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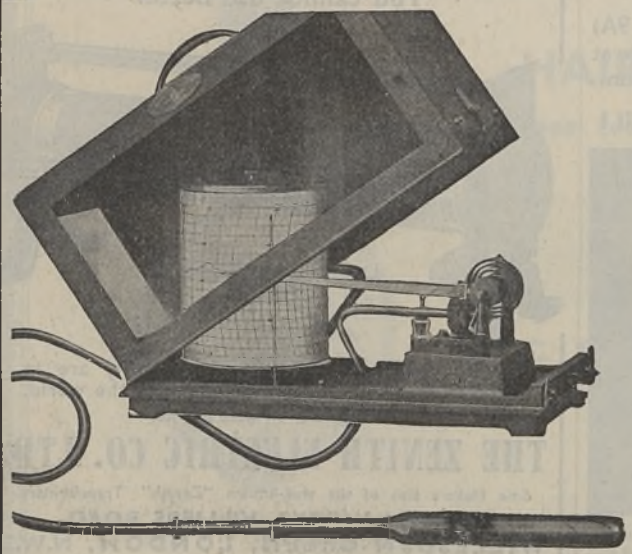
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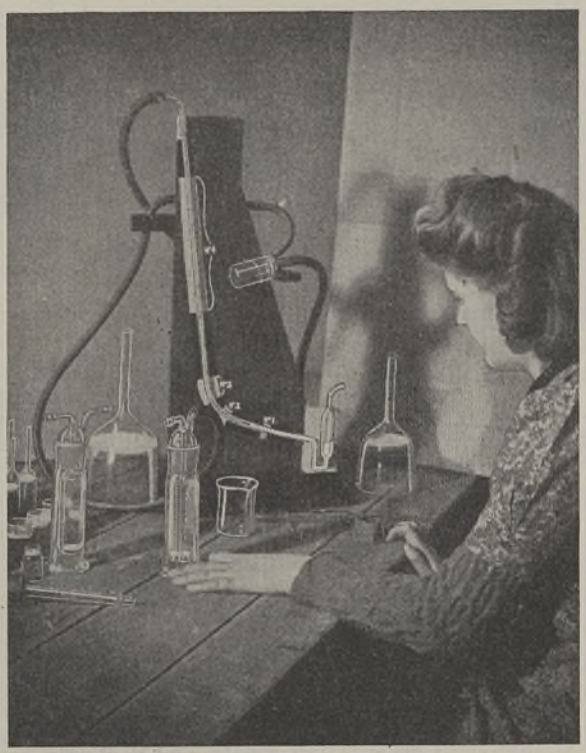

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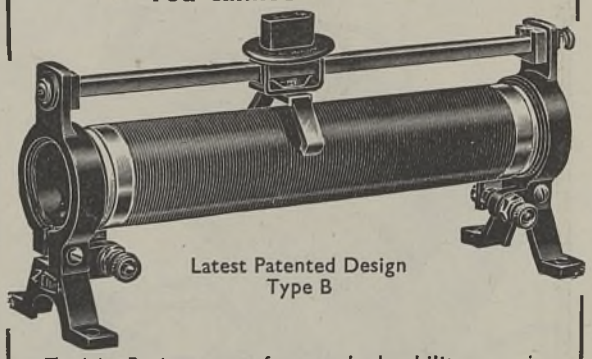

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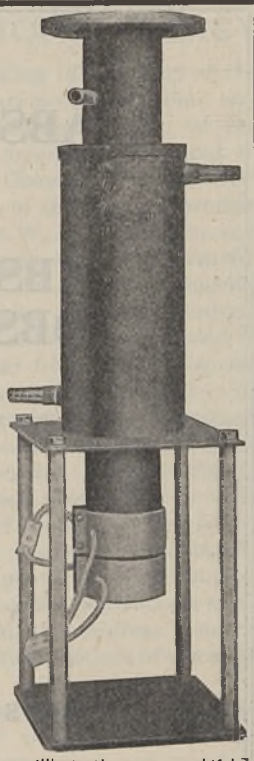

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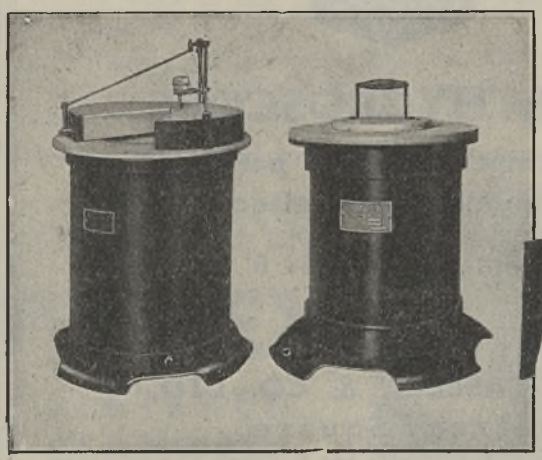

