tests, an acceleration 1,000 times the earth's gravitational acceleration was needed. To secure this acceleration, two parallel steel rods are clamped at their midpoint and rotated by an adjustable speed d.c. motor. Fastened between the rods at their outer ends is a heavy steel plate to which is secured a mounting for the object under test. With the test object in place, the machine may be driven at the speed necessary to give the desired acceleration. After stopping the machine, the effect on the apparatus under test may be determined. Provisions are also made for observing the effect of the accelerations on the object as the speed of the machine is increased. A neon lamp is mounted to shine directly on the object when the arm is horizontal. At each rotation, this lamp lights for a few millionths of a second from an impulse generated in

a winding on a permanent magnet when a small iron bar attached to the rotating arm passes the pole pieces. For the rest of the time, the arm is in comparative darkness. This stroboscopic arrangement makes the arm appear to stand still in the horizontal position and any distortion of the test object can be observed while the acceleration is being increased.

Electric Lighting Installations for Building Interiors

IN A PAPER on this subject read recently before the Institution of Electrical Engineers, R. O. Ackerley examines the methods which should be adopted in order to answer the various questions which arise when designing an electric lighting installation. The paper stresses the importance of careful task analysis in the first instance to determine exactly what is the visual problem for which suitable lighting must be provided, and goes on to discuss methods of lighting, factors affecting illumination requirements, the selection of appropriate lighting fittings and lamps, and the calculations necessary to determine their location and wattage. The paper also deals with probable trends in lighting in the post-war period and the light sources and materials for light-control that are likely to influence them.

Modern Electric Lift Practice

A PAPER read by L. S. Atkinson before the Institution of Electrical Engineers reviews present-day electric lift practice by making brief reference to those aspects of the subjects which are the concern of the architect, and to the application of lift equipment to suit various classes of building. It explains the changes that have been made in general design from time to time to meet the problems created by the increasing height of buildings and their growing populations, and further describes the equipment as generally installed to-day.

Summer School in Social Biology

A SUMMER SCHOOL in Social Biology and Human Affairs will be held by the British Social Hygiene Council at University College, Nottingham, during July 28-August 11, under the directorship of Prof. Winifred Cullis. This School is designed for teachers and social workers, health visitors, superintendents of children's homes, industrial nurses, etc. Special consideration will be given to educational problems in social biology presented by the coming increase in the school-leaving age. Further information can be obtained from the British Social Hygiene Council, Tavistock House North, Tavistock Square, London, W.C.1.

Announcements

DR. W. Q. KENNEDY has been appointed professor of geology in the University of Leeds.

At a meeting of the Royal Astronomical Society held on April 13, the following officers were elected: *President*, Prof. H. H. Plaskett; *Vice-Presidents*, Dr. E. C. Bullard, Sir Harold Spencer Jones, Prof. E. A. Milne and Mr. F. J. Sellers; *Treasurer*, Mr. J. H. Reynolds; *Secretaries*, Dr. H. R. Hulme and Mr. D. H. Sadler; *Foreign Secretary*, Prof. F. J. M. Stratton; *Members of Council*, Miss M. G. Adam, Dr. H. A. Brück, Rev. M. Davidson, Dr. M. A. Ellison, Mr. F. J. Hargreaves, Dr. A. Hunter, Dr. E. M. Lindsay, Captain W. N. McClean, Prof. W. H. McCrea, Dr. G. C. McVittie, Mr. P. J. Melotte and Dr. R. Stoneley.

LETTERS TO THE EDITORS

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

Structure of Colchicine

THE suggestion of Dewar¹ that ring *C* of colchicine is 7-membered is interesting, and the arguments which he advances in favour of this merit consideration. I cannot, however, accept his statement that "Cohen, Cook and Roe have now provided evidence that ring *B* must be 7-membered". The paper² to which Dewar refers merely makes a tentative suggestion that ring *B* might be 7-membered. The only legitimate evidence that ring *B* of a degradation product of colchicine (namely, deaminocolchinal methyl ether) is 7-membered is provided by experiments described in a paper by Barton, Cook and Loudon, recently submitted for publication in the *Journal of the Chemical Society* (and received by the Society on February 1). Consequently, Dewar's assumption in respect of the structure of this part of the colchicine molecule is based on unwarranted speculation. Incidentally, the work of Barton, Cook and Loudon fully establishes the methoxylation pattern of deaminocolchinal methyl ether, and hence probably also the orientation of the substituents in colchicine.

J. W. COOK.

University of Glasgow. Feb. 5.

¹ Dewar, M. J. S., *Nature*, 155, 141 (1945).

² Cohen, A., Cook, J. W., and Roe, E. M. F., *J. Chem. Soc.*, 194 (1940).

My communication on this subject was written in ignorance of the work of Barton, Cook and Loudon, which was partly disclosed at a meeting of the Chemical Society, but is still unpublished. In relation to the facts known when I wrote, my remarks on the nature of ring *B* in colchicine can scarcely be described as unduly speculative. In any event I reserve any possible discussion for the time when all the facts are available. This question of the structure of ring *B* is, of course, important, but it can be settled by application of routine methods of alkaloid chemistry. On the other hand, the suggestion I have ventured to make regarding ring *C* is quite novel in this field.

Confirmation of the tropolone structure of ring *C* has now been obtained by the degradation suggested by me. Dr. I. Berenblum very kindly provided a small specimen of colchicine and this was converted to crude hexahydrocolchicine and submitted to lead tetra-acetate oxidation. About 0.6 molecules of lead tetra-acetate were rapidly consumed and considerable further oxidation took place more slowly. This behaviour would be expected in an unsaturated cyclic α -glycol¹. The oxidation product was aldehydic and gave an amorphous mixture of dinitrophenylhydrazones. Although lack of material prevented purification of the hexahydrocolchicine or isolation of a definite oxidation product, it seems fairly certain that hexahydrocolchicine must indeed be an α -diol. If so, confirmation is provided for the tropolone structure of colchicine.

Previously² resonance chelation was postulated to explain the aromatic nature of the tropolone ring. Calculation shows that in such a structure the O—O distance would be about 2.51 Å. and that the O—H bond would be stretched. It is possible, therefore,

that the resonance is an ionic one of the type postulated for colchicine³ and that tropolone forms a tautomeric system of high mobility. On the other hand, the great solubility in water of colchicine, in contrast to colchicine or stipitatic acid, is better explained if in it alone an ionic resonance (implying a semi-zwitterion structure) occurs.

It may be noted that puberulic acid⁴ is probably one of the three possible monohydroxystipitatic acids, and puberulonic acid the corresponding 'tropolone-quinone'. This relationship was pointed out by Birkinshaw, Chambers and Raistrick⁵, and the existing evidence is insufficient for further comment on the structures of those acids.

M. J. S. DEWAR.

Dyson Perrins Laboratory,
University, Oxford.

¹ Crigee, *Ber.*, 64, 285 (1931).

² Dewar, *Nature*, 155, 50 (1945).

³ Dewar, *Nature*, 155, 141 (1945).

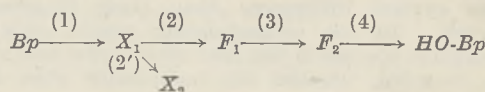
⁴ Birkinshaw and Raistrick, *Biochem. J.*, 26, 441 (1932). Barger and Dorner, *ibid.*, 28, 11 (1934).

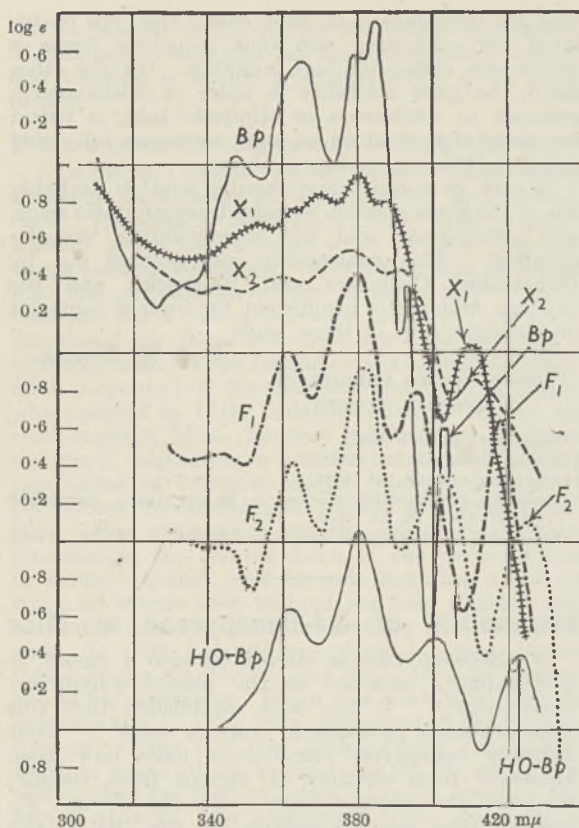
⁵ Birkinshaw, Chambers and Raistrick, *Biochem. J.*, 36, 242 (1942).

