NATURE

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

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POST-WAR CIVIL AVIATION IN GREAT BRITAIN

THE debate in the House of Commons upon the policy of the Government towards the future of civil aviation, which took place on December 17, made public facts that are disturbing. They should be given much more attention than the complacency of the Air Ministry representative's reply suggests that they will receive. Indeed, the relatively small amount of comment which has been published shows that the matter is in danger of being put aside as of little importance except in connexion with plans for reconstruction, a topic which is still unfortunately regarded by many as too speculative to be of immediate importance.

There was a certain lack of perspective in the debate in that an unduly large proportion of the time was taken up in the airing of minor matters concerning the internal management of British Overseas Airways, the company that now exercises a monopoly control over civil aviation under British jurisdiction. Such matters as disciplinary troubles with the staff, and the fact that the Prime Minister's recent flights have been made in charge of pilots not of British nationality were discussed at considerable length. The Joint Under-Secretary of State, Captain Harold Balfour, in his reply, made it quite clear that the Air Ministry does not feel disposed to interfere in such cases, maintaining that, in effect, although these several mismanagements are admitted, they are not sufficiently serious to call for such a drastic step as the removal of the company's Board or even an individual member of it, which is the only real power that the country has in return for paying a subsidy of several million pounds a year.

The much wider and more far-reaching question which arose was that of the Government's attitude towards the present-day development of civil aviation, from the point of view of the situation that will arise in the immediate post-war period. An inter-departmental committee issued an interim report about eleven months ago, in the form of a series of policy questions to the Cabinet. Nothing further appears to have been done since, as until these questions of policy are settled, the committee obviously cannot continue to function on its details.

Meanwhile the gradual absorption of the world's air routes by the American companies is proceeding, sometimes by arrangement with Great Britain, more often because they are the only competitors in the field, but always because we, through lack of an organization and equipment, are not in a position to cater for the demand where it exists.

American air lines have a monopoly in the Pacific and the South Atlantic ; in the North Atlantic they are two to one (our one is run by a British air line but with American machines), in Africa civil air transport is being operated by Americans, and it is reported there will shortly be American air lines operating from Aden and India. This position of inferiority is due partly to the initial lead of the United States in matters of air transport in pre-war days, but it is aggravated by the war-time arrangement that British policy has been to concentrate on the design and production of the smaller aircraft, leaving the larger ones to the United States. This is logical from the delivery point of view, as the large long-range machine can be sent over to the various war centres under its own power, while the small fighter or medium bomber would absorb shipping space and be under greater risk of loss by submarine attack. It is unfortunate, however, in that the large machine is the type that is required for civil air transport, and thus the United States is able to divert a proportion of her output to civil purposes as required, and is gaining experience, and already using it, to design and produce newer and larger transport machines.

Nor does the discrepancy end with this. An air transport concern having a constant supply of newly designed machines and engines must not only be functioning with the utmost efficiency, but also be able to train the personnel in the use of these, and thus build up an organization of skilled staff. British Overseas Airways has no such advantages. Nearly half its equipment is earlier American, the rest being partly obsolete British civil transport machines, or the more modern of them are R.A.F. rejected types, designed for war purposes and converted so far as practicable to civil transport needs. Several of these are fitted with American engines. Actually there are seventeen types of aircraft with fourteen types of engines. The inefficiency, from the point of view of cost and man-hours involved in maintaining such a collection, must be staggering. Also no experience in the use of the more modern machines is being gained, a loss both from their own operational point of view, and that it will not be available to designers of civil aircraft and engines for the post-war period. This is the present position and, so far as is known, the Ministry of Aircraft Production has no plans in hand, nor has it placed any orders for either aircraft or engines specifically designed for civil air transport.

A concrete suggestion for the immediate improvement of this state of affairs, based on partial and rumoured promises, was put forward by Mr. Perkins in the course of the debate. It was that twenty "York" aircraft (a large bomber with a body re-designed for air transport purposes) or else a similar number of another machine outcast by the R.A.F., which he called the "W", together with ten "Sunderland" flying boats, be handed over at once to British Overseas Airways and also the American "Lodestars" now in our possession under the Lend-Lease Act. These should be fitted with the best of the modern developments in variable-pitch airscrews in order to promote safety and maximum efficiency in operation. Financially it would probably be an economy, as it would allow of the scrapping of an equivalent accommodation in old and obsolete aircraft which must now be operating inefficiently, and the reduction in the number of types would economize on maintenance costs. It would give the staffs experience in handling more up-to-date equipment, would help to bridge over the period when inevitably no new civil aircraft will be forthcoming, and would enable us, when the necessity arises, to approach the problem of coming to an arrangement with the United States on more equable terms.

For the future, the long-term policy advocated was to take civil aviation away from the Air Ministry, the principal interest of which, quite rightly, is to develop and maintain the standard of the R.A.F. equipment. A committee should be set up to survey the whole question of civil aviation—not only air transport—with instructions to report quickly, say in three months time. The present monopoly given to one concern only should be abolished, and a healthy sense of competition allowed to function. This could be controlled, giving certain fields to specialist firms to avoid overlapping, without giving complete monopoly to any one. The Government should at once initiate the commencement of the design of three aircraft and three engines definitely suited to three broad types of civil air transport work.

In this respect it is interesting to note the report of the American Maritime Commission, published nearly five years ago. Although not a body primarily interested in aviation, the Committee expressed the opinion that large aircraft are already capable of superseding luxury liners of the *Queen Mary* type. It envisaged a large flying boat, to-day a technical possibility, six of which could carry per year more passengers on the Atlantic crossing than did the *Queen Mary*, and moreover the trip would take ten hours or less instead of five days. The standard of comfort need be no less than we expect upon a night 'sleeper' on the London-Scotland railways.

From the political aspect, the possession of a large air transport organization would be of the greatest help. Rapid travel would expedite that personal contact between the really big executives that will be needed when the question of rearranging the democratic government of the world has to be faced. Many speakers during the debate hoped for the possibility of the establishment of the freedom of the air when that time comes. This 'open sky' policy should follow the lines of the accepted freedom of the seas. Free and unrestricted flight to all points should be given. No small nations should be allowed to obstruct by prohibiting flights over their territory. Unrestricted use of airports, these maintained with an agreed standard of equipment, lighting for night flying, and other such safety devices, must be provided by all nations. At the end of this War, with the Great Powers in a position to dictate, in a benevolent way, to the smaller States, the psychological moment for such an innovation would seem to have arrived.

The reply of Capt. Balfour, on behalf of the Government, was far from reassuring. Apart from answers to the several minor criticisms that were outside the question of broad policy, his speech was mainly a defence of having put the whole of our effort into R.A.F. equipment, concentrating on "first things first", and consequently our inability to get "more than a pint out of a pint pot". He welcomed the taking over of the British African air route by Pan-American Airways, disguised as part of the U.S. Army Air Transport Command, on the grounds that it is helping in our combined war effort. Exactly what the situation will be when the War ends, if the proposed freedom of the air is adopted, he did not mention. Pan-American Airways will have a complete monopoly of this, and possibly other Middle Eastern air routes, with machines, equipment, and personnel suited to the conditions as discovered by their experience. Apart from sentiment, Great Britain cannot show any claim to replace them. Without an alteration in our present policy, we shall certainly not be able to offer to the localities a better or even so good a service, lacking, as we shall, both experience and specially developed equipment.

The crux of the whole matter of policy appears to be that of the proportion of the aeronautical effort in Great Britain which is allowed to be devoted to civil aviation, particularly that part of it which is directed towards the long-range view of post-war requirements. The British allocation during 1942 was £5,000,000 given to one monopoly company, and a promise of a very small number of converted bombers and flying boats, none of which was conceived or designed as a commercial air transport machine, in the problematic future. Incidentally, £5,000,000, which Capt. Balfour described as "not such dusty crumbs", is the equivalent of about one day's expenditure upon war machines "at the rich man's table". Compared with this, the U.S. Aeronautical Chamber of Commerce stated recently that at present one fifth of the multi-engined production of aeroplanes in that country is devoted to cargo aircraft and that it is expected to rise to one third in 1943. In Great Britain we have British Overseas Airways as the only operating company. In the United States there are seventeen air lines operating under the direction of the Government authorities, but retaining their own individualities and spheres of influence. We have not one firm producing or even designing civil transport machines, whereas in the United States three of the largest concerns are producing cargo-carrying planes, while a fourth is just going into production on the world's largest passenger-carrying aeroplane, an 80,000 lb. monoplane, the "Constellation".

Any country's work in connexion with a total war must obviously be a balance between the production of direct war requirements and the many subsidiaries necessary to maintain national life. Aeronautics, as one branch of this, must be governed by similar laws. We may not be able to get more than a pint out of Capt. Balfour's pint pot, but the dregs allotted to civil aviation from the British pint would appear to compare very unfavourably with the gill that American aviation is getting from their pot. It is obvious that there are many facets to a political situation of this kind, and that it needs extremely delicate handling, but to the ordinary man it must appear that, in the world of aeronautics, Great Britain has either blundered or allowed itself to be jockeyed, which is really the same thing, into a position of bearing a little more than a fair share of the burden.

HYDRO-ELECTRIC DEVELOPMENTS AND RECONSTRUCTION

THE report of the Cooper Committee on "Hydro-electric Development in Scotland" (see p. 187), the main recommendations of which have now been accepted by the Government and embodied in the Hydro-Electric Development (Scotland) Bill presented to Parliament, is a reconstruction paper which will require the early attention of whatever planning authority may be entrusted with the responsibilities recommended by the Barlow Commission or the Scott Committee. The report formulates a programme or policy without attempting to work out its practical implications to the last detail, but in doing so it promotes an admirable appreciation of the position of hydro-electric development in Scotland and supplement to the report on the Highlands and islands of Scotland issued by the Scottish Economic Committee in 1938.

The broad conclusion which emerges from the survey of existing electrical development is that the northern area of Scotland differs fundamentally from all the electricity areas of Great Britain and calls for an exceptional development policy, practice and outlook. In that area there is abundant water-power but no coal; there are no substantial industrial concentrations, and the population is very sparse and widely dispersed. Water-power as a source of energy has different economic and financial characteristics from those of coal-fired steam stations. That portion of the area popularly designated the Highlands has for long been a depressed area and will remain so unless vigorous and far-sighted remedial action is taken in hand without delay.

The Committee considers in some detail the two main theories of the future of the Northern Area, on which most of the proposals laid before it were based. One view, that any attempt to introduce modern industries and industrial methods is foredoomed to failure, since the Highlander cannot and should not be separated from his croft or his boat, however meagre the existence they are capable of yielding, is emphatically rejected. The other view, that the real test of the validity of any electrical project is the promise it holds of attracting new industries, proceeds upon the sound and only possible principle of treating the Northern Area as a whole, developing the more advanced districts as fully as possible, establishing new centres of development at selected sites throughout the area, and trusting to the gradual diffusion of prosperity from these focuses of development into the surrounding districts, including the crofting areas.

In regard to this view it should be remembered, as the Committee comments, that the provision of cheap and abundant electricity is only one, though a very important, factor in any programme directed towards the expansion of existing centres of industry and the creation of new ones. Secondly, the types of industry to which under the Committee's proposals the Northern Area could offer a very special inducement are those such as the electro-chemical and electro-metallurgical industries, which employ very large quantities of electricity and for which the abundant supply of very cheap electricity is indispensable. In regard to these industries, the Committee states that it is inconceivable that a country such as Great Britain, which is so deeply interested in every aspect of the metal industries, could refrain from active and intensive participation in their remarkable development in recent years, especially in view of the increasing importance which in modern technique is attached to the use of alloys. Moreover, it is considered beyond controversy that there is only one possible zone for siting such industries in Great Britain, and that is in northern Scotland in the vicinity of the larger hydro-electric sources. In particular, the district adjoining the Cromarty and Beauly Firths, the Lochalsh area, the upper reaches of Loch Tyne and the upper reaches of Loch Linnhe are specified. If the post-war industrial economy of Great Britain is based on deliberate planning on the lines adumbrated in the Barlow Report, the Committee considers there is an unanswerable case for delimiting this area for the purpose of such industries.

The Committee is confident as to the possibility of offering these industries such advantages in power supply as will provide a powerful incentive to their establishment in the Highlands. It attaches importance to the uncovenanted benefits which may be expected to result from the introduction into this area of a new spirit of enterprise and initiative and the provision at strategic points of modern centres of the most modern industry, on the basis of which the local population can erect a better and richer economic structure the advantages of which should permeate every branch of the life of the people. It sees no reason why these new centres should not be planned as a model of what an urban centre in a rural district ought to be, and it anticipates nothing but benefits to the district as a whole from the establishment of such industries as new markets for the produce of the adjoining districts, from the incidental provision of improved transport facilities and from the numerous conveniences and amenities which must inevitably follow.

Whether or not this confidence proves to be justified will largely depend on the machinery by which the programme proposed is executed. Fundamentally, some of the most important opposition due to earlier proposals such as the Glen Affric project derived from the well-founded belief that no private corporation could safely be entrusted with powers which might affect so powerfully the amenities and the development of a whole kingdom. This important objection is eliminated by the Cooper Committee's first proposal, to create a new public service corporation, the North Scotland Hydro-Electric Board, to which would be entrusted the responsibility for initiating and undertaking the development of all further generation of electricity in the Northern Area for public supply, and its transmission and supply in bulk to the existing undertakings, as well as of the generation, transmission and distribution in all areas outside the limits of existing undertakers.

This Board should have three primary objectives in its development programme: to attract to the Highlands through the offer of cheap and abundant power a share in the vital and expanding electrochemical and electro-metallurgical industries; to develop such further power as may be required for the consumers of existing undertakers or for consumers in its own distribution area, the surplus being exported to the grid; and to develop on an experimental and demonstrational basis isolated schemes in isolated districts.

The recommendations of this report are closely linked with the measures recommended by the Barlow Commission and the Scott and Uthwatt Committees. Not merely the reconstruction of a depressed area and the development of important new industries are involved. These problems are interlocked with those of the utilization of land as well as of natural resources—forestry, agriculture, the preservation of natural flora and fauna as well as of our scenic heritage, the provision of opportunities for amenities and recreation for the whole nation, questions of town planning as well as of country planning—all require consideration in the development and execution of a plan which will worthily meet the opportunities.

The Cooper Committee makes plain its opinion that it is opposed to any system under which a person whose property or interests may be affected by the execution of a large public utility scheme is entitled not only to claim compensation for loss he may suffer but also to oppose the entire scheme on its merits. Its proposals for compulsory powers and more business-like and modern machinery in this matter of acquisition and compensation, and for the exemption of new schemes from rates either permanently or for a prolonged development period, however, have not been incorporated in the Bill now before Parliament. The suggested provision for the appointment of an Amenity Committee selected by the Secretary of State to advise the new Board in framing and executing proposals is unlikely to be satisfactory, however favourable the precedents cited, unless the proposals of the Scott Report are also implemented. The issues raised by the Cooper Report are wide and general as well as specific, and afford an outstanding opportunity for bold enterprise on the part of the Government.

MECHANISM OF THE ELECTRIC SPARK

The Mechanism of the Electric Spark

By Prof. Leonard B. Loeb and John M. Meek. Pp. xiii+188. (Stanford University, Calif.: Stanford University Press; London: Oxford University Press, 1941.) 3.50 dollars.

ALTHOUGH this interesting book bears the copyright date of 1941 at the Stanford Press, it has only recently been available in Great Britain, and will be regarded as an important supplement to Prof. Loeb's treatise "Fundamental Processes of Electrical Discharges in Gases" (1939). The reason for the appearance of a supplement to a very modern book of such comprehensiveness is to be found in the discovery by an Englishman, one of the authors, J. M. Meek, of a simple condition or criterion, which, applied to Prof. Loeb's qualitative streamer theory of spark discharge, converted an interesting speculation into a quantitative theory of great power. Dr. Meek (formerly of the University of Liverpool and the Research Department of the Metropolitan-Vickers Company) studied under Prof. Loeb with a Commonwealth Fund Fellowship, and there developed the conception and mathematical argument which has led to the satisfactory explanation and correlation of many inexplicable, apparently unrelated phenomena of the spark discharge.

Meek's work has appeared in several scientific journals, but Prof. Loeb has rendered very useful service in reviewing the former streamer theory afresh in the light of Meek's discovery, and the book will constitute a valuable addition to one's library of "J.J." and other works on gaseous discharges.

The book is dedicated to Townsend, "whose pioneer researches and theory laid the whole foundation for the study of the mechanism of the spark discharge": one wonders whether Prof. Loeb was hoping thereby to bring Saul also among the Prophets, for on p. 374 of the longer treatise he wrote: "Unfortunately Townsend and his school have been the last to concede the errors in reasoning". It must be admitted, however, in fairness to Townsend, that although the second Townsend coefficient β may have been an over-simplified explanation of the true facts, the facts have been so elusive to modern research that hundreds of papers have been written on the subject, and finality is not yet in sight.

The development of new theories of the spark discharge has its origin in three new experimental techniques: first and most important, in the development by Rogowski in Aachen of the high-voltage cathode-ray oscillograph, with which time-lags of spark formation could be measured; secondly, in the application of the Wilson cloud chamber to the study of sparks in the early stage of their formation; and thirdly, in the successful application by Schonland of the rotating camera to the study of the lightning discharge. The book gives full consideration to the first two, but in the writer's opinion does not do justice to the third. After all, we owe to Schonland and his co-workers, so long ago as 1933, the first direct evidence that a discharge occurs in at least two main stages, the electron avalanche or leader stroke of varying degree of complexity, followed by the main stroke developing in the opposite direction to the leader stroke. This dual process (expanded to a triple process by the authors) is the basic idea underlying modern theory.

The book is written in three chapters. The first deals with the Townsend theory and the difficulties revealed by research over the past ten years; the second deals with the mechanism of the positive streamer, including the application of Meek's criterion; and the third gives quantitative examples of Meek's formula applied to breakdown in a uniform field, in the field of a sphere gap and of coaxial cylinders, and the way breakdown is influenced by external ionization.