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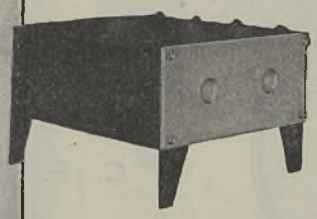

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NATURE

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ETHICAL ASPECTS OF THE DEVELOPMENT OF ATOMIC ENERGY

TO promote an understanding of the aims of the United Nations Educational, Scientific and Cultural Organisation, the Chicago Section of the American Chemical Society arranged a banquet in connexion with the National Chemical Exposition at which the theme was the role of the scientific worker in promoting world peace. Dr. W. A. Noyes, jun., in a broadcast address, emphasized that, for peaceful progress, we cannot rely on the control of specific weapons, atomic or otherwise, because weapons themselves are not the cause of war. He appealed to chemists, who must bear their full share of responsibility for enabling war to be made more and more awful, to give their best support to the subsidiary organisations, such as the Educational, Scientific and Cultural Organisation, which are endeavouring to promote understanding between peoples and to make the world a better place in which to live. Dr. Noyes urged the importance of the objective of raising the level of scientific work throughout the world, and of eventually securing great scientific institutions in all countries. Indeed, his realistic address was in essence yet another plea for full freedom of scientific and cultural intercourse.

Dr. Noyes announced the appropriation by the American Chemical Society of 25,000 dollars to promote international understanding and goodwill by enabling foreign chemists and chemical engineers to pursue advanced study in the United States. Dr. T. H. Hogness in turn stressed the particular qualifications of the scientific worker which enable him to assist in promoting world peace, especially in undertaking certain phases of the task of educating public opinion, through his special knowledge and insight into the implications of scientific progress. The most interesting passage in Dr. Hogness's address is, however, his quotation from a report of scientific men transmitted on June 11, 1945, to the Secretary of War. The justification for the concern of men of science with political issues could not be better put than in this report, written before the atomic bomb was first used.

"The only reason to treat nuclear power differently from all the other developments in the field of physics is the possibility of its use as a means of political pressure in peace and sudden destruction in war. All present plans for the organisation of research, scientific and industrial development and publication in the field of nucleonics are conditioned by the political and military climate in which one expects those plans to be carried out. Therefore in making suggestions for the post-war organisation of nucleonics, a discussion of political problems cannot be avoided."

The report goes on to urge that the political problems arising from the mastering of nuclear power should be recognized in all their gravity, and that appropriate steps should be taken for their study and for the preparation of the necessary decisions. The existence of nuclear weapons is regarded as the most compelling argument calling for an efficient

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international organisation for peace. The quotation from the report shows that, before the world at large was aware of the dangers, the fundamental factual knowledge of men of science had led them to urge the governments concerned to take the appropriate measures to deal with the situation. Dr. Hogness points out that in such educational work, however, the man of science needs the assistance of such a movement as the United Nations Educational, Scientific and Cultural Organisation, and he adduces the international heritage and outlook of the man of science as a further qualification in promoting the organisation of peace.

Quoting appropriately from Edmund Burke's "Reflections on the Revolution in France" that "society is indeed a contract" and that the State "is not a partnership in things subservient only to the gross animal existence of a temporary and perishable nature ; it is a partnership in all science ; a partnership in all art ; a partnership in every virtue and in all perfection", Dr. Hogness concludes with the exhortation that the scientific worker's contract with society includes taking his place among those who are particularly qualified to give leadership in the great effort towards world peace ; and there can be no doubt that, if U.N.E.S.C.O. is to achieve its real purpose of furthering international exchange and understanding, scientific men must make a very real contribution to its proceedings. Something of the realism they have already shown in dealing with the problem of atomic energy and its control will be required. The programme before the General Conference in Paris included more than seventy projects, some of which can scarcely be regarded as possessing the urgency of the restoration of education and cultural activities in the devastated countries.