Metabolism of 3,4-Benzpyrene in Mice

IF 3,4-benzpyrene is introduced into a mouse, it is eventually excreted as the phenol 8-hydroxybenzpyrene^{1,2}. It has been established that this transformation proceeds by various steps^{3,4}. Four different benzpyrene derivatives have now been separated from extracts of various fresh tissues; they are provisionally termed X_1 , X_2 , F_1 and F_2 , because they are responsible for the 'BPX' and 'BPF' fluorescences that Peacock⁵ and Chalmers⁶ discovered in the liver, bile, intestine and faeces of various animals after application of benzpyrene. The separation of X_1 , X_2 , F_1 and F_2 has been effected by fluorescence chromatography and selective extraction, using alumina and silica as adsorbents and acetone, benzene, xylene, petroleum ether, methyl, ethyl and amyl alcohols and water as solvents. X_1 and X_2 occur *in vivo* not only in the liver and digestive system but also in the lung, kidney cortex, subcutaneous tissue, skin (after painting with benzpyrene), and in the mammary glands as evidenced by the milk of mice; F_1 and F_2 occur in the large intestine and faeces, and occasionally in the lungs. The amount of fresh uncontaminated mouse urine did not suffice for a definite analysis, but there were indications of the presence of the X derivatives. *Post mortem*, all X -bearing tissues show slowly increasing amounts of the F derivatives unless they are kept in formol. The 3,4-benzpyrene-5,8-quinone that Berenblum and Schoental² discovered in the faeces never appeared in fresh tissues.

The sequence of the metabolic conversion can best be seen by following the products through the digestive system. In the liver, X_1 is formed almost exclusively, and enters with the bile into the small intestine, where it is converted slowly to X_2 in the tissue of the wall. However, the bulk of the X_1 is changed to F_1 after its passage through the ileocaecal valve. In the later stages of the metabolism, more and more F_2 appears in the faeces. This sequence can be summarized by the scheme:





ABSORPTION SPECTRA ($\log \epsilon$) OF 3,4-BENZPYRENE (TOP), 8-HYDROXYBENZPYRENE (BOTTOM) AND FOUR INTERMEDIATE METABOLITES, X_1 , X_2 , F_1 AND F_2 , DISSOLVED IN ARBITRARY CONCENTRATION IN ETHANOL. THE TYPES OF THE GRAPHS ARE SIMILAR FOR Bp , F_1 , F_2 AND 8-HO- Bp BUT DIFFERENT FOR X_1 AND X_2 . THE WAVE-LENGTHS OF THE LAST VIOLET BANDS OF THE ABSORPTION SPECTRA (INDICATED BY ARROWS) COINCIDE WITH THE FIRST VIOLET BANDS OF THE FLUORESCENCE SPECTRA OF THE COMPOUNDS (NOT INCLUDED IN THE FIGURE).

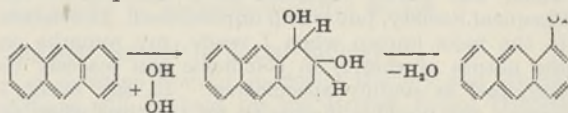
Of these transformations, (2) is the only one as yet that can be effected with the purified substances *in vitro*. It happens when the adsorbate of X_1 on alumina is heated above 150°C . *in vacuo*, and slowly when X_1 is kept in dilute hydrochloric acid. This last change, with a simultaneous oxidation to the quinone, proceeds quickly at 100°C .

It has been established that F_1 and F_2 are phenolic, and that F_2 can act as a fluorescence indicator with a change of fluorescence colour from yellow to blue between pH 10 and 9.5. F_1 is strongly adsorbed from benzene and from petroleum ether to alumina with sky-blue fluorescence, F_2 less strongly with yellow-green fluorescence. They are soluble in organic solvents but insoluble in water. X_1 and X_2 are not phenolic, and both are strongly adsorbed from benzene and from petroleum ether to alumina with blue-banded fluorescence spectra, but silica adsorbs only X_2 from amyl alcohol. The X derivatives are soluble in water and in alcohols, but less soluble in benzene and in petroleum ether. The fluorescence spectra of all four derivatives in solution are of a similar type, and show three diffuse bands in the violet-blue distinguished by their position in the spectrum. Their absorption spectra show much more typical differences than their fluorescence spectra. In the accompanying graph, only the absorption spectra in the near ultra-violet and violet are recorded, because the compounds even after

chromatographic purification may contain cell constituents that absorb in the far ultra-violet. The last violet absorption band (marked by an arrow) coincides with the first fluorescence band of the compounds.

None of the derivatives has as yet been analysed owing to their instability and the small amounts that can be recovered from the fresh tissues of mice. However, the absorption spectra especially furnish some evidence of their chemical nature. F_2 has the same absorption spectrum as that published² for 8-OH-benzpyrene (appearing at the bottom of the graph), and it is probably identical with this phenol or a loose conjugate of it. F_1 has the same absorption spectrum except for the violet bands which are displaced by about $7 \text{ m}\mu$ towards the ultra-violet. This shows its close relationship with F_2 ; but the stronger adsorption to alumina (and silica) of F_1 points to a higher molecular weight.

While the type of absorption spectra of the F derivatives is similar to that of benzpyrene itself (top graph) the absorption spectra of the X derivatives are different. Since it is known that the types of absorption spectra of benzpyrene derivatives with intact aromatic 5-ring nucleus are usually similar to each other, the different type of absorption of the X derivatives indicates that this nucleus is *not intact*. Hence the benzpyrene nucleus is altered during the transformation of benzpyrene into the non-phenolic X_1 and it is restored when X_1 is changed to the phenolic F_1 . Boyland and Levi⁷ observed such a phenomenon during the metabolism of anthracene by rats and rabbits. The urine contained the alcohol 1,2-dihydroxy-1,2-dihydro-anthracene with one double-bond less in the anthracene nucleus. This alcohol changes to the phenol 1-anthrol on addition of dilute hydrochloric acid, and the complete aromatic anthracene nucleus is restored. These reactions proceed as follows:



Fieser⁸ suggested the term 'perhydroxylation' for an addition of hydrogen peroxide followed by loss of water, and advanced the hypothesis that such a reaction might be responsible for the metabolic conversion of carcinogenic hydrocarbons to phenols. Hence it is likely that our non-phenolic benzpyrene metabolite X_1 which changes easily into the phenolic metabolite F_1 is 8,9-dihydroxy-8,9-dihydro-3,4-benzpyrene or one of its conjugates. The stronger adsorption of X_2 on the chromatographic columns points to a higher molecular weight than that of X_1 .

Experiments on the carcinogenic properties of the various metabolites are in progress with Dr. J. C. Mottram, to whom I am indebted for that part of the work concerned with the living animals.

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Isolation of Asparagine from the Hæmolymph of *Melolontha* Larvæ

DURING a study of the amino-acids of the hæmolymph of insects, a substance was isolated from the blood of *Melolontha vulgaris* which turned out to be asparagine. This finding may be of interest because, to my knowledge, this substance has not been met with in animal fluids or tissues before, while it is a characteristic constituent of many plants.

The blood of some hundred larvæ (15 gm.) was deproteinized with trichloroacetic acid, and the filtrate was freed from the acid by extraction with ether. Hexon bases and some peptide or peptides were precipitated with phosphotungstic acid, and dicarbonic acids were precipitated with barium hydroxide and alcohol. After concentration *in vacuo* and removal of barium with sulphuric acid, mercuric acetate and sodium hydroxide were added by drops until no further precipitate would form.

The precipitate was suspended in water, decomposed with hydrogen sulphide and after removal of mercuric sulphide the solution was concentrated on a steam bath. First tyrosine crystallized out and was removed, and the mother liquor was concentrated further. Irregular crystals of another substance now separated out. They were freed from the glassy mother liquor by digestion with warm 50 per cent alcohol in which the crystals were but little soluble. The substance was repeatedly recrystallized and the resulting sample of an apparently pure substance (10 mgm.) was analysed after drying at 110° C. The results are presented below with the theoretical values for asparagine.

	Found (%)	Theory (%)
Total nitrogen	20.7	21.2
Amino nitrogen (per mol titr.) .. .	11.0	10.6
Amid nitrogen (4 hr. hydrolysis with <i>n</i> hydrochloric acid)	9.2	10.6

The crystals resembled in every respect those of asparagine.

