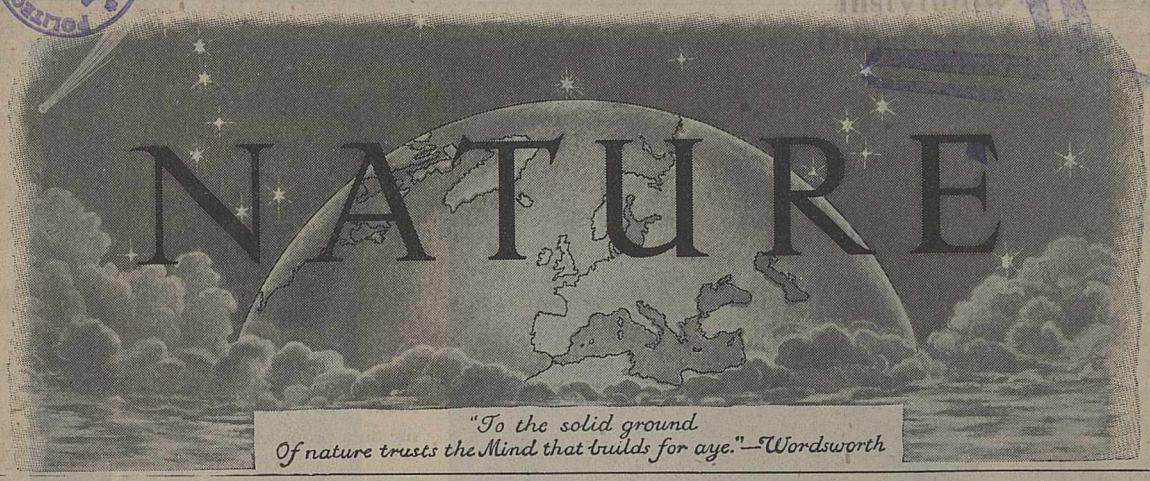

Vol. 153, No. 3889 SATURDAY, MAY 13, 1944 ONE SHILLING & SIXPENCE

NATURE

No. 3889 SATURDAY, MAY 13, 1944 Vol. 153

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ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831
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T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone: Temple Bar 1942
The annual subscription rate is £4 10 0, payable in advance, Inland or Abroad.

Registered as a Newspaper at the General Post Office

INTERNATIONAL CO-OPERATION IN TELECOMMUNICATIONS

THE machinery of international co-operation, which has been allowed, in the political sphere, to break down from frictional wear and tear, is being hopefully re-examined as a prelude to reconditioning or reconstruction. Chatham House has been happily inspired to inaugurate a series of monographs on international transport and communications, and the series opened appropriately with the discussion of international telecommunications*: appropriately, because the Union to which was first entrusted in 1865 the organization and regulation of telecommunications was, as the author of the monograph justly says, "One of the earliest, and also one of the most successful organs of international collaboration". The structure, which was founded on the International Telegraph Union, grew large and somewhat sprawling with the rapid expansion, first of line telephony, and later of radio communication systems. It was redesigned and given good architectural form at a conference held in Madrid in 1932. There the International Telecommunication Union was created as the supreme organ of collaboration in these fields. Brigadier-General Sir Osborne Mance's book is an admirable guide to the past history of international telecommunications, and to those considerations which will be important in the planning and management of their future.

It has been remarked, by those who have had the privilege of participating in the international conferences on telecommunications and on meteorology, that in general the technical world has managed these partial Leagues of Nations more successfully and fruitfully than did the political world its more ambitious and naturally less tractable League. These successes were in part due to the simple and inescapable conviction that the choice lay only between collaboration and chaos. But that has been demonstrated to be true also in the political sphere. There is justification for the claim that the community of interest and mode of thought engendered by a common technique was a major factor in the success attained. The secure foundation of the common technique was, in turn, that universal freedom of interchange of scientific knowledge and thought which has been an enduring encouragement to all who believe that man can learn to forget frontiers without forgetting national pride.

The problems of line communication are of great technical interest, but they are technically, organizationally and politically of a pristine simplicity when compared with those of radio communication. Mutual interference through common use of a medium which facilitates the passage of intelligence to world-wide distances, at an expenditure of power which may be less than that of a pocket torch, can only be avoided by skilled adherence to stringent regulations. The difference in the area served by radio communications on different wave-lengths, the variability of the

* International Telecommunications. By Brig.-General Sir Osborne Mance. (Issued under the auspices of the Royal Institute of International Affairs.) Pp. xii+90. (London, New York and Toronto: Oxford University Press, 1943.) 7*s*. 6*d*. net.

area with the time of day and with the season, the limitation of the service by noises of natural origin —mainly radiated from lightning flashes—all these and similar factors lead to keen competition for wave-length channels, which must be allocated internationally if radio peace is to be maintained.

It has been suggested that allocation should be based on two principles which seem unanswerable in the abstract, but which have not yet been accepted as a basis of action. The first principle is, in its broadest form, that first claim should be conceded to those services in which a metallic conductor cannot be used to link sending to receiving station. Thus maritime and aircraft services would be given absolute priority; and the use of line telegraphy and telephony would be encouraged, in preference to radio links, wherever they could assure a service. The second principle is that where services with a legitimate claim (within the first principle) to radio allocations come into competition for channels, preference should be given to the one which is of the highest social importance. In the absence of an agreed set of principles such as these, allocation has remained a matter for bargaining, compromise and successive readjustments. Difficult as would be the working out of the ethical, organizational and political problems implicit in the "highest social importance" criterion, the absence of even this golden foot-rule leaves still greater difficulties to be faced. Prestige, propaganda and profits are noisier claimants than principles.

The maritime services demand not merely straightforward communication of the content of the spoken or the written word, not merely that vital aid to determination of longitude provided by time signals, the value of which depends on the infinitesimal time they lose in travelling halfway round the world. They require, too, those radio aids to navigation which depend on the fact that it is not difficult to measure, at a receiving station on ship or shore, the bearing, relative to true north or to the ship's heading, from which signals of known place of origin are coming in. Radio beacons and direction-finding services require a special place in the most-favoured-service category.

Still more exacting are the claims of air transport. Radio, with its lusty infant progeny of 'radar' devices, offers the air line of the immediate post-war future a complex of communication, navigational and safety services which leave only one major hazard in all-weather flying. But such services demand monopoly use of a considerable range of wave-lengths, denied to any other user within a wide area which may, in some cases, be a world area.

These are the services which would stand indisputably at the top of the priority list based on the first general principle; the broadcasting services would certainly claim first place in the "social importance" scale—even though the cynic will suggest that a mad dog may, while he runs free, be of more immediate social importance than a young Pasteur.

It is not too soon for the United Nations to be considering now a sound double framework of basic principles and technical performance in the broad field of international communications. Within such a framework must be fitted the post-war solutions of problems which will have become more numerous and more pressing with war-time progress in radio and with the demands of rehabilitation. It may well be believed—and hoped—that no such opportunity for rationalization and reconciliation of competing claims in the field of international communications will ever again present itself.

NATURE CONSERVATION AND ECOLOGY

IN his recent broadcast address, the Prime Minister rebuked those "comfortable people who . . . would rather postpone building homes for the returning troops until they have planned out every acre in the country to make sure the landscape is not spoiled". It is not, perhaps, immediately clear who are the people thus referred to, but we can be sure that the scientific advocates of nature conservation are not among them. They, at any rate, will be content if the place allotted to them in the scramble for post-war priorities is not too near the end of the queue. This is made clear in an admirable pamphlet recently published by the British Ecological Society*, in which the human or social background is constantly kept in view.

When the Nature Reserves Investigation Committee was appointed in response to an official request in 1942, a committee of the Ecological Society was already engaged in considering the same subject and was able to assist in the inquiries. When the first-named Committee's report was published (see NATURE, June 26, 1943) the work of the Ecological Committee might have been thought to require no further record. It was considered, however, that the distinctively ecological point of view deserved to be independently formulated, and the report now published is designed to do this. It forms a very valuable supplement to the earlier report, and its extended treatment of the subject may be found more attractive by many readers.

Ecologists are, of course, primarily concerned with the scientific (or research) and educational aspects of nature conservation, though it is emphasized that these only rarely conflict with, and often reinforce, the claims of amenity and recreation. The subjects of ecological study are less the individual species than the interdependent aggregations or 'communities' of animals and plants that occur in Nature, and ecologists are specially desirous of preserving these communities. "Oak, beech and ash trees, heather and bilberry and bog-moss are very unlikely to disappear altogether from the country, but their continued existence as species is of very limited use to the ecologist if all the oakwoods, beechwoods and ashwoods, the heather and bilberry moors and the undrained *Sphagnum* bogs are destroyed or so modified that they no longer

* "Nature Conservation and Nature Reserves". Report drawn up by a Committee and approved by the Council of the British Ecological Society. Pp. 38. October 1943. (Cambridge University Press.) 1s. 6d.

represent natural plant communities." For this reason the ecologists regard with some suspicion the term 'species reserves' given by the Nature Reserves Investigation Committee to the category of reserves intended to secure the survival of rare or very local species. In every case it is the habitat rather than the individual species to which the conservators must direct their efforts, and 'species reserves' are simply 'habitat reserves' differing from others in the same category only in the reasons for their selection.

The ecologists distinguish between 'natural' and 'semi-natural' communities of plants, with their associated animals, and point out that efforts at conservation should embrace the latter as well as the former. For example, in the southern parts of the British Isles, hedgerows and small copses provide the main habitat for many species of wild flowers and nesting sites for perhaps the majority of our smaller birds. Their destruction, advocated and perhaps inevitable in the interests of large-scale mechanized farming, would not only destroy much of the charm of the lowland countryside but also might have indirect effects harmful in the long run to agriculture, such as the elimination of insectivorous birds and even the erosion of the lighter soils by wind or water.

It may perhaps be doubted whether the distinction drawn by the ecologists between 'natural' and 'semi-natural' communities is of much practical significance in Great Britain. Communities which are 'natural', in the sense that they owe none of their features to the effects of human activities, are probably very rare and are to be looked for only on the tops of the highest mountains and the wilder parts of the sea-coast. Further, the distinction is not always consistently adhered to even in the Ecological Committee's report itself. Thus, on p. 8, the rough grazings of hill pastures "which have never been ploughed or manured" are stated to consist of "entirely wild vegetation", while on p. 4 it is stated that "most of the grassland of these hill grazings owes its present condition largely to the continual nibbling of sheep". It may be added that land which is constantly grazed can scarcely be described as never having been manured.

That part of the report which deals with the relation of nature conservation to the activities of the Forestry Commission is of particular interest. In view of the urgent national need for coniferous timber, it is inevitable that the chief attention of the Commission must be devoted to supplying this. Coniferous plantations are admittedly not picturesque, and their associated fauna and flora are impoverished and lacking in interest to the ecologist, although "the plantations will lose much of their repellent uniformity and ecological poverty as they grow older". The report notes with satisfaction, however, that the Commission has not lost sight of more remote interests, as, for example, in setting aside as 'permanent forest reserves' certain areas of old, undisturbed, deciduous woodland, and it suggests that the Commission might be given a broader mandate to enable it to deal with questions at present excluded from its scope.

The Ecological Committee takes a similarly realistic view of the relations which should obtain between nature conservation and agriculture and game preserving. In connexion with the last-named subject, the Committee rightly deprecates attempts to introduce exotic species of animals. Its condemnation might have been more emphatic. In the past, such introductions have been mostly due to the whims of individual landowners; but it is a regrettable fact that even to-day one does occasionally meet people whose idea of a nature reserve seems to be a combination of Whipsnade with the less formal parts of Kew Gardens.

As regards the administrative machinery which it would like to see set up for the establishment and supervision of nature reserves, the Committee of the British Ecological Society cordially endorses most of the recommendations of the Nature Reserves Investigation Committee. While the latter, however, looks forward to the institution of a national nature reserves authority under the Ministry of Town and Country Planning, the Ecological Committee would like to see a national wild-life service with a status similar to that of the Medical Research Council, under the Privy Council, to embrace the whole field of the native fauna and flora of Great Britain. To this, presumably, would have to be added the conservation of geological sites advocated by the Nature Reserves Investigation Committee. Doubtless we may have to wait a long time to see the full development of such large-scale plans, but meanwhile there is much that might be done to educate the general public in the meaning and methods of nature conservation. For this purpose the pamphlet issued by the British Ecological Society deserves a wide circulation.

WHALEBONE WHALES IN THE ANTARCTIC

The Southern Stocks of Whalebone Whales

By Dr. N. A. Mackintosh. (Discovery Reports. Issued by the Discovery Committee, Colonial Office, London, on behalf of the Government of the Dependencies of the Falkland Islands.) Pp. 197–300. (Cambridge: At the University Press, 1942.) 15*s.* net.

THE main object of the research conducted by the "Discovery" Committee is the investigation of the biology of the economically valuable whales frequenting Antarctic waters. A number of "Discovery" reports dealing with various aspects of the subject have already been published, and Dr. Mackintosh's present paper incorporates much of this material in a comprehensive survey of pre-war conditions. At the present time, whaling is at a standstill, and the stock of whales is enjoying a respite from pursuit likely to extend to the end of the War. The effect of this war-time period of protection can only be measured comparatively in terms of conditions prevailing when whaling ceased. From this aspect, Dr. Mackintosh's review is of particular value. It should be emphasized that his memoir is by no means merely a compilation of already published data. It contains a great body of additional informa-

tion which the author has analysed, and also uses statistics of the whaling industry to provide a statement on the condition of the southern whale stocks which will be invaluable in the investigations necessary when whaling becomes active again.

The specific identity of the main constituents of the Antarctic catch—blue, fin and humpback whales—is briefly considered. This is followed by a section of more general interest in which weights of large whales are stated and formulæ for assessing weight from linear dimensions examined.

The remarkable exclusiveness of krill (*Euphausia superba*) as the food of all the whalebone whales while in the Antarctic has been proved by examination of many thousands of stomach contents. The record of any organism other than krill is so infrequent that its presence can be attributed entirely to chance; and the deterioration in the condition of whales which have moved to warmer waters where this crustacean is not available gives further proof of its importance in the cetacean diet.

The parasites infecting whales, particularly the ecto-parasites, are interesting not only from the range of forms which occurs—Diatomacea, Protozoa, Amphipoda, Copepoda and Cirripedia all figure in the list—but also because of the indications some of them give of migratory movements. Only whales which have been a long time in cold water carry a heavy film of diatoms; on the other hand, the copepod Pennella, a parasite in warmer water, indicates by its actual or recent presence in whales killed in the Antarctic that the cetaceans had not long migrated from lower latitudes.

Figures for the mean length at which sexual maturity is attained have been confirmed or made more definitely known. From this information, obtained by careful examination of genitalia and accurate body-length measurement, it has been possible to compute the proportion of mature and immature whales in the commercial catch, given only species, sex and length of the animals involved. The old corpora lutea in the ovaries, which are persistent, it may be throughout the life of the animal, have helped to provide a solution for many of the problems associated with the sexual cycle. Although much has still to be done, it is clear that the advance in knowledge of this aspect of the work has been most satisfactory.

The statistics of the whaling catch are considered in some detail. An idea of the scope of the industry is gained from the number of whales killed at southern whaling centres between 1904 and 1939. It is 636,426. Although the catches at tropical and sub-tropical stations are included in this total, the preponderating importance of the operations in the Antarctic, including South Georgia, is shown by the fact that 509,784 whales, or more than 80 per cent of the total, were slaughtered in those regions. In the last pre-war season alone 35,770 whalebone whales were taken in the Antarctic.

Marking of whales and the subsequent recovery of the darts from harpooned animals serves a dual purpose. The first and obvious one is the information about migration which can be obtained from recovered darts, and one of the most important new contributions in the paper is concerned with the difference between the humpback and the large rorquals in migration behaviour. During the Antarctic summer, the humpbacks are not distributed uniformly in the far south but are grouped in clearly defined communities, the position of which, Dr. Mackintosh has shown, can be correlated with winter haunts of this species on the South American, African, West Australian and New Zealand coasts. The evidence of marking indicates that each group of humpbacks keeps to its own approximately north–south migration route and that there is little intermixing of adjacent communities. The migrations of the blue and fin whales are less well defined. In winter they disperse in the warmer waters of the southern hemisphere to a greater extent than the humpbacks, and although in the southern summer they have a tendency to concentrate in the same areas as the humpbacks and to return to the same part of the Antarctic after their northward migration, unlike the humpback they sometimes move from one area to another.

But in addition to its primary intention, whale marking can also be used to give an indication of the proportions in which the species distinguished may be considered to be represented in the areas covered. The species ratio of whales marked is blue 13 per cent, fin 76·3 per cent, humpback 10·7 per cent. These percentages bear a remarkable similarity to the species ratio of whales observed at sea by the "Discovery" Committee's vessels, namely, blue 16·5 per cent, fin 77·1 per cent and humpback 6·4 per cent. The percentage of blue, fin and humpback whales killed in the Antarctic in the 1933–38 period was 44, 41 and 14 per cent respectively, figures which point to a disproportionately intensive attack on the population of blue and humpback whales. That the stock of these two whales is being depleted is shown by the progressive decline in the percentage of the two species in the annual catch, by the reduced size and age of the whales killed, and particularly in the humpback by its virtual disappearance in areas where formerly it was abundant. Consideration of this problem is made difficult by a number of qualifying factors, such as the development in the efficiency of hunting methods, regulations protecting certain classes of whales, weather conditions, area exploited, relative economic value of different species and so on.

The report contains much that is of interest to the general biologist, but for those whose concern is the conservation of the stock of whales in the south it must be an indispensable work of reference.

F. C. FRASER.

STATISTICS OF LITERARY VOCABULARY

The Statistical Study of Literary Vocabulary

By G. Udny Yule. Pp. ix+306. (Cambridge: At the University Press, 1944.) 25*s*. net.

A NEW book by Mr. Udny Yule is a statistical event which, though of great rarity, is all the more welcome when it occurs. This, however, is not a formal treatment of a subject which has already shaken down into definite lines of development, or even a systematic introduction to such a subject. Rather is it an account in volume form of Mr. Yule's incursion into a novel and interesting field of research.

That authors have their idiosyncrasies in the choice and use of words has been recognized by literary critics from the earliest times; but attention in the past has been mainly directed to the peculiar or unusual words, or at best to qualities of verbal

style which are so obvious as to require no labour to establish their existence, such as the Germanic vocabulary in Carlyle's work or the Anglo-Saxon preferences of William Morris. Studies of these matters, useful as they are, did not tell Mr. Yule what he really wanted to know about an author's vocabulary. The statistician is interested in populations even of the most ordinary things, and what Mr. Yule wished to discover was what the vocabulary was like *as a whole*. "To tell me that there is a small mole on Miranda's cheek may help me to identify the lady, and may in conceivable circumstances be quite useful information to the police, but it hardly amounts to a description of her alluring features." Mr. Yule might have added that identification by individual feature is a dangerous procedure in literature. Shakespeare's use of legal words and phrases has been claimed as a favourable argument for the Baconian heresy, and the use of conventional adjectives of colour in the Iliad has been supposed to confirm the legend that Homer was blind.

Mr. Yule, then, embarks on the task of forming a picture of a writer's whole vocabulary. He has concentrated his work on nouns, as being most likely to be characteristic, and has drawn his material from five main sources—the Bible, the works of Thomas à Kempis, those of a rival claimant to the authorship of the "Imitatio Christi", Gerson, the essays of Macaulay and the works of John Bunyan. Even though help could be obtained from a concordance in some cases, this involved a fairly extensive inquiry by sample. There is an interesting account of the technique used to obtain really representative samples from the heterogeneous material available. Mr. Yule finally decided on what he calls "spread" sampling, a sort of stratification which distributes the sampling uniformly over the population.

The frequency-distributions of nouns so obtained have interesting features in common. The majority of nouns—about half the vocabulary—occur only once, fewer occur twice, fewer still thrice and so on, the distribution being J-shaped with a long tail furnished by a few words occurring very frequently, such as *Deus* in the "Imitatio" and *King* in Macaulay's essay on Hampden. Mr. Yule recognizes that perhaps for larger samples the modal frequency might be at two or three occurrences and tests the possibility with typical ingenuity, not by extending his already extensive samples but by applying himself to a document in which the writer's vocabulary is severely limited, the Gospel of St. John in Basic English; even here he finds the highest proportion of nouns, about 25 per cent, occurring only once.

The *litterateur* who resents having the cold light of science turned on inspired passages from the classics in this way may stop here and ask whether all this counting and measuring tells him anything he did not already know. If he is prepared to learn, there is in fact a good deal of benefit he can derive from the exact type of study exemplified in Mr. Yule's work. A single by-product of the frequency-distributions will suffice to exemplify their suggestive character. Suppose a reader with no previous knowledge of Latin, and wishing to study medieval authors in the original, decides to begin with the "Imitatio Christi"—an excellent choice because of its simple style. Suppose a noun has to occur a dozen times before its meaning is firmly stamped on his memory. Then at the end of a first reading he will remember 140 out of 1,168 nouns occurring in the book, only about one eighth of the vocabulary encountered.

There are several peculiar features of the word-distributions, one of which is that they change their form as the size of sample increases because of the appearance of new words. Mr. Yule devises a characteristic of the distribution which is independent of the size of sample and permits of comparison between different authors. The work is closely related to the theory of accident distributions. If the author's store of words is regarded as a population with varying proneness to occurrence, the observed distribution may be considered as a compound Poisson. There is one important difference from accident statistics as usually available, because we do not know the number of words at risk which have 'escaped accident', that is to say, have not occurred. But this difficulty is successfully surmounted; and if our carping critic dismisses as absurd the idea that an author selects words out of his store like a man taking tickets at random out of a hat, he has still to explain the fact that Yule's characteristic *is* practically independent of sample size in all the examples he discusses.

In a chapter on "Sources of Fallacy", Mr. Yule does much to clarify the problems with which he is faced and incidentally exhibits serious shortcomings in the work of some of his predecessors. He then turns to a discussion of the English vocabularies of Macaulay and Bunyan. The chance observation that the proportions of nouns classified by initial letters differed very considerably between the two led him to a study of etymological differences. It appears that there is a higher proportion of Romance words in Macaulay which reflects itself in the alphabetical distribution.

Finally, Mr. Yule comes to the question which originally led him to the whole inquiry, whether there is anything in the vocabularies of the acknowledged works of à Kempis and Gerson which throws light on rival claims of the two men to authorship of the "Imitatio". He concludes, after a thorough examination, that Gerson is a most unlikely candidate, whereas Thomas could quite well have been the author. This confirms the evidence provided by distributions of sentence lengths. To me the evidence against Gerson appears quite decisive.

Readers who are unfamiliar with statistical methods need not be deterred from studying this book. Mr. Yule allows himself whatever technique he requires to solve his problems; but, in fact, that technique is not very elaborate and is accompanied by simple explanations which will smooth the way for anyone who is not afraid of an occasional algebraic symbol. The whole work exhibits all those qualities which have made its author celebrated among his fellows. There is the same accuracy of detail, the same careful examination of all the pitfalls, the same cautious but steady advance into unknown territory, the same flashes of insight, the same experimental testing of every link in the chain of reasoning, the same care to make the author's meaning quite clear.

To statisticians the book will be of interest not merely because it throws up all sorts of problems for their consideration, but also as an account of a model investigation in a new and difficult field. To anyone, statistician or not, who takes an interest in the languages which he learns and uses, the book will present many new points of view on a fascinating subject, and much definite information about matters which have hitherto been studied in a vague and intuitive way.

M. G. KENDALL.

THE AFFINE CONNEXION IN PHYSICAL FIELD THEORIES

By PROF. E. SCHROEDINGER
Dublin Institute for Advanced Studies

1. The loss of connexion by general invariance. The essential physical entities are mathematically described as *invariants*, *vectors*, *tensors*. That comes from the isotropy and homogeneity of space in Euclidean geometry—or from the pseudo-isotropy of space-time, in the Restricted Theory of Relativity. When the latter is replaced by the idea of *general* invariance, that is, by regarding the three space-co-ordinates and the time only as continuous labels of the world points, which labels may equivalently be replaced by any quadruplet of continuous functions of themselves, the notion of vector or tensor subsists, but any such entity is now necessarily bound to a given world-point, it is 'a tensor at P'. For example, the *displacement*-vector, dx_k, leading from a world-point P with co-ordinates x_k (that is, x_1, x_2, x_3, x_4) to a neighbouring point Q with co-ordinates $x_k + dx_k$, is the prototype of a contravariant vector A^k at P. If you change the labels (that is to say, if you execute a general transformation of the frame) the A^k transform *by definition* as the dx_k, thus* :

$$d\hat{x}_k = \frac{\partial \hat{x}_k}{\partial x_l}\, dx_l \text{ and } \hat{A}^k = \frac{\partial \hat{x}_k}{\partial x_l}\, A^l. \qquad (1)$$

This rule is obviously inherent in the world point P, because the partial derivatives which form the co-efficients *vary* from point to point. In consequence of this, you cannot directly compare a 'vector at P' with a similar 'vector at Q', even when Q is an infinitely neighbouring point.