Chapter 1 is a condensation of Chapter 10 of Loeb's longer treatise. The Townsend second coefficient β was originally the number of new electrons created in a gas by a single positive ion in unit distance. At N.T.P. the velocity of such an ion in the breakdown field is 10^5 cm./sec., whereas the oscillograph shows breakdown to occur in 10^{-7} sec. for a 1 cm. gap, apart from any statistical time-lag. Thus positive ion ionization is ruled out in accounting for breakdown at such values of pressure and gap; moreover, abundant evidence exists that the positive ions cannot reach ionizing energy in the available field. Nor can any action at the cathode be invoked, especially for long gaps; the secondary processes must all occur in the gas and not at the electrodes. Here the cloud chamber and the Kerr electro-optical shutter camera provided the vital evidence; the initial phases of spark breakdown occur at the anode, anode streamers are found to develop towards the cathode, whereas cathode streamers would be expected from the Townsend mechanisms.

The anode streamer theory is fully developed in Chapter 2. The electron avalanche first develops from cathode to anode at a speed of about 10^7 cm./sec. This results in a large positive ion space charge mainly near the anode, which creates a field of magnitude comparable with that of the main field. Accompanying ionization, there is also produced a large number of excited atoms and molecules, which in 10^{-8} sec. are emitting light of very short wavelength readily absorbed in the surrounding gas and copiously liberating photo-electrons. Those liberated near the positive ion space charge of the initial avalanche will be accelerated in the combined main and space-charge fields, and the positive ions left behind will extend the space charge towards the cathode. Thus the space-charge volume develops towards the cathode as a self-propagating streamer having a velocity probably in excess of 10^7 cm./sec. When this reaches the cathode, there is a conducting filament bridging the gap; and provided the potential is still maintained, current builds up from the cathode to the anode as a highly conducting spark or arc—the 'main stroke' of the lightning terminology. Meek suggested that the self-propagating streamer only developed when the field due to the space charge created by the avalanche reached a magnitude equal to that of the main field. Setting up the equation for this condition, Meek was able to calculate the main field strength for breakdown between parallel planes, and obtained almost exactly the experimental value. Furthermore, his formula gave good agreement with Paschen's law down to 1/8th atmosphere for a 1 cm. gap, below which it is known that time lags increase considerably above values obtaining at N.T.P. We see at once why with over-voltages applied to gaps the positive ion streamer will start even before the avalanche has reached the anode, and thus we get an explanation of the occurrence of mid-gap streamers and reduction in the formative time-lags. Branching of the positive streamer discharge is to be expected, since the incoming avalanches created photo-electrically may come from any direction roughly between the space charge volume and the cathode.

With long gaps at N.T.P., Loeb suggests that the electron avalanche cannot cross the gap in one process; after a certain stage, its progress is arrested by the field of the space charge behind it, and a positive streamer forms and progresses back to the cathode. This results in a reduction of the space-charge field and a virtual extension of the cathode, so that the electron avalanche/retrograde positive streamer process continues in steps across the gap. This is virtually the mechanism of the lightning flash from the negative cloud, and now the succession of retrograde positive streamers becomes Schonland's 'leader stroke': and the 'main stroke', instead of proceeding from cathode to anode, proceeds from ground (positive) to cloud (negative). The discharge mechanism can start also from the anode at suitable field strengths. Here electron avalanches drawn into the anode leave positive space charges which virtually extend the anode towards the cathode. As the space charge here augments the main field, sparkover voltages for large gaps are lower for positive than for negative potentials. This explanation is in line with the explanations already offered for the different appearances of the rotating camera photographs of long sparks. Both authors present theories for the cause of stepping of the lightning leader stroke. Meek suggests this is due to ageing by recombination followed by rejuvenation. Loeb suggests it is due to replenishment of lost electrons in the avalanche process.

Chapter 3 is a valuable exposition of the many spark phenomena correlated by Meek's theory. A most important feature of the calculation is the value to be given to the ratio of main field to space-charge field for breakdown to ensue. A change in this ratio of 10 : 1 only alters the calculated breakdown voltage for a 1 cm. gap by 2 per cent, and the decision as to choice of ratio was taken on the 1 cm. gap breakdown voltage. This arbitrary choice is already the subject of criticism, and further development of spark theory will almost certainly depend on the physical significance of this ratio. The chapter has been extended somewhat in a recent paper by Meek (*J. Inst. Elect. Eng.*, **89**, 335, Aug. 1942), to which interested readers are referred.

The book is well written and most enjoyable. It is unfortunate that errors were not eliminated from the text, but that was due to the separation of the authors and their preoccupation with other urgent problems. T. E. ALLIBONE.

DISCUSSING HEREDITY

Cytology, Genetics and Evolution

By M. Demerec, Charles W. Metz, Franz Schrader, Albert F. Blakeslee, Th. Dobzhansky, Clarence E. McClung, Herbert S. Jennings, William F. Diller, T. M. Sonneborn, Leon Churney, William R. Duryee, Paul S. Henshaw. (University of Pennsylvania: Bicentennial Conference.) Pp. v+168. (Philadelphia: University of Pennsylvania Press; London: Oxford University Press, 1941.) 12*s*. net.

THE second centenary of "The New Building" was celebrated, in more prosperous circumstances than the first, by holding a conference at Philadelphia, during September 15–21, 1940. A part of the proceedings of this conference seems to be included in the present volume. The editor's name is not mentioned; indeed, there is no introduction or preface. In default of any explanation the reviewer may perhaps attempt to fill the gap and place the papers in relationship.

To begin with, the last paper should properly come first. Henshaw's discussion of "Radiation and the Cell Nucleus" is a useful introduction to the physical side of the subject. Reference to the extensive recent American work on the biological side of the mechanism of X-ray breakage of chromosomes is, however, omitted. Jumping this gap we come to two articles on the physico-chemical structure of the cell and nucleus by Churney and Duryee. Duryee describes microdissection and other experiments with the amphibian nucleus. Most striking is his study of the formation of nucleoli and his method of expelling the nucleolus from the nucleus by changing the *p*H of the medium. Some misconceptions could perhaps have been avoided by comparison with fixed and stained preparations.

Third should be taken two articles by Metz and Schrader on chromosome structure. Schrader has evidence that a fusion of heterochromatin is perhaps the basis of the second division pairing of sex chromosomes in the Heteroptera. He does not, however, recognize the relationship of such fusion with nucleolar fusion and its distinctness from the specific prophase association of homologous genes. The situation becomes clear only when plants and animals are considered together.

The next step is shown by Demerec's article on the "Nature of the Gene", which explains the evidence for the chromomere-gene equation. It also explains the connexion between observed breaks and exchanges in salivary gland chromosomes of Drosophila, and the physiological expression of genes. The fifth step is contained in Blakeslee's and Dobzhansky's accounts of the structural changes in chromosomes found to distinguish natural races in Datura and Drosophila. The situation is indeed widely different in the plant and the animal. But it is different, not because they are plants and animals, but because geographical isolation precedes differentiation in Datura, while it may or may not follow it in Drosophila. In the one, therefore, the segmental interchanges occur as accidents; in the other the segmental inversions occur as the condition of isolation—isolation first of segments of chromosomes, and later of individuals and races.

Next we arrive at a disconnected group of papers on Rhizopods and on the ciliated Protozoa. Sonneborn deals with the anomalous genetics, Diller with the anomalous cytology, of the relatives of Paramecium. It has to be admitted that the genetics cannot be satisfactorily considered until the cytological situation becomes clearer. Diller's comparative account, however, stands for a great advance, particularly in regard to the understanding of polyploidy and autogamy. A still further advance will come when the newer methods of recognizing nucleolar and nuclear constituents are applied to the group.

Finally comes an article by McClung on the "Evolution of the Germplasm". McClung presents an abstract of the problems that confronted Lamarck, Darwin and Weismann (whose names he does not mention), together with a mixture of the solutions they offered. The account is mystical and even in places meaningless. Many will regret that, while McClung's initial discovery of the sex-chromosomes has led his disciples forwards, it has apparently led him backwards to such a point as this.

We can gather that at the time these papers were written their authors did not know of the collection that was to be made of them, for only one cross-reference occurs in the book. This is a subject, or a group of subjects, in which above all cross-reference is needed at the present moment, and a symposium should provide precisely the means to this end. A year later the Cold Spring Harbor Symposium on Chromosomes and Genes (see NATURE, **149**, 242; 1942) achieved just this object and in doing so will prove itself an important milestone in the advance of biology. The present series of papers may be taken as an easy introduction to the larger work.

C. D. DARLINGTON.

SIR JOSEPH BANKS, P.C., K.C.B., F.R.S. (1743–1820)

By JOHN D. GRIFFITH DAVIES

"THE works which this man leaves behind him occupy a few pages only: their importance is not greatly superior to their extent; and yet his name will shine out with lustre in the history of the sciences."

With those words Cuvier opened his *eulogium* on Banks at a meeting of the Académie Royale des Sciences at Paris on April 2, 1821. On such an occasion extravagant language is to be expected; but Cuvier spoke no more than the simple truth when he placed the Academy's former foreign member high on the roll of those who have made history in science; and the rightness of his judgment has not been varied in the passing of the years.

Whether Banks is to be accounted a man of science, as this term is now understood, is a debatable point. He described himself as a *botanizer*—a status now to be regarded as inferior to that of botanist. Nevertheless, there are some present-day botanists who are convinced that, when judged against the background of botanical science in his times, the botanizer Banks can justly be acclaimed a competent botanist.

Personal fortune undoubtedly made it easy for him to indulge his life-long interest in natural history. Born in Argyle Street, London, two hundred years ago this month, the son of a wealthy Lincolnshire landowner, he inherited an estate worth £6,000 a year when he came of age in 1764: a princely income in those days when money bought more than it does now, and when the State made far fewer incursions into a man's pocket. Harrow and Eton (he went to both schools), and later the "House" at Oxford, brought him no academic distinctions. Indeed, he had little liking for the customary classical studies. In 1807 he confessed to a correspondent: "I am scarce able to write my own language with correctness, and never presumed to attempt elegant composition, either in verse or in prose, in that or any other language". For that reason, he went on to say, it was improper for him to agree to become a member of the projected Belles Lettres Society: "It is fitting, therefore, that I continue to confine myself, as I have hitherto done, to the dry pursuits of Natural History".

Natural history was his absorbing interest both as a schoolboy and undergraduate. Though Oxford had a chair of botany, its occupant in Banks's time was Humphrey Sibthorpe, of whom it is recorded that he delivered but one lecture on his subject in thirty-five years. It was characteristic of Banks, always the man of action, that he should ask Sibthorpe's permission to import into Oxford the self-educated young Cambridge man, Israel Lyons, recommended to him by John Martyn, professor of botany in that University; and it was under Lyons's direction, and with the enthusiastic support of Banks and his friends, that there was revived in Oxford a lively interest in botanical studies.

Even as a young man Banks must have possessed an attractive personality. He made friends easily, even among men older than himself; and, when shortly after coming down from Oxford he acquired a town house in New Burlington Street, he entertained them with that hospitality which was later to make him famous when he removed to Soho Square. He was elected into the fellowship of the Royal Society in May 1766: among his sponsors were James West, later to be president of the Society, Charles Morton, principal librarian of the British Museum, and William Watson, distinguished both as physician and botanist.

A love of adventure was in Banks's blood. In 1766 he sailed in the fishery protection vessel, the *Niger*, to Newfoundland and Labrador. He at once proved himself to be a good sailor (later he was accused by his enemies of preferring the company of sailormen), and also a skilful collector of botanical specimens, though some of his collection was destroyed by heavy seas on the homeward journey. Two years later he sailed with Lieutenant Cook in the *Endeavour* to Otaheite to observe the transit of Venus, and thus took part in one of the memorable voyages in British naval and exploratory history. When the Council of the Royal Society petitioned the Admiralty for permission for Banks to accompany the expedition, they described him as "a gentleman of large fortune, who is well versed in Natural History", and declared that his going would be "for the advancement of useful knowledge". No doubt the petition was the more favourably received because one of Banks's Lincolnshire neighbours, Sandwich, who was particularly identified with Jemmy Twitcher of Gay's *Beggar's Opera*, was a Minister of State, and had great influence at the Admiralty.

Banks told the story of that adventure in his "Journal": read alongside the log of the *Endeavour* it gives an insight into the character of the man. He is filled with youthful enthusiasm; nothing escapes his notice. Whenever there is opportunity of shore excursions Banks and Solander, the professional botanist, are hard at work collecting specimens or observing natural phenomena. All is recorded faithfully and with commendable modesty, particularly when it is recognized that Cook looked upon him as a tower of strength in adversity. He handled the natives easily and with understanding. When an instrument is stolen it is Banks whom Cook dispatches to effect its return. Great was the disappointment among the natives when on later voyages Cook had to confess that Banks was no longer his companion. One is tempted to think that the great navigator would not have met his tragic end had Banks, in whom the natives placed such complete confidence, been at hand.

Here is not the place fully to examine the reasons why Banks did not accompany Cook on the latter's second voyage. One thing is certain: it was not because of any personal animosity between the two men. Whatever Banks's enemies said (and they said a great deal), the vessel, the *Resolution*, provided by the Admiralty did not permit of the elaborate structural alterations necessary for the accommodation of his suite. Cook, a competent sailor, bluntly said that he would not risk taking her to sea with a superstructure such as was contemplated; his superiors knew that he was right. So Banks and his party consoled themselves with a botanical expedition to Iceland, an account of which is to be found in Troil's "Letters on Iceland" (1781). This was the beginning of a life-long interest in Icelandic affairs. Not only did he serve the Icelanders by persuading the Admiralty to release their ships, held in British ports when the Danes joined Napoleon, but also he was even sounded by the Government with the view of initiating a move in Iceland to break with Denmark and place the island under the protection of Great Britain.

Banks's reputation was now firmly established, and on November 30, 1778, he was elected president of the Royal Society. The election was not universally popular among the fellows. He was young, and, so the mathematicians averred, wholly unfitted to direct the affairs "of that society in which philosophy once reigned, and Newton presided as her minister". The storm burst about him in 1783–84. He had charged Dr. Charles Hutton, the secretary for foreign correspondence, with neglect of duty. When the latter resigned, his mathematical friends, led by Dr. Samuel Horsley, a former secretary of the Society, rallied round him; and strove in open debate and in scurrilous pamphlets to oust Banks from the presidency. The details of this unfortunate dispute are too complicated fairly to be stated in a short article: suffice it to say that in the end Banks triumphed. Whether or not he was overbearing in his treatment of his colleagues, and ruthless in the conduct of his defence when assailed by those who would not yield to his will, cannot easily be decided. Certainly Banks was a masterful man; he was notoriously impatient of slipshod methods; he wanted action; he had his following, those fellows who were admitted to his brilliant receptions in Soho Square. But whatever may have been his faults, he was intensely loyal to the Royal Society, and was resolved that its fortunes should flourish under his direction. If he introduced into the fellowship (as his detractors said he did) men who had no claim to be regarded as men of science, he did so because he sincerely believed that the patronage of such men was essential for the improvement of natural knowledge; and he did not scruple to use their influence to obtain from Government the means to finance scientific research.

Organized science in Britain had no reason to repent of its choice of leader. Herschel's discovery of Uranus and his plans for the making of a large reflecting telescope, the planning of a geodetic survey of the British Isles, the Cavendish-Watt controversy over the composition of water, Young's undulatory theory of light, the need for proving the standards of weights and measures, the possibility of navigation through the North-West Passage—these were only some of the interests which agitated the scientific world during Banks's long presidency of the Royal Society. To assess his part in them is an unenviable task. As president of the Royal Society he was bound to bask in the reflected glory of the achievements of its fellows. Of chemistry, physics and astronomy he knew little (and he would have been the first to admit it); but he considered it his duty to assist all who were grappling with scientific problems; and there was no length to which he would not go in order to obtain official recognition of scientific work. Having the ear of the king, George III, he was able to lighten the privy purse of funds for the geodetic survey and the cost of making Herschel's telescope; with powerful friends at the Admiralty he could easily interest the sailors in the Society's schemes for the exploration of the North-West Passage. That the Government again came to appreciate the value of science is clearly demonstrated by the decision to provide the Royal Society with free quarters in Somerset House (1778): the improvement of that accommodation was incidentally one of Banks's first presidential acts.

Much could be written of Banks's personal relations with the king. George III was "quite a piece of a farmer": he was keenly interested in horticulture and the raising of cattle. Suspicious of the professional politicians, who not only thwarted him at every turn but also ridiculed him in their clubs, it was a relief to enjoy the friendship of a man like Banks, who stood aloof from the political arena. Together they would talk over the best methods of growing wool, even exchanging rams and ewes from their respective flocks; together they would plan the layout of the royal gardens at Kew, so dear to the king's heart since they had been the passion of his unhappy mother. During George III's reign nearly seven thousand exotic plants were introduced into England, and it is estimated that by far the greater number of these came to Kew through Banks's collectors.

It was impossible to enjoy the royal favour without incurring the ridicule of George III's enemies. Peter Pindar's venomous shafts were frequently aimed at Banks. He was accused of trying to amuse the Royal Society with frogs, flies and grasshoppers; he was said to have kept its fellows awake with loud raps of the presidential hammer; and, worse still, he sometimes swore in their august assemblies! Gillray's famous caricature is well known: *The Great South Sea Caterpillar Transformed into a Bath Butterfly*. "This insect," states the legend, "first crawled into notice from among the weeds and mud of the South Seas, and, being afterwards placed in a warm situation by the Royal Society, was changed by the heat of the sun into its present form. It is noticed and valued solely on account of the powerful red which enriches its body and the shining spot on its breast; a distinction which never fails to render caterpillars valuable." The king's enemies laughed heartily at Gillray's work—and, incidentally, so did Banks!