The concentration of asparagine in the blood of the larvæ can only be roughly estimated, due to the inevitable losses on recrystallization. 150–250 mgm. per cent should be a probable guess. Blood from larvæ of the related *Oryctis nasicornis* was found to contain 23.7 mgm. per cent amide nitrogen, corresponding to 223 mgm. per cent asparagine, but the material did not suffice for an isolation. So it still remains to be seen if asparagine is a peculiarity of *Melolontha* or a typical product of insect metabolism.

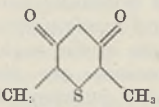
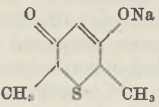
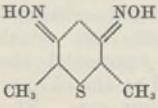
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Antibacterial Activity of 2:6-Dimethyl-Penthiane-3:5-Dione

IN a recent speculation Gulland and Farrar¹ have elaborated a hypothesis for the mode of action of *cyclotelluro-pentane-3:5-dione* and homologues, in which substrate competition with pyridoxin is postulated as a possible explanation of their high bactericidal activity. The structural resemblance of these tellurium compounds to that of pyridoxin is pointed out, and it is suggested that analogous substances containing an oxygen or a sulphur atom instead of tellurium might possess correspondingly high bacteriostatic or bactericidal activity without the extreme toxicity of the tellurium compounds.

As we were interested in heterocyclic ring compounds containing sulphur², we have prepared and tested the sulphur analogue of 2:6-dimethyl-cyclotelluro-pentane-3:5-dione, which is the most active representative of the tellurium series of homologues. 2:6-Dimethyl-penthiane-3:5-dione is a white crystalline substance of m.p. 124–125° C., soluble in hot water. It dissolves easily in cold caustic soda solution, but does not give a coloration with alcoholic ferric chloride except on prolonged standing, in which it resembles *cyclotelluro-pentane-3:5-dione*³. It forms a white crystalline dioxime of m.p. 181–183° C., slightly soluble in hot water. The accompanying table shows the results of the bacteriological examination and gives the minimum concentrations inhibiting the growth of one loopful of inoculum.

	<i>Staph. aureus</i> NCTC 4183 glucose broth (18 hr. at 37°)	<i>Bact. coli</i> NCTC 86 Lemco broth (18 hr. at 37°)	<i>Bact. coli</i> NCTC 86 Reader's medium (24 hr. at 37°)
	1:1,600 (1:800,000– 1:10,000,000)*	<1:1,000 (1:9,000,000– 1:10,000,000)	1:6,400
	<1:1,000	<1:1,000	1:3,200
	1:1,000– 1:2,000	<1:1,000	1:6,400

* The figures given in brackets are the bactericidal concentrations of the analogous tellurium compound reported by Morgan *et al.*⁴

Contrary to expectations, the compounds show little or no activity against the organisms tested. It is interesting to note that enolization, which is a prerequisite in Gulland and Farrar's speculation, in our case decreases or abolishes bacteriostatic activity altogether. The dioxime of 2:6-dimethyl-penthiane-3:5-dione, however, in contrast to the corresponding tellurium compound, is as active as the parent substance. It would appear, therefore, that other factors, apart from the arrangement $-(CH_2)_2C(OH)C-$, are fundamentally concerned in determining the bacteriological properties of this class of compounds. Our results certainly do not favour their speculation of substrate competition with pyridoxin.

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Constitution of the Salivary Gland Chromosomes of *Chironomus*

SINCE the discovery of giant salivary gland chromosomes in dipterous larvæ¹, cytophysiologists have regarded them as the most favourable material for studying the chemical composition and fine structure of chromosomes, especially the leptonic relation between nucleic acid and protein. The view that chromosomes are chiefly composed of nucleoprotein is now generally accepted. In salivary gland chromosomes, the bands represent regions of relatively high nucleic acid content, while the interbands carry very little, if any, nucleic acid. The results obtained by Feulgen staining², histochemical tests³ and ultraviolet microscopy⁴ have all substantiated this conclusion. Digestion experiments by Caspersson and by Mazia and Jaeger⁵ clearly indicate that the salivary gland chromosomes possess a continuous protein framework the integrity of which is independent of the presence of nucleic acid molecules. In a more definite way, Astbury and Bell⁶ and Schmidt⁷ concluded from their X-ray diffraction and birefringence data that the most important elements in the molecular organization of the chromosomes are the partially folded and partially extended polypeptide chains, together with the parallel fitting of thymonucleic acid on to the extended portion of the chains. Based on this structural principle, Pfeiffer⁸ and especially Calvin and Kodani⁹ have proposed a probable structure for the salivary gland chromosome.

More recently, Stedman and Stedman¹⁰ announced the isolation of an acid protein which was named 'chromosomin'. They considered this to be the chief protein constituent of the chromosome, since its staining behaviour was the same as that of the chromosome. These authors also suggested that nucleic acid, instead of being attached to the chromosome, is present mostly in the nuclear sap. They questioned the reliability of the Feulgen technique as a means of demonstrating the actual location of thymonucleic acid, and interpreted the results of its application on a basis quite different from the hitherto accepted interpretation, which appeared to be supported by the success of staining plant chromosomes with 'developed nuclear stain'¹¹. These novel ideas at once attracted the attention of cytogeneticists, and an interesting discussion of the problem began¹².

Since the work of the Stedmans was done on vertebrate tissues, and since they made no comment on the structure of salivary gland chromosomes, which are large enough to permit of separation from the nuclear sap, we have made experiments on such chromosomes in *Chironomus* larvæ. (1) Instead of producing aldehyde groups by the hydrolysis of thymonucleic acid *in situ*, we allowed 5 per cent aqueous formaldehyde solution to react previously with leucobasic fuchsin *in vitro*, thus producing a 'developed nuclear stain'. The dye thus obtained stained the bands without hydrolysis in exactly the same way as in the standard Feulgen reaction. Nor was there any difference with respect to the differentiation between bands and interbands, if we first impregnated the gland cells with formaldehyde and then immersed them in leucobasic fuchsin. (2) When hydrolysis in normal hydrochloric acid at 60° was prolonged beyond 15 minutes, the chromosomes gradually lost their staining capacity toward the Feulgen reagent and eventually became entirely negative after 20–30 minutes hydrolysis. (3) Salivary gland chromosomes in smear preparations were first

excised and then thoroughly washed with insect Ringer to remove as completely as possible the surrounding materials. Such 'naked' chromosomes gave the same Feulgen reaction as when present in the intact nuclei. (4) In the 'naked' chromosomes, formaldehyde-developed Feulgen reagent produced typical banded structures without acid hydrolysis. Likewise, a pretreatment with formaldehyde followed by leucobasic fuchsin yielded essentially similar results. (5) Prolonged hydrolysis also made such 'naked' chromosomes behave negatively toward the Feulgen reagent.

In order to explain these results, we assume that the *Chironomus* salivary gland chromosome has a structure something like that proposed by Calvin and Kodani. The ability of chromosomes to take up basic dyes is normally due to the formation of a salt-like compound of the latter with nucleic acid. The recent investigations of Kelley¹³ on the dye-nucleoprotein reaction has offered confirmatory, though somewhat indirect, evidence on this point. The results of our experiments (1) and (4) might seem at first sight to be in accordance with the Stedmans' view that the chromosomes consist only of acidic protein; though the existence of banded structure in the chromosomes is difficult to explain. But these two experiments can equally well be interpreted by assuming nucleic acid to be present on the band; especially if the perpendicular attachment of plate-like nucleoside molecules to the bands results in a structure of relatively high porosity and consequently in a greater imbibition of formaldehyde or developed fuchsin in these regions. The loss of staining power toward Feulgen reagent after prolonged hydrolysis (our experiments (2) and (5)) may well be due, as Bauer¹⁴ and Hillary¹⁵ have suggested, to the gradual splitting of a bond between the ribose and phosphoric acid within a nucleotide. But it is the result of our experiment (3) which is particularly hard to reconcile with the Stedmans' view. We certainly do not contend that the 'naked' chromosomes as prepared above are completely free from nuclear sap. But it seems certain that the quantity present would not be sufficient to produce the intense chromosome-coloration by the standard Feulgen reaction, if nucleic acids were really present in the sap rather than on the chromosomes. Our experiments, at least those with 'naked' salivary gland chromosomes of *Chironomus*, strongly suggest the presence of nucleic acid in the chromosome.