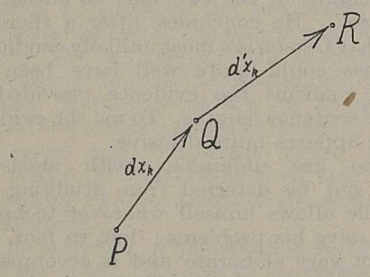

FIG. 1.

For example (see Fig. 1), on proceeding first from P to Q by dx_k, then from Q to R by $d'x_k$, you cannot tell whether the second step is *equal* in direction and length to the first one or not. The bare notion of continuity tells you, of course, that, to indicate *equality*, the $d'x_k$ have to be *very nearly* the same as the dx_k, they must not differ by more than second-order quantities. But within this margin there is no distinction. You cannot tell whether you are moving along a straight line or along a circle, whether in uniform, retarded or accelerated steps. *You have lost the connexion between neighbouring points.* You could no longer, or only in a very restricted way†, set up differential equations to control geometrical or physical *fields*.

* The sum from 1 to 4 always to be taken for an index occurring twice in the same term (as the l in (1)).

† Certain derivatives and combinations of derivatives (H. Weyl[1] calls them "linear fields") do retain a meaning even in a non-connected manifold ; for example, the *gradient* of a scalar or the *curl* of a covariant vector.

2. General affine connexion. To recover this possibility you must reinstate a *connexion*. You must reintroduce some principle to replace the trivial principle of Euclidean geometry : two vectors are equal when their components are equal, quite irrespective of their association with points of the manifold.

What you want to know, or rather, what you want to 'state by decree' in an invariant manner, is : *which* vector at the neighbouring point Q $(x_k + dx_k)$ is to be considered the *same* as a given vector A^k at $P(x_k)$.

The components of that "vector at Q" must differ but infinitesimally from the A^k, and so we suitably term them $A^k + \delta A^k$. The simplest and most straightforward, and at the same time a fairly general way of making the required 'decree', is to demand that the δA^k shall be some bilinear functions of the dx_k and of the A^k, thus :

$$\delta A^k = - \Gamma_{ml}{}^k\, A^m dx_l, \qquad (2)$$

the $\Gamma_{ml}{}^k$ being 64 coefficients, which can vary arbitrarily from world-point to world-point, that is, they are arbitrary continuous functions of the x_k (the minus sign in (2) is conventional).

If we adopt (2) without any further restrictions on the Γ's, we say we impose (the most general form of) an *affine connexion* or an 'affinity' on our continuum. The Γ's are called the components of the affine connexion. Formula (2) is said to determine 'parallel displacement' according to this affine connexion. This name is objectionable in both its terms. The Euclidean analogue is not 'parallelism' but 'sameness' ; moreover, the word 'displacement', used before for the little vector with components dx_k itself, now indicates the act of transferring the vector A^m along dx_l. For clearness and brevity, I shall refer to the parallel displacement just as 'the transfer'.

Equation (2) and the notions introduced with regard to it are common to all (generally invariant) field theories. But various theories differ widely as to the way in which the affine connexion is introduced (see Sect. 4 and 5 below).

3. Curvature. Common to all theories is also the basic notion of *curvature*, which results from the affine connexion as follows. The notion of 'sameness', referring to neighbouring points, can *not* in general be extended, by continuous transfer along a curve, to world points finitely apart from one another. The transfer of a vector A^k from P to the distant point Q along a given curve C *is*, of course, unique and reversible ; that is, on transferring back along the *same* curve you get back the initial vector at P. But the transfer along some other curve C' would lead to another vector at Q. Alternatively, if you transfer A^k from P to Q along C, then back to P along C', you obtain at P a vector different *in direction and length* from the original A^k.

In the complicated case under consideration (*four* dimensions ; *general* affinity) it is scarcely possible to grasp intuitively this interesting behaviour, which is attributed to the *curvature* the continuum possesses in virtue of the affine connexion we have impressed on it.

Mathematically, the curvature is described by a fairly complicated entity, the Riemann-Christoffel curvature tensor $B^i{}_{k,lm}$, which is *always* antisymmetric in l, m, but has in general no other symmetry properties. It has therefore, in the general case, $4 \times 4 \times 6 = 96$ independent components. It is generally believed that this tensor is fundamental in

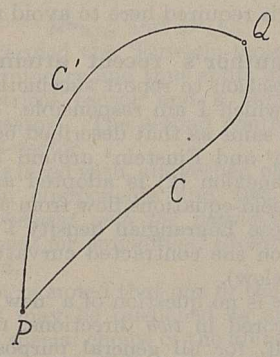

FIG. 2.

field-theory, but that it enters only in the form of its 'contractions', of which there are, in general, two*, namely, $B^{m}{}_{k,lm}$ and $B^{k}{}_{k,lm}$. We shall have to speak of them later.

4. The affinity resulting from Riemannian metric. Now let us turn to the widely different manners in which various theories introduce the affine connexion $\Gamma_{ml}{}^{k}$.

Einstein's[1] theory of gravitation is based on Riemannian metric, and the affine connexion results from the metric as a secondary item thus. By introducing the invariant line-element

$$ds^2 = g_{ik}\, dx_i\, dx_k, \qquad (3)$$

you associate with *any* contravariant vector A^k its *invariant*

$$g_{ik}\, A^i A^k \qquad (4)$$

('square of the length'). The required *correspondence* between the vectors A^k at P and $A'^k (= A^k + \delta A^k)$ at the neighbouring point Q can then be set up by adopting the following *four* rules:

(i) The invariants (4) of corresponding vectors shall be equal.

(ii) If A' and B' correspond to A and B respectively, then $A' + \lambda B'$ (where λ is any numerical constant) shall correspond to $A + \lambda B$.

(iii) The δA^k shall be linear functions of the dx_l. The adoption of these three rules entails the general form (2) for the δA^k. We add a fourth:

(iv) The $\Gamma_{ml}{}^{k}$ shall be symmetric in m and l, that is, it shall equal $\Gamma_{lm}{}^{k}$.

The Γ's which result from these four assumptions are the so-called Christoffel-brackets, $\left\{ {k \atop lm} \right\}$, functions of the g_{ik} and their first derivatives, linear in the latter. We do not need their explicit expressions here.

5. Weyl's Theory and Eddington's point of view. H. Weyl[2] in his famous theory of 1918, the first to account for gravitation *and* electromagnetism, dropped the *first* of the above postulates and replaced it by the following:

(i') The invariants of corresponding vectors shall bear a constant ratio to one another, depending only on the two points P and Q. (Of course, this 'gauging ratio' can differ only infinitesimally from unity.)

The underlying idea was that one ought not to admit the physical possibility of comparing 'lengths' at distant world points, as Einstein's theory did indeed admit. Weyl's modification automatically introduces, in addition to the 'metrical tensor' g_{ik}, a 'metrical vector' φ_k of equally fundamental standing with g_{ik}, and capable of being interpreted as the electromagnetic potential. For the Γ's you now no longer get just the $\left\{ {k \atop ml} \right\}$, but

$$\Gamma_{ml}{}^{k} = \left\{ {k \atop ml} \right\} - \tfrac{1}{2} g_{ml}\, \varphi^k + \tfrac{1}{2} \delta_m{}^k \varphi_l + \tfrac{1}{2} \delta_l{}^k \varphi_m. \qquad (5)$$

Sir Arthur Eddington[3], in what he modestly termed a generalization of Weyl's theory, was actually the first to take an entirely different attitude of great significance for the progress of the subject. The general affine connexion (2) is adopted *immediately* (only with the symmetry restriction $\Gamma_{ml}{}^{k} = \Gamma_{lm}{}^{k}$, which reduces the number of Γ's from 64 to 40). *Metric is made a secondary item.* To appreciate the superiority of this attitude we observe the following.

6. The restrictive Hamiltonian principle. A connected manifold of any type is not yet a field theory. To make it that, you have to impose on its basic geometrical field-quantities—the g_{ik} or the g_{ik} and φ_k or the $\Gamma_{ml}{}^{k}$, as the case may be—certain restrictions, differential equations. One wishes them to flow from some general principle which leaves as little arbitrariness as possible. Now almost every kind of restriction contemplated hitherto has turned out to be equivalent to a *Hamiltonian principle*, demanding that the space-time integral of an invariant density $\mathfrak{L}$, taken over any fixed region, be *stationary*:

$$\delta \int \mathfrak{L}\, dx_1\, dx_2\, dx_3\, dx_4 = 0. \qquad (6)$$

This very convenient way of searching for the 'right' field-equations (you just have to search for 'the right $\mathfrak{L}$') has been widely adopted, and there are general reasons for believing that it is justified. (*If* the field equations amount to a Hamiltonian principle, the *conservation laws* are an automatic consequence of the *general invariance*.)

7. The superiority of the affine point of view. Now if our manifold carries an affine connexion, but *no* metric, the requirement that $\mathfrak{L}$ be an *invariant density* narrows the choice considerably. For the only simple *tensors* indicated by the affinity are in this case the Riemann-Christoffel tensor $B^{i}{}_{k,lm}$ and its contractions, mentioned before. The latter are *covariant tensors of the 2nd rank*. They cannot be contracted a second time to form an invariant, because we have no metric and thus no means of raising and lowering indices. If we exclude the B-tensor itself as 'too complicated', then to get an *invariant density* there seems to be no other means but to avail oneself of the fortunate fact that the square-root of the determinant of any covariant 2nd rank tensor *is* one.

On the other hand, if the basic geometrical field-quantities include a metrical tensor g_{ik}, you can raise and lower indices to your heart's desire and you can turn every *invariant* into a *density* by multiplying it by $\sqrt{-g}$—in a word, the choice for $\mathfrak{L}$ is then well-nigh unlimited.

Eddington[3] was the first to point to the somewhat unique possibility of taking for $\mathfrak{L}$ the square-root of the determinant of the 2nd rank curvature tensor. Einstein[4], early in 1923, worked it out more fully. Both of them were ultimately inclined to think that it led to a discouraging dilemma. You were either confronted with a serious quantitative contradiction

* See the first footnote to Sect. 1. Contraction is only admissible between one upper and one lower index.

of facts, or you had to modify the original simple idea to such an extent that the multitude of possibilities for £, expelled by the front-gate, crept in by the back-door, and rendered the whole enterprise extremely unsatisfactory.

Recent attempts in the same direction take a less pessimistic view. But before speaking of them, we must supplement the "general picture of a field theory" at one point.

8. The problem of identification. When a system of geometrical field-equations has tentatively been established in the way sketched above, the field components which they connect (which are either the original basic geometrical field-quantities or, more often, vectors and tensors built up from them) have to be *identified*, one by one, with the components of the known physical vectors and tensors, connected by more or less well-known *physical* field equations. Now, this business of identification is not so unambiguous and trivial as might be believed on considering that, after all, *gravitation* must be described by a symmetrical g_{ik}-tensor with 10 components, *electromagnetism* by an antisymmetric tensor (6-vector), governed by Einstein's and Maxwell's equations respectively. That does not seem to leave much opportunity for making mistakes in associating geometrical and physical entities.

But even so, the allotment of roles to the single components must be carefully considered. Physicists have got the habit of associating the *electric* field, with the time-spatial components of a 6-vector (that is, with the subscripts (14), (24), (34)) and the magnetic field with the space-spatial ones ((23), (31), (12)). If you are not alive to the fact (pointed out by Einstein[5]) that this is nothing but a habit, and that the converse association is, *a priori*, at least equally admissible, nay even preferable, you may easily reject a field-theory which is powerful enough to include 'sources'; reject it on the ground that it ostensibly produces them 'in the wrong place' (that is, that it exhibits *magnetic* charges and currents instead of *electric* ones, as are observed).

9. The meson-field. Of even greater moment is the following. Recent research on cosmic rays and nuclear structure leave no doubt that a *third* field exists, of equally fundamental standing with gravitation and electromagnetism: the *mesonic* field, responsible for nuclear binding. To-day no field-theory which does not embrace at least this *triad* can be deemed at all satisfactory.

Now the description of the mesonic field includes (or perhaps just consists of) a 6-vector-field governed by equations, of which Maxwell's are a special case. In fact, the two cases differ classically* only by the numerical value of *one* physical constant, the rest-mass, which is very small, possibly zero, for the 'photon', but very much non-zero for the 'meson'. Quantitatively the difference is enormous. It restricts the *range* of mesonic force to 10^{-13} cm., while electromagnetic force certainly extends[6] beyond 20,000 miles from its source and possibly throughout the universe. But general geometrical field theory, by its very nature, does not prejudice the numerical value of any universal constant. Hence very careful consideration is required here to avoid mistakes.

10. The author's recent attempt. We are now in the position to report succinctly on a recent attempt[7] for which I am responsible. The attitude is exactly the same as that described before as taken by Eddington[3] and Einstein[4] around 1923, namely, the affine connexion (2) is adopted as a primitive notion; the field-equations flow from a Hamiltonian principle, whose Lagrangian density £ is allowed to depend only on the contracted curvature tensor (or *tensors*, see below).

Hence there is no question of a 'new' theory. Yet progress is scored in *two* directions, namely, (i) in freeing oneself, for all general purposes, from the special choice of the Lagrangian £ and (ii) in accomplishing the union of the *three* fundamental fields and, at least, preparing their correct identification.

11. Unspecified Lagrangian. The freedom referred to in (i) above rests on *two* pillars, the first of which is the conviction, gained from other modern research[8], that the fundamental description of, for example, the electromagnetic field, must not be expected to involve just *one* six-vector (usually called B,E) but a second, sort of conjugate, six-vector (usually called H,D) whose components are the partial derivatives of the Lagrange function £ with respect to the components of B,E. From this point of view the field equations can be regarded as provisionally satisfactory even though they still contain those derivatives, and even before the exact functional form of the latter has been made out by deciding upon a special Lagrangian. To make the point clearer: we accept

$$\begin{aligned} \text{curl } E + \dot{B} &= 0 \qquad & \text{div } B &= 0 \\ \text{curl } H - \dot{D} &= 0 \qquad & \text{div } D &= 0 \end{aligned} \tag{7}$$

as Maxwell's equations, without bothering at first what functions exactly H and D are of B and E.

This attitude cannot be extended to the *gravitational* field, because in this case the physical nature of the two sorts of conjugate tensors is completely known, namely, the *gravitational potential* g_{ik} and the *tensor of gravitating matter* (usually called T_{ik}). The question is, precisely, whether every field other than gravitation gives its expected 'correct' contribution to the matter tensor. We cannot even be provisionally satisfied, before ascertaining that they all do.

This gap is filled by the "second pillar", consisting of 16 *simple identities* between £ and its partial derivatives. These valuable identities flow merely from general invariance, namely, from the trivial demand that the transformational behaviour as a *scalar density* must be forced upon £, when the tensor components of which £ is a function are transformed in *their* way. As I said, these identities fill the gap, they secure that every other field contributes its due share to gravitating matter, whatever £ may be. (This is a special case of the general rule mentioned before, namely, that the conservation laws always follow directly from invariance.)

12. The tensors engendered by the curvature tensor. It is a great relief not to have to decide at an early stage upon the choice of £, when pursuing the second task, the union of the three fundamental fields. To explain the latter we must enter more closely into the tensors on which £ depends, the *contractions* of $B^{i}{}_{k,lm}$.

* At the back of our striving for a unitary field theory, the great problem awaits us of bringing it into line with quantum theory. This point is still covered with deep mist. The present article does not touch on it and has therefore to ignore such features in the conventional description of the physical fields as are concerned with their quantum character; for example, *complex* field variables, the *operators* of spin and isotopic spin, etc.

As mentioned earlier, there are two of them, namely,

$$B^{m}{}_{k,lm} \text{ and } B^{k}{}_{k,lm}.$$

The first is termed the 'Einstein-tensor'. It has in general no symmetry and thus splits up into the sum of a symmetrical tensor and a skew-symmetrical tensor (a 6-vector). The second contraction, $B^{k}{}_{k,lm}$, is always a 6-vector.

We are thus faced with, altogether, one symmetrical tensor of ten components and two 6-vectors—*in admirable agreement with the physicist's desire, who wishes to account for gravitation, electromagnetism and the meson-field.*

But it must be noted that one or the other of these three tensors may be quenched as an independent entity by the special choice of the affine connexion.

In the affine connexion customarily derived from Riemannian metric ($\Gamma^{k}_{ml} = \left\{ {k \atop lm} \right\}$), *both 6-vectors vanish.* That is why Einstein's theory of gravitation[1] can account for *nothing but gravitation.*

In any *symmetrical* affine connexion ($\Gamma_{ml}{}^{k} = \Gamma_{lm}{}^{k}$) the two 6-vectors *coincide* and thus count only as one. That is why the symmetry condition was, with few exceptions[5], adhered to so long as the meson field and its fundamental nature remained unknown.

13. The union of the three fundamental fields. In pursuing the non-symmetric case (though not yet the completely general one) I have reached, along the lines described above, a fully satisfactory unified description of gravitation, electromagnetism and a 6-vectorial meson[7]. The work is far from completed. The completely general case must be tackled, and eventually, of course, the possible special choices for £ must be examined on their merits. But one point concerning *identification* deserves to be mentioned now.

That 6-vector field which is already obtained with a *symmetrical* connexion and which in all previous attempts was, naturally, identified with electromagnetism, is actually capable of representing either electromagnetism or the meson, according to what value is given to the rest-mass.

The *second* 6-vector field, the one that turns up on dropping the symmetry condition, does not seem to have this equivocal character. It can only be electromagnetism; and that would mean, only it can be electromagnetism.

This means that the meson-field would appear to be an even more fundamental phenomenon than electromagnetism; and that it is even more intimately akin to gravitation, its cousin, as it were. This is just what one would expect, since for all that we know, the mesonic field is produced universally by all gravitating matter, irrespective of its electric charge; whereas the latter is in no recognizable relation to the mass.

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INCOMPATIBILITY IN PLANTS

ITS GENETICAL AND PHYSIOLOGICAL SYNTHESIS

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SEXUAL reproduction is essentially the formation of a new individual resulting from the fusion of two gametic nuclei. Any hindrance to this fusion, within the regular mating group, except when it is due to a defect in the nuclei themselves, is said to be due to incompatibility. In many fungi the cells carrying the nuclei are undifferentiated: they are hyphal cells which, when growing together, fuse and transfer nuclei from one to another. In flowering plants, the cells containing the nuclei are differentiated into the male pollen grain and the female egg-cell. The pollen grain is carried to the stigma by wind or insects, and in this position it produces a pollen tube which grows down the style, penetrates the egg-cell and discharges the male nuclei, so that they can fuse with their female partners. Breeding experiments have shown that incompatibility is: (1) always genetically determined, and (2) that it acts to prevent the fusion of nuclei from closely related parents. It is a limiting mechanism which takes many forms both genetically and physiologically. An examination of the meaning and relationship of these forms not only gives a clue to their evolution but also to the action of the genes controlling them.

For the present purpose, incompatibility in flowering plants can be provisionally classified into two systems:

(1) *Incompatibility without heterostyly*, that is, without any floral morphological differences. (2) *Incompatibility with heterostyly*, that is, differentiation into long- and short-styled plants. Self- and cross-pollination within these long- and short-styled plants are incompatible, while pollinations between them are compatible.

The biological efficiency of these breeding control systems has been discussed by Dr. K. Mather[1], and he has concluded that the intervention of diploid tissue, in the form of a style, between the pollen and eggs in flowering plants results in greater efficiency than when this is lacking, as in the fungi. The two systems in flowering plants, that is, with and without heterostyly, appear, however, to have a similar net advantage for the breeding control, although there are slight differences, such as in the amount of sister mating that is permitted by the two systems. The physiology and chemistry of these systems may help to explain the special advantages of one or the other.

Consider first the fungi. The genetical control of incompatibility ('heterothally') in many fungi is based on one or two major genes, each gene having a large number of multiple alleles[2]. This number, as in plants without heterostyly, cannot be matched or even approached by any other series of multiple alleles in plants or animals. Physiologically, two types of incompatibility can be distinguished. In the most common type the hyphæ of the two haploid mycelia, although incompatible because they have one or more incompatibility alleles in common, may grow together and some hyphal fusion may occur. A transference of nuclei may follow; but the nuclei fail to make co-ordinated divisions and thus fail to establish a diplophase mycelium which is essential for spore formation. Furthermore, when a diplophase mycelium is mated with a haploid mycelium, the two nuclei in

the diplophase are quite independent in their reactions to the nucleus of the haploid mycelium[2]. The reaction is therefore one between haploid nuclei.

The less common type of incompatibility in fungi is called hyphal aversion. Here the hyphæ of certain incompatible strains grow towards each other until they are 3–5 mm. apart. At this point they stop growing or grow in the reverse direction. Aerial hyphæ show aversion quite as strongly as hyphæ growing in the culture medium. According to Vandendries[3] the aversion is prevented when metal strips are placed between the averting strains, but strips of glass and mica have no such effect.

Incompatibility without Heterostyly

In diploid flowering plants, the incompatibility reaction is one between haploid pollen grains and diploid stylar and ovarian tissue. The genetical control of this reaction in plants without heterostyly is based on one major gene having a large number of multiple alleles. These are usually designated S_1, S_2 . . . S_k. The pollen reaction, in contrast to that in heterostyly, is under the control of the one S allele in the pollen grain and not of the two S alleles in the soma from which it originates. These S alleles have the action of inhibiting pollen-tube growth in any style that has the same S allele as the pollen grains. For example, S_1 pollen will not grow in a style carrying S_1, but it will grow in all other styles. When compatible and incompatible pollen-tubes grow side by side in the same style, they exert no influence on each other, thus showing that the inhibition is specific to each pollen-tube. The inhibition may sometimes be accompanied by a swelling of the tube end and a thickening of the cell wall, and occasionally by the tube ends becoming surrounded by a diffuse matter with a similar staining reaction to the pollen cytoplasm, although the tube ends show no sign of rupture. These changes are, however, probably secondary effects and not the cause of inhibition, since they do not occur in all cases.

The time and place of inhibition in the style varies according to the species[4]. In *Raphanus sativus* and *Brassica oleracea* germination is affected, in *Oenothera organensis* the tubes stop growing before they have travelled one tenth of their normal distance[5], in *Prunus avium* inhibition is at half way down the style, while in Pyrus and Nemesia it is within the ovarian cavity. Does this mean that the incompatibility activity of the style is localized ? This is certainly true for the stigmatic cells of Brassica, since cutting them away removes the inhibition and complete fertility results[6,4]; but this is an exceptional refinement which has not been evolved in other species. Thus, in some species, grafting at different levels two styles, one compatible and the other incompatible with the test pollen, has shown that any part of the style is equally effective in inhibiting pollen-tube growth[7]. Furthermore, the place at which pollen-tube growth stops in the style is affected by temperaure[8]. In all species which have been tested, although compatible tube-growth is accelerated by a rise in temperature, incompatible tube growth is stopped in a shorter time at 25–30° C. than at lower temperatures (10°). This reduction is due both to slower growth and to an earlier stoppage of growth.

Thus it seems that: (1) incompatibility is the result of a reaction between any part of the style or ovarian tissue and the pollen grain or tube; (2) the rate of the reaction is greater at higher temperatures; (3) the products of the reaction accumulate during tube growth causing a lower growth-rate, and finally when a threshold concentration has been reached, complete inhibition.

Diploid styles carry two different S alleles, and just as the reaction of incompatible tubes are independent of one another, these two S alleles in the style are independent in their action on the pollen tubes. This independence, that is, lack of dominance or overriding effect of one allele on another, is also strikingly shown in autotetraploids in which two, three or even four different S alleles can be present. Each allele still exerts its specific effect. For example, a tetraploid style of the constitution $S_1S_2S_3S_4$ rejects pollen carrying any one of these alleles, but all other pollen is compatible[14]. Hence reciprocal crosses between tetraploids and diploids often show differences. For example, the cross $S_1S_2S_3S_4 \times S_1S_2$ is incompatible, S_3 and S_4 alleles in the style having no weakening effect on the reaction of the other alleles; but $S_1S_2 \times S_1S_2S_3S_4$ is compatible, S_3S_4 pollen functioning in an S_1S_2 style. The independence is emphasized by the action of self-fertility (S_F) alleles of the same gene. In Nicotiana, pollen carrying S_F is effective on any style, but an S_FS_1 style will not accept S_1 pollen although all other pollen is acceptable[9]. In *Trifolium repens*, however, the S_F allele appears to have some overriding effect on the normal allele in the style[10].