The caricaturist had, however, laid bare one of Banks's weaknesses. There is no doubt that he was inordinately proud of the K.C.B. which the king bestowed upon him in 1795; nor was he less proud of his admission to the Privy Council two years later. At all functions, whether official or semi-official, he appeared in court dress—a splendid figure of a man with the red sash across his body and the order conspicuously displayed on his breast. In that garb he presided over the Council and ordinary meetings of the Royal Society, sitting in the chair (his own gift) which is still used by the president.

Another of Banks's weaknesses was his dislike of all attempts to found new scientific societies. He believed that they must inevitably weaken the Royal Society; and that was not to be tolerated. If they were content to remain associations of scientific men, dependent upon the Royal Society, all well and good: otherwise they were to be opposed with all the powers at his command. Yet he helped to found the Linnean Society in 1788, and was its first president; he was also associated with the founding of the Royal Horticultural Society; it was in Banks's house in Soho Square that the famous meeting was held which resulted in the founding of the Royal Institution. On the other hand, he withdrew from the Geological Society when that body refused to become a dependency of the Royal Society; and, at the close of his life, he resisted most resolutely the move to found the Royal Astronomical Society, even persuading the Duke of Somerset, designated as first president, to refuse to accept office.

After his voyage with Cook, when both New Zealand and Australia were visited, Banks was looked upon by king and ministers as *the* authority on Australasian affairs; and there is positive evidence that he refused high political office in order to leave himself free to watch over the destinies of the young colony, in whose future he had unbounded faith. When Europe was distracted by the Napoleonic wars he could write to Hunter, the governor of New South Wales: "I see the future prospect of empires and dominions which now cannot be disappointed. Who knows but that England may revive in New South Wales when it is sunk in Europe." To those who were entrusted with the government of the newly established colony his advice and encouragement were invaluable. Phillip, Hunter, King and Bligh, fighting manfully to give New South Wales an orderly government and thwarted by the professional soldiers who augmented their meagre pay by trafficking in rum, poured out their troubles to him; he reciprocated by doing everything in his power to smooth over their difficulties. In Bligh, that most maligned of men, he never lost confidence. Banks knew him for an expert sailorman, a wise and just governor; he could appreciate, perhaps better than Bligh's traducers, the courage which had been required of the latter when he navigated the loyal men of the *Bounty* through the Timor Sea. And all the time, intermingled with his words of counsel and encouragement, were requests for specimens of plants and any information which might be of value to men of science. It was not to be a one-way traffic in plants. "My business," said Banks to Hunter, is to be "the encourager of the transport of plants from one country to another." The young colony needed a supply of "useful plants"—hops, for example, were to be shipped to New South Wales in the hope that beer would diminish the consumption of rum; and it was Banks who tried to ensure that the colonists' needs were supplied. There were, of course, disappointments. Consignments of specimens were sometimes lost at sea, on homeward and outward voyages, and official support was not always forthcoming in London; but Banks never lost heart; and he could boast to Hunter that "we shall before it is long see her [Great Britain's] ministers made sensible of its [New South Wales's] real value". It is not to be wondered that our kinsmen in Australia look upon Banks as the 'godfather' of their country, and have zealously collected a great wealth of his papers.

Banks was unquestionably a great European. In London his name was a household word; even the humblest citizen knew of the "great Sir Joseph" who lived in Soho Square. Abroad, men of science looked upon him almost as the protector of all scientific effort, especially when the Napoleonic wars interrupted the free exchange of ideas between England and the Continent. Cuvier's tribute to his brave, and successful, endeavours to raise science high above the quarrels of nations is not an unfitting conclusion to this memoir. "During the long period of two and twenty years," said Cuvier, "in which war extended its ravages to every part of the two worlds, the name of Banks was in all places a palladium to such of our countrymen as devoted themselves to useful researches. If their collections were seized, they had only to address themselves to him to ensure their restoration; if their persons were detained, the time occupied in acquainting him with the fact was the only delay which was interposed between them and liberty. When the seas were closed in upon us on all sides, his voice opened a passage to our scientific expeditions. Geography and natural history are indebted to his solicitude for the preservation of their most valuable labours:—but for him our public collections might now, and perhaps for ever, be deprived of the riches which adorn them."

Banks died at his house at Spring Grove, Isleworth, on June 19, 1820: he was buried, as he wished, with neither pomp nor ceremony, in the graveyard of Heston parish church.

PRODUCTION GENETICS IN SWEDEN

By Dr. C. D. DARLINGTON, F.R.S.

NATIONS often have to rely for their independence on the independence of their food supply. This principle is as well understood in Sweden as in Great Britain, and for similar reasons. Since the War of 1914–18, however, Sweden's position has been greatly improved. The annual yields of wheat and sugar-beet have been increased to the point at which the country is just self-supporting. The most important factor in this increase has been the improvement in the farmer's seed by plant breeding; indeed, one quarter of the wheat and nearly one half of the sugar harvest may be put down to the use of improved seed.

Sweden might seem to be a particularly grateful field for the plant breeder because, like Canada and the U.S.S.R., it lies on the northward margin of cultivation; any slight change in hardiness or growth-rate or light-response which pushes the limit of growth slightly farther north therefore throws open a vast new territory to cultivation. On the other hand, as we shall see, the severity of the Swedish climate does not allow the plant breeder to win his victories without a struggle. What these victories amount to I have recently had the privilege of seeing.

The foundation of Swedish success in plant breeding lies in the small village of Svalöv in Skåne, the richest and southernmost province of Sweden. At this centre we find three partners working together. The youngest of the three is the Institute of Genetics of the University of Lund, some twenty miles from Svalöv. This is a department for teaching and research. It was established for Prof. Nilsson Ehle in 1927 and is now directed by Prof. Müntzing. The second partner is the Svalöv Plant Breeding Institute, formerly directed by Nilsson Ehle and now by Prof. Akerman. This Institute is immediately responsible for the production of new varieties, but is, at the same time, concerned with long-term research and houses a part of the Institute of Genetics. The third partner is the Swedish Seed Company, which has the monopoly of maintaining the stocks and selling the seed of the Svalöv varieties and controls each step between selection and marketing. Without this monopoly it was realized that the maintenance of scientific standards could not be guaranteed. The triple organization, now occupying about three thousand acres, arose at first from a farmers' union, but it is now supported and partly controlled by the Government.

This system has developed during the last fifty years and has grown as the field of possible activity has extended and the numbers of crops that have seemed worth while improving have increased. It began with cereal breeding and with the union, on one hand, of the new genetic analysis of quantitative inheritance in terms of cumulative factors by Nilsson Ehle and, on the other hand, of the practical understanding of the plant breeding problem by the first director, Hjalmar Nilsson. This union we now see bearing fruit equally in the practical and the theoretical field.

The first development of the Svalöv organization was the formation of subsidiary stations to meet the local needs of the main climatic regions of Sweden. For example, the Undrom station deals mainly with herbage plants but also with potatoes, while in the far north (latitude 66°) the Luleå Station produces new types of barley and oats. The station at Ultuna, near Uppsala, is of the first importance, and Ultuna has recently been made the site of a centralized agricultural college for the whole of Sweden, a choice which arises not from its central geographical position but from its marginal agricultural position. The new problems and the most difficult ones are on this northern margin. Here under Prof. Turesson some of the most important work is concerned with genetic acclimatization.

The second development has been the formation of specialized stations for particular crops. For example, at the beginning of the War the shortage of textiles brought home to the authorities the importance of fibres, and the flax research was transferred to a new laboratory under Dr. Granhall at Månsabo, near Svalöv. Just as the wheat-breeding department has its complete milling and baking installation, and the sugar-beet laboratory its complete extraction and assaying equipment, so for flax a complete retting installation has been set up, together with special apparatus for retting small selection samples. The industrial equipment necessary as a foundation for plant breeding is never spared.

Sweden's abundance of forests could not long be overlooked where the possibilities of plant breeding were considered. In 1936 a new research station was established by a Society for Breeding Forest Trees. It lies in fifty acres of experimental ground at Ekebo, near Svalöv. An expedition led by Prof. Turesson in 1938 provided a valuable collection of forest-tree seed from North America as a foundation for the work of acclimatization and hybridization.

Under Dr. Nils Sylvén, this work has already gone far. Four regional branch stations have been set up. A genetic survey of Swedish forest trees has revealed a prodigious range of variation in usefulness (just as one sees in Great Britain) both within communities and between them. The ecotype principle is singularly well demonstrated in the differences within species in regard to long- and short-day habit, for when transplanted to a different latitude the unadapted individual is obviously and entirely useless.

A special form of selection has resulted from the discovery of triploid aspens with as much as twice the growth-rates of the neighbouring diploid trees. Many of the later examples have been discovered by farmers and foresters who had been told to look out for them. These valuable trees are being propagated for their own localities, and tetraploids have also been obtained from them. The discovery of these forms has led to the systematic use of colchicine, which has been successful in producing tetraploids in Sequoia, Larix, Pinus and Abies. Artificial lighting, refrigeration and special grafting methods are being used to shorten the work of breeding and propagating.

Naturally, fruit being something of a luxury in Sweden, fruit breeding has been the last problem to be tackled, but two factors have lately directed attention to its importance. First, the damage done to the orchards in Sweden—only less serious than in Finland—by the three severest winters ever recorded, shows the necessity of producing native fruits selected for the Swedish climate. Secondly, the value of vitamin C in a country cut off from southern fruits is obvious. Valuable work has indeed been done in surveying the native rose population for its ascorbic acid content, and maintenance of vitamin content is regarded as an important object of potato breeding.

The origin of the fruit work at Svalöv is typical of the confident purpose of Swedish plant breeding. Triploid apples are in general not only larger but also later keeping and richer in vitamin content than diploids. In order to produce them regularly it was necessary to have tetraploids. Half a million natural seeds of the best triploid varieties were sown. All of them, of course, would be crosses with cultivated diploids. From them twenty-eight tetraploid seedlings—recognized by their larger stipules—have been obtained in the last five years. With this initial endowment the new fruit-breeding stations which are being set up at Alnarp and Balsgård will have a promising foundation.

Instead of relying on such chance origins, however, the plant breeder can now produce polyploids at will by the use of twin seedlings, collected by the seed-testing stations, by heat, and especially by colchicine treatment. These methods have been taken up with enthusiasm and success in Sweden. Tetraploid forms of clovers, lucerne, herbage grasses, barley, rye, flax, potatoes, sugar-beet and other crops have been produced and are being tested ; some have already been proved of practical use. Octoploid wheat-rye hybrids, first raised in the U.S.S.R., are now regularly produced by the doubling of crosses between suitable parents for different conditions and purposes. The selection of their derivatives has made available a large range of forms of good baking quality and high yield and hardiness. In fact, a new grain crop of special value for Sweden and other countries has been created, the first such invention for three thousand years.

Research in Prof. Müntzing's department has indicated the mode of action of colchicine in arresting cell-division and doubling the chromosomes. It has also shown the nature of the anomalous systems of reproduction in herbage grasses, particularly Poa, where either meiosis, or fertilization, or both, may be omitted, with the production of new forms ; where secondary polyploids breed true ; and where pseudogamy depends on the fertilization of the endosperm nucleus alone. Dr. Å. Gustafsson at Svalöv has succeeded in unravelling another anomalous situation in the Canina roses by crosses which have produced new types of reproduction. These investigations are revealing principles of permanent importance in plant breeding. Similarly, the study of the nucleic acid cycles of crop plants which is now being linked up with Caspersson's cell physiology in Stockholm will lay the foundation of new methods of plant breeding.

Geneticists have long had misgivings about the value of X-ray mutations in plant breeding. Gustafsson, however, has made extensive trials and selections of the progeny of X-rayed barley in the third and fourth generations. From the variety Golden Barley he has obtained selections with as much as 10 per cent increase of yield. Whether or not these forms are directly utilizable it is clear that they provide the material of future improvements by recombination. The use of the X-ray method is therefore being extended.

Animal breeding is generally slower than plant breeding and its advantages take longer to prove. Moreover, in Sweden, as in Great Britain, superstition is deeply embedded in the minds of the breeders, although it is not, as here, incorporated in official handbooks. The Swedish Animal Breeding Institute with its well-equipped laboratories is situated on an extensive stock farm at Wiad, near Stockholm. Here Prof. Bonnier has set about reducing the difficulties of the problem by applying the latest technical devices. Artificial insemination is used to make rapid progeny tests of young bulls so that the same bulls, and not their progeny, can be bred for stock improvement. Special tests, again with artificial insemination, have been made for the choice of parents in hybrid-vigour crosses of poultry. New breeding systems have been established for preserving standardized and uniformly cross-bred stocks of poultry by using mixed sperm. These methods are influenced by the hybrid-vigour technique applied with pre-eminent success by Rasmusson to sugar-beet, and to maize in the United States. Finally, the possibilities of physiological experiment with monozygous twins have been exploited by a national collection of such twins in cattle. This deserves special consideration.

One half per cent of all cattle births are twin heifers. To determine which of these are monozygous a preliminary questionnaire is put to the farmer. Those passing this test are bought and submitted to Kronacher's nose-print and hair-whorl tests. Of the first 215 applications seven pairs fulfilled the conditions of identity. In this way nearly a hundred pairs of monozygous twins have now been collected at Wiad from all over Sweden. With these it has been possible to set up physiological experiments covering the practical problems of nutrition and maintenance. From these experiments the genetical variable has been removed. Already questions have been answered with a certainty which could not otherwise have been attained at fifty times the cost. Further, the answers are of importance far beyond the field of husbandry, especially, of course, in medicine.

The lessons of practical breeding—or production genetics as we may call it—in Sweden have their lessons for Great Britain with its vast responsibilities for farm, forest and fruit crop production at home and overseas. The results depend on a policy consisting of the following coherent elements:

(1) Genetics is taught in the universities;

(2) Posts are available in genetic research for the ablest university students;

(3) Men are therefore available to teach in the universities who have done research in this subject and thus actually understand how it works.

This is a train of events which a little thought shows is indeed necessary for the healthy development of any science. But this is only one side. The university departments carry on their work in close collaboration with the applied departments of agriculture and medicine and with the research stations. This leads to an integration of subjects and methods. It leads to a realization of the use of statistical, chemical and cytological techniques in genetics, and of genetical techniques in physiology. Finally, the research stations benefit by a direct flow of ideas and of trained personnel from the universities, and themselves in consequence conduct long-term or 'pure' research of value.

This integration is responsible for what may be described as the engineering method of Swedish plant and animal breeding: a bold combination of scientific basis and long-term planning, with a practical purpose and with practical collaboration. The practical collaboration depends again on the Swedish farmer or medical man himself understanding, as a result of education and propaganda, what profit can be gained by using the latest scientific methods. Such a system and such results do not arise by individual effort or accidental whim. They depend upon an instructed national policy.

ADVANCES OF CHEMICAL KINETICS IN THE SOVIET UNION

By NIKOLAI SEMENOV

Member of the Academy of Sciences of the U.S.S.R.

[The school of N. Semenov is well known to physical chemists throughout the world. Its outstanding contribution has been the application of the theory of branching reaction chains to problems of combustion and explosion. In 1935 Semenov himself published a standard treatise on "Chemical Kinetics and Chain Reactions". His ideas have provided a comparatively easy way through many complex and mysterious phenomena. The following article describes how the theoretical and practical work of his school has developed.—Editors, NATURE.]

UP to the twenties of the present century, 'chemical kinetics', or the science of the regularities underlying the course of chemical transformations, was largely in obscurity. But from this time onwards it becomes one of the predominating trends of physico-chemical studies.

As regards homogeneous chemical processes, the concepts of van't Hoff and Arrhenius were to undergo considerable modification. The idea was advanced that the reactions proceed through a number of stages, or intermediate products such as free atoms and radicals or particles excited by electrons. The work of Bodenstein, Haber, Christiansen, Polanyi, Lind, Bäckström and others during 1913–28, especially experiments on the formation of hydrogen chloride and bromide, was the first to suggest the new ideas and the methods of computing the velocities of these reactions. It is in connexion with these studies that the first idea of chain reactions was inaugurated.

It will, however, be noted that no general significance was attached to chain reactions up to 1927. They were considered as confined to very few individual cases.

The situation changed appreciably in 1927, after the publication of the first papers from the Institute of Chemical Physics of the U.S.S.R., and, soon after, of quite independent studies by Hinshelwood and his school in England. It was shown that chain reactions represent a large group of chemical transformations. A theory of chain reactions was developed, new and stimulating ideas were introduced regarding branching of chains and their being cut off on the walls of the vessel: the principal laws of these reactions were deduced and verified experimentally.

From 1928 onwards, these new studies in the domain of chain reactions were discussed at physico-chemical congresses and conferences throughout the world, and they have given rise to numerous experimental studies. During 1934–35, Semenov's monograph "Chain Reactions" was published in Russian and in English. This book reviews all the evidence bearing on chain reactions and gives an exhaustive and systematic discussion of the theory. In all monographs and books on chemical kinetics, the doctrine of chain reactions occupies a significant place. During 1941–42 an article by Semenov was prepared for press on the general theory of complex reactions, in which a strict mathematical treatment of the theory of chain reactions was presented in a new general form.

The theory of chain reactions postulates that in the course of chemical transformations there appear extremely unstable energy-rich intermediate products (atoms, radicals, unstable peroxides and other labile products). The urgent necessity then arose of determining the nature of these products. The lack of suitable methods still rendered this task almost impossible, and this most important problem could be solved only in one or two cases.

In 1937, the problem was taken up in the laboratory of Prof. Kondratiev (Institute of Chemical Physics). It was shown that, in rarefied flames of hydrogen, free hydroxyl is formed in very great quantities (up to 0·1 per cent of the initial hydrogen) as an intermediate product of oxidation of hydrogen. The amount of hydroxyl is hundreds of thousands times greater than that corresponding to the temperature of the experiment. Kondratiev determined the hydroxyl by a specially devised absorption spectrum method. He also detected CS and SO radicals in the oxidation of carbon disulphide.