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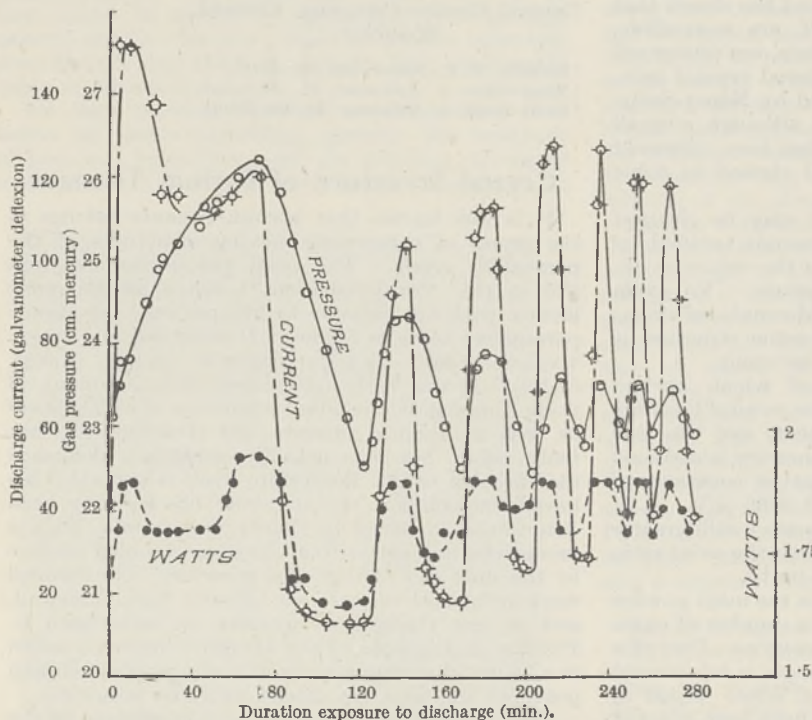
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Interaction of Nitrous Oxide and Hydrogen in the Silent Discharge

THE conductivity i and nature of a discharge reaction have been shown to depend upon $V - V_m$, where V is the applied potential and V_m its 'threshold' value required to initiate i . This is illustrated by the varied results for the above reaction, found sensitive to small changes in the operative conditions. The interaction of nitrous oxide with hydrogen, like its decomposition, sets in only above V_m ; this increases sensibly linearly with the pressure p ; the corresponding total time of reaction rises rapidly with p due to decrease of $V - V_m$.

Compared with its thermal analogue² using different catalysts and a wide range of temperature and pressure, changes in the latter and particularly the ratio of nitrous oxide to hydrogen influence markedly the discharge reaction. Its course, with a small pressure (p) and large excess of hydrogen, is simplest: p and $1/i$ eventually reach a minimum, and remain constant under continued discharge. The final products and p follow the equation $N_2O + H_2 = N_2 + H_2O$; this applies also to the thermal change². As p is increased, p and $1/i$ decrease first slowly and later sensibly faster; these features are accentuated and the initial stage shortens as p and $V - V_m$ are increased. Thus, for example, at 400 mm. and 4.3 kV., the initial stage was scarcely noticed; in 8 minutes, p dropped to 300 mm. and i increased from 0.5 to 4.5 milliamp. At 560 mm. and 5.1 kV., however, a sharp deprecipitation-like sound was produced immediately the discharge was switched on; the consequent fall in p and $1/i$ (which was unsteady) were too large and sudden to follow.

An increase of the proportion of nitrous oxide produces strikingly different results. At low p , after an initial rise, p and i fall to a constant minimum.



INTERACTION OF NITRIC OXIDE AND HYDROGEN IN THE SILENT DISCHARGE. INITIAL PRESSURE, 23.2 CM. MERCURY; APPLIED POTENTIAL, 2.7 KV. (50~); $N_2O/H_2 = 0.61$.

As p increases, there is first a large and steep rise in p and i ; then a smaller and slower change in both to a maximum, and finally an overall diminution. A larger p , however, produces a remarkable periodic effect the frequency and duration of which increase rapidly with p and especially the ratio of nitrous oxide to hydrogen. The accompanying figure reveals a close similarity in the time-variation of p , i and the corresponding energy dissipated in the system, W . As the reaction approaches completion, the successive fluctuations on the p -time curve are 'damped'. At 478 mm., 5.1 kV. and $N_2O/H_2 = 3$, the total time was so long that twenty pressure reversals of practically constant size were observed during about twenty hours. Since i depends upon $V - V_m$, V_m should vary periodically corresponding to i ; this has been observed.

The nature of the glow also changed periodically. As p began to decrease, mobile brushes appeared; their number and intensity increased, and a pink violet glow grew from the annular surfaces; at minimum p it was practically free from brushes. Changes occurred in the reverse order during the ascending part of the cycle. The former spectral sequence was also observed during pressure diminutions with a large excess of hydrogen when the reaction progressed uniformly.

Nitric oxide, nitrogen and free hydrogen observed after short exposures suggest that the decomposition of nitrous oxide predominates in the initial stage¹; this corresponds to the initial sharp rise in p and i .

The subsequent slower rise in p and decrease of i are attributed to the formation of nitrogen trioxide (N_2O_3) and nitrogen dioxide (NO_2)¹. Marked traces of ozone (ozone was also observed in the decomposition of nitrous oxide by silent discharge 1b) together with free hydrogen were detected corresponding to about the first maximum on the p -time curve; oxygen and water were also observed. Likely interactions leading to products such as nitrogen pentoxide and nitric acid show the extreme complexity of the change.

In the so-called rhythmic and pulsating reactions the velocity, and not necessarily the direction of the change, varies periodically³. The pressure and the associated synchronous changes especially during the later stages of the present reaction, however, indicate that the corresponding *direction* is reversed periodically. The entire group of these fluctuations was suppressed when the ozonizer was cooled to 7° C., and revived on restoring the temperature. An alternate film-like condensation and evaporation (or/and desorption) is, however, insufficient as a general explanation⁴. Moreover, attempts to observe such a periodic effect in vapours of water, bromine and iodine under similar conditions of discharge have failed⁴. That the periodic effect does not necessarily accompany at any rate a partial reversal of reaction was observed in the interaction under

discharge of sulphur and nitrogen⁴. During subsequent work on the behaviour of the above products of the nitrous oxide-hydrogen interaction, reversal of change and also a full periodic effect as in the accompanying figure are observed under certain conditions of the decomposition of nitrogen dioxide by the silent discharge⁴.

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Compounds of the Structural Type of Calcium Titanate

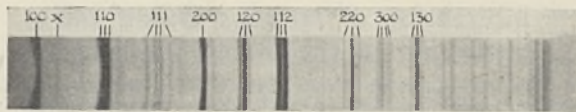
In a previous communication¹, it was recorded that precision X-ray powder methods with a large-diameter camera show that the structure of nickel oxide is not strictly cubic, but only pseudo-cubic. Splitting of some of the X-ray reflexions into more than one component is explained if a small distortion of the cubic lattice along an octahedral axis is assumed, so that the true symmetry is rhombohedral hexagonal.

In the course of investigations on compounds of the structural type of perovskite, CaTiO_3 , it has been found that precision powder methods are capable of demonstrating that only a minority of these crystals have cubic symmetry. Naray-Szabo^{2,3} has recently examined many crystals of the calcium titanate type by means of oscillation diagrams, and has shown that several, including perovskite itself, are monoclinic, and others, for example, lead titanate, are tetragonal or orthorhombic. Using the powdered crystal technique, the differentiations described by Naray-Szabo have been, in general, confirmed, although a small distortion from cubic symmetry has been observed for barium titanate, which is still classed as cubic by Naray-Szabo.

The X-ray powder photographs may be grouped into three main types. For compounds typified by strontium titanate the lines fall in the sequence demanded by the ideal cubic structure. No extra reflexions occur and no splitting of the main reflexions can be distinguished. The ideal cubic structure is therefore valid to a high degree of accuracy.

For some other compounds, of which barium titanate is an example, many of the powder lines are split into more than one component, and the new features can be explained if the symmetry is assumed to be tetragonal. The measured lattice constants of barium titanate are then $a_0 = 3.9866$ kX., $c_0 = 4.0195$ kX. at 22° C. For lead titanate a still greater distortion of the structure is revealed, the axial ratio being much further removed from unity.

With a larger group of compounds the main powder lines show many complexities and a number of extra reflexions appear in intermediate positions. Part of a powder photograph of calcium stannate is reproduced herewith to indicate the kind of effect which is observed. The main groups of lines have been indexed according to the old cubic structure. One noteworthy



PART OF X-RAY POWDER PHOTOGRAPH (COPPER $K\alpha$ RADIATION, 19 CM. CAMERA) OF CALCIUM STANNATE (CaSnO_3).

and characteristic feature of the X-ray pattern of crystals of this type is that a low-order line (x) appears the spacing of which is $2/\sqrt{5}$ that of 100. This indicates that the indices of the main lines should in fact be doubled, and therefore, when an approximation to cubic symmetry is assumed, the unit cell dimensions must be twice those of the ideal perovskite unit cell. For example, the side of the pseudo-cubic unit cell of calcium stannate is approximately 7.87 kX., and not 3.935 kX., the lattice constant for the old structure.