The significance of this independent action will be referred to later, but one point will be made now. The existence of two independent S alleles in the style implies that the physiological mechanism depends on highly specific and independent reactions, such as are characteristic of protein molecules. Clearly, merely quantitative differences in conditions such as osmotic pressure or pH could not be effective in doing this, because two different osmotic pressures or pH values in the diploid, and four in the tetraploid, would be required in each cell of the style to give the reactions produced by the two or four S alleles.

Pollen grains of diploid plants carry only one S allele, thus interaction of these alleles within pollen grains does not arise; but in the pollen of autotetraploids, of which many new types are now available for experiment, we have the possibility of gene interaction.

Autotetraploids of *Pyrus communis*[11], Petunia species[12] and three Solanum species[13] are fully self-compatible, although the diploids from which they arose are self-incompatible. *Oenothera organensis* is partially self-compatible in the tetraploid form. From the analysis of this effect in *Pyrus* and *Oenothera* it appears that pollen grains which carry two different S alleles are compatible in a style carrying both these alleles[14].

For example, an $S_1S_1S_2S_2$ plant is self-compatible and the pollen segregates both compatible and incompatible grains. It appears that the compatible grains are S_1S_2 and the incompatible grains are S_1S_1 and S_2S_2. Thus the normal action of S_1 and S_2 in the pollen has been suppressed by their interaction. The contrast between the pollen grain and the style in regard to gene interaction is summarized in Table 1.

In the interpretation of Table 1 it should be said that the tetraploids are of recent origin, and therefore have not been subject to natural selection. Natural selection in the diploid has produced independent gene action in the style, an effect which is maintained in the tetraploids. In the pollen grains of

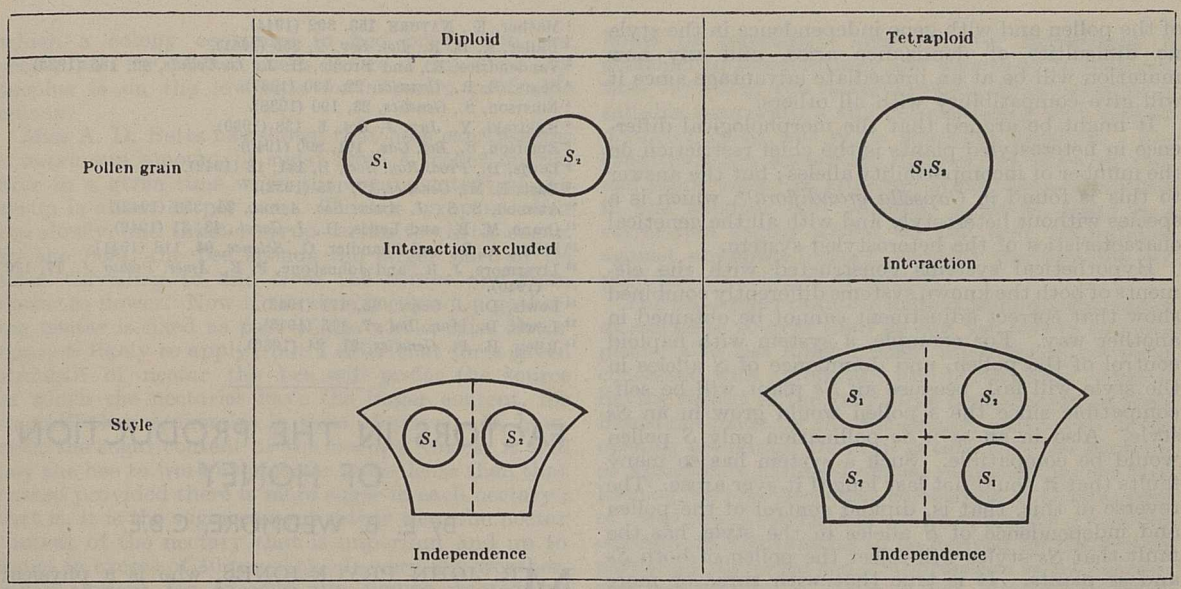

TABLE 1. INTERACTION AND INDEPENDENCE OF *S* ALLELES, SHOWING THAT TETRAPLOIDY HAS A DIFFERENT EFFECT IN THE POLLEN THAN IN THE STYLE. NATURAL SELECTION HAS BEEN OPERATING IN THE STYLE OF THE DIPLOID, BUT NOT IN THE POLLEN ; THIS IS APPARENT ONLY WHEN THERE ARE 2 ALLELES IN THE POLLEN GRAIN.

diploids, although independence is necessary for the system, natural selection has not been operating to produce this effect, since only one allele is present. Hence in the tetraploid gene interaction occurs and the incompatibility system is, in consequence, mainly ineffective.

Incompatibility with Heterostyly

The genetical control of incompatibility in heterostyled plants is based on one gene in distyly and on two genes in tristyly, each gene having two alleles. The pollen reaction is controlled by the diploid soma from which it originates.

Pollen tubes have been examined in three species. In two of these, *Primula obconica* and *P. sinensis*[8], the kind of inhibition of the pollen tubes and the effect of temperature are similar to those in plants without heterostyly. In the third species, *Linum grandiflorum*[15], osmotic pressure differences are the main agent of incompatibility. The osmotic pressure of the style is equivalent to a 20 per cent sucrose solution in the long-styled plants and to a 12 per cent solution in the short-styled plants. The values for the pollen grains are : long-styled plants 50 per cent, short-styled plants 80 per cent. Thus the higher osmotic pressure of the pollen of short-styled plants is suited to the higher osmotic pressure of the long style. The osmotic pressure differences, in the form of a ratio of pollen : style, and the pollen behaviour are given in Table 2.

TABLE 2. SHOWING THE DEPENDENCE OF POLLEN BEHAVIOUR ON THE OSMOTIC PRESSURE RATIOS OF POLLEN : STYLE IN *Linum grandiflorum*.

		Pollen	
		Long	Short
Style	Long	2·5 : 1 No germination or swelling	4 : 1 Normal pollen-tube growth
	Short	4 : 1 Normal pollen-tube growth	7 : 1 Pollen tubes burst

Both compatible pollinations, long × short and short × long, have a pollen to style ratio of 4 : 1, and here the pollen-tube growth is normal. In the incompatible pollinations, the ratio differs from the 4 : 1 ratio, and this affects the pollen-tube growth in a way which is not found in other incompatible species. Furthermore, temperature has no effect on the incompatible pollen behaviour.

This osmotic mechanism is clearly different in principle from the one in Primula species and in plants without heterostyly, in which differences of osmotic pressure have not been found. It is a mechanism which could be associated only with the genetical control characteristic of heterostyly. The other one, in Primula, may well be analogous to that operating in plants without heterostyly. That two different physiological mechanisms exist among heterostyled species shows that the limitation imposed by the genetical control is less severe in these species than in species without heterostyly.

In fungi we do not yet know enough, but in the two types of flowering plants we can now compare the genetical and the physiological control.

Let us first consider the genetical control. We have seen that haploid control of the pollen reaction, independent action of the *S* alleles in the style and a large multiple allele series are characteristic of the system in plants without heterostyly ; while diploid control of the pollen reaction, interaction with dominance of *S* alleles in the style and two alleles of one or two genes are always associated in heterostyly. The probable explanation for these associations lies in the adaptive control of gene action and interaction. With diploid control of the pollen and dominance in the style, any effective new mutation of the *S* gene must not only produce a new type of style-and-pollen reaction but must also have its dominance relations with the other alleles selectively balanced. In these cases a large multiple allele series is therefore very improbable. With haploid control

of the pollen and with gene independence in the style no difficulties of dominance arise, and any new mutation will be at an immediate advantage since it will give compatibility with all others.

It might be argued that the morphological difference in heterostyled plants is the chief restriction on the number of incompatibility alleles; but the answer to this is found in *Capsella grandiflora*[16], which is a species without heterostyly and with all the genetical characteristics of the heterostyled system.

Hypothetical systems constructed with the elements of both the known systems differently combined show that correct adjustment cannot be obtained in another way. For example, a system with haploid control of the pollen, and dominance of *S* alleles in the style will fail, because an *Ss* plant will be self-compatible since the *s* pollen would grow in an *Ss* style. Also in an *ss* × *Ss* pollination only *S* pollen would be compatible. Such a system has so many faults that it could not last long if it ever arose. The reverse of this, that is, diploid control of the pollen and independence of *S* alleles in the style, has the fault that *Ss* styles will reject the pollen of both *Ss* and *ss* plants. It is true that with three or more alleles and special dominance relations between them a perpetuating system can be imagined; but this involves such unusual properties of the gene that it can be disregarded.

TABLE 3. A SUMMARY OF THE GENETICAL AND PHYSIOLOGICAL CONTROL OF INCOMPATIBILITY SHOWING THE RELATIONSHIP BETWEEN THEM.

Morphology	Species	Physiology	Genetics
Not heterostyled	*Oenothera organensis*	(1) Independent gene action in the style but not in the pollen	One gene
	Prunus avium, *Nicotiana sanderæ*	(2) Haploid pollen control	Multiple alleles
		(3) No dominance	
		(4) Protein reactions	
Heterostyled	*Capsella grandiflora*	(1) Co-ordinated gene action in style and pollen	
	Primula obconica	(2) Diploid pollen control	1–2 genes
	Primula sinensis, *Linum grandiflorum*	(3) Dominance	2 alleles
		(4) (*a*) Protein reactions (*b*) Osmotic pressure	

In their physiological control of incompatibility, plants without heterostyly and heterostyled plants differ in a way which reflects the genetical differences. This relationship is summarized in Table 3. Only one mechanism has been found in plants without heterostyly, and this appears to be an immunity type of reaction between specific proteins of the pollen and style. This alone has the possibility of variation necessary to meet the requirements of a large multiple allele series and the specificity necessary for the independent gene action in the style. In heterostyly it appears that this type of reaction is also present in some species; but another mechanism based on osmotic pressure has been found in Linum, and from the genetical evidence there is reason to believe that others exist. Thus a variety of different combinations of physiological and genetical mechanisms have been appropriately combined by selection, in favouring outbreeding modifications of the genetic system which have a long-term evolutionary advantage.

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FACTORS IN THE PRODUCTION OF HONEY

By E. B. WEDMORE, C.B.E.

MR. JOHN PRYCE-JONES, who is a physical chemist, discusses "Some Problems Associated with Nectar, Honey and Pollen" in forty-five pages of the *Journal of the Linnean Society* (Pt. 2, 1942–43). This critical résumé will be most valuable to future workers in the same field. A strong case can be made out for further work. The honey bee in Great Britain contributes, by its pollinating activities alone, £4,000,000 a year to the economy of fruit-growing and seed production. An annual expenditure on research of £4,000 would show a return of 10 : 1 if it only increased efficiency by one per cent per annum; incidentally, in the U.S.S.R. the figure is £40,000,000 a year.

Future investigators will need to study far more than the fifty-six principal references cited by Mr. Pryce-Jones. How hard it is to persuade experimenters that the last thing they must do is make an experiment, and the last but one is to record all the circumstances and features that may affect interpretation and application of the results! Many of the researches cited lose permanent value through failure in the latter duty. The conflicting and partial conclusions reached are faithfully dealt with by Pryce-Jones, but many are open to further criticism. For example, there is the investigator who correlates percentage of nectar in fireweed with the humidity of the atmosphere, expressing the results to four significant figures; evidently the arithmetic took charge of the investigator. Having regard to the very large variation disclosed of sugar content with humidity, the meaningless nature of figures given for sugar content without reference to humidity is at once apparent; yet the records abound with them.

Based on the capacity of the bee's honey sac, a round figure of 20,000 flights is quoted for the collection of one pound of nectar. This is converted to 80,000 for honey. Taking the sugar content of honey at 80 per cent, this puts that of the nectar at 20 per cent. Now in the first place, the bee scarcely ever arrives home with a honey sac anything like full; again, a full sac will carry nearly three times the figure quoted; and the figure of 20 per cent is near the lower limit of what interests the bee, and it will generally find a much more profitable source to work upon. It is certain that the figure of 80,000 flights is too high for profitable harvesting. Incidentally, the figure of 200 lb. given as the honey

which a colony consumes in bee production per season and for its own needs before it can show any surplus is on the low side for a really profitable colony.

Miss A. D. Betts has shown that bees can transfer a maximum amount of sugar from a feeder on the hive in a given time when the sugar content of the syrup is about 40 per cent. Thicker syrup is taken too slowly, and thinner syrup carries too little sugar. In the field, the bee spends the larger part of its time travelling to and from the source and from flower to flower. Now if the time occupied in gathering nectar is fixed as part of the whole, Miss Betts' figure is likely to apply; but I infer that for a given strength of nectar the bee will prefer the source in which the nectaries have the larger content, for she will then economize in time of travel. If, however, the sugar content of the nectars varies, it will pay the bee to work at a nectar more dense than that named provided there is more sugar in each nectary; that is, it is the sugar content rather than the nectar content of the nectary that is important and up to limits in excess of 40 per cent. In very dry weather, sugar content far exceeds any figures quoted by Pryce-Jones; indeed, a supersaturated solution is found in very dry weather. In 1942 in Kent and elsewhere, the bees could not work on the limes because the nectar was crystallized.

There is a great deal yet to be done to solve the problems associated with nectar production. No fewer than five theories are quoted and discussed; only one touches upon the relationship of sugar production to soil content; that deals with nitrogen content, but leaves potassium and phosphorus out of account. Pryce-Jones remarks that while the nectary acts as a semi-permeable membrane, holding back the proteins in the sap, no explanation has yet been offered of the diffusion of a dilute solution of sugar in the sap into a more concentrated solution in the nectary.

Pryce-Jones himself has shown that the thixotropy characterizing a very few honeys, notably that from ling and from manuka, is due to the presence of about 1 per cent of a protein. Honey usually contains but a trace of any protein. This particular protein may be extracted and when added to another and liquid honey causes it to become thixotropic. It is difficult to attach much weight to the criticism by Paul 'Espinasse that it has yet to be proved that the protein is of vegetable origin and not added by the bee. Why should all bees add so unfortunate a protein only to those particular nectars, introducing a property which may cause them later to starve in the apparent presence of plenty? It would appear to be far more probable that in these plants a small quantity of a certain protein passes through from the sap. There is room for further investigation of this protein and especially its molecular weight.

In the study of the relationship between the honey crop and the weather, much confusion has been introduced through failure to recognize the large variation of sugar content of nectar when observing changes of hive weight. Certain correlations with weather conditions, however, have been obtained. These indicate that in summer and early autumn, temperatures are generally adequate, but humidity tends to be too low; hence a wide variation in temperature with its wide variation in relative humidity tends to bring the sugar contents within the range for efficient collection for some period of the day, and perhaps to assist in nectar secretion. In the spring, however, temperatures may be inadequate, also hours of sunshine; hence greater importance is attached to temperatures and especially to temperature variation, the latter bringing about periods of suitable temperature and corresponding with periods of intermittent but more adequate sunshine. The conditions are somewhat different as between clay and sandy soils. In studying atmospheric conditions in the summer and autumn, however, there is a correlation factor above 50 per cent outstanding against unknown factors, showing the supreme importance of sources of nectar.

The bee-keeper desires a more continuous succession of adequate sources than he can yet find in any one place; also less unintentional interference by those concerned with agriculture and horticulture. Surely, having regard to the very large contribution to these industries made by the bee-keeper, referred to in the opening paragraph above, it is time that the Ministry of Agriculture assumed official responsibility for bee-keeping, and secured some correlation of the interests of these several industries. A co-operative study, for example, of the benefits to be derived by the several parties by increased use of appropriate sweet clovers, and incidentally of Zofka clover, should provide a very large return for a small expenditure by the Ministry. Any programme should be examined by practical bee-keepers and agriculturists as well as by scientific men if it is to be really effective and profitable. On the practical side, there should be no lack of assistance if only someone in authority would bring the parties together.

OBITUARIES

Dr. J. Argyll Campbell

ARGYLL CAMPBELL was a most distinguished student at Edinburgh, gaining very many university prizes and honours. He unfortunately suffered early in his career a catarrhal infection which resulted in deafness, a handicap which he most bravely overcame so far as his output of research was concerned, but which prevented him gaining full recognition of his worth. As professor of physiology at the Government School of Medicine, Singapore, he did valuable work, and in the War of 1914–18 prevented the authorities from substituting an equal weight of sweet potatoes (a watery food) for rice in the workers' ration. As one of a small commission, he was largely instrumental in securing the addition of the province of Trengannu to the Malay States.

Returning to Great Britain, Campbell joined the Department of Applied Physiology at the National Institute of Medical Research, where, until ill-health led to his recent retirement, he carried out very valuable research work. An inquiry with me into the protective effect of water-proof clothing against exposure, such as results from shipwreck, resulted in the adoption by the Ministry of Transport of a suitable suit for merchant seamen in the present War; a quarter of a million such suits have been issued, and high value is given to these as the result of experience.

Campbell developed a simple method of measuring the tension of oxygen and carbon dioxide in tissue spaces, and made the interesting discovery that high pressures of oxygen, such as produce oxygen poisoning, occasion a high tension of carbon dioxide in these spaces. The power of hæmoglobin to combine with and carry carbon dioxide from the tissues is thwarted by its saturation with oxygen. He carried out most

important work on oxygen-want at high altitudes, finding that animals could not continue for long to live at altitudes above 20,000 ft. This degeneration has been fully confirmed for man by the experiences reported by Everest climbers such as Mr. Shipton. Although 27,000 ft. has been reached, the incapacity of the climbers is such that there is little hope of Everest being climbed without use of oxygen-breathing apparatus, and that use is beset with difficulties.

Campbell pointed out that one of the means of acclimatization to high altitudes was hypertrophy of the heart. His work on oxygen-want led to the contrivance of a simple but effective oxygen-breathing face mask. With the late Dr. Poulton he published a valuable book on "Oxygen and Carbon Dioxide Therapy", a standard work on the subject. Further researches showed him that oxygen-want is better resisted on a certain diet, such as one of carrots, and this inquiry led to possible means of improving the resistance of high flyers. He also found that the effects of oxygen poisoning at high pressures are warded off by a fall in body temperature; animals are more susceptible at high than at low external temperature.

With me he carried out an investigation of the washing out of nitrogen dissolved in the body by the breathing of oxygen, and the amount of nitrogen in the bone marrow of animals exposed to high air pressures—work of interest in regard to compressed-air illness.

Another important line of inquiry carried out by Campbell was on the effect of inhalation of dust on the production of pulmonary cancer. He found that tar-containing dust from roads greatly increased the frequency of such cancer in mice; dust not containing tar did so also, but to much less extent.

Whatever researches Campbell carried out, of which a few have been mentioned, were executed with the greatest accuracy and thoroughness, so that his results stand unquestioned. He was so deaf that one had to communicate with him by writing, and this fact prevented all but a few from realizing his high worth and modest character. LEONARD HILL.

Mr. E. C. Stuart Baker, C.I.E.

BY the death of Mr. Stuart Baker on April 16 at the age of seventy-nine, ornithology, and especially Indian ornithology, has lost one of its most eminent exponents. He was born in 1864; after being educated at Trinity College, Stratford-on-Avon, he followed his father's career in entering the Indian Police Force in 1883. Nearly all his service was spent in Assam, then, even more so than now, a wild mountainous region peopled by primitive and savage tribes, which offered unbounded opportunities for sport and the observation of wild life, of which he took every advantage. He rose to be officiating inspector of police for the Province in 1910; in 1912 he was selected to reorganize the special police force of the Port of London Authority, a post which he held until he retired in 1925.

On his return to England Stuart Baker settled at Upper Norwood and, taking an interest in local politics, he was elected a councillor of the Croydon Town Council, where he served two terms as mayor during 1937–38.

It was not until about the time of his return from India that Stuart Baker began to publish his numerous works on Indian ornithology. These include volumes on the Indian ducks, doves and game-birds, and finally he was asked to prepare a new edition of the birds for "The Fauna of British India" series, issued under the authority of the Secretary of State for India in Council. The first edition by E. W. Oates and W. T. Blanford was in four volumes. Stuart Baker expanded these into eight, published during 1922–30, and practically rewrote the whole. It has since become the standard work on the subject. As he felt he had not done justice, for want of space, to nesting and other habits, he prepared four more volumes, "The Nidification of Birds of the Indian Empire", which appeared during 1932–35.

Perhaps Stuart Baker's most valuable work was on the cuckoo problem. Always deeply interested in the study of birds' eggs, of which he amassed a very large collection, he paid special attention to the cuckoos, especially those of the many Indian and Asiatic species. The results of these observations and reflexions appeared in 1942 under the title of "Cuckoo Problems", in which he discussed such questions as adaptation of cuckoo's eggs to those of the fosterers, how far the 'survival of the fittest' has been concerned in the evolution and adaptation of the eggs, and such lesser questions as the method by which the cuckoo egg has been introduced into the nest of the fosterer and the ejection of fosterers' eggs from the nest by the young cuckoo. The value of this work was greatly enhanced because Baker had at his disposal much evidence from the many Indian species and did not confine himself to the European cuckoo, which had been the case with most previous writers.

Stuart Baker received the C.I.E. in 1932. He was a fellow of the Linnean and Zoological Societies and a member of the British Ornithologists' Union, of which he was honorary secretary and treasurer from 19 3 until 1936.

He married in 1897 Ethel May Roffey, who survives him together with four daughters. W. L. SCLATER.

Mr. J. W. Bullerwell

JOHN WILLIAM BULLERWELL began teaching (two years before he entered college) as an assistant master at the Orphan House School, Newcastle, where he had previously been a student. While an undergraduate at Armstrong College, he taught mathematics and mechanics in Newcastle School Board evening schools, and after graduating in 1896 he became science master at St. Cuthbert's Grammar School and part-time lecturer in mathematics at Armstrong College. In 1901 he became lecturer in mathematics at Hartley College, Southampton, a post which he held only for a short time, before returning to Newcastle as lecturer in physics in 1902, becoming senior lecturer in 1919. He retired in 1938, but returned to duty again until 1942.

Two or three generations of students will remember Bullerwell for his novel and well-thought-out methods of presenting his subject. He was above all other things a teacher, whose every desire was to help and advise his students. He had no grudges against anyone, and he was always ready to rejoice in the promotions and successes of others. With his six feet four inches he commanded discipline with ease, but it was always a parental rather than a dictatorial discipline.

Bullerwell was appointed secretary of the University of Durham Schools Examination Board in 1932, and he carried out the duties with efficiency until

illness forced him to retire in 1942. He acted as treasurer of the Armstrong (later King's) College Choral and Orchestral Society for forty years and in the same capacity for the University of Durham Philosophical Society. The Newcastle Bach Choir was one of his greatest interests, and he was associated with it from the time of its foundation. For many years also he was a member of the committee of the Newcastle upon Tyne Literary and Philosophical Society. He had some reputation as a collector of North Country folk songs, and many people will have pleasant memories of his lectures on the subject.

Bullerwell died on March 17 at the age of seventy.

GEORGE W. TODD.

Prof. W. G. MacCallum

PROF. WILLIAM GEORGE MACCALLUM, the eminent American pathologist, who died on February 3 at the age of sixty-nine, was born at Dunnville, Ontario, on April 18, 1874, the son of a medical man. After qualifying at the University of Toronto in 1894 and at the Johns Hopkins University School of Medicine in 1897, he held the post of intern and later of resident pathologist at the Johns Hopkins Hospital. In 1899 he was appointed assistant in pathology at Johns Hopkins, where he afterwards became assistant professor and professor in pathological physiology and lecturer in forensic medicine. In 1909 he was appointed professor of pathology at the Columbia University College of Physicians and Surgeons, as well as pathologist at the German Hospital and Presbyterian Hospital. In 1917 he succeeded the well-known pathologist Dr. William H. Welch as professor of pathology at Johns Hopkins, and held this appointment until the spring of 1943.

In addition to a "Text-book of Pathology", of which the first edition appeared in 1916 and the seventh and last in 1940, MacCallum's chief publications were on the sexual conjugation of the parasites of avian malaria (1897), the pathology of pneumonia following influenza in the United States during the winter of 1917–18, calcium in tetany (1918), and with Ella H. Oppenheimer "Centrafugalization, a Method for the Study of Filtrable Viruses as applied to Vaccinia". He was also the author of a biography of the surgeon W. S. Halstead.