Of great interest also is the work of N. Emanuel (1939–42), in which large quantities of SO were shown to appear in the course of carbon disulphide oxidation, and the role of this active intermediate product was established.

A specially detailed study was made of the kinetics of the oxidation of hydrogen and of various hydrocarbons. Naboldin's work (1932–42) showed that the theory of chain reactions accounts for the whole peculiar course of the reactions not only qualitatively but also quantitatively. Concurrently with studies in other countries, the intermediate products of hydrocarbon oxidation were explored in detail, since owing to their relative stability they can be detected with less difficulty. By 'freezing' the reactions at a given stage, Prof. Neuman detected and determined quantitatively by various methods (in particular, polarographic methods) different intermediate products (peroxides, aldehydes, etc.) appearing in the course of oxidation of hydrocarbons.

The phenomenon of cold flames of hydrocarbons, which is very interesting and significant in connexion with detonation in the petrol engine, was subjected to an especially detailed analysis by Prof. Neuman and his collaborators at this Institute (concurrently with the English school of Bone).

Another important branch of chemical kinetics deals with the theory of flame, where chain reactions, as shown in this Institute, mostly play a significant part.

In the twenties of the present century, no satisfactory theory of burning existed—a direct result of the backwardness of chemical kinetics. The work of the Institute of Chemical Physics introduced into the theory the major element, namely, the chemical kinetics of the reactions. This resulted in the establishment of the fundamentals of a theory which accounts for all the principal phenomena associated with burning in gaseous systems. Most of the results obtained are discussed in Semenov's papers (1940–41) under the general title "Theory of Burning", and in articles by Prof. Seldovich.

In 1927 Semenov formulated the now universally acknowledged theory of thermal explosion. At the same time he defined another type of inflammation, namely, the chain type. It was shown experimentally by Sagulin and others how to differentiate between the two types of explosion.

In 1931 the theory of the 'degenerate' explosion was developed, and also the theory of inhibition of explosion applicable to those cases where slow development of the branching chains (chain 'degenerate' explosion) results in an acceleration of the reaction to the point of thermal ignition. This accounts for the induction period, which sometimes lasts scores of minutes before explosion sets in. These phenomena have been studied in detail in the U.S.S.R. and elsewhere, the results being in full conformity with the theory. Degenerate explosions occur, in particular, in the oxidation of hydrocarbons. The great significance of the induction phenomenon and of the laws studied at the Institute of Chemical Physics on the theory of detonation in the internal combustion engine was soon realized, accounting for the interest aroused by these studies among engineers. All modern theories of detonation in internal combustion engines stand in close relation to the theory of burning, which was largely developed in this Institute.

Prof. Sokolik and his associates not only extended the theory in this direction but have also drawn from it a number of practically important conclusions.

The theory of the slow propagation of the flames with reference to chemical kinetics was first developed by Lewis in the United States (1934). Seldovich and Frank-Kamenetzky of this Institute extended this work by developing a consistent theory of the slow propagation of flame. The validity of the theory was shown experimentally by Baliaev (burning of liquid nitroglycerine), by Semenov and Seldovich (burning of carbon monoxide) and by Kokachashvili and Seldovich (burning of a mixture of hydrogen and bromine).

Just as with thermal self-ignition (calculation of the temperature of self-ignition from kinetic data of the slow process), so in the present case we were able to calculate the absolute value of the rate of flame-propagation in addition to its dependence on temperature, pressure and composition. Seldovich also developed the theory of various practically important phenomena such as limits of inflammation and detonation. He also completed the theory of the detonation wave, which previously had not been brought into relation with the rate of the actual chemical process.

In this way the phenomena of burning were correlated with chemical kinetics. Burning differs from slow reaction only in one respect—the powerful liberation of heat, and the hydrodynamic phenomena associated with it, influence profoundly the rate of the chemical process. To take these influences into account offers great mathematical difficulties. In developing the theory these have been overcome to a considerable extent, and the formulæ derived from the theory have been verified by experiment.

Concurrently with studies on the burning of gaseous systems, Prof. Khariton's group carried out extensive work on the burning and detonation of explosives. The results obtained are also of fundamental importance. Here also many new phenomena have been observed, and the theory has been clarified, but this domain still requires further theoretical work.

It cannot be assumed that we have reached complete certainty in the theory of burning, or that no unsolved problems will remain in this field of research. Here, as in the theory of chain reactions, a solid basis has been laid, the physical meaning of the processes has been clarified, and the method of approach established. Nevertheless, each individual reaction requires a special study, its specific character being different.

In this way we have worked step by step during the last twenty-five years in developing chemical kinetics in close contact with the English and American men of science who have frequently attended our conferences or sent us their papers.

Now our work has been interrupted. Many young workers of this Institute voluntarily joined the army during the first days of the War; one of my closest associates and followers, P. Sadovnikov, whose name is known among scientific circles of Great Britain, has been killed. But the majority of our collaborators are still in the laboratories of the Institute, where work has been greatly intensified.

HYDRO-ELECTRIC DEVELOPMENT IN SCOTLAND

ON October 27, 1941, the Lord Advocate for Scotland, then the Right Hon. Lord Cooper, was appointed chairman of a committee of five to inquire into a report on hydro-electric development in Scotland. The report now issued* is dated August 24, 1942—so the Committee wasted no time. The Committee recognizes that hydro-electric planning is a matter for many years ahead—though it may not be out of place to remark that the national grid in Great Britain is an established success for war as well as peace conditions.

In the historical survey, the record of the last twenty years, with its six successive abortive promotions, comes boldly and badly into the picture. All major issues of policy, both national and local, have tended to become completely submerged in the conflict of contending national interests. But even governments do not escape if their policy is that they will neither develop the resources themselves nor allow anyone else to do so.

Excluding all burghal areas, the overall density of population on the mainland of the Northern Area is less than 20 per square mile. Northern Scotland is the only part of Great Britain not covered by the Grid scheme. The Committee finds that for such an area the policy embodied in the 1926 Act (which led to the formation of the Central Electricity Board) is essentially inappropriate and inapplicable. The progress of the Grampian Company, the control of which was obtained by the Scottish Power Company, in 1927, is traced. By supplying 106 million units per annum to the Central Electricity Board, the Grampian Company has an assured market to enable it to embark on a general supply in an extensive and sparsely populated territory. In 1940, the units sold, other than to the Central Electricity Board, totalled 63 million at an average of 1·55*d*. per unit. Here, then, is indicated a practical way for development. The Committee considers these results to justify the decision of the Electricity Commissioners and Central Electricity Board in 1931 to leave the development of this area to the Grampian Company.

Commenting on the criticisms against the Grampian Company, the report shows a sympathetic appreciation. Even so, doubts may still exist. On one occasion, when the present writer was visiting the Loch Rannoch and Tummelbridge Works, it struck him as strange to see two joiners making a coffin by candlelight in a house in the village of Kinloch Rannoch.

In the existing state, it is stressed that it will be essential at the earliest possible date to provide a substantial new source of power in the extreme north of the Grampian territory, to meet normal expansion. To construct a large steam station in a district so remote from coal and so rich in water-power would involve a major error of misplanning. It is not agreed that the cancellation of the bulk supply to the Central Electricity Board would solve the problem, both because of the effect of the loss of the contract, and the fact that Loch Rannoch and Tummelbridge Works have been designed for a 50 per cent load factor and not for supplying a general demand.

In the study of comparative costs of steam and hydro-electric generation, attention is directed to the rising price of coal in recent years, and in the fall in the basic rate of interest—the main components in the cost of electricity generated from steam and water respectively. On the financial side, the Committee considers its recommendations preferable to the provision of an equivalent capacity of new steam plant. Any likely improvement in water or steam-power technique is unlikely to influence the position. Provisional estimates disclose some seventy favourable schemes in the Northern Area capable of yielding not less than 4,000 million units per annum, or 450,000 kW. continuous.

Of the opposing theories for revitalizing the Highlands, the Committee regards the introduction of modern industries in which an abundant supply of cheap electricity is indispensable as the only means of securing a prosperous population in the area. These industries are electro-chemical and electro-metallurgical: calcium carbide and cyanamide; reduction or refining processes for aluminium, copper, zinc, vanadium and cadmium; the ferro-alloys. The defeat of the Caledonian Power Bill is regarded as a tragic mistake, not only for Scotland but also for Great Britain. Assuming that these industries on a substantial scale are essential to Great Britain, northern Scotland offers the only solution. By suitable planning, natural beauty can be preserved. The Committee challenges the critics to offer any other scheme to arrest the growing decay in the Highlands.

From independent computations, it is found that the ultimate local demand for general supply represents about 8 per cent of the ultimate power capable of development; consequently the position for the local population would be adequately safeguarded. In the long-term plan of development, the national grid forms the indispensable background as a market for surplus power.

The Committee's recommendations include the creation of a non-profit-earning, public-service corporation to work in close partnership with the Central Electricity Board. This new corporation would be responsible for the further development of electricity generation, transmission and distribution in the Northern Area. The corporation should attract to the Highlands a share of the industries demanding abundant and cheap power, develop such further

* Scottish Office. Report of the Committee on Hydro-Electric Development in Scotland. (Cmd. 6406.) Pp. 38. (London and Edinburgh: H.M. Stationery Office, 1942.) 9*d*. net.

power as may be required, and develop on an experimental basis isolated schemes in isolated districts. Local requirements should be given priority.

The Committee also considered the safeguarding of fishery interests, the need for compulsory powers, the present inequitable valuation and rating of hydro-electric undertakings, and the preservation of the amenities.

From the foregoing digest of the report, it will be seen that the Committee has not only considered all relevant matters, but has also taken into account the views of opposing interests. A careful examination of the report leads to the conclusion that this is the first complete study that has been made of this matter, and that the general conclusions reached are the only sound ones possible.

S. Parker Smith.

OBITUARIES

Dr. C. Tate Regan, F.R.S.

Charles Tate Regan, formerly director of the British Museum (Natural History), who died on January 12, was born at Sherborne in February 1878 and was educated at Derby School and Queens' College, Cambridge. The choice of Derby was probably influenced by the fact that his parents were professional musicians, for the head-master at that time was J. R. Sterndale-Bennett, a son of the composer, and music took a serious place in the life of the School. The appreciation of great music thus inherited and cultivated gave Tate Regan great pleasure in later years. It was L. J. Fuller, the science master at Derby, who first suggested a career at the Natural History Museum to the boy, among whose interests natural history was already prominent, and Tate Regan stayed a fourth year at Cambridge to wait for a vacancy to occur at South Kensington. At Cambridge he studied under Sedgwick, and he worked and played with equal zest. He played both Association and Rugby football, and was a good sprinter, hurdler and jumper. At this time he was uncertain whether to specialize in plants or animals, but of one thing he was sure, that his interest would be in the structure of living organisms, and its bearing on their relationships and evolution.

In 1901 Regan joined the staff of the British Museum (Natural History). Günther, who was then keeper of zoology, advised him to specialize in fishes, and he joined G. A. Boulenger on this group, starting, at Günther's suggestion, with a revision of the family Stromateidæ, which was the subject of his first paper (1902). Boulenger had just received the proofs of the "Cambridge Natural History" volume on fishes, and asked his young colleague to look through them. Regan suggested that the Gadoidea were wrongly placed and Boulenger challenged him to prove it, finally accepting Regan's arguments (published in 1903) and altering the book accordingly. Regan would tell this story in later years, wondering at his own temerity.

From this time on, every year saw a long list of titles under Regan's name in the *Zoological Record*, and one is left amazed at the mental energy that allowed him to work on so many lines at once. His most important contribution to ichthyology was the series of papers on the major classification of living fishes, beginning with the "Classification of the Selachian Fishes" (1906) and continuing with the Teleostean orders and sub-orders, which were treated severally in some score of papers appearing in the *Annals and Magazine of Natural History*, mainly during the years 1911–13. This work was based on the study of a big collection of dried skeletons and on spirit specimens, and was written in a form and style so concise as to give little idea of the amount of research behind it. It is summarized in articles on selachians and fishes in the fourteenth edition of the "Encyclopædia Britannica", and presents a classification which is accepted as a basis by serious ichthyological workers all over the world.

In 1911 there appeared a work of a very different type, "The Freshwater Fishes of the British Isles". This is perhaps the most fascinating of Regan's works, combining as it does the results of intensive studies in the museum with knowledge gained in delightful days spent angling in the rivers and streams near his home in Dorset, and in visits to the English and Scottish lakes that harbour the relict char. At once authoritative and readable, this is a model book of popular natural history.

It fell to Regan's lot to write the section on fishes in the "Biologia Centrali-Americana" (1906–8) and to report on the fishes of the Antarctic expeditions of the *Scotia* (1913) and *Terra Nova* (1914, 1916). From these results syntheses were made which increased considerably our knowledge of the laws governing the geographical distribution of fishes. His conclusions on this subject, too, are gathered together in an "Encyclopædia Britannica" article. Regan's systematic revisions of families are many, and in every case have that masterly quality which has put subsequent work upon a sound basis, and has been a powerful influence in keeping the standard of systematic ichthyology high.

I first met Dr. Regan in 1921, when as a student I visited the Museum to learn something about the classification of fishes, and received unstinted help. Regan had then just become keeper of zoology. When, in 1927, he was appointed director, he found that administrative duties left him little time for scientific work. He was able, as always, to do a great deal in the evenings, but he needed a collaborator who could deal with the practical work on the collections all day, allowing him to follow it in what time he could spare, and in the following year I was appointed as his scientific assistant. He had already, in 1925, dealt with the deep-sea angler-fishes of the first *Dana* expedition, and had described for the first time the dwarfed and parasitic males of this group. He was now about to tackle the *Dana* Stomiatoid fishes, and had also large collections of African Cichlidæ to work out. I soon understood that I was highly privileged to work upon such material under the guidance of such a man, and my admiration for his outstanding brain, his memory, his enthusiasm and drive grew with our association. With the second collection of *Dana* deep-sea angler-fishes, we elaborated together Regan's earlier discovery of the parasitic males. Parr's announcement that some males were dwarfed but free-swimming came when we were already working on this collection, and was not a surprise, and the *Dana* material made it possible for us to relate the free males to their extremely dissimilar mates. This work gave Regan special pleasure, as also did his earlier discovery of the nature and structure of the complicated copulatory organ of the minute East Indian fishes of the family Phallostethidæ. The latter work appeared in 1916, the year before his election to the Royal Society at the age of thirty-nine.

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Assistant required with knowledge of Russian, German, and other European languages; on grade £250—£12 10s.—£300. Some experience of abstracting scientific literature, especially biological, an advantage. Application giving qualifications, experience, and references to be sent by March 5 to the Deputy Director, Imperial Bureau of Animal Breeding and Genetics, King's Buildings, Edinburgh, 9, from whom further information can be obtained.

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Ten copies of applications, together with the names of three referees, should be sent before March 1, 1943, to the undersigned, from whom further particulars can be obtained.

The University, Edmund Street, Birmingham, 3.
December, 1942.

C. G. BURTON, Secretary.

Analytical Chemist, preferably with experience of silicate analysis, required for factory in Midlands engaged on essential work. Applicants must give particulars of age, training, experience and salary required. Box 912, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

UNIVERSITY OF LONDON

GRANTS FOR RESEARCH

Applications are invited from members of the University for grants from the Central Research Fund for assisting specific projects of research and for the provision of special material and apparatus. Application forms (which must be returned by March 31, 1943), and further particulars may be obtained from the Academic Registrar, University of London, at 42 Gyles Park, Stanmore, Middlesex.

THE GAS RESEARCH BOARD

Applications are invited for the Post of Director of The Gas Research Board of the Gas Industry. Only such candidates will be considered as have qualifications and experience justifying a salary of not less than £2,000 per annum. Particulars of the appointment can be obtained from the Secretary, The Gas Research Board, Gas Industry House, 1 Grosvenor Place, London, S.W.1, with whom applications must be lodged not later than February 22, 1943.

Assistant Chemist for general and analytical work required by firm engaged on essential work in London. Sound academic training and experience in investigating works' problems necessary. Age not less than 25.—Apply giving full particulars of age, experience and salary required to Box 908, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Applications are invited from qualified Chemists, experienced in Analytical and Research work for vacancy in Laboratory of Food Manufacturers. Applications must detail qualifications, industrial experience and salary required to Box 906, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Wanted: to purchase a refractometer. Pre-ferably Pulfrich or Abbe.—Box 913, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Manager (qualified metallurgist) required for metallurgical research section of large organisation in London district manufacturing aircraft and other scientific instruments. State qualifications, experience and salary required to Box 914, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Director of research and development, to take complete charge of these departments, required by a London firm of Electrical Engineers manufacturing radio frequency, acoustic and electrical instruments. First class qualifications in Physics or Electrical Engineering essential, coupled with wide industrial experience.—Write, stating full particulars to Box 915, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Shorthand-typist and secretarial assistant. The British Association for the Advancement of Science, Burlington House, London, W.1. (Applicants should not be liable to call-up under existing conditions.)

Laboratory assistant wanted for school laboratory. All particulars may be obtained from, and applications sent to: The Senior Science Master, The Science Schools, Harrow School, Harrow, Middlesex.

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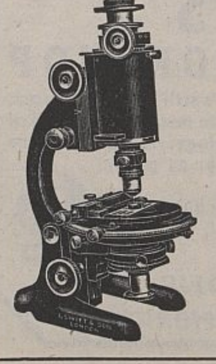

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Although he was a good systematist, Regan never mistook the minutiæ of taxonomy for an end in themselves, and his outlook is well summarized in the following quotation from his address on "Organic Evolution" before Section D (Zoology) of the British Association in 1925: "Every good systematist must feel some satisfaction when he has written a diagnosis that is diagnostic, or has made a key that will work; but this satisfaction is small compared with that which he feels when he has reason to think he has settled the position of some doubtful form, or has discovered the origin of a group and the lines of evolution within it. The main interest of systematic work lies in the fact that it is a study of the results of evolution, and that from such a study one may hope to get some light on the meaning of evolution".