It will be seen that all the members of this large class of compounds, having the general formula ABO_3 , cannot be regarded as isomorphous in the strict sense of the term. Although the ideal lattice has cubic symmetry, in the majority of cases, the cubic structure is appreciably distorted and the true symmetry may be tetragonal or more often monoclinic. There are, no doubt, other groups of compounds, the members of which have similar structural relationships, which would not be embraced by the term isomorphism as at present understood. Naray-Szabo³ suggests that such related structures should be described as 'sister' structures. An alternative would be to use the term 'pseudo-isomorphous' to denote the close structural similarities. This would have the advantage that it follows the accepted custom of using the prefix 'pseudo' to denote structures that are distorted but closely related to the more symmetric crystal systems.

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Crystal Structure of Barium Titanate

It is well known that barium titanate belongs to the group of compounds having structures of the perovskite type¹. The ideal perovskite structure ($G5$ in the "Strukturbericht") has a simple cubic lattice, with one formula-weight per cell, the atomic parameters being as follows: 2-valent cation, (0,0,0); 4-valent cation, ($\frac{1}{2}, \frac{1}{2}, \frac{1}{2}$); oxygens, (0, $\frac{1}{2}, \frac{1}{2}$), ($\frac{1}{2}, 0, \frac{1}{2}$), ($\frac{1}{2}, \frac{1}{2}, 0$). It was early recognized² that for many of these compounds, including perovskite (CaTiO_3) itself as well as barium titanate, the structure was not truly cubic, but was actually a slightly deformed modification of it. Perovskite itself is generally believed monoclinic; the structure has recently been determined in detail by Naray-Szabo³, who finds a monoclinic unit cell with all its edges doubled relative to the unit cell of the ideal structure. No detailed work on barium titanate has hitherto been published, and it was thought of interest to investigate it. Powder photographs of the synthetic material taken in a 19 cm.-diameter camera with copper $K\alpha$ radiation provided the data for determining the structure.

The structure is tetragonal, the dimensions of the unit cell at 20° C., for a typical sample of material,

being as follows: $a = 3.9860 \pm 0.0005$ kX., $c = 4.0263 \pm 0.0005$ kX., $c/a = 1.0101 \pm 0.0002$. This cell contains one formula-weight, BaTiO_3 . The atomic parameters are the same as in the ideal cubic structure. The relationship between the tetragonal and cubic structure is close; the tetragonal unit cell may be simply derived from the cubic by stretching it homogeneously by about 1 per cent along one tetrad axis, which becomes the c axis.

This close relationship suggests that a transition to the cubic structure may occur at higher temperatures. This was verified from photographs taken with a high-temperature camera. At 200°C ., barium titanate has the ideal cubic structure, with $a_0 = 4.0040 \pm 0.0005$ kX.

Further work is in progress.

I wish to express my gratitude to Sir Lawrence Bragg for allowing me the use of the high-temperature camera in his laboratory. I wish also to thank Mr. J. A. M. van Moll (head of the Material Research Laboratory) and the directors of Philips Lamps, Ltd., for permission to publish this work.

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Abrasion of Porcelain Balls

IN *Nature* of August 5, 1944 (p. 169), Lord Rayleigh gives a very interesting description of the production of pebbles of regular shape by laboratory abrasion tests. His main conclusion seems to be that pieces of marble of apparently homogeneous texture tend to become oblate or prolate spheroids even though they start from shapes that are roughly cubic or spherical.

We have recently observed a phenomenon that seems far more mystifying, namely, the tendency of porcelain balls when used for grinding refractory materials in a ball mill to assume a roughly cubic

shape. The samples shown in the reproduction at approximately actual size were originally essentially spherical and assumed this dice-like shape after a few months of service. Their original size was approximately twice that shown. The manufacturers of these balls state that they are made by extruding a cylindrical column of batch, cutting this off into lengths, and rolling to give sphericity. Had the extruded section been square an obvious explanation would have suggested itself.

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Stocksbridge, Nr. Sheffield.
March 2.

Nomenclature of Animal Behaviour

Dr. J. S. Kennedy and Dr. D. L. Gunn¹ have discussed the difficulties inherent in the creation of new technical terms in connexion with animal behaviour. Recently Donisthorpe and I have listed (in a paper now in the press²) the specialized scientific terms used in describing and classifying the behaviour of ants. So far as possible, terms used generally in entomology and other branches of biology have been omitted, except where they have a special myrmecological meaning. One hundred and seventy terms have been listed, and each one has been defined, the original author of the term being cited.

In many cases the original definition of a term is inadequate, or common usage may slightly change its meaning, and in such cases a new and, we hope, adequate definition has been given. Numerous synonyms occur, and in such cases both terms have been defined and included in the list. No attempt has been made to 'sink' one term or another.

I hope that when myrmecologists throughout the world have considered this list with its definitions and synonyms, and have pointed out any omissions, then it will be possible to decide by common consent to use certain terms and not others, and to set up a standard myrmecological terminology. It is to be hoped that this process may be continued throughout the biological sciences; but, to my mind, the first and essential step in the process is the listing and defining of the already existing terms.

I agree with Dr. Gunn that the use of common words as technical terms should be avoided. A flagrant case of this exists in myrmecology in the restriction of the terms 'mixed nests' and 'compound nests'. Wheeler³ defined 'mixed nests' as colonies of ants which are composed of more than one species, and in which the brood is not kept separate; and 'compound nests' as colonies of ants which are composed of more than one species, and in which the broods are kept separate. This is most confusing to the non-specialized biologist, and destroys both the natural collective terms for colonies of ants which are composed of more than one species. To get over this difficulty I have recently proposed⁴ the term 'mixtobiosis' to include all cases of mixed and compound nests of ants.

B. D. WRAGGE MORLEY.

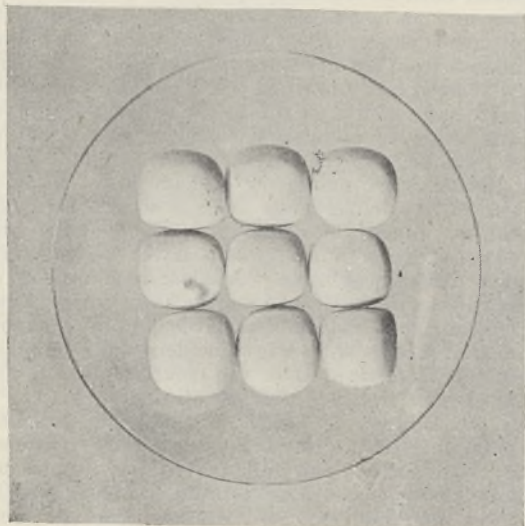
School of Agriculture,
University, Cambridge.

¹ *Nature*, 155, 178 (1945).

² *Roy. Ent. Soc. Lond.*, in the press.

³ "Ants", 423 (New York, 1910).

⁴ *Roy. Ent. Soc.*, in the press.



THE BRITISH EMPIRE CANCER CAMPAIGN

ANNUAL REPORT

IN the introduction to the twenty-first annual report of the British Empire Cancer Campaign, the honorary secretary, Mr. J. P. Lockhart-Mummery, says that "it is a matter of satisfaction that, at the end of five years of war, cancer is being studied in this country with even greater intensity than before". It is indeed remarkable that so much progress should be made. Soon the work should be accelerated.

*. When proposing the adoption of the report, Prof. F. L. Hopwood directed attention to the possibility of introducing radioactive elements in non-toxic compounds into the body. In this way local concentrations of radioactive material in particular organs or tissues might be achieved. Such a new technique would require expensive equipment for the preparation of radioactive elements, and the work would not be without risks for the operators; but interesting results should be obtained.

Therapy. The treatment of cancer of the prostate with oestrogens has been developed during the past year. The present report gives further evidence of the effectiveness of this treatment. The benefits of therapy have been maintained for long periods in many cases. Cancer of other organs has also been treated with oestrogens. Thirty-six cases of late cancer of the breast have been treated with trichloroethylene or stilboestrol at the Royal Cancer Hospital and the Christie Hospital, Manchester. Of these cases, fifteen showed temporary retardation of the growth, although the effects were in general less than could be expected from local palliative X-irradiation. Of twenty-nine cases of advanced cancer of organs other than prostate and breast, only one (a case of carcinoma of the bladder) showed undoubted partial retrogression. Triphenylmethylethylene was less effective than either stilboestrol or triphenylchloroethylene.