MacCallum was well known in Great Britain, where he was elected an honorary fellow of the Royal Society of Medicine in 1934. He was also honorary fellow of the Swedish Medical Society at Stockholm, a member of the U.S. National Academy of Sciences, and of the Harvey Society, of which he was president in 1914.

J. D. ROLLESTON.

We regret to announce the following deaths:

Dr. J. C. Dunlop, formerly registrar-general for Scotland, and an honorary fellow of the Faculty of Actuaries of Scotland, on April 10, aged seventy-eight.

Sir Clement Hindley, K.C.I.E., member of the Advisory Council for Scientific and Industrial Research, and president in 1939 of the Institution of Civil Engineers, on May 3, aged sixty-nine.

Mr. C. B. Rickett, an authority on the birds of southern China, aged ninety-three.

Commander J. A. Slee, C.B.E., chairman in 1938 of the Wireless Section of the Institution of Electrical Engineers, aged sixty-five.

Prof. W. M. Thornton, O.B.E., emeritus professor of electrical engineering at King's College, Newcastle upon Tyne, on May 2, aged seventy-four.

NEWS and VIEWS

Water Supply in Great Britain

A WHITE PAPER on water supplies ("A National Water Policy." H.M. Stationery Office, 6*d*.) points out that the problem facing Great Britain is one of organization and distribution, not of total resources, which are ample for all needs. Since water is a bulky commodity, its costs of distribution are relatively high and therefore local sources must be used so far as possible. To do this efficiently will require, not only changes in law and practice, with the co-ordination of the many varied authorities up and down the country, but also a fuller survey of resources than is at present available, and adequate protection against pollution and waste. There must also be a satisfactory supply for industrialists and farmers, who now are normally outside the obligations of public water-undertakings. Agricultural production must no longer be hampered by insufficiency of water and haphazard dependence on casual supplies. The proposals embodied in this report are based on three principles: first, adequate control of water supply services, including changes where they can be justified by greater efficiency or reduction in costs; secondly, responsibility for water supply to rest with democratic bodies ranging from Parliament to local authorities; and thirdly, sectional interests to be subordinate to the national interest, subject to Parliamentary approval.

In the light of these principles, the main proposals of the Government are as follow: the Minister of Health and the Secretary of State for Scotland would be given the statutory duty of promoting the provision of adequate water supply and the conservation of water resources, and their policy would be based on the collection of full information regarding sources and needs. The Central Advisory Water Committee of England and Wales should be reconstituted as a statutory body, and a similar committee set up for Scotland. Survey of the needs of large areas and the efficiency of supplies should be continued, close touch being maintained with town and country planning policies. Amalgamation of water undertakings may be necessary in order to secure efficiency and economy, and also the giving of bulk supplies by one water undertaking to another. Steps must be taken to prevent misuse, waste and pollution. Industry and agriculture are to have the right to water supplies. Compulsory powers, under proper safeguards, should be granted to take water from streams. The Ministers responsible should be given powers to require information and statistics from all users of water and sinkers of wells. The White Paper also contains certain financial proposals; but its main importance is that it considers the problems of water supply on a national basis, and admits the need for rural supplies, even though urban

populations afford the most serious problems in their steadily increasing demands.

The White Paper was discussed on a motion moved by the Minister of Health, Mr. Willink, in the House of Commons on May 3. While the statement received a general welcome, there was criticism from all sides that the suggested procedure was slow and the scheme lacked boldness. Mr. Willink said that the main instrument for collecting information on the yield and quality of water resources is the Inland Water Survey, and the Government proposes to press on with it at the earliest possible date. The Central Advisory Water Committee, with new powers, would advise the Minister of Health on general policy in the light of the information provided by the Survey. As an alternative to this Central Committee, a national water board under a strong, well-qualified chairman, was suggested as a means of co-ordinating the water policy of Great Britain. Against this suggestion it was urged by the Minister of Agriculture, Mr. R. S. Hudson, that water policy touched on too many aspects of national administration, such as housing, health, drainage and agriculture, to make a national water board feasible and practicable.

Regional Organization in Australasia

THE Agreement between the Commonwealth of Australia and the New Zealand Governments signed at Canberra on January 21, 1944, has now been published (Cmd. 6513). In addition to undertaking general collaboration with regard to the location of machinery set up under international organizations such as the United Nations Relief and Rehabilitation Administration, the two countries agree to promote the establishment of a regional organization with advisory powers, which could be called the South Seas Regional Commission, on which the Governments of the United Kingdom, the United States and the French Committee of National Liberation might be represented. Such a Commission would have as its function to secure a common policy on social, economic and political development directed towards the advancement and well-being of the inhabitants themselves and, particularly, the Commission would recommend arrangements for the increasing participation of local inhabitants in administration, with a view to the ultimate attainment of self-government in the form most suited to the circumstances of the peoples concerned; arrangements for material development, including production, finance, communications and marketing; for the co-ordination of health and medical services and education; for the maintenance and improvement of labour conditions and social services as well as collaboration in economic, social, medical and anthropological research.

The publication of periodical reviews of progress in this field is also visualized, and in addition to the establishment of a regional zone of defence and of permanent machinery for collaboration and co-operation between Australia and New Zealand, the Agreement provides for joint action in support of the principles that full control of the international air trunk routes and the ownership of all aircraft and ancillary equipment should be vested in an international air transport authority operating those routes, and that the routes themselves should be specified in an international agreement. Failing such agreement the two Governments support a system of air trunk routes controlled and operated by Governments of the British Commonwealth of Nations under Government ownership.

Colonial Geological Surveys

THE function and future of the Colonial Geological Surveys formed the subject of a recent article in NATURE (153, 273; 1944), in which a discussion on the matter, held under the joint auspices of the Geological Society of London and the Institution of Mining Engineers in November last, was summarized at some length. The subject has again been dealt with in the *Bulletin of the Imperial Institute* (41, No. 4, 255; 1943), by the 'intelligence staff' of the Institute, under the heading "A Review of Geological Survey Work in the Colonies". In this article the authors refer to all the Colonies except those small islands and groups where, it is stated, the question of establishing official Surveys scarcely arises. Particulars are given separately for each Colony as to area, the years, if any, during which geological survey work has been carried out, the amounts of money expended on such work, the staffs employed and the maps that have been published. Reference is also made to the question of water-supply and to mining activities. With few exceptions, it appears that in none of the colonies was a Geological Survey established earlier than 1918. In Ceylon, a mineral survey was commenced in 1903; and in British Malaya a Geological Survey has existed for forty years, though until 1912 it employed only one geologist. In certain other Colonies short-term mineral surveys were carried out in the early years of this century by the Imperial Institute, under the auspices of the Colonial Office.

The information supplied is based on published records, and it certainly provides factual support for the views expressed at the joint meeting of the Geological Society and the Institution of Mining Engineers at their joint meeting last year. It makes it clear, in fact, that there is ample room for enlargement, and improvement in the continuity and scope, of the work of the Colonial Geological Surveys. Actually the matter is in hand, for the Secretary of State for the Colonies has appointed a panel of experts to advise him on the subject. The intention of the authors of the Imperial Institute article is to point out the desirability that a fair share of the Colonial Office grants for the extension of scientific investigation into Colonial problems should be allocated to the expansion of geological survey work. In the view of the Institute, a Geological Survey should be regarded as a public service available to the mining, agricultural and other industries; as well as for government-sponsored public works and water supply services; and also as an educational institute. The association of the Imperial Institute with the Colonial Geological Surveys is one of long standing, and the recommendations made in this article, backed by an authoritative statement of facts, should command the attention of those interested in the welfare and development of the Colonies.

Archæological Find in Kenya

DR. L. S. B. LEAKEY, honorary curator of the Coryndon Museum, who is employed in war-time duties with the C.I.D., Nairobi, has spent eighteen days leave on Site 10 at Mount Olorgasailie in Kenya, accompanied by Mrs. Leakey, Mr. A. J. Arkell, the Commissioner for Archæology in the Sudan, Miss E. Cory, Mr. F. de V. Kirk and Mr. G. Alkin. The excavations carried out showed that the surface indications noted early in 1942 had not been misleading and that the site is of outstanding importance.

The trial trenches that have been dug have revealed that the deposits consist of lake beds alternating with land surfaces. Upon four of the land surfaces—or layers—exposed, there are abundant signs of occupation by Acheulean man, and very large numbers of hand-axes, cleavers and bolas stones have been found closely associated with the fossilized remains of extinct animals. Another discovery of importance is the finding of another occupation floor that represents the first well-authenticated evidence of the existence of a flake-culture people anywhere in East Africa, in the deposits of the Middle Pleistocene. The animal fossils found include those of extinct species of elephant, hippopotamus, giraffe and rhinoceros, a baboon that was as big as a gorilla, and a pig that was as large as a present-day rhinoceros. The Kenya Government has fenced the site, and it is proposed that the various occupation floors shall be exposed and then roofed so that visitors can see the implements and fossils lying in position.

Science and the War

A SYMPOSIUM of papers presented at the seventy-fifth anniversary meeting of the Kansas Academy of Science on April 10, 1943, has now been reprinted (*Trans. Kansas Academy of Science*, 46) under the title "Science and the War". L. E. Cull deals with the place of food and J. H. McMillan with that of physics in the war effort. The latter points out that when Japan began hostilities, the United States had nearly two hundred physicists directing about five hundred professional physicists, investigating specific war problems. This represented about seventy-three per cent of the physicists in the United States who were judged capable and free to carry on this type of work. Both in government research laboratories and in industry there has been an acute shortage of physicists, and the programme for training war-time physicists does not appear to have been so well organized as that for research. N. P. Sherwood's paper on "Bacteriology, Medicine and the War" emphasizes the marked advance in our knowledge and resources since 1928 for dealing with wound infections, venereal disease, typhoid and tetanus, etc. J. W. Greene, discussing "Chemistry and the War Effort", briefly reviews the familiar achievements of the chemist in such fields as explosives, synthetic rubber, plastics, fertilizers, aviation spirit, solvents, synthetic organic chemicals, etc. "The Role of Botany in War-time" is outlined by P. B. Sears, who refers to the services of botanists in camouflage work, cotton fibre problems, plant breeding and control of disease, the preparation of airfield runways with sod covers which will prevent erosion, and particularly in food production. J. C. Frye and C. P. Kaiser's paper, "Geology in the Present War", refers to the services of the geologist in meeting difficulties in the supply of strategic minerals and other raw materials, domestic water supplies, and in mapping. J. Breukelman deals with the "Relation of Zoology to the War Effort", and refers in particular to its contribution in the field of nutrition, in pest control, in jungle warfare and in the conservation of fauna. The final paper, by H. B. Reed on "Some Contributions of Psychology toward the War Effort", after referring to the neglect of psychology after 1918 by the Armed Forces, indicates the value of the psychologist in placing men in the activities for which they are best qualified and in which they may be of the greatest service to the country, in devising technique for effective training in the skills required in military work or for building up civilian and military morale and propaganda effects, in handling and dealing with children in bombed areas, and in the effective care of war orphans. A brief account of the classification work in the U.S. Army is included.

William H. Nichols Medal of the American Chemical Society : Award to Prof. C. S. Marvel

THE William H. Nichols Medal for 1944 of the New York Section of the American Chemical Society has been presented to Prof. Carl Shipp Marvel for outstanding contributions to knowledge of the structure of vinyl polymers, the long-chain molecules used as rubber substitutes, in production of plastics, and as thickening and blending agents in chemical manufacturing, and for his research in the structure of sulphur dioxide – olefin polymers. Prof. Marvel is professor of organic chemistry at the University of Illinois, and president-elect of the American Chemical Society. As a graduate student at the University of Illinois, Prof. Marvel became interested during the War of 1914–18 in the development of synthetic chemicals, at a time when the United States was dependent upon Germany for many drugs and dyes. He is now recognized as one of the outstanding authorities in the United States in organic chemistry, especially in the field of polymers, and for his extensive knowledge of organic chemical reactions. He is also a leader in the development of synthetic methods for making organic compounds, and early in his career at the University of Illinois began manufacturing chemicals needed for research there and elsewhere. One contribution in this latter field was the production of pure amino-acids, which have served brilliantly in vitamin studies and determinations of essentials of diet. The amino-acids also are used for intravenous feeding of persons unable to tolerate proteins. Other work by Prof. Marvel has dealt with the relationship of hydrogen bonding and solubility behaviour, the synthesis and rearrangement of polyenes and polyines, association of free radicals, and other research fields. Prof. Marvel was born at Waynesville, Ill., on September 11, 1894, and received his bachelor of arts degree from Illinois Wesleyan University in 1915. He was a student of Dr. A. W. Homberger, Illinois Wesleyan, and of the late Prof. W. A. Noyes, at the University of Illinois. He has been associated with the editorial board of "Organic Syntheses" since 1923, and with the *Journal of Organic Chemistry* since its founding. He is a member of the National Academy of Sciences, and was chairman of Section B–3, National Defense Research Committee, during most of 1941 and 1942.

Tannic Acid and Burns

THE impression that tannic acid is a safe and reliable dressing for burns is nowadays so widespread that there will be much interest in recent experimental evidence suggesting that tannic acid should be abandoned because of the risk of the damage to the liver which it may cause. S. L. Rae and A. W. Wilkinson (*The Lancet*, March 11, 1944, p. 332) studied, by the lævulose-tolerance test, the liver function of 27 children, aged twelve years or less, who had been burned or scalded. Of these children, 12, who had burns covering an average of 17 per cent of the body surface, were treated with 2 per cent gentian violet followed by silver nitrate; and 8 of them, whose burns were smaller, covering an average of 5 per cent of the body surface, were

treated with tannic acid jelly containing one part in 5,000 of merthiolate. Impairment of liver function was least in the group treated with gentian violet and silver nitrate, although the burns in this group were much larger. In a large series of children treated with silver nitrate, there was no case of the acute toxæmia which may occur after tannic acid treatment. Impairment of liver function was commonest and most severe in the group treated with tannic acid. The authors think that this agrees with clinical experience. They suggest that the merthiolate in the tannic acid jelly used may have been partly responsible for the impairment of liver function.

Seven cases with injuries covering 5 per cent of the body surface were treated with sulphacetamide paste, and these occupied an intermediate position between the groups treated with tannic acid and gentian violet – silver nitrate. The authors point out that sulphonamide drugs may be rapidly absorbed from superficial burns and may also cause liver damage; they should be used with care. Their general conclusion is that there is now sufficient clinical and experimental evidence to justify the abandonment of tannic acid as a local application for burns. R. H. Franklin (*The Practitioner*, **62**, 167; 1944) also discusses the use of tannic acid and agrees that it is being largely abandoned now. Rae and Wilkinson think that coagulation treatment may save life in the early stages of very extensive superficial burns and that, from the point of view of toxic absorption, silver nitrate is probably a safe coagulant. In an annotation, *The Lancet* (March 11, 1944, p. 344) refers to other experimental work on the toxicity of tannic acid which has been done on dogs, rats and mice, and says: "There seems little doubt now about the experimental facts concerning the toxicity of tannic acid". The *British Medical Journal* (April 1) agrees and adds that, although mortality from burns has diminished since tannic acid was introduced in 1925, there is no evidence that it has "any advantage in this respect over other methods".

Classification of Diseases and Injuries

ASKED by the Ministry of Health to advise on a system for collecting and recording statistics of patients admitted to hospital, the Medical Research Council appointed a Committee on Hospital Morbidity Statistics, which has now issued "A Provisional Classification of Diseases and Injuries for Use in Compiling Morbidity Statistics" (Med. Res. Council, Special Report Series, No. 248. H.M. Stationery Office, 1944. 3*s*. net). The classification here recommended has been adopted by the Ministry of Health for the classification of all Emergency Medical Service records, and the Ministry of Pensions is also using it. It will also be used in the Regional Bureaux of Health and Sickness records which the Nuffield Provincial Hospitals Trust is establishing in some areas. It is comparable with the International List of Causes of Death and the Diagnosis Code of the United States Public Health Service, the code numbers of both of which are included. It is also comparable with the Diagnosis Codes of the Royal Navy, Army and R.A.F. Medical Services. The coding system has been planned for use with mechanical sorting, but may be used equally well with manual filing. It is not suggested that it should replace the Standard Nomenclature of Disease of the American Medical Association.

The Committee has issued this provisional scheme as a Special Report so that it may be available for as wide a trial as possible. Dr. Percy Stocks, in a brief historical introduction, reminds us that every deceased person was either a sick or an injured person and, if his illness is classified during life, it will usually be the same as the cause of death defined in the Registrar-General's Manual. But the bulk of illnesses do not lead to death, so that a classification of diseases and injuries must give greater attention to minor and disabling conditions than a classification of causes of death needs to do. It is recognized that the diagnoses of some diseases, even when they are made by experts, may not agree, so that only tentative groupings are made in some sections. In some groups (for example, heart disease) the classification has been framed with the object of getting information necessary for a better classification. The Committee hopes, indeed, that any errors, omissions or inconsistencies observed will be reported, so that they may be incorporated in a future revised edition.

Value of Human Milk

BRADFORD-HILL has pointed out in his "Principles of Medical Statistics" that bottle-fed babies are 'selected', in that some factor has determined whether or not the mother feeds her baby. Deductions as to the relative values of breast- and bottle-feeding, based on comparisons of growth and health of groups of babies fed by one or other method, are vitiated by this selection. Mr. Eric Wood points out, in an article in the *Medical Press and Circular* of February 9, that no controlled experiment has been made in which the two groups have been comparable at the start, in heredity, environment and physical conditions. Nor is this possible; for readiness to agree to give up breast-feeding would, in itself, make the 'bottle' group a selected one. In default of this possibility, Mr. Wood points out the need for much more information on the following points. (1) The effects of the mother's environment, food, etc., on the ability to suckle and on the quality and quantity of the milk. We now realize that the easy assumption that the mother is sacrificed to the baby does not hold without qualification. (2) The response of babies to their food. Is the flying start of the breast-baby due to the composition of the colostrum? Babies are not, like lambs, dependent on the colostrum for a supply of antibodies from their mothers; antibodies (the antibody to the *Rh* factor, for example) pass through the human placenta. Both flying start and ability to suckle may both be evidence of a superior reproductive capacity. (3) The advantages, if any, of breast-fed babies that persist into later life. Mr. Wood points out that this information would be given only by long-term investigations based "on co-ordinated planning, a long time in advance, by some suitable 'ad hoc' committee or other body". Actually, very valuable work into the composition of human milk has been carried out, for two years, at the National Institute for Research in Dairying, supported by the Medical Research Council; and more extensive investigations, on the lines suggested, had been planned and work on them had started at the beginning of this year.

President Jefferson, Statesman-Scientist

THE recent bicentenary celebrations of Thomas Jefferson's birth have directed attention once again to the versatility of this remarkable man, some of whose special scientific interests are the subject of a 'pre-reprint' of 64 pp., with illustrations and maps, from *Chronica Botanica* (8, Nov. 1943), of a study by

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

THE ROYAL INSTITUTE of CHEMISTRY of GT. BRITAIN & IRELAND

(Founded 1877)
(Incorporated by Royal Charter, 1885)

APPOINTMENTS REGISTER

A Register of Chemists (Fellows, Associates and Senior Registered Students), who are available for appointments or who are seeking to improve their position, is kept at the office of the Institute. The facilities afforded by this Register are available (free) to Companies and Firms requiring the services of chemists, and to Universities, Colleges and Technical Schools requiring Teachers of Chemistry and Technology. A list of Laboratory Assistants is also available.

Particulars of the Regulations and Examinations of the Institute can be obtained (free), on application to the Registrar.

All communications to be addressed to The Registrar, the Royal Institute of Chemistry, 30 Russell Square, London, W.C.1.

UNIVERSITY OF EDINBURGH

ADMISSIONS—SESSION 1944–5

FACULTY OF MEDICINE.—Entrance to the Faculty will be limited and candidates for admission in October, who have not already applied, must submit an application to the Dean of the Faculty of Medicine—on a form to be obtained from him—not later than July 1, 1944.

FACULTIES OF ARTS (including COMMERCE AND SOCIAL STUDY), SCIENCE, LAW, and MUSIC.

The number of admissions to Courses in these Faculties will probably be limited.

Application should be made by July 15 on a form to be obtained from the MATRICULATION OFFICE, Old College.

Information regarding the conditions of admission to these Faculties may also be obtained at the MATRICULATION OFFICE.

All admissions will be subject to any regulations made by the Ministry of Labour and National Service.

A stamped addressed envelope (1d.) should accompany postal requests for forms.

W. A. FLEMING,
Secretary of the University.

May, 1944

MINISTRY OF LABOUR AND NATIONAL SERVICE

Vacancies exist for ENTOMOLOGISTS in the Medical Departments of Uganda, Northern Rhodesia, and the Tanganyika Territory, who are required for general entomological work ; with special emphasis on the investigation of tsetse fly and mosquito problems in the field as well as in the laboratory.

Candidates, who should preferably be under 35 years of age, must be British subjects, should have a sound theoretical and practical knowledge of general entomology, and preferably have had practical experience in mosquito control.

All posts are pensionable, at salaries of £400 rising to £1,000 in the case of Northern Rhodesia and the Tanganyika Territory (the salary for the Uganda post is at present £400 rising to £840). Free quarters are provided. Free first-class passages are also given.

Applicants should write quoting F 2421 A to the Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2, for the necessary forms which should be returned completed on or before June 17, 1944.

MINISTRY OF LABOUR AND NATIONAL SERVICE

A vacancy exists for a BACTERIOLOGIST on the staff of the Water Pollution Research Laboratory of the Department of Scientific and Industrial Research. The appointment will be made in the grade either of Junior Scientific Officer or Scientific Officer (£275 to £550 plus Civil Service War Bonus £49 10s.) according to qualifications and experience.

Candidates should possess good Honours Degree or equivalent qualification and preferably some experience in research.

Applicants should write quoting F 2248 A to the Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2, for further particulars and the necessary forms which should be returned completed on or before May 31, 1944.

UNIVERSITY COLLEGE of SOUTH WALES AND MONMOUTHSHIRE

COLEG PRIFATHROFAOL DEHEUDIR CYMRU A MYNWY

The following Chairs in the University College of South Wales and Monmouthshire will become vacant at the end of the current academic year:

(*a*) Philosophy ;
(*b*) Zoology and Comparative Anatomy.

Salary £850 per annum.

Twelve copies of application and testimonials (which need not be printed) must be received by the undersigned, from whom further particulars may be obtained, not later than May 31, 1944.

The inability of any candidate who may be engaged on national service to take up the appointment at the beginning of next Session will not prejudice his claims to the appointment.

LOUIS S. THOMAS,
Registrar.

University College,
Cathays Park, Cardiff.

CHELSEA POLYTECHNIC, LONDON, S.W.3

DEPARTMENT OF BIOLOGY

Applications are invited from women university graduates for the temporary full-time post of LECTURER IN ELEMENTARY SCIENCE and PHYSIOLOGY at the Chelsea College of Physical Education, which is temporarily evacuated to Borth, near Aberystwyth.

Salary in accordance with the provincial Burnham Scale for Technical Teachers. Further particulars and form of application may be obtained by sending a stamped addressed foolscap envelope to the Principal, Chelsea Polytechnic S.W.3, to whom applications must be returned by May 27.

UNIVERSITY OF LIVERPOOL

CHAIR OF GEOGRAPHY

The Council of the University of Liverpool invites application for the John Rankin Chair of Geography about to become vacant owing to the resignation of Prof. P. M. Roxby. Salary not less than £1,200 per annum. The University has power to grant leave of absence on the ground of work of national importance to a professor who is unable to take up his duties upon appointment. The last date for the receipt of applications is July 31, 1944. Candidates who are overseas may apply by cablegram, giving the names of three referees. Further particulars can be obtained fom the undersigned.

STANLEY DUMBELL,
Registrar.

May, 1944.

UNIVERSITY COLLEGE OF SWANSEA

The Council invites applications for the post of LECTURER in the Department of MATHEMATICS. The salary will be determined according to qualifications and experience, with a minimum of £400 and a maximum of £500 per annum. The appointment will date from October 3, 1944.

Further particulars may be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications must be received on or before Saturday, May 20, 1944.

EDWIN DREW,
Registrar.

UNIVERSITY OF GLASGOW

LECTURER IN CHEMISTRY

Applications are invited for the post of Lecturer in Chemistry, to date from October 1, 1944. Applicants should have special qualifications in Inorganic or Physical Chemistry, with teaching and research experience. The commencing basic salary will be between £400 and £550 per annum, depending upon qualifications and experience. At present there is also a scheme of family allowances, and in addition there may be a war bonus of £20. Further particulars may be obtained from the undersigned, to whom applications (3 copies), with names of two referees, should be sent not later than May 26.