Regan found in the fishes ample scope for his energies, but his interests extended beyond, and especially into other vertebrate groups. His interest in the geographical distribution of animals led him to suggest to other specialists lines of research on the interrelationships of frogs and the classification of mammals. He was convinced, moreover, that false ideas were prevalent as to the origin and classification of the primates, including the ancestry of man, and in 1930 he published a preliminary statement of his views. He followed this by an elaborate investigation into the structure and relationships of insectivores and lemurs, and left unfinished manuscripts and drawings which it is greatly to be hoped will be put into order and published. Of recent years, too, he had embarked on a general classification of the fish-like vertebrates, and, to clear up a doubtful point, had undertaken an investigation of some fossil forms. This paper also was left unfinished.

In addition to his scientific work, Regan performed important services for the British Museum (Natural History) as keeper of zoology and director. His first duty on taking the directorship was to give evidence before the Royal Commission on Museums, and as a result of this the Commission recommended increases of staff and of buildings. The increase in staff, though delayed, was finally accomplished, but the financial crisis of 1931 interfered with the plans for building to such an extent that the War found them still only partly carried out. It is sometimes thought that Regan had little interest in the exhibition side of the Museum. This was not so, but his large-scale ideas were bound up with the new building plans, and were never even put on paper.

Regan had the gift of lucid expression, founded on clear and concentrated thinking, and he enjoyed talking on a subject that interested him. He was a member of the Royal Society Dining Club and often entertained his fellow "royal philosophers" over their port with an account of his latest discovery, illustrated by specimens and drawings. Many an impromptu lecture, which would have delighted a class of students, has been reserved for my unworthy ears at South Kensington, illustrated by drawings on the back of an envelope or an empty cigarette packet.

Tate Regan was an honorary fellow of his College, received the degree of D.Sc. *honoris causa* from the University of Durham, and was *Academico Honorario* of the University of La Plata. He was a foreign member of the Royal Danish Academy, of the American Academy of Arts and Sciences, and of the American Society of Ichthyologists and Herpetologists; the Geoffrey de St. Hilaire Medal was awarded to him by the Société Nationale d'Acclimatation de France.

Regan's outstanding qualities were generosity and frankness, which endeared him to his friends, and an enthusiasm and energy which made him, like the sprinter he was in his youth, go all out for some desired objective, and left him the victim of a too severe disappointment if it failed him. He was a keen gardener and enjoyed watching a good game of football or an athletic contest. His friends mourn a rare and stimulating companion.

Sincere sympathy goes out to Mrs. Regan and their four children, one of whom is now a prisoner of war.

E. TREWAVAS.

Dr. Nikola Tesla

NIKOLA TESLA, who died on January 7, was born in 1857 at Smiljan in Croatia. His father, a Serb, was a clergyman of the Greek Church; his mother is remembered as very inventive and is credited with making improvements in churns, looms and other rural machinery. Nikola, while at school, began to make electrical experiments, and finished his formal education in the engineering faculty of the Graz Polytechnic School. After a period in the Government telegraph department at Budapest, he joined the Edison concern in Paris and went to the United States about 1883. Here he worked under Edison for a time, but soon set up his own firm for the manufacture of arc lighting plant.

At this period the applications of electric power in industry were effected mainly by direct current, but many inventors were attacking the problem of making motors suitable for use with alternating current. Tesla in the United States and Ferraris in Italy each published in 1888 the results of several years of independent work on motors utilizing rotating magnetic fields produced by two-phase currents. Both inventors envisaged machines in which the rotor is propelled asynchronously by means of currents induced in it by the rotating field, and Tesla described also motors in which the rotor is pulled round in synchronism with the rotating field. Neither type need employ brushes or commutators. These rotating-field motors, together with the introduction of polyphase currents, proved to be the solution of the problem of using alternating current in factories. In addition, by 1890, Tesla also invented methods of starting and running motors on single-phase current. His designs were so sound that his larger machines attained efficiencies of 95 per cent. Having completed his task, he disposed of his patents to the Westinghouse Company and dropped the subject.

Hertz's work was directing attention to high-frequency alternating currents, so Tesla turned to the problem of generating these currents on an engineering scale. First he designed and built a succession of alternators, and by 1891 attained a frequency of 30,000 cycles per second. He studied the properties of these currents in circuits possessing distributed inductance and capacitance, and developed tuned coupled circuits for enhancing their voltage by resonance. For higher frequencies he employed the discharge of condensers through induction coils, obtaining big powers by aid of rotating dischargers or magnetic blow-outs at the spark gap. On coupling the primary circuit to a resonant secondary circuit comprising metal areas, large flaming and streaming ionization currents were obtained in air and in Geissler tubes. Ionic bombardment was observed to produce brilliant phosphorescence, and sometimes fusion, of solid matter.

But Tesla's main purpose was the transmission of power and messages across space. In 1892 and 1893 he developed his scheme. High-frequency power was to be led to a large antenna consisting of an elevated metal area connected by a vertical wire to a large metal plate buried in the earth. The receiving antenna was to be equal in every respect. The figure in the *Journal of the Franklin Institute* shows the source of oscillations connected into the vertical wire near the earth at the sending station, and the receiving apparatus in the corresponding place at the receiving station. He did not patent the antenna. Tesla states his belief that the electrical oscillations will be propagated along the surface of the earth and that they may be assisted by an upper conducting layer of the atmosphere—this is eight years before Heaviside and Kennelly. Tesla had thus supplied, two years before wireless began its commercial career, all the elements of both spark and continuous wave sending stations. For the receiving station the Lodge or Branly coherer was already available for spark telegraphy, but Tesla concentrated on continuous waves because he was more interested in the transmission of power than in the transmission of messages. After building one or two small stations, he started in 1897, at his own expense, a station of 200 kilowatts in Colorado. From this point in 1899 he transmitted power enough to light a lamp at 30 km. For the reception of continuous wave signals he invented the interrupter device known as a ticker, which was employed by others for the next dozen years, and from the Colorado station received signals at a distance of 1,000 km. Later, his form of antenna, his rotating discharger, and his tuned transformer were used successfully by many others at spark stations in every country.

Space limits this survey to a few of the new things which Tesla's creative imagination and constructive genius gave to the world. His other inventions include pyro-magnetic generators, thermo-magnetic motors, unipolar dynamos, meters, lamps, mechanical vibrators of huge power and a variety of instruments. Some seven hundred patents stand in his name, mostly taken out before he was fifty years of age. Apparently his method of work was to state a problem, devise solutions, build machines and file a patent specification or, possibly, read a paper to a technical society. Then he would start on a new problem. It happened that one of his subjects, high-frequency discharge, made a brilliant display, and he was persuaded to lecture upon it several times. The demonstrations were perfect and very showy; consequently sober folk concluded that Tesla was somewhat of a showman. This is quite wrong. Throughout his long life of eighty-five years, Tesla seldom directed attention to his own successes, never wrote up again his old work, and rarely claimed priority though continually pirated. Such reserve is especially striking in a mind so rich in creative thought, so competent in practical achievement.

W. H. Eccles.

Dr. A. L. Lowell

Of the two late presidents of Harvard, Eliot and Lowell, it was said that Eliot found Harvard a college and built upon it a university, while Lowell found a university and unearthed its college. Eliot developed great post-graduate schools, from medicine to business administration; but his free elective system for undergraduates left the college almost spineless. It was for his successor to revalue the meaning of a B.A. degree, and he did.

The chief monument of Lowell will be his scheme of concentration (reading one main subject) and his general examination (final schools). Anglophile in nothing so much as in education, he had always approved of this method, nearly identical with that of Oxford and Cambridge, but had to watch the previous regime spare the rod and spoil the undergraduate. In the last decade of Eliot's reign, most pupils used to scoff at honours; in the last decade of Lowell's, the tendency was to scoff at those unequal to reading for them.

The second great change under Lowell was likewise of British pattern. He broke up an unwieldy university into colleges, again like Oxford and Cambridge. Long a cherished plan of his, he lacked funds for it, until one day about fifteen years ago a stranger called at the President's office. Lowell, in the midst of a busy morning, almost did not see the caller—a certain Mr. Harkness. "If," said the stranger, "you suddenly had a lot of money given you—let us say millions—for the university, what would you like to do with it?" Lowell actually produced a set of blue-prints from a drawer. "Build separate colleges," said he promptly. "Exactly my idea," responded Harkness. "Yale, where I come from, has declined such a gift. Will you take it, and how much do you need?" The result was the seven 'Harvard Houses' —built either entirely new or to include conversion of several hostels already in use—at the cost of $3\frac{1}{2}$ millions sterling. (Yale then changed its mind, whereupon Harkness cheerfully donated enough more to Yale for a similar project. It was Harkness funds, of course, which also came later to Great Britain for the Commonwealth Fellowships and for the Pilgrim Trust.)

The third milestone in the presidency of Lowell was once more inspired by the example of England. He founded in Harvard the Society of Fellows, an adaptation of All Souls, Oxford. Under this foundation—the funds said to have been given by Lowell, himself a wealthy man—a committee of senior fellows, members of staff in Harvard, elect each year eight junior fellows, graduates of any American university of standing, for postgraduate research. These fellowships yield enough to cover all expenses of the holder, and are renewable (from three to six years) until his specific problem of research is completed. He has the utmost freedom, being not required to work for a degree. Junior fellows live in the various 'Houses', and in time may be offered appointments to the staff.

As the most important personality in American education in his time, Lowell exerted a national influence. So appreciative of his leadership were benefactors, whether old Harvard men or not, that during his own tenure of office—twenty-four years—he saw the endowment of his University tripled; when he retired in 1933 it stood at some thirty millions sterling. A dozen books which Lowell wrote will ensure him remembrance as an authority on government—government in America, in Great Britain, and on the Continent; but his annual reports, as president, to the Overseers of Harvard, are essays in the advance of education, not at Harvard only, but also throughout America.

Lowell died on January 6 at the age of eighty-six.

Willard Connely.

NEWS and VIEWS

British Association

Conference on Science and the Citizen

THE British Association, through its Division for the Social and International Relations of Science, is arranging a conference on Science and the Citizen : the Public Understanding of Science, to be held on Saturday and Sunday, March 20 and 21, at the Royal Institution, Albemarle Street, London, W.1, by kind permission of the Managers. The Conference will be opened by Sir Richard Gregory, president of the Association, and there will be four sessions, the subjects of which will be the exposition of science, radio and cinema, science as a humanity, and science and the Press. The chair will be taken, at the successive sessions, by Sir Henry Dale, president of the Royal Society and director of the Royal Institution, Sir Allan Powell, chairman of the governors of the B.B.C., Prof. J. L. Myres, and Sir Richard Gregory. It is hoped that an exhibition of films of scientific interest will follow the session on radio and cinema. A list of speakers and other particulars will be issued in due course, and these and tickets of admission will be obtainable from the British Association, Burlington House, London, W.1. The Association, in arranging this conference, is continuing its policy of dealing, by this and other methods, with subjects of especial importance in relation to post-war reconstruction, which were touched upon in the course of the conference on "Science and World Order" held in September, 1941.

Dr. Godfrey Rotter, C.B., C.B.E.

DR. GODFREY ROTTER has recently retired from the post of director of explosives research, Woolwich, after about forty years in Government service. Having graduated from the University College of North Wales, Bangor, he entered the then Experimental Establishment of the War Office in 1903 ; for the last twenty-one years he has been the head of the Directorate of Explosives Research. Before the War of 1914–18 he had proved his capacity for design, and he received an award for his part in the design of the 106 Fuze, of which nearly a hundred million were made. As a chemist, he showed his skill in devising apparatus for the study of the properties of explosives, of which that for the determination of their sensitiveness is the standard instrument to-day. During 1914–18 he took his full part in the invention and development of new high explosives and propellants, so that when Sir Robert Robertson left in 1921 he succeeded him as director. Of his achievements during the last twenty years it is impossible at this time to speak, but it may be said that he has been associated with notable advances. Of an engaging disposition, and giving an example of an extraordinary capacity for hard work, in an endeavour to keep abreast of ever-increasing activities, he retained the affection and respect of all his staff. He is succeeded by Prof. S. Sugden, of University College, London, who was a member of the Department during the War of 1914–18.

Prof. S. Sugden, F.R.S.

PROF. SAMUEL SUGDEN, who has been appoin superintendent of explosives research, Royal Arsenal, Woolwich, for the duration of the War, has been since 1937 university professor of chemistry, University College, London. Prof. Sugden's massive achievements in research cover a wide field. His native inspiration led to the discovery of a property related to the molecular volume and known as Sugden's parachor. This inspired chemical investigations all over the world, and supplied much valuable information regarding the constitution of chemical compounds and the nature of valency linkages. In his book "The Parachor and Valency", published in 1929, he gave a masterly account of the subject. He has made notable contributions to magnetochemistry. For example, when Pauling concluded from wave mechanics that bivalent nickel, palladium and platinum, unlike the non-transitional elements, can form 4-covalent compounds of plane type which can further be distinguished by their smaller paramagnetic moments, Sugden supplied the first experimental evidence to support this view. It is significant of his keen interest in this field of investigation that he has selected magnetochemistry as the subject for the ninth Liversidge Lecture which the Chemical Society has invited him to deliver. Further evidence of the great fertility of Sugden's researches is found in his investigations on dipole moments, induced radioactivity and the rare earths. He was elected a fellow of the Royal Society in 1934. His powers as a thinker and investigator allied with a flair for exposition have earned him distinction as a scientific writer and teacher.

Institution of Electrical Engineers Awards

THE council of the Institution of Electrical Engineers has elected the Right Hon. Lord Hankey to be an honorary member of the Institution. This distinction has been conferred upon Lord Hankey in appreciation of the valuable services rendered by him as chairman of the Scientific and Engineering Advisory Committees of the War Cabinet, and more recently as chairman of the Technical Personnel Committee. In the latter capacity he has dealt with many problems which have arisen in meeting the demand for engineering personnel for the Forces, the supply establishments and for industry, and has been instrumental in establishing special schemes, notably the intensive training scheme, State bursaries and the engineering cadet scheme, for the training of engineers to meet the needs for future personnel.

The Faraday Medal of the Institution has been awarded to Sir Archibald Page, honorary member and past president of the Institution, in recognition of the outstanding services rendered by him in the sphere of electricity supply, and especially for the prominent part he has taken in the planning, construction and operation of the national grid system in Great Britain, the establishment of which has proved of such inestimable value in the prosecution of the war effort. The Faraday Medal is awarded by the Council of the Institution not more frequently than once a year, either for notable scientific or industrial achievement in electrical engineering or for conspicuous service rendered to the advancement of electrical science, without restriction as regards nationality, country of residence, or membership of the Institution.

Chemists in Great Britain

A MEMORANDUM to which are attached the signatures of many of the leading chemists, pure and applied, of Great Britain, has recently been circulated.

It is addressed, by members of bodies concerned with the interests of chemists and chemistry, to fellow-chemists, and it asks for increased collaboration between the respective bodies in the form of a federal body "to administer and guide, in accordance with the clearly-expressed will of its members, all the main activities that concern chemists as professional men and working scientists". Whatever the body created for such a purpose, its chief functions would be related to: (1) publications for the exchange and dissemination of chemical knowledge; (2) scientific meetings for the discussion of problems under investigation and for the survey of specific fields of knowledge; (3) libraries, both central and regional; (4) qualification, directed to the maintenance of a high standard of professional competence and of such methods of registration as the profession may decide, whether this registration have *de jure* or only *de facto* recognition by Government; (5) publicity, to ensure that the general public be accurately informed of what chemists and chemistry are doing and could do for the benefit of the community; (6) social security, whereby the economic position and the legal interests of all chemists may be safeguarded; (7) social functions.

A common secretariat, a central house, and close co-operation in all centres between bodies representing chemists are believed to be necessary for the discharge of such functions. As a first step in this direction, the councils of the Chemical Society, the Society of Chemical Industry and the Institute of Chemistry are asked to consider and report immediately on how to expedite the action advocated and to obtain advice as to whether the agreement constituting the Chemical Council can be amended so as to enable the Council to function as a central organization such as that envisaged. Should it be found that the Chemical Council cannot undertake the new functions suggested, it is asked that a new federal body be set up at once, to enable chemists to take their proper part in planning and building the post-war world.

The First Man-Carrying Aeroplane

THE Smithsonian Institution, Washington, has recently issued a pamphlet which settles a controversy that has existed for many years. It is universally acknowledged that the Wright brothers were the first to make sustained flights in a heavier-than-air machine at Kitty Hawk, North Carolina, on December 17, 1903. Earlier in the same year a machine built by Samuel Pierpont Langley was reported to have flown, and this was exhibited in the Smithsonian Museum with the label that this "Was the first man-carrying aeroplane in the history of the world capable of sustained free flight". These reported flights had never been officially observed, and in the light of later aerodynamic knowledge it was debatable whether the machine could have accomplished sustained flight under its own power. In order to settle this matter, the Institution reconditioned the machine in 1914, when it was flown successfully, but the fairness of the test was challenged on the grounds that vital alterations were introduced during this rebuilding, which improved its aerodynamic and structural characteristics sufficiently to allow it to be capable of flight. It was claimed that without these changes, based on knowledge that was not available in 1903, the machine could not have flown. These claims have since been upheld by experts, and the Smithsonian Institution has now issued a statement on the results to Dr. Orville Wright and changed the wording of the label on the Langley machine accordingly. Although the detailed explanation has only just been issued, the description on the exhibit was altered in 1928. As a result of this misrepresentation, the Wrights lent their original machine to the Science Museum at South Kensington, where it has been exhibited for many years. The Smithsonian Institution has expressed a hope that Dr. Wright will now consider bringing it back to the United States, where it will be given "the highest place of honour in the United States National Museum".