Experiments on chemotherapy of cancer carried out by Dr. A. Hadow and Prof. G. A. R. Kon have been concerned with the action of symmetrical diphenylethylene derivatives. Two of these compounds are especially active in checking tumour-growth in animals.

Carcinogenesis. Studies in carcinogenic action during the past year appear to have been concerned with the elucidation of the action of known carcinogenic agents rather than with the search for new compounds. Carcinogenic agents inhibit body-growth, but this inhibition is most unlikely to be solely due to deprivation of cystine, as had been suggested by American workers.

2-Acetylaminofluorene has been further investigated by Prof. H. N. Green and Dr. F. Bielschowsky. This substance induces liver tumours and a few mammary tumours in rats. Liver damage is probably the primary change, and as a result oestrogens in the body are not metabolized and so may cause an increase in the number of mammary tumours. 2-Acetylaminofluorene does not normally induce tumours of endocrine glands, but in an experiment in which rats were treated with the carcinogen and allylthiourea to stimulate the thyroid, adenomata of the thyroid were induced. Allylthiourea itself induces hyperplasia of the thyroid but is not carcinogenic. Thus acetylaminofluorene is able to induce tumours

in hyperplastic thyroid tissue but not in the normal gland. No liver tumours have apparently been induced in mice treated with acetylaminofluorene in the Sheffield laboratories. Aminofluorene has pronounced bacteriostatic action *in vitro* and this action is inhibited by blood and tissue extracts. Mouse liver gives a much more potent antagonizing extract than does rat liver. 2-Acetyl-amino-7-hydroxyfluorene has been isolated from the urine of rats as a metabolism product of the carcinogen.

There is considerable variation in the response by different species or even by different strains to carcinogenic agents. Thus, although coal tar will produce tumours on the skin of mice and rabbits, many hydrocarbons that induce skin tumours in mice will not do so in rabbits. Dr. I. Berenblum has now found that the potent carcinogen, 9:10-dimethyl-1:2-benzanthracene, will produce skin carcinomas on the ears of rabbits. Experiments are proposed to determine if this compound will also induce skin tumours in rats and guinea pigs, which are resistant to most carcinogenic agents.

Dr. A. Glücksmann suggests that the sensitivity of mouse skin varies with the density of the hair coat. The hair follicles act as germinative centres, and the onset of ulceration and papilloma formation coincide with certain phases of the normal hair cycle.

Examination of lubricating oils for carcinogenic activity had made it possible for the Manchester Committee on Cancer to recommend oils which would be expected to be non-injurious from an examination of physical properties. Owing to war conditions, however, the safer oils were not available for some time and there was an increased amount of illness and even death due to epitheliomata of the skin of mule spinners and other workers in cotton mills.

Oestrogenic substances. The possible carcinogenic effects of a number of oestrogenic stilbene derivatives on the skin of mice have been investigated at the Middlesex Hospital. Of thirteen substances tested only one, α -ethyl- β -sec-butylstilbene, induced skin tumours. This compound is but feebly carcinogenic to skin, as only two tumours occurred in twenty-one mice that survived a year of treatment. Attempts to find water-soluble oestrogens have led to the synthesis of sodium hexoestrol phosphate and stilboestrol potassium sulphate. The biological action of aqueous solutions of both these products is being explored both *in vivo* and *in vitro*.

Tumours in pure-line mice. The occurrence of spontaneous cancer in pure-bred strains of mice may be related to other characters of the mice. Thus Dr. F. L. Warren has confirmed the American findings of lowered hæmoglobin in the blood of female mice of strains liable to mammary cancer. The strain of CBA mice kept at the Royal Cancer Hospital has a low incidence of mammary cancer, and the mice appear to live longer than mice of strains in which mammary cancer is common. The ovaries and adrenals of mice of this strain have distinct histological differences from corresponding organs of other strains, in which mammary cancer is often seen. The mean concentration of ascorbic acid in the livers of mice of strains with a low incidence of mammary cancer is often lower than the concentration in the livers of mice from high cancer strains.

Dr. G. Bonser, of Leeds, has induced testicular tumours in mice of a number of strains by treatment with oestrogens. The milk factor, or mammary tumour inciter, appears not to influence the incidence of these tumours, but no testicular tumours were

obtained in the *CBA* strain (a low mammary cancer strain) while all the treated mice of the Strong *A* strain developed tumours. Other strains gave intermediate responses: the 'white label' and *IFS* strains gave a few tumours, and the *RIII* strain a moderate number of testicular tumours if the mice lived long enough.

The British Empire Cancer Campaign has been concerned with research for twenty-one years and is now taking on the additional duty of advising medical practitioners as to the value of any new form of treatment about which the Campaign has knowledge.

E. BOYLAND.

GENETICAL ASPECTS OF THE CANCER PROBLEM

A "PRELIMINARY Report on a Survey of the Situation in Cancer", by Dr. Fritz Blank, appears in the *Archives of Surgery, Chicago* (49, No. 5, 301; 1944). The general interest of the study warrants a digest showing the limits of the field surveyed and the findings. In his foreword, Prof. F. A. E. Crew points out that this survey of the biological background in cancer is the first major attempt by the Bureau of Human Heredity (115 Gower Street, London, W.C.1) to present the results which can be achieved through the 'clearing-house method'. It has been made possible by international collaboration between the Institute and the Department of Medical Genetics of Ohio State University, both of which are foci of much friendly co-operation between individual workers and numerous institutes.

The Bureau of Human Heredity has been developing the mechanism for such work as this since it opened in 1936. The method by which the cross-reference index is made is best compared to a great sorting machine. The desiderata were outlined early on by Profs. R. A. Fisher and J. B. S. Haldane in consultation. It works well; three thousand sections on constitution and traits were already available when Dr. Blank began the cancer collection; points in the present survey can be set against a further 1,500 or so. This preliminary survey covers most of the literature between 1900 and 1941, with data from about four thousand papers.

The summarized genetical findings are not the less important for presenting no surprises. The myth of hereditary cancer is disposed of. Geneticists are more and more aware in other fields of the fact that hereditary make-up controls type of constitution; in other words, individual variations in physiological function. There is evidence from many sources that carcinogenic agents react differently on various types of constitution. This would be expected from physiological genetics. An illuminating point may be gleaned here, namely, that certain types respond quickly to diverse kinds of irradiation. In another series it appears to be mainly hormone imbalance which prepares the body for growths and/or malignancy. Fortunately, data give at least a rough guide as to means of differentiating between these two major sources of the disease.

It is significant to learn that certain diseases of hereditary type appear frequently as precursors of neoplastic growth and malignancy. Here the clearing-house method may have special importance. Practi-

tioners, by contributing their observations to the Centre, will do much to accelerate accumulation of knowledge of practical value to their colleagues and to humanity.

Dr. Blank's survey is set out in chapters dealing with those aspects in which research was sufficiently advanced in 1940 to show a bearing on the biological background; no reference is therefore made to the data on nuclear division, including polyploidy and extrachromosomal factors, on which researches are now in progress. Statistics come first: of high genetical interest are comparative figures for different parts of the world and different races. These show that for all those areas and peoples for which reliable figures are available, the general incidence of cancer is practically the same, although site and type of the disease vary greatly; and there is a hint in the Dutch East Indies that hereditary racial characteristics underlie this fact where Malays and Chinese working side by side demonstrate racial incidence comparable to that of their home areas.

Detailed studies in Norway (Waalder, 1931), later repeated by Wassink in Holland, throw light on the question in general and show the complexity of the problem. Greenwood's analysis is as follows: (1) "some forms of cancer (e.g. lip cancer) are produced quite independently of any inheritable *anlagen*; extrinsic factors have greater, perhaps exclusive, influence upon males; (2) the heritable factors show two independent factors, both of which occur with a frequency of about 16%". These, according to Wassink, are the existence of a general predisposition and also a tendency to certain localization.

'Cancer families' are reviewed, beginning with studies in 1856; it has been shown that simple statistical study here is unreliable (Cramer, 1937), since in large families where sibs survive to thirty-five years, the expectation will be approximately that of the general population. Twin studies are mentioned, but since none conforms to the criteria set up by von Verschuer and Kober, the findings are omitted from the general argument.

The work on rodents receives notice proportionate to its importance and covers spontaneous tumours and the reaction of different strains to transplantation and induced tumours. In each series sharp differences in incidence and reaction are noted between stocks within any given species or variety: there are immune, partially immune or tumour-prone. There remains an unresolved problem here in a change of average incidence in experiments with foster suckling (the so-called milk factor). But here also a variation in resistance of the stocks persists; recent work on agglutinogens in milk were not available at the date to which the survey is carried.