ROBT. T. HUTCHESON,
Acting Secretary of University Court.

April, 1944.

LEVER BROTHERS & UNILEVER

Lever Brothers & Unilever announce that after reinstatement of the large number of their technical staff who have been employed on National Service they will still have vacancies in their research departments and their factories for a considerable number of qualified chemists, physicists, and engineers. At a later date applications for these appointments will be invited. An appreciable proportion of the positions available will be suitable for scientists capable of controlling Research Sections, and applicants will require to be in the 30/40 age group. The remaining posts will require men with good scientific and technical training in the age group about and below 30. Whilst applications are not invited at present, if intending applicants would like further information regarding these posts they should apply to the Personnel Department, Lever Brothers & Unilever Limited, Unilever House, Blackfriars, London, E.C.4.

MANCHESTER ROYAL INFIRMARY

CLINICAL LABORATORY

Applications are invited for the post of LABORATORY TECHNICIAN (MALE) holding the Certificate in Bacteriology of the Institute of Medical Laboratory Technicians. Candidates without the Certificate, but with experience in bacteriological technique may be considered. State salary required.

Applications, with testimonials, to be addressed to the Director of the Clinical Laboratory.

ROYAL HOLLOWAY COLLEGE

(UNIVERSITY OF LONDON)

Appointment of ASSISTANT LECTURER and DEMONSTRATOR IN CHEMISTRY. The Governors invite applications for the above post, which is resident and open to women only. Applications are required not later than May 31, 1944. Full particulars may be obtained from the Principal, Royal Holloway College, Englefield Green, Surrey.

THE UNIVERSITY OF SHEFFIELD

The Council of the University invite applications for the CHAIR OF BOTANY, about to become vacant owing to the appointment of Prof. W. H. Pearsall, F.R.S., to the Quain Chair in University College, London. Salary £1,000 per annum plus wartime allowances. The successful candidate will be required to enter upon his duties on October 2, 1944. Applications should reach the undersigned (from whom further particulars may be obtained) by June 1.

W. M. GIBBONS,
Registrar.

UNIVERSITY OF READING

An ADMINISTRATIVE ASSISTANT (MAN) is required in connection with the scheme of the Ministry of Agriculture and Fisheries for the provision of technical advice to farmers. Salary £250 per annum plus a war bonus of approximately £50 per annum, rising by annual increments to £400 per annum. Preference will be given to a candidate possessing a degree or a diploma in agriculture. Further particulars may be obtained from the Dean of the Faculty of Agriculture and Horticulture, The University, Reading.

Experienced laboratory assistants wanted for chem. and phys. labs., Highgate School. —Apply, stating salary required, to P. Bateman, 9 Bishopswood Road, N.6.

B.E.A.I.R.A.

The Council of the above Association are making an early appointment of a new DIRECTOR. Age preferably not exceeding 50 years. Commencing salary not less than £2,000 per annum (with superannuation F.S.S.U.). It is desirable that the new Director should be able to take up the appointment at an early date. Applications with supporting particulars should be sent under personal cover to the Chairman of the Council, The British Electrical and Allied Industries Research Association, 15 Savoy Street, London, W.C.2.

Biochemical Research Assistant, preferably with research experience, required by reputable, old-established firm working in the medical field. Applicant must have degree in biochemistry and be fully conversant with standard biochemical technique. The laboratory is situated in the West End of London. The salary will be according to qualifications and experience.—Write, in first instance, giving full details of experience, qualifications and salary required to Box 181, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Organic Research Assistant, preferably with research experience, required by reputable, old-established firm working in the medical field. Applicants must have honours degree in chemistry. The work will be pure organic research, and the laboratory is situated in the West End of London. Salary will be according to qualifications and experience. —Write, in first instance, stating qualifications, experience, and salary required to Box 182, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

A Research Laboratory (scheduled E.W.O.) situated in Manchester invites applications from qualified chemists and physicists. Opportunities exist for men with sound knowledge of inorganic chemistry, plastics, the testing of materials, and chemical engineering. —Apply Box 184, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

A Bacteriologist is required for research work in connexion with bovine mastitis. Applicants for the post, which will be temporary in the first instance, should possess an Honours degree in science or a veterinary diploma, and should have had post-graduate research experience in bacteriology. The salary will be according to qualifications and experience with a maximum of £500 per annum plus war bonus. Applications, together with the names of three referees, should be sent not later than May 20, 1944, to the Secretary, Hannah Dairy Research Institute, Kirkhill, Ayr.

Insect Physiologist required with a good knowledge of biochemistry for research work in Toxicology. Applicants must have University Degree in Biochemistry or Biology (with extensive physiological training) and research experience on problems of insect physiology. Will have small staff of assistants. Progressive position with good post-war prospects. Work of national importance.—Write details of qualifications and experience, stating salary required. Box 189, T. G. Scott & Sons, Ltd., 9 Arundel Street, London, W.C.2.

Applications are invited for the post of assistant in biochemistry (male) at the Courtauld Institute of Biochemistry, Middlesex Hospital, W.1. Salary up to £450 per annum will be offered to suitable applicant. Duties will include practical and theoretical teaching of Second M.B. students in biochemistry and routine clinical biochemistry. A medical qualification is not essential. Applications to the Medical School Secretary, Middlesex Hospital, London, W.1.

Laboratory Assistant wanted : experience desirable. Reply to Secretary, Department of Zoology and Comparative Anatomy, University Museum, Oxford.

Microscope (Pallischer) two eyepieces, three objectives incl. 1/12 oil immersion. Lamp and stand, hand microtome, slides, culture dishes, sundry stains, etc. £35.—Box 190, T. G. Scott & Sons, Ltd., 9 Arundel Street, London, W.C.2.

Applications are invited from a qualified scientist, with a sound knowledge of plastic materials, particularly in relation to their electrical properties, for a Research Laboratory (scheduled E.W.O.) situated in Manchester.—Apply Box 183, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Junior Entomologist required to take charge of the collection and breeding of insects. Good knowledge of entomology and Natural History required, but degree not essential. Work of national importance. Salary £250 to £330 according to experience. Box 188, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

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

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

Disbanding Research Laboratory, Colorimeter, balance electric centrifuge, drying bath, various glassware, refrigerator and Hearsons insulator.—Dr. Annis, Chesswood Road, Worthing.

Wanted Urgently: Bacteriological laboratory autoclave, maximum working pressure 30 lb. per sq. inch, state how heated. Also bacteriological incubator, preferably water-jacketed, working temperature 37° C., state how heated and make.—Box 187, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

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

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Dr. Charles A. Browne, of the Bureau of Agricultural and Industrial Chemistry, U.S. Department of Agriculture, on "Thomas Jefferson and the Scientific Trends of his Time". The famous statesman-scientist —a type not unknown among the countrymen of Franklin, Rumford, and Hoover, and all too rare elsewhere—was, it appears, not greatly attracted by theory and speculation, which, indeed, he occasionally condemned in severe terms; his scientific interests were largely utilitarian, as is evidenced by many passages from his voluminous correspondence; and his outlook thus admirably fitted him to play the part of scientific scout for America during his residence in Paris as Minister to France (1784–89).

It is interesting to note that during these years in Paris, though he was an eye-witness of the chemical revolution effected by Lavoisier, he was sceptical about the new system of chemical nomenclature. Writing to Madison on this matter on July 19, 1788, he concluded: "The attempt, therefore, of Lavoisier to reform the chemical nomenclature, is premature. One single experiment may destroy the whole filiation of his terms, and his string of sulphates, sulphites, and sulphures, may have served no other end, than to have retarded the progress of the science, by a jargon, from the confusion of which, time will be requisite to extricate us. Accordingly, it is not likely to be admitted generally."

Jefferson's "Notes on the State of Virginia", his magnificent labours in bringing science to the service of the young and undeveloped country in the guidance of the destinies of which he was ultimately called to the highest place, his devoted work for agriculture, and his outstanding services to the cause of science in education, are all well summarized in this interesting memoir.

Stars with Large Proper Motions

A. VAN MAANEN has prepared a paper with this title (*Astro. Soc. Pacific*, Leaf. 176; 1943) which deals with the developments in the discoveries of stellar motions, from the time of Tobias Mayer who determined the motions of several stars in 1760, by comparing his own observations with those of Römer made fifty years earlier. A useful table gives the proper motions of thirty stars with the largest proper motions, in all cases exceeding 3″ annually. Large proper motion suggests relative proximity to the earth, and for this reason it is not surprising that nineteen of the thirty stars are less than 16·3 light-years distant from the sun, and seven are nearer than 32·6 light-years. A very interesting feature in the table is the luminosity of each star, that of the sun being the unit. Only one star—ω Centauri *A*—is brighter than the sun, its luminosity being 1·14. The table also shows that stars with the faintest luminosities belong to the most advanced spectral types and so have the lowest temperatures, with the exception of the white dwarfs. The luminosities of the latter are very low, that of Wolf 489 being only 0·00008.

Electrical Aspect of Farm Mechanisms

A PAPER on this subject was read in London recently by Mr. C. A. Cameron-Brown before the Institution of Electrical Engineers in which, for the benefit of those interested but not actively engaged in rural electrification, a picture is drawn of the general developments of electrical participation in farm processes; the paper also offers a clearing house of ideas for those actively engaged in rural electrification but whose interest is localized. The paper is devoted chiefly to the less common applications, to those which are the subject of controversy, and to those which may appear to have a wider field of application in the future. Emphasis has been placed on trend rather than on facts and figures; thus Mr. Cameron-Brown covers general trends and observations, specific applications of electricity to farming operations such as grinding mills, threshing, crop drying, milk production and certain special applications. The scope of the paper is confined to general farming—arable, dairy and mixed.

Theodor Puschmann (1844–1899)

PROF. THEODOR PUSCHMANN, the eminent medical historian, was born on May 4, 1844, at Lowenberg in Prussian Silesia. He studied medicine successively at Berlin, Marburg, Vienna and Munich, and qualified at Marburg in 1869. He first made a study of psychiatry under von Gudden at Munich and then practised for some years in Cairo. In 1878 he specialized in the history of medicine at Leipzig, and in the following year was appointed extraordinary professor of medical history at Vienna, becoming full professor in 1879 in succession to Prof. R. Seligmann. He died on September 28, 1899. His principal publications were an edition of Alexander of Tralles (1878–79), a "History of Medical Education" (1889) and "Medicine in Vienna during the last 100 Years" (1884). He also wrote the introduction to a great work on the history of medicine which was completed by Prof. Max Neuburger and J. Pagel. His name has been given to a medico-historical institute in Leipzig founded by his wife.

Announcements

THE twenty-third Silvanus Thompson Memorial Lecture of the British Institute of Radiology will be delivered by Prof. Sidney Russ on May 20; he will speak on "The Man Silvanus Thompson".

A WHOLE-DAY conference of the Nutrition Society will be held on May 20, beginning at 10.50 a.m., at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1, on "Budgetary and Dietary Surveys of Families and Individuals, Part 2". Papers will be communicated by Miss E. M. Widdowson and Dr. R. A. McCance ("Dietary Surveys by the Individual Method"); Dr. Gertrude Wagner ("Surveys of Methods Used in Preparing and Cooking Foods"); Dr. G. N. Jenkins, Dr. L. W. Mapson and Miss M. Olliver ("Laboratory Assessment of Nutritive Value of Meals as Eaten"); Miss E. M. Langley ("Food Consumption: Data Obtained from Analyses of Institutional Diets: (*a*) School Diets"); Dr. M. Pyke ("Food Consumption: Data Obtained from Analyses of Institutional Diets: (*b*) Industrial Canteens"); Dr. A. Lyall ("Food Consumption: Data Obtained from Analyses of Institutional Diets: (*c*) Hospital Diets"). The openers of the discussion will be Prof. V. H. Mottram, Mrs. Barbara Callow, Dr. C. P. Stewart and Miss M. C. Broatch.

ERRATUM.—In connexion with the article in NATURE of April 29 on "X-Ray Analysis in Industry", Mr. C. W. Bunn states that the concluding sentence on his paper (p. 534, col. 1) should read "This last effect has been observed in polyethylene, and confirmed by the magnetic properties of single crystals of chain compounds".

LETTERS TO THE EDITORS

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

Molecular Co-ordination in Cellulose

No published hypothesis completely satisfies the evidence on the structure of cellulose, though the approximations derived by workers from Polanyi onwards have provided brilliant essays in reducing chaos to order. What appears to be a closer approximation is described below. A thorough treatment of all the lines of more or less indirect evidence supporting this hypothesis has been held up since the outbreak of war, but the bald description may be of value to those interested in cellulose from other points of view, and may enable those possessing modern forms of atomic models to check the probability of the structure.

In the crystalline structure of cellulose suggested by Meyer and Misch[1], the unit cell contains four glucose residues related by two screw axes. This co-ordination is essentially orthorhombic, with no molecular feature capable of maintaining the distortion to monoclinic form. The latter is also denied by the clear existence of odd orders of (*o k o*) diffraction, particularly (*o* 3 *o*). Geometrical calculation does not confirm that their assumptions on atomic bond lengths, and angles give a molecular unit that fits into the unit cell—the cellobiose unit is longer than the identity period (*b*) observed, which is 10·3 A.

The molecular form was reconsidered in view of the studies in the crystallo-chemistry of the sugars by Cox and co-workers[2]. Their view that the five carbon atoms of the pyranose ring are nearly co-planar was expressed in a rigorous model, suited to geometrical calculation, built on the assumption of tetrahedral carbon bonds, with a right angle between the bonds of the ring oxygen. It fits into the cellulose lattice better than the Sachse form of strainless ring, though the details of the structure derived would be improved by making the ring carbons more nearly co-planar, by straining the tetrahedral angles to anything less than 111°.

When the chains are oriented with the principal plane of the rings in the (*a b*) plane of the lattice, the primary alcohol group appears to approach and to form hydroxyl bonds with the pair of secondary alcohol groups of the neighbouring parallel chain. As the chains are related by a pure translation normal to the *b* or chain axis, this possibility of hydroxyl bond formation is an accidental coincidence due to the particular stereochemical form. If the coincidence were perfect, the orthorhombic symmetry of the ($P_{2_1\,2_1\,2_1}$) group would be retained. The observed distortion suggests that this uncovenanted bonding is only realized by sacrificing one of the four possible bonds.

In the molecular model, the freely rotating primary alcohol group has an alternative bond, with two oxygen atoms of the same chain. The displacement of the primary alcohol groups on one side of one of the two sets of chains to form this chelate bond explains quantitatively the odd order (*o k o*) spots, with the intensities described by Kiessig[3]. It also allows and maintains the slight distortion of the basic $P_{2_1 2_1 2_1}$ cell, to a form which is strictly triclinic P_1.

In a re-examination of the evidence, a different choice from that of Meyer and Misch was made of the *b* parameter which determines the relative position of the two sets of anti-parallel chains. This new choice better fits the evidence on the regenerated form of cellulose.

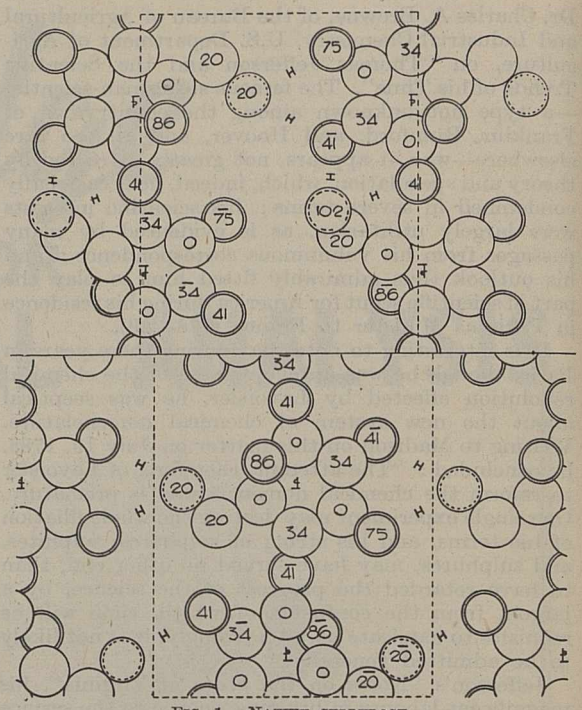

FIG. 1. NATIVE CELLULOSE.

In this form, the pyranose rings are turned from the plane of similarly oriented chains towards the plane containing chains of alternating sense. On general grounds, this is a more normal form of co-ordination, as it gives extra freedom for the formation of local bonds with stringent steric demands. A value of the *b* parameter in accord with the X-ray evidence produces a model with a series of hydroxyl bond possibilities, best explained by the plan of the cell (Fig. 2). Again such local bonds are necessary to explain the loss of symmetry, from the orthorhombic ($B_{2\ 2_1\ 2}$) cell that would be produced by eight identical units to the observed monoclinic P_{2_1} cell, described by Andress[4].

The regenerated form should be that of lower free energy, as it appears to be from the phenomena of dimorphism. The alternative forms of cohesion between cellulose chains, shown by the two forms

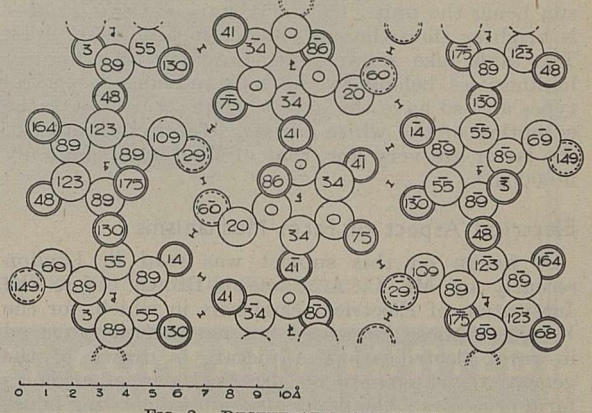

FIG. 2. REGENERATED CELLULOSE.

(which are freely available for local contacts in the deranged regions of cellulose) and the slight distortion from an orthogonal lattice of the crystalline regions (which may occur in either sense to suit the environment) provide a mechanism for the adaptation of the ordered molecular structure to the histology of tissues, and for the production of a strong, but adaptable, continuous lattice work of chains. In such a structure, one can scarcely define strict crystal boundaries; but some statistical description of the distribution in size and locality of the crystallized regions or 'fascicles' is essential for progress in the quantitative theory of fibre behaviour. In particular, the reaction kinetics of polymeric bonds in groups is determined by the size of the group as well as by the energy of the individual bond. This effect of polymeric co-operation explains the striking difference in the physical chemistry of polymers from that of the monomeric congeners.

The molecular structures assigned to cellulose are given in Figs. 1 and 2. Both are projections of the mats of chains on the plane in which the pyranose ring lies, to the scale shown, with normal displacements from the reference plane shown by figures in units 10^{-10} cm., plain above, barred below. In Fig. 1 the plane of reference is the (a b) plane of the lattice described by Meyer and Misch; in the top half through the set of chains with chelate bonds; in the bottom half through the set below the first, at a distance $\frac{1}{2}$ $c.\sin\beta = 3{\cdot}93$ A. In Fig. 2 the plane of reference lies in the plane of the rings in the central chain, normal to the (101) plane of the lattice adopted by Andress (the small monogram in each ring indicates the symmetry operations, and the sign H represents a hydroxyl bond).

The models were constructed by geometrical calculation, assuming the lengths of C–C bond 1·52 A., C–O bond 1·43 A.; the O–O hydroxyl bonds suggested are about 2·6 A. Material models might be cut rather smaller to allow fitting in space.

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Molecular Shape and Size of Hyaluronic Acid and Chondroitinsulphuric Acid

THE hyaluronic acid, which was first isolated from vitreous humor[1], and later has been found in, for example, synovial fluid[2] and navel cord tissue[3] gives highly viscous solutions and is often precipitated as fibres. Its molecules have therefore been assumed to have a chain structure. The chondroitinsulphuric acid gives less viscous solutions and is precipitated at most in small fibres of little coherence. Levene and La Forge[4] tentatively expressed its structural formula as a tetrasaccharide, a view which seemed to receive support from von Fürth and Bruno[5], who by the aid of Northrop's diffusion method obtained a molecular weight of about 975.

Both these polysaccharides are rapidly degraded by alkali even at room temperature[6] and are also very easily broken down by oxidative agents[7]. In order to obtain the substances in a state as native as possible, they must therefore be prepared without the use of alkali and excluding air. We have found that solutions of hyaluronic acid and chondroitinsulphuric acid so prepared show a marked double-refraction of flow. The hyaluronic acid preparations were all rather polydisperse. For those isolated from vitreous humor, the particle-length was estimated to about 4800 A. The hyaluronic acid from synovial fluid showed a higher degree of polymerization with a particle-length of about 700 A.; that from the navel cord was still more polymerized, the particle-length lying outside the range that could be estimated with the apparatus used[8]. An extrapolation attempted from viscosity measurements gave a value of the order of about 10,000–12,000 A. These results leave no doubt of the long-chain structure of the hyaluronic acid and, assuming a length of about 10 A. of the disaccharide unit, suggest molecular weights of the order of 200,000–400,000.

The chondroitinsulphuric acid appeared somewhat less polydisperse. The best preparations showed particle-lengths of about 4700 A. This acid, too, has thus without doubt a linear structure, the molecular weight probably being of the order of 200,000.

A detailed report of this work will be published elsewhere.

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Lattice Constant of Diamond and the C–C Single Bond

RECENTLY, Lonsdale[1] has published a brief account of her measurements on single crystals of diamond using the divergent beam method[2]. At the same time, measurements were made by me on a specimen of diamond dust employing the X-ray powder method developed to a high degree of precision by Bradley and Jay[3] and others. The two sets of measurements are of interest to the physicist because they provide a comparison of the accuracy obtainable by the powder method with that obtainable by Lonsdale's method; they are of interest to the chemist because they lead to the most accurate value yet of the C–C single bond in diamond.

The specimen was obtained from commercial diamond dust by sieving through a very fine bolting-silk sieve (*c.* 175 mesh). The sizes of the small diamond crystals were therefore in the range 0·01–0·001 cm. approximately. The method used was that described by Lipson and Wilson[4]. The lattice constant of diamond is such that the K-radiations of cobalt, iron and manganese are most suitable for precision measurements as they give the 19 β, 16 β and 11 α_1 + 11 α_2 lines respectively at high angles (*c.* 80°). A 19-cm. diameter camera was used; in addition, one photograph was taken in a 9-cm. diameter camera of the van Arkel type. The apparent

lattice constants for the high-angle lines in each photograph were plotted against $\sin^2\theta$, and the result extrapolated to $\sin^2\theta = 1$. In this extrapolation more weight was given to the high-angle values and to the α_1 values as compared with the α_2. It was not considered advisable to use the analytical method of least squares in preference to graphical extrapolation in order to arrive at the best values for a. For if the former method is used, giving an equal weight to each observation, it will give rise to a misleading result; if, on the other hand, different weights are given to the various observations, the method becomes subjective and possesses no advantages over the graphical solution besides being very much more tedious and lengthy. It was, furthermore, obvious from the plots of apparent lattice constants against $\sin^2\theta$ that in each case *all* reasonable extrapolations would give rise to a value of a lying within the region bounded by the limits of error quoted below. The graphical method was therefore adopted. The values obtained, after correction for refraction, are summarized in the accompanying table. The temperature at which the photographs were taken was 18° ± 0·5° C.

Radiation	Camera diameter	a in kX.	Arithmetic mean
Co	19 cm.	$3{\cdot}5595_7$	
Co	19 ,,	$3{\cdot}5595_9$	
Fe	19 ,,	$3{\cdot}5597_8$	$3{\cdot}5596_5$ kX.
Fe	9 ,,	$3{\cdot}5596_1$	
Mn + Cu	19 ,,	$3{\cdot}5597_1$	

The five results are in good agreement and lead to a value for a of 3·5597 kX., the limits of error being ± 0·0001 kX. This is in excellent agreement with Lonsdale's figure of 3·55970 ± 0·00020 kX. (at 18° C.), the variation here referring to different specimens. Dr. Lonsdale gives the limits of error in measuring any *one* diamond as ± 0·00005 kX., which are twice as good as those obtainable by the X-ray powder method and allow her to add a further significant figure. Dr. Lonsdale points out, however, that this very high accuracy is attainable only in exceptional cases, the case of diamond being particularly favourable. This comparison demonstrates the power of the X-ray powder method, which combines the advantages of nearly universal application with simplicity of technique.