Meteors Seen in the United States

J. HUGH PRUETT has written an account of a detonating meteor (Ast. Soc. Pacific, Leaf. No. 165, Nov. 1942) under the title, "The Portland Meteor and Resulting Meteorite". The meteor was seen soon after 8 a.m. on July 2, 1939, and was not only a conspicuous fireball, but was also responsible for a panic among many people in Portland, Oregon, owing to the jarring of the houses while it passed over the town. From data supplied by a number of observers, it was found that the fireball became visible near the northern Oregon coast-line, and passing over northern Portland, disappeared beyond Bonneville at a height of 10 miles. It was moving in a direction opposite to that of the earth in its orbit and for this reason had a fairly high velocity—probably 40 miles a second. Next day a portion of the fireball was picked up on a farm near Washougal, fifteen miles east of Portland, and it was found that it belonged to the type of stony meteorites known as Howardites. Although search parties were organized, no other pieces were found; but it is fairly certain that the Washougal portion, weighing 225 gm., is not the only fragment which reached the earth. Howardites are described as friable and easily destroyed because the material composing them is cemented together rather loosely.

Another meteor is described by Oscar E. Monning in *Sky and Telescope* (November 1942). It appeared on August 7, 1942, at 9.30 C.W.T., when it was still twilight in the more western regions of its flight, and its magnitude was estimated to be -4. When first seen it was some miles north of Shreveport, and its height then was about 80 miles. In 30 sec. it had moved to a point less than 20 miles north and east of Guymon. Its length of flight may have been 600 miles and its motion was nearly horizontal, as its total drop was about 65 miles during this long flight. It had a long tail and left an evanescent train which was 30° in length as seen from some places, but it persisted for only 5–10 sec. No fragments of the meteor have been found and there were no detonations, so far as present evidence is available, but it is possible that additional information will be obtained which may assist in elucidating further important facts about this bright meteor.

New Projector for Navigational Stars

JAMES R. BENFORD has given a description of a Bausch and Lomb artificial star projector recently installed at the United States Air Station, Pensacola, Fla., which overcomes many of the difficulties of star charts (*Sky and Telescope*, November 1942). The instrument is located in the centre of a hemispherical dome upon which it projects images corresponding to 145 navigational stars. The instructor and the students sit inside the dome at a level a little below that of the star projector, which makes the stars appear in the darkened room as points of light in a twilight sky. As the projector rotates on its axis once in 20 minutes, the stars swing slowly across the face of the dome in this time, and students are able to gain true impressions of the form, location, and interrelations of the constellations much more clearly than they can from star charts. The apparatus supplies the nearest approach to the actual study of the heavens from outdoor instruction. The latter is not always a satisfactory method when large groups of students have to be considered, and in addition, weather conditions and the season of the year are disturbing factors. The star projector is a most important adjunct to-day in pilot training when speed is so essential.

Effects of Altitude

According to the *Journal of the American Medical Association* of October 24 a law was recently passed by the Senate of Argentina for the creation of a committee to supervise studies on the effects of altitude. The committee, which will consist of medical men, chemists, physicists and biologists, will form a branch of the Ministry of Internal Affairs. The field covered by the committee will be (1) biological problems in relation to the most adaptable human biotypes; (2) working capacity, feeding, housing and climatological, hydrological, geological, zoological, botanical and physiochemical factors in relation to the life of normal men in various altitudes; (3) pathology of altitudes, studies of diseases which may be improved by hypsotherapy, and the establishment of sanatoria and hospitals and proper altitudes for the cure of certain diseases; (4) creation of portable laboratories and establishment of experimental hypsological centres; and (5) studies of the animals and plants of different regions, the constitution of the soil and meteorological phenomena.

Folk-Lore of Children's Diseases

At a meeting of the Folk-Lore Society on January 20, Dr. J. D. Rolleston read a paper on the folk-lore of children's diseases. The field is extensive, since it covers the popular conceptions of the acute exanthemata and other infectious diseases, especially whooping cough and diphtheria, venereal infections, cardiac, respiratory, alimentary disorders and isolated diseases, especially enuresis, infantile convulsions, rickets, hernia and the supposed effects of the 'evil eye'. As regards causation, belief in the doctrine of maternal impressions is still far from extinct, although there is no scientific foundation for such a view. The recognition of astrology by orthodox medical practitioners survived until the eighteenth century, as was shown by Mead's work. The visitation of the 'evil eye' also accounted in popular estimation for many diseases, especially in countries bordering on the Mediterranean. Although a vast number of more or less irrational and inexplicable beliefs were connected with the newborn period, comparatively few of them were of medical interest. Dentition, like menstruation and pregnancy, is a normal process, and was much less frequently the cause of disease than was popularly supposed, especially by mothers who were liable to regard any of their infants' ailments as due to this cause. In like manner, tongue-tie, though often alleged by a mother to account for her child's inability to take the breast, was usually non-existent. The belief in the superstition that venereal disease could be cured by transfer to healthy young virgins of either sex was still prevalent, and was one of the chief causes of acquired syphilis or gonorrhœa in children. Although in other departments of medical folk-lore, especially dermatology, ophthalmology and otology, prophylaxis has received much less attention from the folk than curative treatment, in the case of children's diseases, much more importance seems to have been given to prevention than in other branches of folk-medicine. Examples of the kind were the use of salt for guarding the newborn against evil demons and evil influences, the use of amulets and the administration of coral in the mother's milk.

Infant Mortality in the United States

In a recent article on infant mortality in rural and urban areas in the United States (*Public Health Rep.*, 57, 1494; 1942), Herbert J. Sommers, of the United States Public Health Service, states that the infant mortality-rate in the registration areas of the United States has been reduced by more than a half. From 1915 until 1929 the urban rate, though higher than the rural in every year, decreased more rapidly than the rural, so that in 1929, for the first time on record, the rate was lower in urban than in rural areas, and since then the urban rate has remained lower than the rural. The rates were generally higher in the south than in other regions and rural rates were generally highest in the Middle West. The reduction in infant mortality which has taken place in cities is to be attributed to increasing emphasis being laid on the principles of sanitation, the establishment of 'well-baby' clinics, the increasing use of hospitals for delivery, the compulsory pasteurization of milk and the application of modern medical knowledge.

Physical Education

In a lecture delivered before the Anglo-Swedish Society and published in the December issue of the *Anglo-Swedish Review* on the development of physical education in Great Britain and the Dominions, Miss P. Spafford, organizing secretary of the Ling Physical Education Association, said that organized physical education in Great Britain and the Dominions originated in the elementary schools, while the educational, medical and recreative gymnastics were based on Per Henrik Ling's principles. In newly built schools throughout the country conditions for physical education are excellent. Many have their own swimming bath as well as a field for games and a gymnasium. The physical education scheme in schools in Canada, South Africa, Australia and New Zealand is largely that carried out in British schools. The War has inevitably caused a certain set-back in physical education owing mainly to a shortage of gymnastics and game schooling as well as a lack of gymnastics equipment. The most popular physical activity in all the countries of the British Commonwealth is swimming. Physical training in the Services is based on the Swedish and Danish systems and is closely linked up with recent research in physiology and psychology. Until recently there has been little or no organized physical training in the universities, although there has always been sport of various forms. There is a real need for further instructional co-operation, and further research is essential, especially into the physiological basis of exercises.

Medico-Dental History of Cloves

THE issues of *Dental Items of Interest* for June–October 1942 contain an interesting and scholarly article on this subject by Dr. Eugene J. Molnar, research associate of the Northwestern University Dental School, Toledo, Ohio. Originally, cloves were first used in the East Indies, India and China. After the decline of the Roman Empire the medical use of cloves was introduced into Byzantium, probably owing to its proximity to the East. The practice of using cloves for the treatment of dental caries, which developed in the middle of the sixteenth century, was introduced from extra-dental sources, namely, laymen, amateur botanists, apothecary-grocers and others. Eugenol, which was first extracted from oil of cloves by Ettling in 1834, received its name from Cahours in 1858, and is widely used in dentistry for the relief of pain. Its exact pharmacological properties for the treatment of caries and odontalgia have received considerable attention, but have not yet been fully determined. The action of eugenol in zinc-oxide-rosin cements, which form the best temporary filling material, also remains unknown.

Larch and Scots Pine Poles

RESULTS of tests carried out on British-grown poles suitable for transmission lines have been reported (*Electrician*, Jan. 22). The tests were made to measure the deflexion of the poles, rigidly supported at 5 ft. from the butt, for any given loading, up to the ultimate load, applied at 2 ft. from the top of the pole; to obtain a value for their ultimate breaking load, and to calculate the average value of fibre stresses. The poles tested were 36 ft. long by 11½ in. diameter at 5 ft. from the butt, with an average diameter of 8½ in. at the top. An analysis of the test results shows the deflexion for any given loading is much greater for Scots pine than for larch poles. On the other hand, the larch has a much greater ultimate strength, requiring an average load of 4,443 lb. compared with an average of 2,800 lb. for Scots pine. Other things being equal, it is apparent from these tests that, from a strength point of view, larch poles are much better for transmission line supports than Scots pine. The ultimate fibre stress of larch is much greater than that of pine, being of the order of 10,500 lb./sq. in., as against 6,500 lb./sq. in. in the case of pine. The figure for Scots pine is well below the generally accepted figure of 7,800 lb./sq. in. for Baltic fir.

The creosote penetration was found to be much better with Scots pine poles than with the larch. The poles were creosoted six days before the tests were carried out, and from an examination of the cross-sections, it appeared that the penetration in the larch poles varied between ⅜ in. and ⅝ in. with an average of ½ in., and in the Scots pine between 1 in. and 4 in. with an average of 2⅜ in. From the figures obtained it is evident that with the same loading and in order to maintain a given factor of safety, the span-length allowed with Scots pine poles should not exceed 63 per cent of the allowable span-length with larch poles; the ultimate fibre-strength of larch accords closely with the figure of 10,000 lb./sq. in. given in *B.S.* 513–1933; the ultimate fibre-strength of Scots pine is considerably below the value generally assumed for Baltic fir (6,500 lb./sq. in. as compared with 7,800 lb./sq. in.); there does not seem to be any relationship between ultimate load and the moisture content of the pole.

Otto Obermeier (1843–1873)

DR. OTTO HUGO FRANZ OBERMEIER, the founder of German parasitology and father of German tropical medicine, was born at Spandau in Prussia on February 12, 1843, the son of a non-commissioned officer. He received his medical education in Berlin where he studied under Du Bois-Reymond, Virchow, Langenbeck and Frerichs and qualified in 1866 with a thesis on Purkinje's fibres. While working in a laboratory at the Charité Hospital in Berlin he discovered in the blood of persons suffering from relapsing fever minute organisms presenting a twisting or rotatory movement. His first publication on the subject appeared on March 1, 1873, in the *Zentralblatt für die medizinische Wissenschaften*, and a few weeks later he gave an account of it at the Berlin Medical Society. His attempt to transfer relapsing fever to laboratory animals by intravenous or subcutaneous injection of blood from relapsing fever patients was unsuccessful. His promising career was cut short by a laboratory infection with cholera, and he died at the early age of thirty on August 20, 1873. The following year, at Cohen's suggestion, the organism which he had discovered was given the name of *Spirochœta obermeieri*.

Earthquakes Registered in Spain

DURING October 1942, twenty-four earthquakes were registered on the seismograms obtained at the Geophysical Observatory at Toledo. The greatest shock was on October 20 when, from an epicentre calculated to have been some 12,010 km. distant, an earthquake recorded *PPz* at 23h. 41m. 25s. U.T. and attained a maximum ground amplitude at Toledo of 170 μ. The shock finished recording at 01h. 30m. U.T. on October 21. Other strong shocks were on October 9 (max. ampl. 50 μ), October 26 (max. ampl. 27 μ) and October 28 (max. ampl. 2 μ). The earthquake of October 14 which began recording at Toledo with *ePz* at 8h. 26m. 45s. U.T. had an estimated epicentral distance from Toledo of 390 km. The epicentre may have been situated at lat. 38° 50′ N., long. 0° 55′ W., which is nearly 80 km. north-north-west of Alicante, and the focus may have been some 29 km. deep. Microseisms interfered with some of the interpretations during the month, all interpretations being provisional.

Disinfection of Cereal Seed

IN reply to a question by Major Thorneycroft in the House of Commons on February 4, as to whether, in view of the importance which the Minister of Agriculture and Fisheries attached to the increased production of spring cereals, he would consider making it compulsory on all farmers to disinfect their seed according to the best modern practice, Mr. Hudson said that he is anxious that all oat and barley seed should be dressed this spring with a mercury dressing to prevent disease but he prefers to rely on propaganda and advice rather than compulsion. War agricultural executive committees are carrying out campaigns to this effect.

Errata

IN the article "Utilization of Glass", in NATURE of February 6, p. 173, it should have been stated that the electrical resistance varies by "at least ten thousand-million-fold", and that plate glass is "rolled continuously eight to nine feet wide".

LETTERS TO THE EDITORS

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

A Synthetic Differential Growth Inhibitor

IT has been shown[1,2,3] that malt, ungerminated grain and oranges contain a water-soluble, thermostable substance which permits the free growth of epithelial tissues *in vitro* at concentrations at which it inhibits totally the growth of fibroblasts and other mesenchyme cells. In the present investigation, commercial malt extract has been employed, and the methods of biological assay with fragments of ten-day chick's heart have already been described[2,3]. Vigorous steam distillation of malt extract affords a distillate which contains a variety of substances among which, after suitable treatment, a differential inhibitor can be detected.

This was presumably derived from the original factor by hydrolytic fission, but, as it should be a relatively simple substance, attention was focused on its study as likely to provide a valuable clue. The compound is produced in such small quantity that it has not yet been possible to identify it with certainty; its properties and the analysis of derivatives indicated the probability that it is an unsaturated lactone, $C_6H_8O_2$.

A natural product of this composition and character is the so-called parasorbic acid (δ-$\Delta^{\alpha\beta}$-hexenolactone) which occurs in the berries of the mountain ash[4]; this dextro-rotatory substance has not yet been synthesized so far as we are aware. We have obtained *dl*-δ-$\Delta^{\alpha\beta}$-hexenolactone in small yield by condensation of acetaldol with malonic acid in pyridine solution (b.p. 116°/16 mm. Found: C, 64·6; H, 7·3. $C_6H_8O_2$ requires C, 64·3; H, 7·1 per cent); sorbic acid is the main product[5]. Benzoylation of aldol in pyridine solution followed by condensation with malonic acid afforded a solid mixture of acids, and from these by steam distillation and gradual addition of sodium hydroxide a mixture of δ-hexenolactone and benzaldehyde was obtained (Found after removal of benzaldehyde: C, 64·7; H, 6·8 per cent). δ-Hexenolactone exhibits the usual properties of an unsaturated substance and slowly develops acidity in cold aqueous solutions as the result of hydrolysis; it is unstable, becoming orange-coloured in air and light, and it displays a marked tendency to polymerize both as a lactone and as a derivative of an αβ-unsaturated acid. It readily forms a complex condensation product with 2 : 4-dinitrophenylhydrazine ($3:2-3H_2O$). It is completely removed from aqueous solution by charcoal, possibly in the form of a polymeride. In all these properties it resembles the lactone present in the malt extract steam-distillate.

Synthetic δ-hexenolactone exhibits the differential growth-inhibitory property: the two analysed specimens were active at a concentration of 0·011 mgm./c.c.; a specimen made by the first method and not distilled (avoidance of toxic decomposition products) was active at 0·006 mgm./c.c. A rough quantitative comparison with the malt distillate factor shows, however, that the latter is the more active. Three possibilities therefore arise: (*a*) that the malt distillate factor is optically active δ-hexenolactone, (*b*) that it is δ-hexenolactone and that other substances are accessory to the effect, or that the synthetic compound contains traces of toxic impurities; or (*c*) that it is another substance closely resembling δ-hexenolactone.

The discovery of the differential growth inhibition produced by δ-hexenolactone suggests that it is able to inhibit a growth factor which is more specifically required by fibroblasts than by epithelial cells, and an obvious provisional hypothesis is that the factor may be pantothenic acid, or an analogous substance. We are engaged in experiments designed to test this theory, the first step being the synthesis of δ-hydroxy-$\Delta^{\alpha\beta}$-hexenoyl-β-alanine.

A few further observations are that δ-valerolactone (dihydro-δ-hexenolactone) is non-toxic in the special sense and non-inhibitory. The malt extract distillate contains a highly toxic substance of salicylic acid type and several aldehydes (for example, acetaldehyde and furaldehyde) which are non-differential inhibitors.

Aldol and acrolein are toxic; crotonaldehyde inhibits all growth at a concentration between $M/3{,}000$ and $M/3{,}600$, whereas propionaldehyde and furaldehyde are much weaker inhibitors, the limiting concentrations lying between $M/150$ and $M/200$.

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Jan. 25.

[1] Heaton, *J. Path. Bact.*, **29**, 293 (1926).
[2] Heaton, *J. Path. Bact.*, **32**, 565 (1929).
[3] Medawar, *Quart. J. Exp. Physiol.*, **27**, 147 (1937).
[4] Hofmann, *Annalen*, **110**, 129 (1859); Doebner, *Berichte*, **27**, 345 (1894).
[5] The acid, $C_{12}H_{18}O_5$, described by Riedel (*Annalen*, **361**, 89; 1908) is doubtless a dimeride of δ-hexenolactone + H_2O, that is, *O*-δ-hydroxy-$\Delta^{\alpha\beta}$-hexenoyl-δ-hydroxy-$\Delta^{\alpha\beta}$-hexenoic acid.