Carcinogenic agents are surveyed in detail; the organic type, the viruses, have been the focus of the search for a possible causative factor or prime agent. Occupational cancers stimulated research on chemical agents, and these are reviewed. Work with hormones proceeding over the same period is not unrelated to those investigations; of these, oestrin has given important results, namely, the production of mammary cancer in 100 per cent of male mice in a cancer-prone stock. Cramer and Horning relate this to a heritable faulty metabolism shown as 'brown degeneration of the adrenals'.

Of great practical interest are the data on those diseases with genetic background which are frequent precursors of cancer. These are spoken of as the internal carcinogenic environment. In addition to

neuro-fibromatosis and xeroderma pigmentosum, achlorhydria is typical. The racial data demonstrate a constitutional susceptibility to physical irritants, particularly radiation. The work of Roffo and Findlay calls for further research in this direction although the general facts are clear.

Dr. Blank concludes that the complexity of factors noted above will be found to prevail equally in most forms and types and sites of tumours. As the cases of cancer in which we can trace direct hereditary transmission are rare, admittedly they cannot provide a valid answer to the question of whether, or to what extent, an inherited susceptibility plays a part in the general incidence of malignancies. From disorders indicating a purely hereditary proneness to tumour formation, such as xeroderma pigmentosum or neuro-fibromatosis, must be differentiated many other types of tumour formation about which nothing yet is known of an inherited tendency as, for example, cancer of the lip, which according to Waaler seems to be distributed quite independently of any inherited disposition.

Much remains to be done before these problems can be solved, but our task will be lighter if we heed the lesson already taught, namely, that it is vain to ask, "Is cancer hereditary?" and that we must inquire *separately* for each organ, tissue and type of the disease, whether any hereditary factors, *direct* or *indirect*, are involved in a specific form of the malady.

Summarizing our present position meanwhile, we can say that enough evidence has been accumulated to warrant at least the following statements: (a) Cancer is not a unit disease, at least so far as its genetical behaviour is concerned. Tumours of different sites and types differ in their genetical behaviour. (b) Therefore it is unlikely that a heritable condition of 'cancer' exists as such. (c) There does exist a general inherited disposition, whether of susceptibility or refractoriness to tumour formation. (d) In certain individuals factors exist, most probably inherited quite independently of a general disposition, which govern the localization of the disease. This localization in turn seems to depend upon a favourable 'internal environment' in certain tissues or organs. (e) If general susceptibility and inherited favourable internal environment are combined in an individual, these factors may be strong enough in themselves to lead to cancer formation in certain tissues. (f) If general susceptibility is very marked in an individual, even relatively slight irritation by agents of many kinds may lead to cancer formation. (g) But quite apart from these heritable conditions, there exist purely external carcinogenic agents of various kinds, which are obviously strong enough to lead to cancer-formation in certain tissues, even in individuals in whom there is no inherited predisposition, or perhaps it is too weak to be detected by methods used at present in testing for hereditary traits.

The above is a picture of cancer research as seen by the genetically minded physician. The chief aim of the survey has been to show that the whole problem of heredity and cancer is a biological question of highly practical bearing. The writer endorses MacDowell when he says: "It is highly regrettable that outside the immediate circle of geneticists, there seems to be an impression that the gene is self-sufficient and is either dominant or recessive. Especially as applied to neoplasms, this misunderstanding has led to erroneous conclusions both on

the part of hostile critics and ardent believers. Dominance is only a special case at the end of a continuous series of interrelations between pairs of genes. . . . No gene can produce its effect without the cooperation of many other genes. . . . And genes and extrinsic conditions cooperate in all cases'.

ANTHONY FEILING.

POPULATION PROBLEMS IN BRITAIN

SIR W. LANGDON-BROWN, addressing the British Social Hygiene Council on the relation of social biology to the population problem (*Brit. Med. J.*, 766, Dec. 9, 1944), said that he regarded with grave suspicion the efforts of planners to de throne the family and hand children over to the State. Some family life is unsatisfactory, but the majority is good. The birth-rate in Britain has fallen steadily since 1870 and, in the same period, the infant death-rate had decreased and expectation of life had lengthened. There is evidence that the fertility-rate decreases with improved chances of survival. The British Social Hygiene Council has estimated that one-tenth of all marriages in Britain remained childless, but not deliberately so. A study of 2,000 cases suggested that in 60 per cent there was a defect on the man's part. In general, the average male fecundity is much lower than was generally assumed.

Other factors operating against the family are increased rents and rates, which absorb much more than the one tenth of income allowed for these in the Victorian scheme of things. This means that money which should go for food is spent on housing, with alarming effects on infant mortality and family life. There is an increase in life in flats due to aggregation of urban populations, and flats are unsuitable for children. A standard rate of family allowances would not be satisfactory. The effects of late marriages and the consequent celibacy forced on our younger people by social changes must be recognized and studied by social biologists.

These and allied problems are the subject of a booklet issued by the Tory Reform Committee entitled "Tomorrow's Children" (P. S. King and Staples, Ltd., 14 Great Smith Street, London, S.W.1, 1s. net). This pamphlet rejects the thesis that the world will get too full in the future, because efforts to raise the birth-rate cannot do more than arrest the decline and because the progress of invention and science is always enabling us to support far greater populations at a higher standard of living. The maintenance of these greater populations depends on the fathers and mothers of the next thirty years. The problem before us is whether there will be enough people to keep things going when our grandchildren are grown up. Immigration may affect this problem considerably. Before this War, 50,000 more persons a year were entering Britain than were leaving it. In the future, Britain may attract thousands of the peasant populations of eastern Europe, and we may then be glad to let them in, just as the Dominions and the United States were before the War of 1914-18. But at present we are faced with a progressive decline of the population. The apparently satisfactory conditions at present are due, not to a good birth-rate, but to a low death-rate, resulting from improvements in public health, which allow more old people to survive. The raising

of the net reproduction-rate to 1, instead of the existing rate of 0.75, which this pamphlet recommends as a practical policy, would tend to stabilize the population at about three-quarters of its present figure.

The trend towards a rapid decline of population affects not only Great Britain, but also Norway, Sweden, France, Belgium, Switzerland and Austria, where populations will decline at about the same rate as Britain's will. Other countries, including Ireland, Germany, Italy, Russia, Japan, China and India, will show an increase by 1970.

Among the causes of the population decline the pamphlet discusses (1) the enormously higher standard of living, leisure and comfort; (2) the great increase in mobility, which often makes the home into a place to be left as often as possible; (3) the almost universal literacy and widened outlook, due to reading in the local libraries and daily papers and to the radio; (4) the wide availability of contraceptives, which tend to affect the birth-rate in the groups of higher income and education; and (5) profound changes in our conceptions about religion, duty and social behaviour.

In Britain there is no spiritual significance of parenthood comparable to that which exists in India and China. Education stresses the importance of the individual, so that the child tends to ask what it can get out of life, rather than what it can give.

Among the remedies proposed by the Tory Reform Committee is the creation of a domestic service, which would make housework an attractive career. It also suggests that positive action should be taken in Parliament to bring this whole problem of population and family life more frankly before the people, to remove economic barriers to early marriage and to make two, three or four children an economic possibility in all classes, instead of a severe liability as they are at present. The alternatives against which the young married couples of the next few years can protect us if we enable them to do so are, the Committee thinks, decay through a progressively declining population, or immigration from countries with growing populations, including those of the East.

G. LAPAGE.

POLLEN ANALYSIS AND THE MUSEUMS

H. A. HYDE, of the National Museum of Wales, has published an informative article on the technique, history and applications of pollen analysis (*Museums J.*, Dec. 1944).

The study of atmospheric pollens in England began in 1867 when Charles Blackley, a Manchester medical practitioner, exposed to the air micro-slides treated with an adhesive, and found that the days when the slides showed most pollen grains coincided with those on which his hay-fever patients suffered worst.

In 1941 a detailed day-to-day census was begun at Cardiff, and the results obtained during 1942 (see "Studies in Atmospheric Pollen. I. A daily census of pollens at Cardiff, 1942". By H. A. Hyde and Dr. D. A. Williams. *New Phyt.*, 43, 49; 1944) showed that the effective pollen season lasted from early March until late September, and (as previously discovered in the United States) presented three phases characterized by the pollens of trees, grasses and other herbs respectively. The applications of pollen research are numerous. At Cardiff the work is maintained chiefly for the purpose of assisting

medical allergists in making their diagnosis; but in addition because it is of value in the pollen analysis of peat, in experiments on the hybridization of plants, and in meteorological work concerned with the movement of air currents. Again, pollen analysis has been employed—notably in Central Europe—in the determination of the source of origin of honey, and the author suggests that in the future bee-keeping and other departments of horticulture are likely to benefit from similar research. In this connexion he directs attention to the fact that the kinds of pollen collected by certain species of bees are already being investigated under official auspices.