The C–C single bond. The C–C bond in diamond is a 'pure' single bond, as there are only carbon atoms present. An accurate knowledge of its length is of interest because it provides a norm from which to measure divergencies from 'pure' single bonding in carbon compounds. Although it has been decided, for the time being, to give lattice constants on the kX. (Siegbahn) scale, it is advisable to quote chemical bond-lengths in Angström units, as they are the basis of spectroscopic measurements. For this purpose a conversion factor of 1·002034 is used[5]. The results, taking Lonsdale's value, are shown below.

a in kX.	a in A.	C–C in kX.	C–C in A.
3·55970	3·56694	1·54140	1·54453
± 0·00020	± 0·00020	± 0·00009	± 0·00009

The C–C bond-length in diamond is therefore 1·5445 ± 0·0001 A.; there is a slight variation from specimen to specimen, but the effect of temperature is small. This value has been arrived at by two completely different methods, and other X-ray measurements[6] on single crystals of diamond are also in agreement. In any one specimen, Lonsdale's method permits a still more accurate knowledge of bond-length; thus, in the specimen measured by her giving $a = 3{\cdot}55974 \pm 0{\cdot}00005$ kX., the C–C bond length is 1·54455 ± 0·00002 A.

It is clear that X-ray methods are capable of measuring bond-lengths with very great accuracy in certain cases. An accuracy of one part in 30,000 is relatively easily achieved in the measurement of lattice constants, and where the lattice constant is defined in a simple geometrical way by the bond-length under consideration, this length can be determined with comparable accuracy. Similar measurements are being undertaken for graphite with the view of fixing accurately two points on the order/length curve for C–C bonds.

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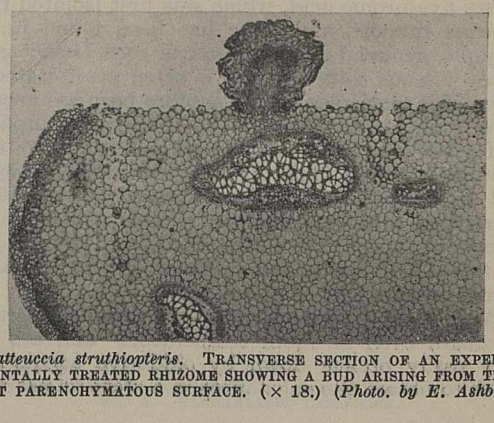
Bud Regeneration at Cut Parenchymatous Surfaces in Onocleoid Ferns

IT has been shown that the removal of the rhizome apex in the ostrich fern (*Matteuccia struthiopteris*) and in *Onoclea sensibilis* is attended by bud development at specific positions along the rhizome. These positions are occupied by superficial areas of meristematic cells, or detached meristems, which at an earlier stage formed part of the apical meristem. Those buds which arise in older regions of the rhizome have no vascular connexion with the shoot stele[1,2].

Two further significant observations have now been made: (1) that if a young induced lateral bud of *Onoclea sensibilis* is excised, new buds may arise from the cavity so produced; and (2) if the superficial tissue containing a detached meristem is removed, that is, as a thin tangential section, from the rhizome of *Matteuccia struthiopteris*, bud development takes place at the cut parenchymatous surface immediately below the position occupied by the detached meristem. This is illustrated in the accompanying photograph: the bud, which is seen to have arisen from a cut parenchymatous surface, occupies a characteristic position, as do induced lateral buds,



Matteuccia struthiopteris. TRANSVERSE SECTION OF AN EXPERIMENTALLY TREATED RHIZOME SHOWING A BUD ARISING FROM THE CUT PARENCHYMATOUS SURFACE. (× 18.) (*Photo. by E. Ashby.*)

opposite a point of meristele conjunction in the vascular system of the shoot; the bud stele ending blindly in the cortical parenchyma.

The potentiality for direct meristematic activity which was known to be present in detached meristems is thus seen to extend locally into the underlying cortical parenchyma also. So far as I am aware, bud regeneration from the cut surface of cortical parenchyma has not hitherto been recorded among the ferns, though a somewhat similar phenomenon has been observed in the genus Lycopodium. These ferns thus appear to afford unusually favourable materials for the investigation of meristematic activity and regeneration phenomena.

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A New Antigen of Salmonella

FOLLOWING the study of a new salmonella type (*S. hormœchei*: XXIX.*Z*30.—.) made by one of us (M.), which has a flagellar antigen not referred to before (*Z*30), we find it in *S. ballerup* (XXIX.(Vi). *Z*14.—.) and in other salmonella (*LC*54) isolated from Buenos Aires sewage; this new antigen has been named *Z*30.

Natural selection and artificial induction show that this "H" *Z*30 antigen occurs in *S. ballerup* with or without *Z*14. Only after careful selection is it possible to obtain *Z*30 or *Z*14 alone.

The salmonella type obtained from Buenos Aires sewage (*LC*54) presents the curious phenomena of a flagellar phase variation in a new aspect: $Z30 \rightleftarrows Z14$. This can be demonstrated using the Sven Gard method of artificial induction of flagellar phases. We have named this variation the 'Zeta Variation'.

Another interesting phenomenon has been observed in the *LC*54 strain. When it has the flagellar antigen *Z*30, the somatic antigen observed is XXIX; but when *Z*14 is present, it is not found.

We are continuing the study of the subject, of which the above is a preliminary account of work we have been doing since September 1942.

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Production of Seed Potatoes in a Hot, Dry Climate

AFTER Maldwyn Davies's demonstration[1] that low temperatures and high relative humidities were needed to check the flight of the aphids that transmit potato virus diseases, it was widely accepted that these conditions were necessary for growing healthy seed potatoes. The absence of these conditions over most of South Africa, and difficulties in importing seed during the past few years, led to a review of the question, and it has been found beyond reasonable doubt that Davies showed only one side of the picture. Very high temperatures and low relative humidities are as effective as low temperatures and high humidities. At both ends of the scale there is an extreme at which the potato will thrive, but aphids not; it is in intermediate climates that heavy infestations occur.

The first demonstration of the value of a hot, dry climate escaped recognition. Porter[2] showed that at Davis, in the hot Sacramento Valley of California, the spread of virus diseases in potatoes was slow provided that their planting was delayed until mid-summer; and making use of this fact he produced seed for three years which was both healthy and productive. In Australia, Norris and Bald[3] noticed at Canberra that hot, dry weather reduced infestation, but the spells there seem to be too short to be of much use. The evidence in South Africa is that there is an optimum temperature for aphids at which infestation reaches a peak, and that rising temperatures above this optimum progressively reduce the population of aphids until a point is reached at which it virtually disappears. A similar suggestion of an optimum was made by Stepantzev[4]. From observations on the weather conditions favouring infestation of cotton fields in Uzbekistar, he concluded that numbers of *Aphis gossypii* Glov. and *A. laburni* Kalt. were greatest when the mean day and night temperatures were 20° C. (68° F.) and 18° C. (64·4° F.), respectively. Optimum temperatures of about the same order, or a little lower, seem to hold for the aphids *Myzus persicæ* Sulz. and *Macrosiphum solanifolii* Ashm. in potato fields in South Africa; but it is more to the point to determine how high the temperature must be before infestation practically ceases. This happens when the mean daily maximum temperature for the summer months is 32° C. (90° F.), which is the condition in dry, central South Africa around Kimberley. This must not be confused with the highest temperature at which aphids will grow and reproduce in the artificial state of a pure colony in a glasshouse. It refers to field conditions, and is strongly influenced by the host plant. In the field, *Myzus persicæ*, for example, will thrive on cabbages at higher temperatures than on potatoes. Very decidedly, high temperatures will not control all aphids on all crops.

Like high temperatures, very dry air is harmful to aphids, as Stepantzev also pointed out, and is important if seed potatoes are to be grown in hot climates. The Sacramento Valley is in a winter-rainfall zone, and aphids flourish in the mild, moist weather of spring. Consequently, Porter was able to control the spread of virus diseases there only if potatoes were not planted before mid-summer. This allows only one generation a year, which in a hot climate is not enough to stop seed from becoming over-sprouted and stale between harvesting and replanting. At Kimberley, on the other hand, winter rains are negligible; with rising temperatures in early summer the air becomes so dry that aphids are held in check, and there is no dangerous interval between winter and summer. Two crops can be planted, one in August to emerge after the last frost, and one in summer, about January. Since potatoes ripen quickly in a hot climate, these intervals between plantings are enough to allow two generations in one year, with just sufficient time between to sprout the seed.

During the past three years, counts of aphids have been made on thousands of leaves in hundreds of acres of potatoes in all stages of growth at the Vaal Harts and Riet River irrigation settlements near Kimberley. The records are such as few of the world's seed areas apart from the west coast of Ireland could

boast. The average of all counts of *Myzus persicæ* was 1·1 per 100 expanded compound leaves. The highest record was 10 on 275, or 3·6 per 100, compound leaves; this was in April, when the vines were ripening and the danger of virus spreading presumably almost past. Also important is the fact that the life of an aphid in these conditions is so hazardous and short that the vast majority of records were of very young nymphs which could not possibly have transmitted diseases like leaf-roll with a long incubation period in the insect.

To meet the critical shortage of good seed, brought about by reduced imports, action was taken in 1943, and more than 1,000 tons was raised by State production at these two settlements. This found its way throughout the length and breadth of the Union, and in the crucial test of productivity proved to be the best ever available in bulk in the country. The production in 1944 will be still higher; and since yields of seed per acre on the settlements have been excellent, the outlook for the future is bright.

The great limitation of seed production in hot, dry climates is its restriction to varieties in which the symptoms of diseases are not masked by heat. So far, only Up-to-date, South Africa's most popular variety, has been produced in quantity. This is immune in the field to virus *A*[1]; and all diseases to which it is subject (apart from virus *X* with which all commercial stocks are now saturated) remain evident in hot weather, though sometimes in a modified form. A start is now being made with Katahdin.

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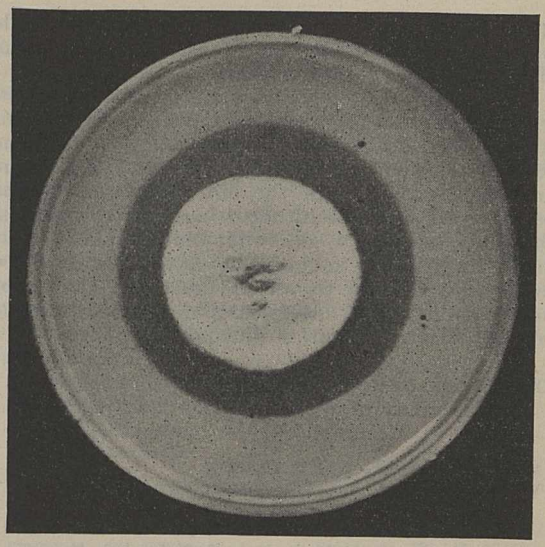
Estimation of the Anti-Bacterial Activity of Fungi that are Difficult to Grow on Liquid Media

THE more detailed work on the quantitative estimation of bacteriostatic substances has been concerned with the assay of penicillin, and the most generally favoured method is the 'cylinder' method as given by Abraham *et al.*[1], amplified by Heatley[2] and discussed by Foster and Woodruff[3]. On beginning our investigation in 1941, the above method was tried but, though apparently satisfactory for its original specific purpose, we found it to be less so for the widespread estimation of the bacteriostatic effect of fungus extracts and metabolism solutions than a method devised by ourselves[4]. Briefly, this method consists of putting a few drops of the liquid to be tested into a circular hole cut in the centre of a plate of bulk-seeded agar medium, with the subsequent production, after incubation at 37° C., of a zone of bacterial inhibition the width of which varies in proportion to the concentration of the bacteriostatic substance. This method only differs from somewhat similar methods mentioned by other workers in that the standardized technique enables it to give a relatively quantitative estimation.

This method has been used for the testing of some



5 MM. ZONE OF INHIBITION PRODUCED BY A 'MYCELIAL DISK' AGAINST *Staph. aureus*.

thousand fungus products of various kinds with complete success; but it is not so useful for the testing of fungi such as the larger Basidiomycetes which are sometimes difficult to grow in culture, usually grow very slowly and do not grow well on liquid media. For fungi of this kind the preliminary test described below will considerably reduce the experimentation time. Assuming a pure culture of the fungus to have been isolated, this is grown as a plate colony on 20 ml. of its most favourable medium. The most generally useful medium is 2 per cent malt extract in distilled or tap water with 2 per cent agar. When the colony has attained a diameter of about 2–2½ in., which may be anything from one to three weeks after inoculation, it may be tested as follows.

Plates are poured containing 20 ml. of nutrient agar to which has been added a suspension of the bacteria against which the test is to be made. Allow these to cool to between 50° and 45° C., then, with a sterile cork-borer, cut from the colony a disk of mycelium and agar and drop it into the centre of the still warm bacterial agar plate. The disk will settle into the agar and the fungus will appear as if it had originally grown there. Incubate at 37° C. overnight. The following morning, if bacteriostatic substances have been produced, there will be a clear, bacteria-free zone around the edge of the disk.

In order to facilitate comparison with the 'hole' method, the mycelial disks are cut out with the same size of cork-borer, namely, 11 mm. diameter. As the medium in the plate containing the fungus colony is always of standard depth, the mycelial disks are of uniform volume. All disks are cut at approximately the same distance from the edge of the colony. The nutrient agar is made up exactly as in the 'hole' method and the concentration of the bacterial suspension is kept as similar as possible.

The advantage of the above method is that, in our experience, the positive or negative result obtained in the test indicates the type of result to be expected if the fungus were to be grown in liquid culture. This shortens the experiment by approximately a month, as the negative fungi can be eliminated forthwith. The method is applicable to any type of fungus, but it is particularly useful for those with a non-sporing mycelium such as the Basidiomycetes, which have

to be grown by the 'disk-inoculum' method. It amplifies, but in no way supersedes, the method in general use in this Laboratory.

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Influence of Green Food on the Prevention of Piglet Anæmia

PIGLET anæmia is a microcytic hypochromic anæmia which may affect suckling pigs during the first 21–30 days after birth, especially when they are reared in such a way that access to pasture is excluded. The treatments at present adopted aim at supplying an additional amount of iron to the suckling pigs, either by dosing them individually or by allowing them access to a box of soil which is sometimes dressed with a solution of iron salts.

During the winter of 1943–44, investigations were undertaken to determine the possibility of prevention of anæmia in the suckling pigs by adjusting the diet of the pregnant sows. Four sows which had been running at pasture were housed in concrete-floored styes with open concrete-floored runs one month before they were due to farrow. The following ration was fed at the rate of 6 lb. per day during pregnancy and 10 lb. a day during the lactation period: pollards 60 per cent, beanmeal 30 per cent, fishmeal 10 per cent. To this was added 2 per cent of a mineral mixture containing calcium carbonate 35 per cent, bone ash 35 per cent, salt 18 per cent, ferric oxide (comm.) 12 per cent. Two of the sows received, in addition, two plants of marrow stem kale daily. Weaning of the litters was commenced five weeks after birth.

The litters were weighed bi-weekly and the blood of each piglet was examined at frequent intervals. In the accompanying table are shown the average values for one litter in each group at 2 days, 27–28 days and 51 days.

Age (days)	Erythrocytes (10^6 per c.mm.)	Hæmoglobin (gm. per 100 c.c.)	Packed volume (per cent)	Mean Corpuscular Vol. (μ^3)	Mean Corpuscular Hæmoglobin ($\gamma\gamma$)	Mean Corpuscular Hæmoglobin Cone (per cent)
			Group *A* (Kale).			
2	7·01	13·5	50·2	71·6	19·3	26·9
28	5·18	7·0	32·0	61·7	13·5	21·8
51	6·9	11·1	46·5	67·5	16·2	24·0
			Group *B* (no green food).			
2	4·61	9·7	34·8	75·5	21·2	28·0
28	5·3	5·3	24·4	46·0	10·0	21·8
51	6·05	7·8	30·5	50·5	12·4	25·7

The piglets in Group *A* remained free from anæmia while those in Group *B* became anæmic.

A preliminary trial is in progress to determine the nature of the factor or factors in the kale responsible for the effects described above.

The above is a summary of the findings of work financed by a grant from the Agricultural Research Council. It is intended to publish the findings in full elsewhere.

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Viscosity and Contraction of Unstriated Muscle

THERE is a close resemblance between the effects of ions on the protoplasmic viscosity of simple organisms and plants on one hand and their effects on the viscosity of unstriated muscle on the other. The viscosity of the protoplasm in these simple organisms can be measured by standard methods (for literature see ref. 1), but the viscosity of unstriated muscle is measured by comparing it to known viscous-elastic systems[2,3]; the similarity of the effects on simple organisms and on muscle gives an insight into the structure of the latter, and further establishes the validity of the indirect methods for determining its viscosity.

Sodium and potassium increase, and magnesium and calcium decrease, the viscosity of the *interior* protoplasm of the sea-urchin Arbacia, of the protozoa Stentor and Amœba, and of the alga Spirogyra. In the *cortical* protoplasm of Amœba, calcium causes a pronounced stiffening of the cortical gel, and this effect is antagonized by sodium, potassium and magnesium; potassium has the strongest liquefying effect, magnesium the next and sodium has the least action. Potassium loses its liquefying action in acid solution. The effect of acids is increased in the absence of calcium.

The effects noted above were reproduced in studies of the action of ions on the viscosity of Mytilus muscle. If the sodium chloride of the saline is replaced with calcium, magnesium or potassium chlorides, the viscosity is increased in the order Ca > Na > Mg > K. Indeed, potassium is the most powerful agent I have known for decreasing the viscosity; the effect of potassium is completely counteracted if the *p*H of the saline is reduced to 5 – 4·4. The effect of acid is increased in the absence of calcium. If smaller concentrations of potassium are used (0·1 *M* potassium chloride), then sodium and potassium increase the viscosity, and calcium (0·01 *M* calcium chloride) and magnesium (0·03 *M* magnesium chloride) decrease the viscosity, as in the interior protoplasm of Amœba.

These experiments suggest that plain muscle fibres consist at least partly of undifferentiated protoplasm like that of Amœba. The fact that isolated myosin is effected by temperature, alkalis and distilled water[4] in a similar way as isolated living muscle[3], as described previously, suggests that the contractile element of the muscle consists of myosin.

Plain muscle fibres thus consist of (*a*) a viscous element, (*b*) a non-viscous contractile element. This view is in agreement with (1) the differential action of drugs, (2) the visco-elastic properties, and (3) the histological picture of the muscle. Thus calcium decreases the viscosity of both the guinea pig uterus and Mytilus muscle, but causes contraction of the former and relaxation of the latter. Similarly, hydrogen ions increase the viscosity of Mytilus muscle, but may cause relaxation or contraction. Lastly, histologists have described plain muscle

fibres as consisting of fibrils embedded in sarcoplasm. The contractile fibrils may be disseminated throughout the sarcoplasm, or may be collected into a peripheral zone[5].

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Origin of the Planets

THE development of planets from a filament of material formed between two separating stars may not prove so great a difficulty in the theory of the origin of the solar system as is suggested in Dr. Jeffreys' recent letter[1]. It has generally been maintained that the filament would be of such small mass and at such high temperature that its immediate dispersal would occur by lateral expansion. But this view neglects the force field of the two stars transverse to their line of centres, which in the early stages is enormously in excess of the gravitational field of the filament and of enough strength to control thermal velocities due to stellar temperature.

In the lengthwise development, the residual differential attraction of the two stars opposes the self-gravitation of the filament, and to begin with may slightly preponderate, though the two effects are of the same order. At first, pressure differences must urge the matter towards the neutral point, while later the transverse force field of the stars may also be concerned, since during the orbital motion after closest approach their line of centres rotates through more than 90°. The possibility of tidal disruption would not be a fatal objection however, since it is not required that the filament should collect into a single mass. At least three primitive planets must have remained captured by the sun, and possibly others may have escaped, so there seems to be a need for some tendency for the filament to break into a number of masses. But the only worked-out cases of tidal action by stars refer to steady equilibrium forms, and the various forces have unlimited time to operate; such examples do indicate that tidal forces may affect the filament, but they do not enable us to go so far as to say that tidal forces will prevent its gathering into planets.

The situation is in any case much improved as compared with the earlier ideas in that it is sufficient if aggregations form with masses of the order of those of the present great outer planets. There is no necessity for bodies as small as the terrestrial planets to form initially; indeed, the differences of composition of the four inner planets, now ascertained, could scarcely have resulted from simple condensation in the original filament.

There are of course difficulties in the theory, but they are chiefly analytical in nature and are not fundamental inconsistencies involving serious order of magnitude discrepancies. Moreover, the initial hypotheses that lead to material being removed from a star by collision with another, or by rotational instability, have valid observational and theoretical warrant, whereas most proposed alternative starting points are very gravely deficient in this respect. The nebular hypothesis, the planetesimal hypothesis with its bolts shot from the sun, the meteoric swarms, and the lately revived hypothesis of a distended primeval star, all picture initial conditions for the sun that have no support in theory or observation. This is not to say that such hypotheses must be incorrect (though experience shows that they usually are), but they could not be regarded as satisfactory until their connexion with accepted hypotheses had been made clear: that is, until the omitted stages of the theory had been filled in, and this may as well be attempted first as last. Such hypotheses should be preceded by the essential astrophysical investigations demonstrating their legitimacy.

One further point. The central situation of the sun in the solar system is settled by its mass and is not a consequence of the mode of origin of the system. Accordingly, it is not valid to infer from its central position that the sun is necessarily the parent body.

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[1] NATURE, **153**, 140 (1944).

Rate of *n*-fold Accidental Coincidences

THE time-rate of an accidental coincidence (resolving time t) of n Geiger counters with time rates N_1, $N_2 \ldots N_n$, is most easily obtained by classifying the coincidences according to the counter which goes off first. The time rate of each class is obviously $N_1, N_2 \ldots N_n t^{n-1}$, and hence the total time-rate is

$$R_n = n N_1 N_2 N_3 \ldots N_n t^{n-1}, \qquad (1)$$

as indicated by Jánossy[1]. The present derivation shows that the formula is *exact* on the understanding that any two groups fulfilling the requirements are counted separately, even when they differ only by one of the n constituent pulses. But physical counting will as a rule distinguish at best such coincidences as differ with regard to all n constituents. That is how the terms of higher order in t mentioned by Jánossy come in. They are sort of a 'correction for overlapping'.

Let us compute the next approximation. The most frequent kind of 'overlapping' (order t^n) occurs when $n + 1$ pulses (two of them from the same counter, say, from No. 1) crowd, so as to contribute *two* coincidences to (1). There are two possibilities. All the $n + 1$ may fall within an interval t. The time-rate of *this* event is, analogously to (1),

$$n N_1^2 N_2 N_3 \ldots N_n t^n. \qquad (2)$$

But, in addition, the two No. 1 pulses are allowed to have an interval $t + \tau$, greater than t, provided that the others fall in an interval $t - \tau$, situated midway between the two No. 1 pulses. The time-rate of *this* type of event is easily found to be

$$N_1^2 N_2 N_3 \ldots N_n \int_0^t (t - \tau)^{n-1} \, d\tau$$

$$= \frac{1}{n} N_1^2 N_2 N_3 \ldots N_n t^n \qquad (3)$$

The sum of (2) and (3) and of the analogous expressions, with No. 2, No. 3 . . . yielding the double pulse, is the correction to be subtracted on the right-hand side of (1). Hence the *next approximation* reads

$$R_n = n N_1 N_2 N_3 \ldots N_n t^{n-1} \left[1 - \left(1 + \frac{1}{n^2}\right)\left(N_1 + N_2 + \ldots + N_n\right)t\right]. \qquad (4).$$

Note added in proof.—The factor n in (2) is a

'howler', as I discovered thanks to Dr. Jánossy's criticism. From elementary principles it must be $\frac{n-1}{2} + 1 = \frac{n+1}{2}$. In (4) you then get the factor $\frac{1}{2} + \frac{1}{2n} + \frac{1}{n^2}$ in lieu of $1 + \frac{1}{n^2}$.

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[1] Jánossy, L., NATURE, **153**, 165 (1944).