The Saponin of Fenugreek Seeds

THE presence of a saponin in the seeds of *Trigonella Foenum græcum* (Leguminosæ) was first reported by Wunschendorff[1], who had subjected the defatted seeds to a process of extraction with alcohol. He obtained from the alcoholic extract a gelatinous precipitate which was afterwards dissolved in alcohol and reprecipitated with ether. Wunschendorff described the product so obtained as a white semi-crystalline powder, m.p. 214–215°, which gave a yellow colour test with concentrated sulphuric acid, and a white precipitate with barium hydroxide solution. However, he could not assign a definite formula to the saponin, but showed that it gives by hydrolysis a reducing sugar and water-insoluble sapogenin.

In view of the fact that very little is known of the chemical nature of the sapogenin, we have systematically investigated the seeds, and succeeded in isolating the sapogenin in a pure state. The powdered seeds of Trigonella were defatted by extraction with light petroleum, then extracted three times with alcohol. Concentration of the combined alcoholic extracts yielded a brownish syrup which dissolved freely in water, and the solution exhibited considerable frothing on shaking. A solution of the syrup in water was treated with a saturated solution of barium hydroxide; thus a saponin complex was obtained in the form of an orange amorphous precipitate. Further, the complex was suspended in alcohol and decomposed with carbon dioxide, then the alcoholic solution was concentrated to a faintly coloured syrupy solution. The latter solution was gradually poured into dry acetone; thus a white ashless powder was obtained. It melted between 190° and 200° (decomp.), and characterized by giving a white precipitate with barium hydroxide, a bluish precipitate with Fehling's solution, and a yellow colour with concentrated sulphuric acid. Hydrolysis of the saponin with hydrochloric acid gave a water-insoluble precipitate which crystallized from acetone in the form of a brownish semi-crystalline product. It was further purified by extraction (Soxhlet) with light petroleum, then crystallized from dioxan in white plates, m.p. 184°. The crystalline product gave the colour reactions of sapogenins, and appeared to be a mixture of sapogenins from which a pure compound, m.p. 198°, was isolated and assigned the formula $C_{27}H_{42}O_3$, comprising a free hydroxyl group and two inactive oxygen atoms. There is also evidence that it belongs to the sarsasapogenin group of sapogenins, and identity of its structure is now the subject of a detailed study.

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Sept. 29 (recd. by NATURE, Jan. 27, 1943).

[1] *J. de Pharm. et. de Chim.*, 20, 183 (1919).

Dynamics of Real Crystals

IN his well-known theory of the specific heat of solids, Einstein made the fundamental assumption that all the atoms in a crystal are capable of vibrating independently of one another with the same frequency. It was not meant as an exact description : the intention was to get a sufficiently good approximation without unessential intricacies. His theory has been recalled here at the outset because we find that his approximation is only an extreme form of the hypothesis to be formulated at the end of this note.

In their theory of the vibrations of solids, Born and Kármán introduced the so-called "cyclic lattice hypothesis", which is the basis of the whole theory of crystal dynamics developed by Born and his collaborators. Sir C. V. Raman has recently questioned the correctness of the hypothesis and has suggested that it is dynamically unsound ; it need scarcely be said that if the hypothesis is unjustified from the mathematical point of view it must be given up. Even if the exact theory of the lattice vibrations based on certain extreme idealizations be worked out, it will not serve to describe the vibrations of a real crystal unless it conforms to experiment. The exact and complete solution of the problem of the vibrations of a linear diatomic lattice under internal forces was obtained here some time last year, and has been given independently by Born. Born's work, however, contains some mathematical errors, for his enumeration does not include the obvious translation of the lattice as a whole, or that vibration which, when the number of atoms is only two, corresponds to their mutual vibration.

The cyclic lattice method originally proposed by Born affords the solution that the vibrations take place as those of the infinite lattice the wave-lengths of which are sub-multiples of the dimensions of the finite lattice. In his recent paper he appears to suggest that the cyclic lattice method is justified because the frequency-range given by it is the same as that given by the exact theory. This is not the point of dispute. What had to be shown is that there are vibrations of the finite lattice to which we can ascribe wave-lengths, and that they are of the order $L/N + o(1/N)$.

There are certain features of the cyclic lattice solution which are misleading, such as the degeneracy of over-vibration, and secondly, the existence of progressive wave solutions. It can be shown that over-vibration of a finite lattice is non-degeneracy, and progressive wave solutions are impossible. The exact theory shows that there will be the so-called optical and acoustic branches. However, for displacement (a) of the first atom, the maximum displacement of any atom will be $O(a)$ in acoustical vibrations, while the maximum amplitude will be $O(Na)$ in optical vibrations. The magnitude of the maximum amplitude falls off far more readily in the case of the optical branch than in the other. The important point is that whereas the acoustical vibrations depend on the nature of the boundary, it would require a very perfect crystal with perfect boundary conditions for all the atoms in an optical vibration to vibrate in the same phase, though not with the same amplitude. In the exact solution, infinitesimal displacements in not negligible regions have to form as nodal bridges. These considerations force us to draw a distinction between vibrations in perfect crystals and in real crystals.

The following is a working hypothesis to describe the vibrations taking place in a real crystal :

(1) There will be two types of vibrations, one of high frequency and the other of low frequency. These types must not be confused with the optical and acoustical branches introduced by Born.

(2) Almost all the vibrations will be of the high-frequency type, that is, the number of vibrations will be $O(3N)$.

(3) A high-frequency vibration can appear anywhere in the crystal, being limited only by a closed surface which we term the 'vibrational volume', outside which the disturbance caused will be negligible. The dimensions of the vibrational volume depend only on the nature of the crystal forces and crystalline symmetry, for the high-frequency spectrum will be a monochromatic one with a small number of frequencies.

These assumptions include Einstein's hypothesis in an extreme form when the vibrational volume is the atomic volume itself and over-vibration is a high-frequency one. The ideas contained in (2) and (4) have been stressed by Sir C. V. Raman in his publications.

In contrast with the difficulties of the idealized theories, and the lack of satisfactory correspondence with experimental results, the above hypothesis would seem to account for many of the results, especially the numerous Raman lines in crystals, the infra-red bands, the specific heat and the thermal conductivity of crystals.

Details of this work will appear elsewhere.

N. S. NAGENDRA NATH.

Andhra University,
Guntur.

[1] *Proc. Roy. Soc.*, A, July 1942.

Density of Frequencies in Lattice Dynamics

THE preceding communication by Dr. Nagendra Nath is one of a series attempting to defend Raman's interpretation of the diffuse spots in X-ray photographs of crystals by discrediting the thermal theory accepted by other investigators of this phenomenon. Raman insists that not only is this application of lattice dynamics to X-ray scattering wrong, but also the foundations of lattice dynamics itself. He questions in particular the method of the 'cyclic boundary conditions', which consists in the following: The vibrations of a finite piece of the crystal depend in principle on the shape of the surface and the dynamical conditions prevailing on it. But if the dimensions of the piece are large compared with the single cell, it is plausible that the dependence on the boundary conditions will be inessential, so that these can be replaced by simpler ones (periodicity). The same assumption is made in the theory of radiant heat (black body radiation) and of the electrons in metals. It has never been doubted in these applications, and whoever rejects it would have to reconstruct these extended theories without this simplification.

In order to disprove Raman's objections directly, I have published the solution of a simple example, the finite diatomic chain (linear lattice), and shown that the quantity essential for the thermal applications, the density of the frequencies, is asymptotically the same for the rigorous and the cyclic solution. Dr. D. E. Rutherford, of the University of St. Andrews, who has checked my results by a different and ingenious method, has found that one of the frequencies given in my paper is incorrect; but this is, of course, quite insignificant for the problem considered, as a linear lattice of 1 cm. length has about 10^8 frequencies. In the preceding communication Dr. Nagendra Nath reports that he has worked out (but apparently not published) the same example and found the same mistake (he claims to have found another one, but this statement of his is incorrect). He has also confirmed the splitting of the frequencies into two branches; whether he has found the asymptotic density law is not evident from his letter, as he speaks only about the 'range of frequency', which is not relevant in this connexion.

Dr. Nagendra Nath's subsequent considerations are incomprehensible to me, as for example: "In the exact solution, infinitesimal displacements in not negligible regions have to form as nodal bridges", from which he infers that one has to consider 'real' instead of 'perfect' crystals. For this purpose he formulates four "working hypotheses" the meaning of which is hard to understand (even if a "monochromatic one [spectrum] with a small number of frequencies" is allowed for as a lapsus linguæ). There seems to be no more justification for these hypotheses in the extensive literature on 'real' crystals than in lattice dynamics.

To end this discussion about the cyclic condition, I have asked the help of a mathematical expert, Dr. W. Ledermann, of the University of St. Andrews. He has proved (see the following letter) a theorem which suffices for the foundation of all purely thermal applications of lattice dynamics (specific heat, thermal expansion, etc.) and in addition shows that a break in the regularity (missing or wrong atoms) at a number of places small compared with the total number of lattice points does not materially influence the thermodynamical results. This theorem may not be quite sufficient for all problems of crystal theory. The scattering of X-rays, however, which is the main object of Raman's attack, is quite independent of it. In a paper which will soon appear in *Proc. Roy. Soc.* I have shown that the formula for the diffuse thermal scattering can be derived in such a way that no other mathematics is used than in the Laue-Bragg theory of ordinary scattering, namely, the fact that certain lattice sums, which are simple generalizations of the Laue function $\sum_{n_1n_2n_3} \exp i(n_1x_1+n_2x_2+n_3x_3)$, are approximately independent of the boundary for large crystals.

MAX BORN.

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University, Edinburgh.

IN connexion with the asymptotic distribution of the eigen-frequencies of a cyclic and a finite lattice, the following mathematical theorem will be found helpful:

Let A be a real symmetric matrix of order n in which we display a 'core' C bordered by a single row and column, thus:

$$A = \begin{bmatrix} C & h \\ h' & \eta \end{bmatrix},$$

where C is a symmetric matrix of order $n-1$, h a column, h' its transpose and η a number. The latent roots of A are n real numbers $\mu_1, \mu_2, \ldots, \mu_n$. Let the number of latent roots which lie in the interval $\alpha \leqslant \mu \leqslant \beta$ be denoted by $P(\alpha,\beta)$. We wish to compare the latent roots of A with those of the matrix

$$B = \begin{bmatrix} C & k \\ k' & \varkappa \end{bmatrix},$$

which differs from A only in the last row and column. If the number of latent roots of B in the same interval be denoted by $Q(\alpha,\beta)$, it can be shown that

$$|P(\alpha,\beta) - Q(\alpha,\beta)| \leqslant 2.$$

This inequality is independent of the particular border (h,η) or $(k,\varkappa)$ and is independent of n. The result is especially interesting for large values of n, as it provides a proof of the plausible fact that the distribution of the latent roots of a *large* symmetric matrix is not materially changed by the modification of the last row and column. When the last p rows and columns are modified, the inequality reads

$$|P(\alpha,\beta) - Q(\alpha,\beta)| \leqslant 2p.$$

Hence if p be small compared with P or Q, it follows that P and Q are asymptotically equal.

The bearing of this theorem on the problem of crystal vibration is as follows: the N atoms of the lattice are divided into internal atoms and boundary atoms, according as the atom has a complete set of *acting* neighbours or not. Instead of numbering the atoms with three indices corresponding to their spatial arrangement (as is usual in lattice theory) we imagine the atoms to be enumerated in a simple sequence, starting somewhere in the interior and taking first all the internal atoms and then adding the boundary atoms. As the vibration is vectorial, there are three equations of motion for each particle. The number, p say, of 'boundary' equations is of smaller order of magnitude than that of the 'internal' equations ($p \sim N^{2/3}$). The matrix whose latent roots are the squares of the frequencies is of the type A considered above, involving a border of p rows and columns. The introduction of the cyclic condition causes a change only in the border elements of the matrix, and the theorem regarding the asymptotic density of the latent roots can be applied ; that is, this density is practically the same as that for the cyclic lattice.

The application of the method to the case of defects of the lattice (missing or wrong atoms) is obvious.

WALTER LEDERMANN.

University,
St. Andrews.

Classification of Rheological Properties

I HAVE been interested by recent reports in NATURE, by the British Rheologists Club, relating to the classification of rheological properties. Since suggestions have been invited for improving the table of deformation, I put forward the following for consideration.

I believe that the table in NATURE of June 20, 1942 (p. 702), already an improved form of the earlier table shown in NATURE of February 14 (p. 197), can be made still clearer if the heading "Flow" is omitted and the first division made a three-fold one into "Elastic", "Plastic", and "Viscous". It may be natural to classify bodies according as they flow or do not flow under stress, but I suggest that this is as arbitrary a classification, scientifically, as some that have been adopted in other parts of the system, its main virtue being that it is based on phenomena readily appreciated by the non-scientific mind.

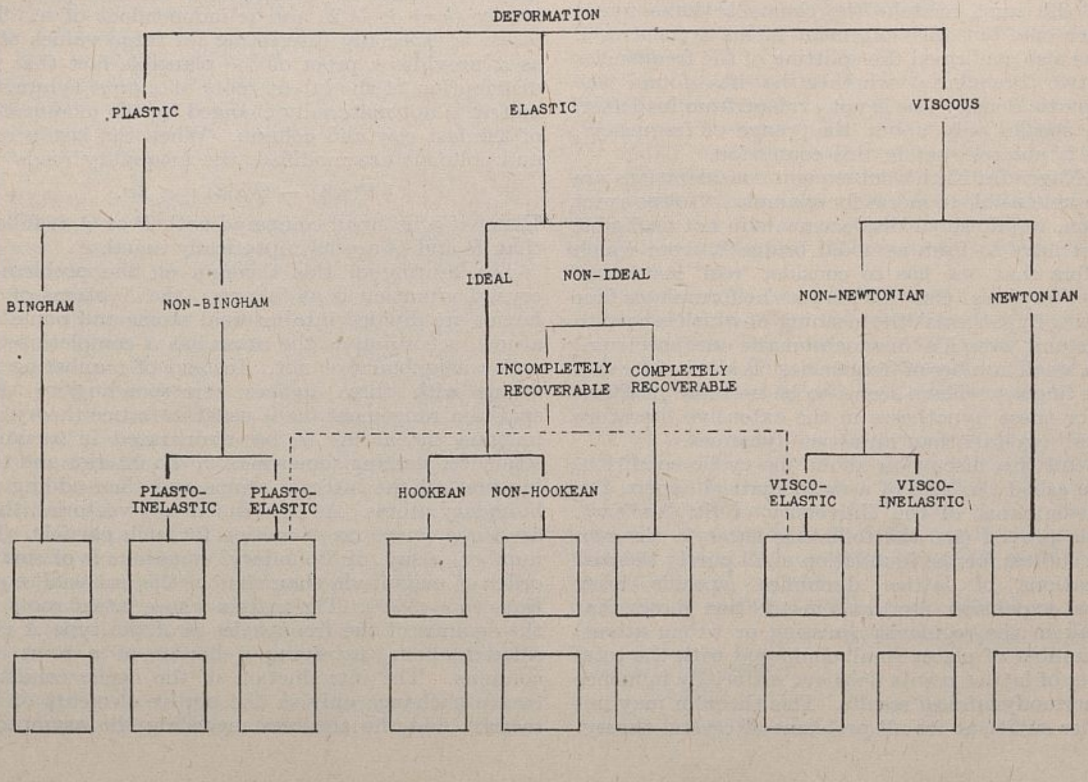
Further, the groups "Elastic" and "Plastic" overlap at the lower end of the table, and the groups "Elastic" and "Viscous" also overlap, whereas "Plastic" and "Viscous" remain distinct, although these actually have a common heading in the present table. This seems to me a little illogical.

If this step is allowed, then by setting out the three main headings with "Elastic" placed centrally, we can construct the table with less interference of the lines, and keep the three main groups separated. The balance of the table is also preserved. The accompanying diagram shows the arrangement that I propose.

I do not, of course, claim that I am making any addition to the system of rheological classification, but I think that it will be agreed that the proposed rearrangement has some points in its favour.

R. BARTLETT.

17 Walker Avenue,
Prestwich,
Manchester.
Dec. 31.



Detection of Acid or Basic Substances in Damaged Fabrics

Feigl and Da Silva[1] have put forward methods for detecting basic and acid substances when present in many materials normally regarded as insoluble, when acidity or basicity cannot be detected in the normal manner, for example, by a pH determination.

We wish to direct attention to a possible use of these methods in the examination of faults in textile materials. It has long been known that acid or basic substances often damage textile fibres, but whereas certain methods of detection are available, there is plenty of room for a quick and reliable method. Feigl and Da Silva's work seems to make this possible.

If a solution of a nickel salt is incompletely precipitated with dimethyl glyoxime and filtered, one obtains a solution which on application to a fabric damaged by alkali (for example, caustic soda) causes the damaged fibres to take on a pink colour which is easily visible. This test has been tried with cotton and woollen fabrics.

Similarly, a saturated solution of silver chromate in ammonia ($6N$), when applied to fabrics damaged by acids, shows a dark red-brown colour. This test did not work so well with damage by hydrochloric acid on cotton ; wool damaged by this acid gives a white spot inside a dark ring.

With coloured materials, while the coloured precipitate is not so noticeable to the naked eye, we have found it easily visible under the microscope even when the fabric and precipitate are the same colour.

Further investigations are in progress with the view of extending the scope of these tests.

C. WHITWORTH.
D. W. POXON.
Loughborough College,
Loughborough.
Jan. 14.

[1] *J. Ind. Eng. Chem.*, Analyt. Ed., **14**, 317 (1942), and **14**, 519 (1942).

Soil Conditions Affecting Production of Perithecia in Banana Leaf Spot Disease

RECENT research[1] has brought to light the existence of the ascigerous stage (*Mycosphærella musicola*) of the fungus *Cercospora musæ*, during studies on the etiology of leaf spot or 'Sigatoka' disease of bananas. Perithecial formation is mainly seasonal, being greatest between August and January.

Experiments have shown that three-weekly spraying cycles, for example, with 4-4-40 Bordeaux mixture, are unable to control banana leaf spot satisfactorily unless the disease is brought under control before the start of the ascospore season. This applies to almost the whole of the banana-growing districts in Jamaica.