Geological or archaeological correlations are probably the most widely known applications of pollen analysis, but the work so far carried out does not yet provide a complete and independent time-scale for dating archaeological finds. It has, nevertheless, made possible the reconstruction of the forest history of England and Wales since the close of the last Ice Age, and the working out of a number of correlations with human culture periods.

At the end of his paper the author suggests that "(pending the establishment of an institute of palynology?)" at least the national museums should carry out fundamental pollen research, and that the larger regional museums might consider undertaking certain aspects of the work. In support of the desirability of this, he points out that certain public authorities in the United States carry out daily analyses of atmospheric pollens, and he is of the opinion that it will not be long before similar observations will be required in Great Britain. Collaboration between museums and public health authorities (both often under the same municipal authority) would, therefore, be of mutual advantage.

FORTHCOMING EVENTS

Saturday, April 21

SOCIETY OF INSTRUMENT TECHNOLOGY (at the London School of Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.), at 11 a.m.

ASSOCIATION FOR SCIENTIFIC PHOTOGRAPHY (at Caxton Hall, Westminster, London, S.W.1), at 2.30 p.m.—Mr. E. Mackie: "A Consideration of the Requirements for Micrography and Cinemicrography Apparatus".

Monday, April 23

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Sir Frank Smith, G.C.B., G.B.E., F.R.S.: "Chemicals from Petroleum" (Cantor Lectures, 2).

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, South Kensington, London, S.W.7), at 5 p.m.—"Enthronement of the Dalai Lama, and Journeys in Bhutan" (Kodachrome Films by Sir Basil Gould, with Commentary by Colonel F. M. Bailey).

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion of "Electrical Aids to Public Speaking" (to be opened by Mr. P. G. A. H. Voigt).

ASSOCIATION OF AUSTRIAN ENGINEERS, CHEMISTS AND SCIENTIFIC WORKERS IN GREAT BRITAIN (PHARMACEUTICAL GROUP) (at the Austrian Centre, 69 Eton Avenue, Hampstead, London, N.W.3), at 7.30 p.m.—"Some Interesting Facts on Sex-determining Compounds" (based on work by Mr. R. Kuhn).

Tuesday, April 24

SHEFFIELD METALLURGICAL ASSOCIATION (at 198 West Street, Sheffield 1), at 6.30 p.m.—Dr. H. O'Neill: "The Significance of the Mechanical Test Properties of Metals".

QUEKETT MICROSCOPICAL CLUB (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Mr. A. C. G. Best: "Celloidin Embedding and Sectioning".

Wednesday, April 25

SOCIETY OF CHEMICAL INDUSTRY (FOOD GROUP) (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Annual General Meeting; Mr. A. N. Duckham: "Food Management and the Chemist".

SOCIETY OF CHEMICAL INDUSTRY (NEWCASTLE-UPON-TYNE SECTION) (in the King's Hall, King's College, Newcastle-upon-Tyne), at 5 p.m.—Dr. M. P. Appleby: "The Chemist and the Air" (First Dunn Memorial Lecture).

Thursday, April 26

LINNEAN SOCIETY OF LONDON (joint meeting with the ZOOLOGICAL SOCIETY OF LONDON) (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Frank Colyer: "Caries of the Teeth in Animals"; Dr. Clara M. Warren: "Fungus Infections of the Skin"; Mr. V. V. Tchernavin: Description of Five Specimens of Lyomeri (Deep Sea Fishes) preserved in the British Museum, with Notes on their Skeletons; Mr. C. J. A. Berkeley: "The Ovale of *Digitalis purpurea* Linn."

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Sir Edward Appleton, K.C.B., F.R.S.: "The Scientific Principles of Radiolocation" (Thirty-sixth Kelvin Lecture).

Friday, April 27

ROYAL INSTITUTE OF CHEMISTRY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5 p.m.—Dr. J. H. Quastel, F.R.S.: "Soil Metabolism".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5 p.m.—Prof. P. A. Buxton, F.R.S.: "Natural History of Scrub Typhus".

TELEVISION SOCIETY (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Mr. S. Rodda: "Beam Tetrodes".

Saturday, April 28

NUTRITION SOCIETY (joint meeting with the BIOCHEMICAL SOCIETY) (at the London School of Hygiene, Keppel Street, Gower Street, London, W.C.1), at 11 a.m.—Discussion on "The Vitamin-B Complex".

INSTITUTE OF PHYSICS (ELECTRONICS GROUP) (joint meeting with the MIDLAND BRANCH) (at the University, Edmund Street, Birmingham), at 2.30 p.m.—Dr. H. Kuhn: "Atomic and Molecular Beams".

Sunday, April 29

ASSOCIATION OF AUSTRIAN ENGINEERS, CHEMISTS AND SCIENTIFIC WORKERS IN GREAT BRITAIN (at the Austrian Centre, 69 Eton Avenue, Hampstead, London, N.W.3), at 11.30 a.m.—Dr. B. Burzryn: "On Recent Applications of Thermo-setting Resins on Paper and Textiles".

APPOINTMENTS VACANT

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

ENGINEER by the Government of Iraq to take charge of the Central Technical Section of the Directorate of Municipalities—The Ministry of Labour and National Service, Central (T. and S.) Register, Room 5/17, Sardinia Street, Kingsway, London, W.C.2 (quoting C.2378.A) (April 26).

DEPUTY ELECTRICAL ENGINEER to the Stalybridge, Hyde, Mossley and Dukinfield Transport and Electricity Board—The Ministry of Labour and National Service, Central (T. and S.) Register, Room 5/17, Sardinia Street, Kingsway, London, W.C.2 (quoting D.1170.XA) (April 26).

BOROUGH ELECTRICAL ENGINEER AND PUBLIC LIGHTING SUPERINTENDENT—The Town Clerk, Town Hall, Morley (endorsed "Borough Electrical Engineer") (April 30).

ASSISTANT MASTER to teach SCIENCE in the Junior Technical School and in part-time Engineering and Building Classes in the Hinckley Technical College (special qualifications in CHEMISTRY would be an advantage)—The Director of Education, County Education Offices, Grey Friars, Leicester (May 3).

MANAGER for an important Division of well-known Precision Engineering Company (good engineering degree or equivalent professional engineering qualification will be regarded as essential, in addition to technical, commercial and production experience)—The Ministry of Labour and National Service, Central (T. and S.) Register, Room 5/17, Sardinia Street, Kingsway, London, W.C.2 (quoting C.2550.XA) (May 5).

ASSISTANT LECTURER IN THE MECHANICAL ENGINEERING DEPARTMENT—The Principal and Secretary, Harris Institute, Preston (May 7).

SENIOR LECTURER (woman) IN APPLIED MATHEMATICS—The Principal, Royal Holloway College, Englefield Green, Surrey (May 8).

SUPERINTENDENT OF TECHNICAL SUBJECTS (candidates must have an Honours Degree in MATHEMATICS and/or SCIENCE) to the Glasgow Education Department—The Director of Education, 129 Bath Street, Glasgow C.2 (May 12).

DEMONSTRATOR (man or woman) IN THE PHYSIOLOGY DEPARTMENT—The Warden and Secretary, London (Royal Free Hospital) School of Medicine for Women, 8 Hunter Street, London, W.C.1 (May 19).

PRINCIPAL OF THE DARWEN TECHNICAL SCHOOL—The Divisional Education Officer, Education Offices, Darwen, Lancs. (May 31).

ENGINEER to the Clyde Navigation Trust—The General Manager and Secretary, Clyde Navigation Trust, 16 Robertson Street, Glasgow, C.2 (endorsed "Engineer") (May 31).

READER (full-time) IN INDUSTRIAL HEALTH—The Secretary of University Court, The University, Glasgow (June 1).

ASSISTANT LECTURER (Grade III) or LECTURER (Grade II) IN GEOGRAPHY—The Secretary, The University, Edmund Street, Birmingham 3 (June 2).

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

BIOCHEMIST, preferably with some experience of INDUSTRIAL BACTERIOLOGY—The Director of Research, Linen Industry Research Association, Research Institute, Lambeg, Co. Antrim, Northern Ireland.

TEACHER (full-time) OF MATHEMATICS—The Principal, Enfield Technical College, Queensway, Enfield, Middlesex.

CHIEF ENGINEER to work in close collaboration with scientific staff in machinery development—The Director, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

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