A TREATMENT of the higher order terms of the n-fold accidental rate is given by Prof. Schroedinger. A treatment leading to a slightly different result follows. Assume that pulses of the counters 1, 2, . . . $n-1$ arrive in the time intervals $t_1, t_1 + dt_1$, . . . $t_{n-1}, t_{n-1} + dt_{n-1}$ with

$$0 \leqq t_1 \leqq t_2 \leqq \ldots \leqq t_{n-1} \leqq t,$$

where t is the resolving time. The above pulses together with one from counter n at the time $t_n = t$ give rise to an n-fold coincidence. The probability per unit time of such an event is

$$P = N_n(N_1 dt_1) \cdot (N_2 dt_2) \ldots (N_{n-1} dt_{n-1}) \quad . \quad (1)$$

To obtain a unique classification of the coincidences, we select all those coincidences under (1) for which the pulse of counter 1 in the interval $t_1, t_1 + dt_1$ is the first pulse of this counter to contribute to the coincidence. Both necessary and sufficient conditions for this are that no pulse of the counter 1 should arrive in the interval 0 to t_1. The probability for this is $\exp(-N_1 t_1)$. Imposing similar conditions on the pulses coming from the other counters, one finds,

$$P' = \exp(-N_1 t_1 - N_2 t_2 - \ldots N_{n-1} t_{n-1} - N_n t) \cdot P, \quad (2)$$

where P' is the probability that the pulses from the counters arrive in specified time intervals and that the first pulses from the counters 1, 2, . . . n taking part in the coincidence arrive in a specified order. The total coincidence rate is obtained by integrating over the t_i ($i = 1, 2 \ldots n-1$) and summing over the $n!$ permutations of the counters. We thus obtain

$$R_n = N_1 N_2 \ldots N_n \sum_{\text{perm.}} e^{-N_n t} \int_{0 \leqq t_1 \leqq t_2 \ldots \leqq t} \int \ldots \int_{t_1 = t_2 = \ldots t_{n-1} = 0} P' \, dt_1 \, dt_2 \ldots dt_{n-1}$$

$$= \sum_{\text{cyclic perm.}} e^{-N_n t} (1 - e^{-N_1 t}) \ldots (1 - e^{-N_{n-1} t}) \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For $n = 2$ one finds

$$R_2 = N_1 e^{-N_1 t} + N_2 e^{-N_2 t} - (N_1 + N_2) e^{-(N_1 + N_2) t}.$$

Developing (3) into powers of t one finds,

$$R_n = n \cdot N_1 \ldots N_n t^{n-1} \left[1 - \left(\frac{1}{2} + \frac{1}{2n}\right)(N_1 + \ldots N_n) t\right] + \ldots \quad (4)$$

It is seen that (3) reduces to the expression I gave[1] when neglecting higher powers of t. (The expression for R_n giving the lowest power of t only was also given by Eckart and Shonka[2] some time ago.)

Regarding the practical applications, we note:

(1) In a counter arrangement consisting of n counters, the accidental coincidences are usually due to various overlappings. One has to consider the overlap of a single pulse with a genuine $(n-1)$-fold coincidence; further, one has to consider the overlap of two single counts with a genuine $(n-2)$-fold coincidence, etc. Thus one obtains for the rate of accidental coincidences an expression containing various powers of t. This expression may have no meaning if the higher powers in the terms due to low multiplicities are neglected.

(2) The expression (3) is only valid if the ineffective time following each pulse is short compared to t. In most practical cases, however, the ineffective time will be larger than t. In those cases the expression neglecting higher powers gives the correct rate.

Note added in proof.—The difference between the results as given above and as given by Prof. Schroedinger seems to be connected with the question as to what combination of pulses is recorded as one n-fold coincidence. My picture is as follows. Each pulse sets off the recorder for a time t. Any *connected* period of time for which the recorder is set off by all n counters is counted as 'one coincidence'.

I am indebted to Prof. Schroedinger for an interesting correspondence.

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[1] Jánossy, NATURE, **153**, 165 (1944).
[2] Eckart and Shonka, *Phys. Rev.*, **53**, 752 (1938).

Donnan Membrane Potential

IN a recent communication in NATURE (July 17, 1943, p. 76) I applied the Boltzmann distribution law to the Donnan membrane equilibrium between two compartments, compartment (1) containing colloidal (or non-diffusible) ions plus diffusible ions, compartment (2) containing only diffusible ions. From the equations obtained, it follows that at the same pH of the solution the ratio of the membrane potential (E'_m) for a dibasic acid to the membrane potential (E_m) for a monobasic acid should be

$$\frac{E'_m}{E_m} = \frac{\frac{RT}{N^*F} \cosh^{-1} \frac{3y + z}{3x}}{\frac{BT}{N^*F} \cosh^{-1} \frac{2y + z}{2x}} = 0{\cdot}66 \text{ nearly},$$

where y is the concentration of positive, $y + z$ that of negative ions in compartment (1), x the concentration of positive and negative ions in compartment (2), $N^* = \frac{1}{2}(N_1 + N_2)$, N_1 is the valency of the cation, N_2 is the valency of the anion, and z is *small*. At the same pH value of the solution, z in the case of sulphuric acid is not equal to z in the case of hydrochloric acid. According to Donnan, at the same pH of the protein solution, the value of E'_m/E_m has been given as $\frac{2}{3}$, or 0·66 by Loeb. But this ratio should be 0·66 nearly, since the value of z is different in the two cases.

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Copper Carbonyl : a Correction

RECENTLY[1] we described a volatile compound, traces of which were formed when a variety of specimens of cuprous oxide were heated in carbon monoxide, as a carbonyl of copper. Further experiments have shown that the phenomena observed resulted from adventitious halide present in the oxides used.

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King's College, University of Durham,
Newcastle upon Tyne. April 24.

[1] Robinson and Stainthorpe, NATURE, **153**, 24 (1944).

ACTIVATION OF PYRETHRINS IN FLY-SPRAYS

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MOST mosquito- and fly-control sprays contain pyrethrins, so that, during the present shortage, methods of economizing pyrethrins are of considerable importance. One accepted method of effecting an economy is to add to the spray a small proportion (usually less than 5 per cent) of a material which although not insecticidal in itself yet has the property of making the pyrethrin spray a great deal more effective. Such non-toxic additions are commonly called adjuvants or activators; for example, *iso*-butylundecylenamide[1] and sesame oil[2]. So far as we are aware, this phenomenon of activation has never been explained, and indeed certain observers have experienced difficulty in demonstrating its existence.

We have recently had occasion to examine the efficiency of many spray formulæ containing adjuvants. The method used consisted of exposing the test insect *Aëdes aegypti*, reared under standard conditions, to the spray-mist produced in a cabinet maintained at 28° C. and 70 per cent relative humidity. An Aerograph M.P. paint spray-gun adjusted to produce a finely divided mist served as the atomizer. A sample of the mist mechanically deposited showed that when odourless distillate was sprayed at 0·5 oz. per 1,000 cu. ft., practically no droplets above 7·5 microns in diameter reached the sampling apparatus at the end of the first minute after spraying. The insects were introduced into the cabinet four minutes after spraying, enclosed in paper-walled cages having wide-mesh gauze ends, through which the mist penetrated. They remained in the cabinet for ten minutes.

With the test system outlined we have come to the conclusion that: (1) The four activators tested delay the occurrence of 'knockdown' and so prolong the period of flight through the mist. As the activator content of the spray is increased, within limits there is a progressive increase in the percentage kill recorded, and at the same time a progressive delay in the occurrence of knockdown. These statements may be illustrated by data on *iso*butylundecylenamide.

Insecticide	% Knockdown (min.) 2	4	6	8	10	Av. percentage kill after 24 hr.
Pyrethrins, 0·1 % wt./vol.	10	95	100	100	100	50
Pyrethrins, 0·03% wt./vol.	5	20	97	100	100	20
Pyrethrins, 0·03% wt./vol.; *Iso*butylundecylenamide, 0·50% wt./vol.	0	10	40	95	97	27
Pyrethrins, 0·03% wt./vol.; *Iso*butylundecylenamide 1·50% wt./vol.	0	5	15	75	95	55

(2) The insect picks up its dose of insecticide by impaction with the spray droplets during its period of flight through the mist. Since this is the case, the delay in the occurrence of knockdown gives the insect a greater chance of picking up a heavy dose of insecticide. The importance of flight through the mist is confirmed by two observations. Insects in the following conditions were exposed to the spray mist simultaneously: (*a*) not chloroformed; (*b*) chloroformed and recovered; (*c*) chloroformed but wings were removed before recovery; (*d*) chloroformed—still motionless when exposed. Unsprayed chloroformed controls all recovered.

State of insects	Average percentage kill after 24 hr.
Not chloroformed (*a*) ..	62
Chloroformed and recovered (*b*)	58
Wingless (*c*)	13
Under chloroform (*d*)	12

The low kill with the walking (wingless) and motionless insects will be noted in comparison with that of flying insects. (Another possible suggestion, which is, however, largely discredited by observation 3, is that there was greater intake of spray mist through the spiracles of the flying insects due to increased respiratory exchange.

(3) The rate of movement of the insect in relation to the droplet and the relative momenta are important. The test procedure was modified so that the spray mist moved past insects which had been chloroformed at known speeds. The same total volume of atmosphere was passed over the insects in the two cases below.

Wind speed m.p.h. (approx.)	Average percentage kill after 24 hr.
0·3	8
3·0	97

(4) Activation of sprays by adjuvants can be demonstrated by the method outlined in (3) above. Here the insects do not fly through the mist, hence prolongation of the period of flight (discussed in (1)) is not the only factor in activation.

Insecticide	Average percentage kill after 24 hr. (wind speed 3 m.p.h. approx.)
Pyrethrum, 0·10% wt./vol. ..	96
Pyrethrum, 0·05% wt./vol. ..	53
Pyrethrum, 0·05% wt./vol.; activator, 5·00% wt./vol.	100

In the above table the activator may be either sesame oil, *iso*butylundecylenamide or lubricating oil; in all cases the kill obtained was 100 per cent.

(5) All the above-mentioned activators have a very marked effect on the particle size and persistence of the insecticidal mist. This is due not to the slight effect on the degree of atomization originally produced at the spray-gun nozzle, but to the fact that all the activators are substances of low vapour pressure, so that they persist when the more volatile carrier has evaporated. A comparison of non-activated and activated mists mechanically deposited ten minutes after spraying from an atmosphere dosed with approximately 0·5 oz. per 1,000 cu. ft. shows that, whereas the former contains few droplets per litre 5 microns or bigger, with an activated spray mist there are very many thousands. Further measurements of size and persistence are being made, and at this stage satisfactory figures cannot be given.

(6) Following the observation of the effect of an activator on particle size, it was expected that many substances of low vapour pressure would show this kind of activation. This has been found to be the case with olive oil, oleic acid, sesame oil free from sesamin and lubricating oil, for example.

Insecticide	Average percentage kill in 24 hr.
Pyrethrins, 0·05% wt./vol. ..	12
Pyrethrins, 0·10% wt./vol. ..	65
Pyrethrins, 0·50% wt./vol.; oleic acid, 5·00% v./v. ..	89
Pyrethrins, 0·50% wt./vol.; olive oil, 5·00% v./v. ..	73
Pyrethrins, 0·50% wt./vol.; lubricating oil, 5·00% v./v.	80
Pyrethrins, 0·50% wt./vol.; sesame oil free from sesamin, 5·00% v./v.	81

From the cabinet tests there seems to be little doubt that two of the factors which contribute to activation are (1) prolongation of the period of flight through the mist; (2) increased persistence of droplets of the order of 10 microns in diameter.

This physical explanation of activation does not cover the whole of the facts. For example, the observation of Haller *et al.*[3] that pure sesamin at 0·2 per cent is capable of acting as an effective activator against the housefly, whereas certain allied substances fail, is not covered.

We have been able to show activation against *Aëdes aegypti* with pure sesamin and, as mentioned earlier, with desesaminized sesame oil. The occurrence of knockdown is also delayed by pure sesamin.

Insecticide	%Knockdown (min.) 2	4	6	8	10	Av. percentage kill after 24 hr.
Pyrethrins, 0·05% wt./vol.*	2	40	95	100	100	36
Pyrethrins, 0·05% wt./vol. + Sesamin 0·20% wt./vol.*	0	20	60	95	100	75

* Both dissolved in 10/90 v./v. mixture of acetone and kerosene.

When sesame oil, *iso*butylundecylenamide or lubricating oil is used in the spray formula, the resulting droplets after evaporation consist of a solution of pyrethrins in a medium which is considerably more viscous than that resulting from an unactivated spray. They are also less concentrated. It was originally thought that the higher viscosity and lower concentration of pyrethrins in the droplets (resulting from the activated spray) delayed the penetration of pyrethrins and so the occurrence of knockdown. However, this explanation does not account for the delaying effect shown by sesamin and so probably has little validity.

When a spray droplet evaporates, non-volatile insecticides persist as sub-microscopic particles, as may be shown by spraying a dyed oil and mechanically depositing the resulting mist after four minutes. A cloud of dye, unassociated with oil, is obtained. Under suitable conditions the particles which persist when using any of the activators mentioned here, except sesamin, are of the order of 1–10 microns, and within this range impaction occurs at lower velocities. It appears that there is an optimum final droplet size for securing a maximum kill. If the droplet is too small, impaction with the insect does not take place; whereas if it is too large, the toxic principle is rapidly lost from the air space by sedimentation. Here it may be noted also that, for a given activator content of the spray, the final droplet size will depend upon the size of the particles produced by the atomizer. Theoretically, therefore, it would be expected that for an atomizer giving a coarse spray a lower activator content would be required than for a fine spray, since after evaporation the coarse spray leaves a residual droplet which may be so large that it will be rapidly lost by sedimentation.

At the time of writing we have some evidence that activation becomes more apparent as the degree of atomization produced by the gun increases. Finally, it is perhaps worth emphasizing that only *Aëdes aegypti* has been employed in these tests, and that the conclusions may not hold good for other insects.

This work is being carried out under a grant from the Medical Research Council.

[1] Weed, A., *Soap*, **14**, No. 6, 133 (1938).
[2] Eagleson, C., *Soap*, **18**, No. 12, 125 (1942).
[3] Haller, La Forge and Sullivan, *J. Econ. Ent.*, **35**, 247 (1942).

THE CEDAR TREE

By ALEXANDER L. HOWARD

ALTHOUGH the cedar tree is not indigenous to Great Britain, it has been established so long and has become a peculiar and ornamental feature of our parks around country houses, churches, and rectories, and so much admired that its absence would be a grievous loss. It is safe to affirm that up to seventy years ago very many thousands of trees could be counted throughout the country. During this period many have been destroyed, blown, or cut down, and it would be difficult to count up to four figures the numbers which have been replanted. Unfortunately, in too many cases a little cedar tree was planted close to the house, the original owner failing to recognize that the time would come, and that soon, when the cedar tree would top the house, so that additional loss has been caused by so many fine trees of this character having to be sacrificed.

The cedar is reared with difficulty. Many years ago the capable gardener at Mill Hill School told me that it had taken him several years—I think from six to nine—before he had been able to raise one tree from the well-known Linnean cedars there. William Boutcher in "A Treatise on Forest Trees", dated 1776, says:

"The way that was first practised for procuring their seed, was by splitting the cones length-ways through the centre, with a sharp piece of iron, and to pick them out with your fingers, which may be easily done, after the cones have been exposed some hours before a warm fire. Should the cones be two years old, they will emit their seed more freely than when just gathered, and the seed equally good.

"The best soil to raise these plants in, is that of a rich old cow pasture, which, if not naturally of a light quality, must be mixed with a fourth or fifth part of sea-sand, or that taken from the sides of rivulets, to be well blended together for some months, before it is used. I have already mentioned that this tree will not require any attention after it has arrived to the age of three or four years, nor is it very delicate from the beginning; yet at the same time, it is absolutely necessary to give them abundant nourishment at first, in order to raise a fair and vigorous plant; for if they once become dwarfish, stunted, or to lose their leading shoot, no art will be possible ever afterwards to restore them to a good figure."

Strutt says, in 1830, while mentioning that the cedar has not been much cultivated in England until of late years:

"its quick growth and its capability of thriving in a meagre soil, renders it peculiarly desirable for those bleak and barren situations which have hitherto been principally devoted to the fir. The frequent and solemn allusions to the Cedar in Holy Writ, seem to give it something of a sacred character; which is increased by a knowledge of the esteem in which it was held by the ancients, on account of its fragrant scent, its incorruptible nature, and above all its durability, insomuch that it is recorded that in the Temple of Apollo at Utica, there was found timber of Cedar nearly 2,000 years old."

From the financial aspect, no satisfactory result can be expected, and suitable sites for planting will be increasingly difficult to find. Only an enthusiastic desire on the part of those who might be able to re-afforest the country with this noble tree can prevent its final disappearance.

There is only one true cedar.

Quoting from "Timbers of the World":

"Under this commercial name (cedar) a motley collection of woods is included. In the first place comes the true cedar, a coniferous genus, Cedrus, of which there are three species or varieties: the cedar of Lebanon, the deodar, and the Mount Atlas cedar. Another coniferous type, the Port Orford cedar (*Cupressus Lawsoniana*), should more correctly be termed a cypress, for the tree is familiar in gardens under the name of Lawson's cypress. The pencil cedars, being the wood of several American species of Juniperus, are truly junipers and likewise conifers. All these woods possess a very fragrant scent. It is not surprising that the name cedar has popularly, and hence commercially, been attached to the cigar-box, a West Indian wood derived from a tree (*Cedrela odorate*) which is in no way allied to Cedrus but is a member of the mahogany family (Meliaceae). Other species of Cedrela, including the Indo-Australian *C. Toona* and *C. australis* and the Paraguayan cedar *C. braziliensis*, are more or less fragrant and receive the name cedar.

"The wood of Cedrela in many respects resembles mahogany, and has to some extent similar characteristics, so that the name has been extended to various American, African, etc., woods, which more or less resemble in appearance those of Cedrela, though not necessarily possessing any fragrance or strong scent. Some of the woods belong to the mahogany family, some do not, while the sources of still others are unknown. Then again there is in British and Dutch Guiana the so-called cedar, the product of *Protium altissimum*. The tree is not a cedar, nor has it any of the characteristics, and it is entirely without the fragrant scent usually associated with that wood.

"Further confusion arises owing to the fact that between mahogany and cedar woods of the Cedrela type there exist transitional forms, which are termed mahoganies or cedars according to the will of the vendor."

There are three different kinds of true cedars belonging to the genus Cedrus. The differences between them are so slight and fluctuating that all three are frequently included under one botanical name, *C. Libani*; sometimes, however, each is given a separate name. All are mountain trees; the first-named growing on Mount Lebanon, in Cyprus, and the Orient; the second being Himalayan, and the third African and growing on the Atlas Mountains. All these are grown in English gardens. The timbers of the three kinds are almost indistinguishable. An easy way of identifying the varieties has been mentioned to me, though it should be taken as general and not absolute: L. for Libani, l. for level (the branches extend from the tree in a more or less horizontal manner); D. for Deodar, d. for drooping (the branches generally droop); A. for atlantica, a. for ascending (the branches generally slope upwards).

Besides the references to cedar wood in the Bible, and in the earliest Greek and Roman writings in their poetry and prose, Pliny says:

"As for Cedars, the best simply be those that grow in Candie, Affricke, and Syria. This virtue hath the oil of Cedar, that if any wood or timber be throughly anointed therewith, it is subject neither to worm nor moth, ne yet to rottenness. The Juniper hath the same properties that the Cedar. They prove in Spain to be exceeding big and huge, the berries also greatest of all others. And wheresoever it groweth, the heart thereof is more found than the Cedar. . . .

. . . "the kings of Egypt and Syria, for default and want of Fir, have used (by report) instead thereof Cedar wood about their shipping. And verily the voice goeth of an exceeding big one which grew in Cyprus, and was cut down for a mast to serve that mighty galleace of king Demetrius, that had eleven bankes of oares to a side; a hundred and thirty foot it was high, and three fatham thick. And no marvel, since that the pirates and rovers who haunt the coasts of Germanie, make their punts or troughs of one entire piece of wood and no more, wrought hollow in manner of a boat, and some one of them will hold thirty men."

Although we have evidence that some of the wood of the true cedar was actually used, it is probable that by far the greater number referred to other scented woods. No greater confirmation of the above confusion over the name can be advanced than the interesting and informative remarks contained in Pliny's Discourse. He says:

"The great Cedar, called by the Greekes Cedrelate, as one would say, the Fir-Cedre, yieldeth a certain pitch or paraffin named Cedria, a singular medicine for the tooth-ache; for it breaketh them, fetcheth them out of the head and easeth all their pain. . . . This kind of pitch were excellent for the eyes but for one discommoditie, in that it causeth headache. It preserveth dead bodies from corruption, a world of years: contrariwise, living bodies it doth purifie and corrupt. A strange and wonderful propertie, thus to mortifie the quicke, and quicken (as it were) the dead. It marreth and rotteth apparell, as well linnen as woollen: and it killeth all living creatures."

And further:

"Also the Phœnicians have a lesse kind of Cedars much like to the Juniper; and two sorts there be thereof, the Lycian and the Phœnician, which differ in the leafe: for that which hath an hard, sharpe, and prickie leafe, is called Oxycedrus: full of branches it is besides, and so knurrie, that it is troublesome to the hand. As for the other Cedar, it hath an excellent smell. . . . And the timber of it is everlasting: wherefore in old time they were wont to make the images of the gods, of this wood, as it appeareth by the statue of Apollo Sofianus, made of Cedar wood, brought from Seleucia. In Arcadia there is a tree like the Cedar, but in Phrygia it is called a shrub."

We might be in doubt, since Pliny describes the tree, using the word "fir", but afterwards he speaks of "berries" and "fruit", which while it is a true description of the foliage, is not a description of the cones of cedar of Lebanon. It is possible that the translation from Pliny's Latin to our language explains the point, as Strutt in his "Sylva" sets all doubts at rest when he refers to cedar of Lebanon and further says:

"It entered largely into the construction of the most celebrated buildings of antiquity; and in the glorious Temple of Solomon it seems to have been recorded of it, as one of its proudest boasts, that 'all was Cedar; there was no stone seen'.

Elwes says the cedar was introduced into England during the seventeenth century, and quotes Loudon "who held the Cedars at Chelsea mentioned . . . in England". But he says further that Mr. Challis informed him that he counted 236 rings on the Hammersmith tree when fallen, which would date the introduction back to 1638. Strutt mentions the Hammersmith Cedar, which at the time he wrote measured 16 ft. 6 in. in circumference at the ground, 59 ft. in height, and branches covering an area of 80 ft.

According to Dr. Hunter in his notes in Evelyn's "Silva":

"The trees in the Apothecaries Garden at Chelsea were planted in 1683. In 1774 they had attained a circumference of 12½ feet at 2 feet from the ground, while their branches extended over a circular space 40 feet in diameter. 27 years afterwards the trunk of the largest one had increased more than ½ ft. in circumference: this shows the quickness of its growth in proportion to that of the Oak, which in the same period would probably not have made half that progress."

Strutt says:

"The Enfield Cedar stands in the garden of the Manor House, or old Palace in Enfield, the occasional retirement of Queen Elizabeth before she came to the throne, and the frequent scenes of her royal pleasures afterwards, in the early part of her reign. In the year 1660 it became the residence of the learned Dr. Uvedale, master of the Grammar School of Enfield at that time, and famous for his curious gardens and choice collection of exotics. The Cedar, which is now perhaps the largest in the kingdom, was put into the ground by him, a plant brought direct from Mount Libanus. In 1779 it measured 14 ft. 6 in. at the base, and 45 ft. 9 in. in height, 8 ft. of the upper part having been broken off by a high wind in 1703. The principal branches extended in length from the stem from 28 to 45 ft., and the contents of the tree, exclusive of the boughs, was about 293 cubic feet. In 1821, Dr. May, its present proprietor, and the master of the Grammar School at Enfield, took its measurement, which was as follows: 17 ft. in circumference at 1 ft. from the ground, 64 ft. in perpendicular height, and containing 548 cub. ft. of timber, exclusive of the branches, which from north-east to south-west extend 87 ft. and contain about 250 ft. of timber, making in the whole nearly 800 ft. of timber."

A remarkable cedar (*Cedrus Libani*) at Brockett Hall, in full vigour of life, measures 18 ft. in circumference, with fine healthy bark to the height of 20 ft., where it branches out with huge limbs. The total height is 80 ft., and from the crown there are nine branches averaging 35 ft. long, each 4–5 ft. in circumference, giving a roof span of 62 ft. It is a beautiful specimen, having regard to its great age. At Brockett Hall there are 85–90 cedars in the Park, of which 45 or more are *C. Libani*, 2 *C. Deodara*, and about 40 *C. atlantica*.