In a few isolated areas, however, it has been found that perithecia are produced in profusion throughout the year. A recent survey of these areas has shown that this 'out-of-season' production of perithecia is positively correlated with the growth of banana plants on highly acid soils (pH 4·0–4·75 approximately). Regular three-weekly spraying has likewise failed to give satisfactory control of the disease at any time throughout the year. Only by employing the weekly heart-leaf spraying method[2] has control been obtained. This method is impracticable once the plants have grown tall ; unless liming or some other means can be found to ameliorate the effect of high soil acidity on the metabolism of the Gros Michel banana and its parasite (*M. musicola*), spraying will prove useless as an economic measure of controlling this leaf spot disease under these conditions.

No experimental data are at present available to explain this physiological problem. It is possible that the water relationship of the soil may also be found to play a part in this abnormal production of perithecia. A search through available literature has failed to disclose a similar example of soil conditions affecting the fructifications of a leaf spot fungus.

R. LEACH.
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Department of Agriculture,
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[1] Leach, R., *Trop. Agric.*, **18**, 91 (1941).

[2] Leach, R., "Banana Leaf Spot—When to Spray and Why". (Dept. of Agriculture, Jamaica, 1942.)

Rumford's Contributions to Nutrition

THE instructive note on Charles Darwin's health by Sir Buckston Browne in NATURE of January 2, p. 14, lends interest and certainly gives point to the forthright opinions expressed by Count Rumford about ". . . that most pernicious wash, *tea*, with which . . . the inhabitants of this island drench their stomachs, and ruin their constitutions".

"When tea is mixed with a sufficient quantity of sugar and good cream," he wrote ; "when it is taken with a large quantity of bread and butter, or with toast and boiled eggs ; and, above all, *when it is not drunk too hot*, it is certainly less unwholesome ; but a simple infusion of this drug, drunk boiling hot, . . . is certainly a poison which, though it is sometimes slow in its operation, never fails to produce very fatal effects, even in the strongest constitution, where the free use of it is continued for a considerable length of time."

When, some years ago[1], attention was invited to Rumford's contribution to the science of nutrition, the substitution of potatoes for bread had not the importance which it has now and which it had in Rumford's day. Rumford gives many interesting recipes and records that so strong was the aversion of the (Bavarian) public to potatoes that for a time he found it necessary to disguise them by boiling them down entirely to destroy their form and texture and so prevent them being detected. This is how he made *calecannon*, an Irish dish : potatoes 19 cwt., greens 295½ lb., butter 98 lb., onions 14 lb., salt 40 lb., black pepper 1 lb., ginger ½ lb. 273 gallons of pump water were brought to the boil ; the greens were added, and fifteen minutes after they had come to the boil they were taken out and replaced by the potatoes, which were cooked in the same way. The potatoes being mashed (without peeling them), and the greens chopped fine with a sharp shovel, they were mixed together. The other ingredients were added, the whole was well mixed and it was served in wooden noggins to 927 persons. It would be scarcely possible, Rumford remarks, to invent a more nourishing or more palatable kind of food than calecannon ; and with this kind of food there is no allowance of bread, nor is any necessary.

Rumford's advice on how to dress salt-fish to perfection has likewise an added interest at the present time : "the secret of cooking it is to keep it a great many hours in water that is *just scalding hot*, but which is never made actually to boil".

A. F. DUFTON.
The King's Lodge,
Hunton Bridge, Hertfordshire.

[1] Dufton, A. F., *The Lancet*, **231**, (5913), 1535 (1936).

Sir Henry Miers

EXCEPT in popular estimation, no man's reputation really rests upon a single discovery, and whether Ramsay or Rayleigh discovered argon, or whether Ramsay, Hillebrand or Miers discovered helium, are really questions involving the definition of the word 'discovered', and, as Mr. Humberstone has found[1], of little or no interest to those most particularly concerned.

However, the circumstances surrounding those discoveries are of real interest, and may be made living stories through the correspondence which passed between those who participated in them. I have in safe keeping the letters which passed between Ramsay and Miers and a mass of papers and correspondence belonging to Ramsay, which were left by Lady Ramsay. I hope to publish them after the War.

MORRIS W. TRAVERS.

[1] NATURE, **151**, 111 (1943).

FORMATION OF PLANETARY SYSTEMS

A CONSIDERABLE amount of interest has been shown in recent times on the subject of the origin of planets and satellites, and various theories have been developed with the primary object of circumventing the angular momentum difficulty. A recent paper by B. M. Peek, entitled "The Formation of Planetary Systems" (*J. Brit. Astro. Assoc.*, **53**, 1; December, 1942), puts forward a theory which possesses at least the merits of simplicity. He starts off with a quotation from Sir James Jeans's "Astronomy and Cosmogony" (1928), which attempts to explain the angular momentum of the nebulæ: "Any currents or motion in the original medium would contribute angular momentum to the nascent nebulæ, and as these shrank to nebular dimensions, the constancy of angular momentum would result in fairly rapid rotations of the shrunken masses". Peek extends this view to the next order of condensation—the stars—and is thus able to explain how the necessary angular momentum of the solar system, and other possible planetary systems too, can be accounted for.

Starting with a portion of the galaxy having a nearly uniform distribution of matter, Peek postulates the beginning of the gravitational instability which produces *stars*, and further postulates that the random currents in the medium contribute angular momentum to these nascent *stars*. After a time any diffuse star rotating about an axis which is perpendicular to its equatorial or invariable plane will have most of its angular momentum concentrated close to the rim of this plane. The system has no resemblance to Laplace's nebula, which was supposed to rotate almost like a rigid body. For this reason the main bulk of the star will be almost spherical, not lenticular, as contraction proceeds. In time, however, the small portion of matter at the rim, which received its momentum from the original current, will have communicated some of its motion to other portions in the immediate vicinity, owing to viscosity. The shrinking of the star is necessarily accompanied by an increased angular velocity, in order that the angular momentum may be preserved, and finally portions of matter will be expelled from the periphery and will describe orbits about the still shrinking star. Some quantitative results are given, among which reference may be made to one in particular. Peek has calculated that if the original current had the same order of mass as all the planets combined and moved with a velocity of two metres per second, this current would have been able to endow the whole of the solar system with its observed angular momentum.

By the time all the matter had been shed, a small fraction of the angular momentum would have been communicated to the condensing nucleus, and this may be the explanation of the rotation of the sun in a plane which does not differ very much from the invariable plane. It is suggested that after the main nebula collapsed into discrete condensations, stray wisps of the material composing the nebula, possessing random velocities, would hang about in conditions of unstable equilibrium between the stars in process of formation, and would finally be captured by one or the other of these. Here is a tentative explanation of the origin of the long-period comets. The theory is also able to explain the origin of the satellites and especially their direct motion, but it is admitted that retrograde satellites and also a system like that of Uranus present difficulties. Periodic comets may have been formed from matter left over from the planetary condensations.

No detailed explanation is attempted regarding the manner in which matter would be shed from the contracting mass, though certain possibilities are suggested. This particular part of the subject involves very abstruse mathematics dealing with gas-kinetics, and it is to be hoped that this branch will be developed further. It is conceivable that the theory may encounter some of its greatest difficulties here.

HEALTH IN INDUSTRY

THE importance of securing, in the crisis of man-power and woman-power through which Great Britain is now passing, that there is no waste of labour and that the full woman-power and man-power of the country is utilized to the maximum extent possible in furtherance of the nation's war effort—though it should be noted that the latter is not to be interpreted too narrowly—is now generally appreciated. As the last report of the Chief Inspector of Factories showed, the importance of eliminating the loss of man-hours and woman-hours due to accidents and to sickness is still far from being realized. Nor, as that report and successive reports of the Select Committee on National Expenditure have indicated, have managements either in industry or in Government departments and factories learnt the lessons and applied to good purpose the experience acquired during the War of 1914–18.

That truth is well emphasized in the third report of the 1942–43 session from the Select Committee on National Expenditure. Here the results of the investigations of the Committee on the health and welfare of women in war factories are detailed, and the observation recorded at the outset that little attention seems to have been paid to many of the constructive suggestions contained in earlier reports on health and welfare problems would justify this further inquiry. The relation of health to production is indeed one of the widest interest, as well as of growing importance as the demands of the War grow more imperative. It involves the co-operation of the worker as well as of factory management and of the Government.

Broadly speaking, an efficient general state of health in industry depends on the improvement and maintenance of what is commonly called physical fitness; the prevention of diseases and of accidents; the treatment of sick and injured persons and their rehabilitation to fit them for return to industry. The problem to-day is largely one of the most economical use of women, particularly in view of the breakdown of any system of medical examination as to the fitness of women for factory work before they are transferred to work away from home.

The results of this inquiry are set forth in three main divisions: health and welfare within the factory, and, secondly, outside the factory; and the State and industrial health. In regard to the first, matters relating to the maintenance of health can be grouped under three general headings: (*a*) physical amenities, such as the provision of satisfactory canteens, cloak-rooms, rest-rooms, etc.; (*b*) medical provisions, such as first-aid, preventive measures for specific industrial diseases, and the general medical supervision of the life of the factory ; and (c) general oversight, such as the administrative and executive action which has to be undertaken by welfare or personnel officers. While the general level of physical amenities is on the whole satisfactory and in many factories the standard reached is high, the Committee raises a number of matters in relation to canteens, including inadequate time for meals, and to cleanliness and rest-rooms, which should be brought to notice.

It is recommended next that the Government should give the closest attention to the problem of securing a satisfactory industrial medical service, at least within all the factories engaged on Government work. In this connexion the Committee considers that greater use could be made of women medical practitioners and recommends further that consideration should be given to the question of establishing a centralized employment register for trained nurses. Once again the recommendations that further energetic measures to improve the general standard of lighting in the medium-sized and small factories should be taken by the Ministry of Labour and the supply departments concerned, and that the provision of adequate ventilation in royal ordnance filling factories should be dealt with as a matter of urgency indicate how far we are even yet from harnessing to the service of our war effort even existing scientific knowledge.

Other recommendations in this field are that the supply departments should assist contracting firms to introduce black-out arrangements that will allow of the entrance of a reasonable amount of daylight to workshops, canteens and rest-rooms, and that when new Government factories are in course of construction, or are to be built in the future, expert advice and co-operation should be sought at the earliest stage to ensure that adequate systems of lighting and ventilation are adopted. Further evidence confirms the comments of the Chief Inspector of Factories as to the frequent neglect to take the elementary precaution of training new workers in the use of safety devices, and in regard to hours of work further research and experiment are recommended to determine the best method of arranging a rotation of shifts in royal ordnance factories so as to reduce fatigue and to ensure a minimum of inconvenience to workers and managements. The Committee suggests further that, where a two-shift week is worked, it would be advantageous for departments to organize a five-day week for their women employees.

Once again the crucial importance of personnel management is stressed. The Appointments Board of the Ministry of Labour should carefully consider whether more use could not be made of older men and women with a good educational background as labour officers in factories, and the Select Committee recommends further that the Ministry of Aircraft Production should co-operate with the Ministry of Labour in organizing courses for training personnel managers and welfare workers for firms in the aircraft industry, to which the existing staff in aircraft firms might be sent for refresher courses. It is somewhat disturbing to find that there is still neglect of personnel organization in the aircraft industry, and the Committee also comments on some lack of co-operation between the production staff, labour management and the medical officers in the royal ordnance factories. Examination by the Ministry of Labour of the existing machinery for transferring workers from one district to another with the view of securing a closer relation between regions that are exporting labour and those that are receiving it, so as to ensure that factories are notified of the arrival of new workers in sufficient time to enable the necessary arrangements to be made for their reception, is also recommended, as well as a review of the subject of wartime nurseries.

The latter question falls into the section of the report dealing with health and welfare outside the factory. Here stress is laid on shopping difficulties, which are still acute for most women-workers in many areas, and on the provision of billets, to which a like remark applies. Here the Committee suggests that the regional and local welfare officers of the Ministry of Labour might impress on the more backward firms the advantage to be gained by making better provision for the welfare of workers outside the factory, such as the development of social centres or clubs, and the installation of shower-baths for those unable to obtain baths.

The section of the report which deals with the State and industrial health is of major interest to scientific workers. Discussing first the allocation of responsibilities, the Committee agrees with the broad division of functions between the Ministry of Labour and the supply departments, which should carry a joint responsibility for the maintenance of good personnel management. It is recommended that the factory inspectorate should be relieved of any tasks that can be transferred elsewhere without loss of efficiency, so that the inspectorate may be free to concentrate on the maintenance of good standards of safety and health. It is pointed out, however, that co-operation between the inspectorate and those responsible for the royal ordnance factories has not been as full as it might be. The constitutional relationship is not altogether easy, and the medical branch of the factory inspectorate from its composition has neither a staff sufficient to provide advice and instruction on a wide scale nor the authority to ensure that the advice it is able to proffer is accepted by those who need it most. Again, while the Ministry of Labour's welfare officers have done much useful work in securing the provision of facilities for the health and welfare of workers outside the factory, difficulty has been experienced in obtaining suitable people for this advisory work by local recruitment, and the Select Committee recommends that the Ministry of Labour should take immediate steps to recruit older women with the right type of experience.

Neither the Ministry of Supply nor the Ministry of Aircraft Production has, in the Committee's opinion, given the attention to the problems of industrial health and welfare in contractor's factories that is desirable, and the Committee recommends the appointment of medical women as additional advisers to both Ministries. The report once again notes the failure of the supply departments to utilize fully the special knowledge of the Industrial Health Research Board, and while expressing the hope that the fullest use will be made of the results of the work now being undertaken, stresses the need also for comprehensive planning.

To meet this need and to place the existing organization for creating and maintaining the standards of industrial health on a surer foundation, the report finally recommends a rearrangement of the medical supervision of industrial health. First, the medical branch of the factory inspectorate should be enlarged and strengthened. Secondly, a central industrial health advisory committee should be set up forthwith to advise the Ministry of Labour and the supply departments on all questions of industrial health and on the co-ordination of medical services to meet the requirements of the war effort. Regional industrial health advisory committees should also be set up to advise the Ministry of Labour, the regional boards and employers on the co-ordination and extension of industrial health centres in each region. A central bureau should be established for collecting, abstracting and disseminating information and literature relating to all questions of industrial medicine. The need for this is particularly stressed, including the publication of a bulletin, and the bureau might be modelled on similar organizations existing in other fields of applied science. Working in close association with the British Medical Association, the Medical Research Council (particularly the Industrial Health Research Board), and the Association of Industrial Medical Officers, and with an enlarged and strengthened organization of medical inspectors of factories, these committees should do much to reduce the incidence both of industrial disease and of general sickness among industrial workers and others, and thus materially increase the volume of output with a corresponding reduction in cost to the nation.

FORTHCOMING EVENTS

(Meeting marked with an asterisk is open to the public)

Saturday, February 13

IRON AND STEEL INSTITUTE (JOINT MEETING WITH THE SHEFFIELD METALLURGICAL ASSOCIATION, THE SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS, AND THE SOUTH YORKSHIRE SECTION OF THE INSTITUTE OF CHEMISTRY) (at the Royal Victoria Station Hotel, Sheffield), at 2.30 p.m.—Mr. H. T. Shirley and Mr. E. Elliott: "A Critical Consideration of some Applications of the Spectrograph to Steelworks Analysis".

Monday, February 15

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 8 p.m.—Dr. Kaare Rodahl: "The Swedish-Norwegian Expedition to North-East Greenland, 1939–1940".

Tuesday, February 16

ROYAL SOCIETY OF ARTS (DOMINIONS AND COLONIES SECTION) (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Dr. S. S. Pickles: "Rubber, Natural versus Synthetic".

SOCIETY OF CHEMICAL INDUSTRY (JOINT MEETING OF THE AGRICULTURE GROUP AND THE LONDON SECTION) (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 2.30 p.m.—Prof. G. W. Robinson: "Methods and Interpretation of Soil Analysis".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 3 p.m.—Sir Lawrence Bragg, F.R.S.: "The Solid State" (iv) "Plus-plus Compounds".*

INSTITUTION OF ELECTRICAL ENGINEERS (WIRELESS SECTION) (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Electronics in Industry" (to be opened by Mr. E. Cattanes, Mr. G. T. Winch and Mr. A. L. Whiteley).

Wednesday, February 17

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Dr. C. H. Desch, F.R.S.: "Magnesium" (Peter le Neve Foster Lecture).

ROYAL METEOROLOGICAL SOCIETY (at 47 Cromwell Road, South Kensington, London, S.W.7), at 4.30 p.m.—Major H. C. Gunton: "Report on the Phenological Observations in the British Isles from December 1941 to November 1942".

INSTITUTE OF PHYSICS (at the Royal Institution, Albemarle Street, Piccadilly, London, W.1), at 6 p.m.—Annual General Meeting. Dr. J. R. Baker: "Freedom in Science".

Thursday, February 18

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Prof. J. M. Gulland: "Aspects of Nucleotide Chemistry" (Tilden Lecture).

PHARMACEUTICAL SOCIETY (at 17 Bloomsbury Square, London, W.C.1), at 7 p.m.—Charter Centenary Meeting and Address by the President, Mr. W. Spencer Howells.

Friday, February 19

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5 p.m.—Prof. E. J. Salisbury, F.R.S.: "The Flora of Bombed Areas".

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Annual General Meeting. Mr. K. S. Laurie: "Some Textile Finishing Machines".

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at Bolbec Hall, Newcastle-upon-Tyne), at 6 p.m.—Dr. W. D. Jones: "Powder Metallurgy, its Products and their Various Applications".

ASSOCIATION OF SCIENTIFIC WORKERS (HARPENDEN BRANCH) (at the Congregational Hall, Harpenden, Herts.), at 5 p.m.—Mr. F. Le Gros Clark: "Agriculture in relation to Food Policy".

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

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