The Rev. C. A. Johns gives an interesting account of the introduction of the cedar tree into France, as follows:

"Many years ago a Frenchman, who was travelling in the Holy Land, found a little seedling among the Cedars of Lebanon, which he longed to bring away as a memorial of his travels. He took it up tenderly, with all the earth about its little roots, and, for want of a better flower-pot, planted it carefully in his hat, and there he kept it and tended it.

"The voyage home was rough and tempestuous, and so much longer than usual, that the supply of fresh water in the ship fell short, and they were obliged to measure it out most carefully to each person. The captain was allowed two glasses a day, the sailors, who had the work of the ship on their hands, one glass each, and the poor passengers but half a glass. In such a scarcity you may suppose the poor Cedar had no allowance at all. But our friend the traveller felt for it as his child, and each day shared with it his small half glass of precious water; and so it was, that when the vessel arrived at the port, the traveller had drunk so little water that he was almost dying, and the young Cedar so much that, behold, it was a noble and fresh little tree, six inches high!

"At the Custom-house the officers, who are always suspicious of smuggling, wished to empty the hat, for they would not believe but that something more valuable in their eyes lay hid beneath the moist mould. They thought of lace, or of diamonds, and began to thrust their fingers into the soil. But our poor traveller implored them so earnestly to spare his tree, and talked to them so eloquently of all that we read in the Bible of the Cedar of Lebanon, telling them of David's house and Solomon's temple, that the men's hearts were softened, and they suffered the young Cedar to remain undisturbed in its strange dwelling. From thence it was carried to Paris, and planted most carefully in the Jardin des Plantes. . . . The Cedar grew larger and larger, and became the noblest tree there."

Those who have only seen cedars in England, or even been fortunate enough to have visited Mount Lebanon, can have no conception of the glory of these trees in the Himalayas. The late Sir George Hart, inspector-general of forests, made a wonderful collection of pictures, some of which I have. The wealth and magnificence of the cedars in the Himalayas is beyond description: the measurement of some is recorded by J. S. Gamble, who says of the deodar that it is the principal timber tree of the Himalayas, and quotes Thomson ("W. Him. and Tibet"), who mentions:

"One near Nachar on the Sutlej that had 35½ ft. in girth. Brandis mentions trees in Kunawar that had 30 to 36 ft. in girth; Dr. Stewart measued one at Kuarsi, in the valley of the Ravi, that was 44 ft. at 2 ft. and 36 ft. at 6 ft. from the ground, and another was ascertained to be 34½ ft. in girth, and to be about 900 years old. Minniken records a tree at Punang in Bashahr that was 150 ft. high, and had a girth of over 36 ft., the clean bole height being 45 ft. The great section in the corridor of the Imperial Forest School at Dehra Dun shows 23 ft. in girth and 665 annual rings, equivalent to about 13 rings per inch of radius; it came from the Gokul Forest in Tehri-Garhwal, and was cut by Mr. E. M. Moir. In the Moriru Forest in the Tehri-Garhwal Leased Forests, I measured in 1898 a stump—or rather shell, for the interior had decayed—that was 34 ft. in girth; while not far off, in Dumrali Block, a dry fallen tree was unearthed, 90 ft. long, and over 7 ft. in diameter at base. It had been dead for at least 100 years, and was, when it fell, probably 550 years old. . . . Aitchison mentions a tree in the Kuram Forests 22 ft. in girth and 150 ft. high. Schlich found a tree in the Sutlej Valley 240 ft. high; and W. R. Fisher tells me he saw one of 216 ft. in the Bashahr forests of the Pabar Valley."

From earliest times history continues to emphasize the high value placed on the tree and the wood of the cedar of Lebanon which the writings of the Greeks and Romans have handed down to posterity. The beauty of the tree is referred to over and over again in verse and prose, while the usefulness and durability, and the chemical properties, are emphasized. It is curious to notice that in spite of what was within our knowledge and that we have been familiar with the tree in Great Britain for three hundred years, the former of these qualities has been only partially recognized, while the latter has been entirely ignored.

The wood forms a good medium for decorative furniture and panelling. The preference shown by architects and principals unfortunately excludes twisted grain and sound knots, which being admitted give admirable character and variety to the finished work. The trees imported from North Africa and India contain less knots and twisted grain, thus producing a larger proportion of clean boards. All three varieties mixed show no apparent difference and are equally aromatic and durable.

The cedars in the Apothecaries Garden, referred to earlier, were made use of for the manufacture of three chairs for the use of the master and wardens of the Apothecaries Company, and are still in regular use. They were exhibited at the Empire Timber Exhibition at Holland Park in 1920, and were greatly admired by all who saw them.

The Rev. C. A. Johns says:

"the value of the timber of the Cedar, as a building material, is now thought to have been over-rated by the ancients. It is reddish white, with streaks, and does not seem to be much harder than deal. It is sweet-scented only for the first year after its being felled: it soon begins to shrink and warp, and is said to be by no means durable. But

this is rather the character of English-grown Cedar than of timber which has come to maturity in its native mountains."

I do not find that I often differ from Johns, but in this case I am afraid that he is quite wrong. The quality and durability of English-grown cedar is in every way as good as that produced elsewhere, and the aromatic scent is persistent—undeniable facts which can be proved.

The forests of cedars on Mt. Lebanon, which were known to the civilized world nearly two thousand years ago, have gone. The Rev. C. A. Johns, in 1849, quotes Maundrell as follows, who measured the largest cedar on Mt. Libanus :

"I found it 12 yards 6 inches in girth and yet sound, and 37 yards in the spread of its boughs."

To-day the traveller would have difficulty in counting a score still remaining. This is a terrible illustration of the destruction of forests with the march of civilization. From every quarter of the globe, whichever way we turn, we are confronted with the same story.

Dr. Fosdick, in a book entitled "A Pilgrimage to Palestine", says, speaking of the country between Samaria and Galilee, and the Plain of Sharon by the sea :

"Whether or not there used to be more trees upon these hills than now has often been discussed, but I do not see how anyone can doubt it. In this last war alone (1914–1918) it is estimated that 40 per cent of all the olive trees in Palestine were cut down for military purposes. To say nothing of the locusts, two great enemies of the trees have ravaged the land for centuries—Militarists and goats. . . . When Pompey came to take Palestine for Rome, the record says that he cleared away the trees, and Josephus tells us that Titus cut down every tree within ten miles of Jerusalem. . . . Even in the Lebanons they are finding boundary stones set by Hadrian's foresters—I saw one in Beirut—where to-day only bare mountains remain. The forest of Hereth, where David hid, is gone ; there is no forest of Bethal to shelter bears to-day ; Kiriath-jearim, which means 'city of forests', would have no excuse now for such a name, and the woods of Sharon, which Strabo called 'a great forest', and which once stretched from the valley of Ajalon up to Mount Carmel, now have few relics of their ancient glory."

We should indeed be a decadent people if we allowed a thing of such beauty and interest as the cedar tree to vanish from our landscape.

ANTIBACTERIAL SUBSTANCES IN GREEN PLANTS

FROM the earliest times, writes E. M. Osborn (*Brit. J. Exp. Path.*, 24, 227 ; 1943), plants have been used in the attempt to cure disease. After giving a brief summary of recent work on the well-known occurrence of antibacterial substances in green plants, he records the results of his own investigation of about 2,300 different green plants, most of them flowering plants. All the plants used were freshly picked and all available parts of them were tested. The method of testing used was the diffusion method of Abraham and other Oxford workers (*The Lancet*, ii, 177 ; 1941), the antibacterial substance being tested against *Staphylococcus aureus* and *Bacterium coli*. The test shows only the presence or absence of the antibacterial substance and is not quantitative. A negative result does not necessarily prove the absence of the antibacterial substances, and the possibility of their destruction by enzymes must also be remembered.

At the time when this paper was written, antibacterial substances had been found in sixty-three genera of plants belonging to twenty-eight families. Extracts from plants belonging to the same families tend to show similar specificity and potency. Inhibiting substances are distributed throughout some plants (for example, *Asarum europæum* (Asarabacca)). In others their distribution is restricted. There is more of them in the seeds of *Brassica oleracea* (cabbage) than in other parts of this plant, and they were found only in the bark of *Magnolia acuminata*. This restricted distribution, together with differences in method of testing, may account for some negative results obtained with plants from which other workers have obtained bactericidal effects (for example, *Chelidonium majus* (greater celandine) and the turnip and horse radish). In many plants the inhibitory substances are produced by enzyme action ; for example, *Plumeria bicolor*, *Cheiranthus cheiri* (wallflower) and *Crepis taraxacifolia* (hawk's-beard). In some instances the inhibitory substance is produced by the action of an enzyme situated in one part of the plant on an inactive precursor situated in another part of it. The drying of some plants causes loss of inhibitory power, for example, Clematis, Anemone, Ranunculus ; but the drying of others does not (for example, *Crepis taraxacifolia* (hawk's-beard), *Reseda lutea* (wild mignonette) and *Asarum europæum*). Certain well-known drug plants (Atropa, Datura, Digitalis) show no inhibitory power against the organisms used, nor do many plants recommended by herbalists.

A table shows the species from which "frankly positive" results were obtained. A feature of it is the activity of the Ranunculaceæ tested, some of which (for example, Anemone, Clematis, Helleborus and Ranunculus) inhibit both *S. aureus* and *Bact. coli*. Extracts of some plants inhibit only *S. aureus*. Two of the plants tested were specific against *Bact. coli*. A full list of the species tested and the results obtained may be obtained from the Sir William Dunn School of Experimental Pathology, Oxford, and a similar list has been deposited in the archives of the Royal Society at Burlington House, London.

FREQUENCY PERFORMANCE OF QUARTZ PLATES

AN article by W. P. Mason (*Bell Lab. Rec.*, 22, No. 6 ; February 1944) discloses some of the results of researches carried out to determine the frequency performance of quartz plates cut and oriented in a variety of ways. The natural frequencies depend largely on the plate dimensions and orientation with respect to the faces and angles of the original crystal, and on temperature.

Rectangular co-ordinates x, y, z, were used for specifying the manner of cutting. The z, or optical axis, runs vertically up the centre of the hexagonal prism assumed by the crystal ; the y, or mechanical, axis is taken perpendicular to any one of the three pairs of opposite faces ; and the x, or electrical, axis runs horizontally through opposite edges of the crystal. The first crystals used were known as x-cut and y-cut. Both have their width parallel to the

z-axis, but the x-cut has its face perpendicular to the x-axis and its length parallel to the y-axis, while the y-cut has its face perpendicular to the y-axis, and its length parallel to the x-axis. For the x-cut crystal the voltage is applied along the electrical axis, and the vibration occurs parallel to the mechanical axis; the frequency is a function chiefly of the crystal length. For the y-cut crystal, the voltage is applied along the mechanical axis; voltages appear along this axis when the applied pressure is at 45° to the mechanical and electrical axes, and thus, when voltage is applied along the y-axis, the vibration is one of shear.

The factors that make it desirable to seek other forms of cuts may be illustrated with the x-cut crystal in which, when voltage is applied along the electrical axis, the vibration is along the mechanical axis. Motion along the electrical axis also gives a displacement of charge along the electrical axis, and thus the x-cut crystal could vibrate in either direction; but the vibration frequency, which will be determined chiefly by the dimension of the crystal in the direction of its vibration, will be much lower when the vibration is along the y-axis than when it is along the x-axis. As used, a voltage frequency was applied corresponding to the length vibration, and thus was comparatively low. If an effort were made to use the crystal for a high frequency, utilizing vibration along the x-axis, difficulties would occur because harmonics of the y-axis frequency might be very close to the x-axis frequency, and slight changes in conditions might cause the controlling vibration to shift from that of the x-frequency to a harmonic of a y-frequency.

The most common of such changes of conditions is the temperature, since the frequency of the x-cut crystal, and of the y-cut, is very sensitive to temperature changes. With a crystal of zero temperature coefficient, the frequency can be held to almost negligible variations by maintaining the crystal at the proper temperature. Accurate temperature control apparatus, however, is necessary when high constancy of frequency is desired. It would be very desirable if a crystal cut were available that had a zero temperature coefficient over a wide range of temperature, since this would make temperature control unnecessary over this range. Search for such a cut resulted in a crystal having a temperature coefficient essentially zero from 0° to 100° C. The various cuts, besides giving the temperature characteristics desired, are also selected, and the dimensions of the crystal chosen, so that there will be only one mode of vibration of fundamental or harmonic frequency in the neighbourhood of the frequency at which the crystal is to be operated.

THE 'MICROTIMER'

AN electronic timing device called the 'Microtimer' has been produced by R. K. Dundas, Ltd., The Airport, Portsmouth. This measures the time interval between the making, or alternatively, the breaking, of two electrical contacts, or between any other combination of contacts. In addition it may be operated, without contacts, by a suitable valve amplifier in conjunction with, for example, a photo-electric cell. The time indication is given by the position of a pointer moving over the dial of a meter, and the standard instrument has ranges covering 10 to 1,000 milliseconds for full-scale deflexion. It operates entirely from the standard A.C. mains, although a battery model is available. Tests show that the instrument has negligible zero drift, is simple to calibrate and use and is of rugged construction. After taking a measurement, the deflexion of the meter is maintained for several minutes without appreciable drift; throwing a switch brings the meter back to zero for the next measurement. The accuracy claimed is within $\pm$ 2 per cent of the full scale deflexion on any range, even allowing for violent changes in mains voltage or changes of the valves.

The principle of the circuit, which incorporates patented features, may be briefly described. A condenser is charged up from the high-tension supply, and at the beginning of the interval to be timed, the energy in this condenser is allowed to flow through a constant-current pentode valve into a precision condenser. At the end of the timed interval this current is stopped, and the voltage which has been built up across the precision condenser is measured by means of a high-impedance valve voltmeter, to which the output meter is connected, this meter being, of course, calibrated in milliseconds. A voltage stabilizer in the high-tension supply and the provision of considerable negative-feedback assist in maintaining the accuracy of calibration and freedom from drift.

The 'Microtimer', although designed as a laboratory instrument, may be readily operated in routine work by unskilled personnel, and may have a large variety of applications, such as timing the operation of relays, switches, fuses, contact breakers, camera shutters and automatic machinery of all kinds, and in radio, physical and explosives research.

FORTHCOMING EVENTS

Monday, May 15

ROYAL COLLEGE OF SURGEONS OF ENGLAND (at Lincoln's Inn Fields, London, W.C.2), at 4 p.m.—Prof. John Beattie: "Clinical Aspects of Methionine Metabolism".

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 5 p.m.—Dr. Olaf Devik: "The Formation of Ice in Lakes and Rivers".

INSTITUTION OF ELECTRICAL ENGINEERS (LONDON STUDENTS' SECTION) (at Savoy Place, Victoria Embankment, London, W.C.2), at 7 p.m.—Annual General Meeting.

Tuesday, May 16

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 1.30 p.m.—Lieut. Bernard Mishkin: "The Indians of the Andes".

Wednesday, May 17

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

ROYAL COLLEGE OF SURGEONS OF ENGLAND (at Lincoln's Inn Fields, London, W.C.2), at 4 p.m.—Prof. John Beattie: "Clinical Aspects of Methionine Metabolism".

ZOOLOGICAL SOCIETY OF LONDON (at Regent's Park, London, N.W.8), at 4.30 p.m.—Exhibition of a Soviet Film on "Animal Life in the Kara-Kum Desert", with commentary by Dr. Edward Hindle, F.R.S.; Dr. Ruth Deansley: Demonstration of the Breeding Habits and Life-cycle of *Xenopus*; Mr. G. P. Wells: "The Parapodia of *Arenicola marina* L. (Polychæta)".

INSTITUTION OF ELECTRICAL ENGINEERS (WIRELESS SECTION) (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. R. B. Armstrong and Mr. J. A. Smale: "High Speed Recording of Radio-Telegraph Signals".

INSTITUTE OF WELDING (joint meeting with the INSTITUTE OF THE PLASTICS INDUSTRY) (at the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1), at 6 p.m.—Dr. J. H. Paterson: "The Welding of Plastics".

BRITISH INSTITUTION OF RADIO ENGINEERS (MIDLAND SECTION) (at the University (Latin Theatre), Edmund Street, Birmingham), at 6.30 p.m.—Dr. Emrys Williams: "Relaxation Oscillators and Trigger Circuits".

Thursday, May 18

ROYAL SOCIETY OF ARTS (DOMINIONS AND COLONIES SECTION) (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Mr. H. C. Waite: "African Art".

ELECTRICAL ASSOCIATION FOR WOMEN (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 2 p.m.—Annual General Meeting.

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the PLASTICS GROUP and the BIRMINGHAM AND MIDLAND SECTION) (at the Chamber of Commerce, New Street, Birmingham), at 2.30 p.m.—Dr. J. Hofton: "Amino Resins".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. F. G. Mann: "Some Aspects of the Organic Chemistry of Phosphorus and Arsenic" (Tilden Lecture).

INSTITUTE OF FUEL (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. R. H. Anderson, Mr. D. C. Gunn and Dr. A. L. Roberts: "Uses of Permeable Refractories for Furnace Construction".

Friday, May 19

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 4.30 p.m.—Dr. H. S. Souttar: "Team Work in the Treatment of Cancer" (Twenty-first Mackenzie Davidson Memorial Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS (MEASUREMENTS SECTION) (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Dr. L. Hartshorn: "Foundations of Electrical Measurements".

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Prof. G. V. Lomonossoff and Capt. G. Lomonossoff: "Condensing Locomotives".

Saturday, May 20

NUTRITION SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 10.50 a.m.—Conference on "Budgetary and Dietary Surveys of Families and Individuals", Part 2 (to be opened by Prof. V. H. Mottram, Mrs. Barbara Callow, Dr. C. P. Stewart and Miss M. C. Broatch).

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 2.30 p.m.—Annual General Meeting; at 3.15 p.m.—Prof. S. Russ: "The Man Silvanus Thompson" (Twenty-third Silvanus Thompson Memorial Lecture).

INSTITUTE OF PHYSICS (joint meeting of the INDUSTRIAL RADIOLOGY GROUP and the MANCHESTER AND DISTRICT BRANCH) (in the Physics Department, The University, Manchester), at 2.30 p.m.—Mr. C. T. Snushall: "Filters and Intensifying Screens—their Applications in Light-Alloy Radiography".

APPOINTMENTS VACANT

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

GRADUATE ASSISTANT MISTRESS to teach CHEMISTRY and PHYSICS to School Certificate and Higher School Certificate standard, at the Plymouth High School for Girls, and an ASSISTANT MASTER qualified to teach PRACTICAL PLANE AND SOLID GEOMETRY for Engineering and Building Courses, at the Plymouth Junior Technical School for Boys—The Director of Education, Education Offices, Cobourg Street, Plymouth (May 18).

EDUCATIONAL PSYCHOLOGIST (man or woman)—The Director of Education, Education Department, Town Hall, Crouch End, London, N.8 (May 20).

TEACHERS (with Graduate or equivalent qualifications) IN ENGINEERING AND BUILDING SCIENCE, ENGINEERING WORKSHOP SUBJECTS and TECHNICAL DRAWING (Engineering and Building), at the Wolverhampton Technical High School—The Director of Education, Education Offices, Wolverhampton (May 20).

LECTURER IN BIOLOGY (to give assistance with Chemistry), and a LECTURER IN CHEMISTRY (to give assistance with Biology or Physics), at the Hull Municipal Technical College—The Director of Education, Guildhall, Hull (May 20).

BACTERIOLOGIST for research work in connexion with Bovine Mastitis—The Secretary, Hannah Dairy Research Institute, Kirkhill, Ayr (May 20).

ASSISTANT to teach ENGINEERING DRAWING, MATHEMATICS, and ENGINEERING SCIENCE, at the Jarrow Technical School—The Director of Education, Shire Hall, Durham (May 22).

ASSISTANT ENGINEER for the Northern Rhodesia Government Public Works Department—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. E.697A) (May 24).

LECTURER IN CHEMISTRY—The Acting Secretary of University Court, The University, Glasgow (May 26).

TEACHER OF BOTANY in the Science Department, to take classes up to General Degree standard—The Clerk to the Governors, South-West Essex Technical College and School of Art, Forest Road, Walthamstow, London, E.17 (May 27).

ASSISTANT LECTURER AND DEMONSTRATOR (woman) IN CHEMISTRY—The Principal, Royal Holloway College, Englefield Green, Surrey (May 31).

ASSISTANT MASTER (with Graduate or equivalent professional qualifications) to teach MATHEMATICS AND GENERAL SCIENCE at the Scarborough Technical Institute—The Secretary, Education Offices, County Hall, Northallerton (June 3).

STAFF LECTURER IN SCIENCE AND HYGIENE—The Principal, Northern Counties Training College of Cookery and Domestic Science, at Tower House, Tweedmouth, Berwick-upon-Tweed (June 10).

HENRY MECHAN CHAIR OF PUBLIC HEALTH—The Acting Secretary of University Court, The University, Glasgow (June 15).

METALLURGIST by Firm of Engineers with wide interests (Ph.D., or equivalent, minimum technical qualification)—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. F.2286XA) (June 17).

JOHN RANKIN CHAIR OF GEOGRAPHY—The Registrar, The University, Liverpool (July 31).

W. H. COLLINS PROFESSORSHIP OF HUMAN AND COMPARATIVE PATHOLOGY—The Secretary, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2 (July 31).

SENIOR LECTURESHIP IN THE DEPARTMENT OF METALLURGY of the University of the Witwatersrand—Dr. W. Cullen, 4 Broad Street Place, London, E.C.2 (July 31).

ARC WELDING ELECTRODE PRODUCTION ENGINEER, with experience of solid extrusions, to take charge of latest type manufacturing plant—The Ministry of Labour and National Service, Appointments Department, Sardinia Street, Kingsway, London, W.C.2 (quoting Reference No. O.N.Q.S.178).

LECTURER IN BACTERIOLOGY to students preparing for the National Diploma in Dairying—The Principal, Studley Agricultural College for Women, Studley, Warwickshire.

LABORATORY TECHNICIAN (male) holding the Certificate in Bacteriology of the Institute of Medical Laboratory Technicians—The Director of the Clinical Laboratory, Royal Infirmary, Manchester.

ASSISTANT MASTER FOR ENGINEERING SUBJECTS, at the Burton-upon-Trent Technical Institute—The Secretary and Director of Education, Education Offices, Guild Street, Burton-upon-Trent.

WELDING ENGINEER by a Steel and Engineering Firm in the North-East, to initiate and develop fabrication of steel forgings and castings of heaviest types—The Ministry of Labour and National Service, Appointments Office, 38 Great North Road, Newcastle-upon-Tyne (quoting Reference No. 397).

SENIOR STRUCTURAL DESIGNER (Reference No. O.S.86), and a CHIEF MECHANICAL DESIGNER (Reference No. O.S.87), by a large Firm of Structural and Mechanical Engineers in India—The Ministry of Labour and National Service, Appointments Department, Sardinia Street, Kingsway, London, W.C.2 (quoting the appropriate Reference No.).

ASSISTANT (male) IN BIOCHEMISTRY at the Courtauld Institute of Biochemistry—The Medical School Secretary, Middlesex Hospital, London, W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Economic Proceedings of the Royal Dublin Society. Vol. 3, No. 17: The Centenary of the First Geological Survey made in Ireland. By Prof. H. J. Seymour. Pp. 227–248. (Dublin: Hodges, Figgis and Co., Ltd.; London: Williams and Norgate, Ltd.) 2*s*. [174

Ministry of Health, Ministry of Agriculture and Fisheries, Department of Health for Scotland. A National Water Policy. (Cmd. 6515.) Pp. 32. (London: H.M. Stationery Office.) 6*d*. net. [194

Some Problems of International Organisation. By Prof. C. K. Webster. (University of Leeds: Second Montague Burton Lecture on International Relations.) Pp. 18. (Leeds: The University.) 6*d*. [204

Carnegie United Kingdom Trust. Thirtieth Annual Report, 1943. Pp. 8. (Dunfermline: Carnegie United Kingdom Trust.) [214

Imperial Agricultural Bureaux. Joint Publication No. 4: Co-ordinated Trials with Phenothiazine against Nematodes in Lambs. A Report prepared at the instance of the Agricultural Research Council of the United Kingdom. Pp. 56. (Weybridge: Imperial Bureau of Animal Health; St. Albans: Imperial Bureau of Agricultural Parasitology.) 3*s*. 6*d*. [214

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Printed in Great Britain by FISHER, KNIGHT & CO., LTD., The Gainsborough Press, St. Albans, and published by MACMILLAN & CO., LIMITED, at St. Martin's Street, London, W.C.2, and THE MACMILLAN CO., 60 Fifth Avenue, New York 11, N.Y., U.S.A.—Saturday, May 13, 1944.