It may well be that the most important contribution of the United Nations Educational, Scientific and Cultural Organisation to the solution of the problem of control of atomic energy will be in bringing about a more favourable 'climate' of political opinion. Meanwhile, it is interesting to note that, just as much in the report from which Dr. Hogness quotes has stood the test of the last eighteen months, so also much of Prof. Lewis Mumford's latest book, "Programme for Survival"*, written in August 1945, is as pertinent and relevant to-day as when it was written. Few readers will dissent from Mumford's comment in his preface that his conclusions would have been unchanged had he written in the spring of 1946. The book, in fact, is a continuation of the final chapters of "The Condition of Man", and is an urgent penetrating study of the tendencies now dominant in modern society, and an unmistakable warning as to the catastrophe they involve if unchecked.

Prof. Mumford urges that the vital question before us is whether mankind has imagination enough to mobilize, on behalf of peace and co-operation, forces that men have hitherto conscripted only for war and destruction. It is a question of dynamic will-power and time ; Prof. Mumford is as insistent as scientific men themselves that we have only a limited time in which to learn the art of control and to prevent the suicidal misuse of scientific knowledge. To do this is, in fact, to outlive the atomic age itself, the age of unqualified indiscriminate power, and it is at least encouraging to find in this book the recognition that we must be prepared, as part of the price of the safety and continued development of mankind, to scrap any part of the modern world. Preconceived ideas and political prejudices are in fact the gravest danger to which mankind is exposed, and nothing less than the same clear, fearless thinking at the political level, which in the scientific and technical field has placed at man's disposal nuclear energy, is likely to avert disaster.

Unconditional co-operation, Prof. Mumford holds, is the price of mankind's survival ; and he sets that as the objective, urgent and imperative, but not to be attained unilaterally or forthwith as Mr. Lionel Curtis is inclined to suggest. He makes, incidentally, a powerful case for some attempt to redress the lopsidedness of scientific advance : appropriations like those for the development of nuclear energy should be matched by commensurate appropriations for the promotion of the social knowledge and technique which would facilitate the control of such weapons. Advances in the human and social sciences must be kept more and more in step with advances in the physical sciences.

The first step toward control of atomic energy, Prof. Mumford agrees, must be an international one. No one country can establish adequate controls. Moreover, military control must precede industrial exploitation : to foster the industrial uses of atomic energy and to widen the processes of creating it, without first establishing world government, is to cause chaos. He even argues that there is no pressing need for the rapid extension and exploitation of atomic energy for peaceful purposes. Here he parts company with the report of the Lilienthal Board, on which the proposals presented by Mr. Baruch to the Atomic Energy Commission are based, and states that he would be willing to urge the relinquishment of the use of atomic power for the next decade or so while we perfect the system of international control. From this point of view he argues quite logically that freedom of research, for the present, should not apply to this field, nor should the control of research be left even to the most responsible group of scientific workers. Prof. Mumford might thus be expected to approve the appointments made by President Truman for the Atomic Energy Commission : headed by Mr. David Lilienthal, supported by Mr. Robert Bacher, who was second in command of the Los Alamos Laboratory during the War, the members designated for the Commission are, with one exception, intelligent laymen rather than the scientific men and engineers who were concerned with the plants of the Manhattan Project.

Neither Dr. Hogness, Dr. Noyes, nor Mr. Lilienthal himself, who also addressed the American Chemical Society at Chicago, advocated that the scientific man as such should enter the political field. What they urged was the introduction of the fact-finding method of science into the political sphere as a step towards

* Programme for Survival. By Lewis Mumford. Pp. iv+67. (London : Martin Secker and Warburg, Ltd., 1946.) 3*s.* 6*d.* net.

the elucidation of policy and measures, and while Prof. Mumford points out, as Dr. A. MacLeish has done before him, that the reactions of the intellectual classes to the Second World War show how little their special discipline is to be trusted in the appraisal of realities, he finds in the response of the physical scientists to the human threat of their most significant single advance in science and technology one of the few encouraging signs in the present situation. His tribute to the capacity for personal re-integration which such men of science have shown in order to deal unreservedly with this emergency is generous and deserved ; and the scientific world should not dismiss too lightly Prof. Mumford's pleas that at the moment the issue of freedom in nuclear research is not the decisive factor, and that the world can afford to wait a decade if need be before the harnessing of atomic energy to peaceful purposes proceeds apace.

We are, in fact, concerned here with a problem in the relation of science to ethics and the restrictions which ethics may place upon the use of the scientific method to which the Bishop of Durham directed attention in his Fisson Lecture. "Scientific method," said Bishop Henson, "is ethically conditioned in three respects. First, there are the moral obligations which attach to the scientific student by virtue of his manhood, and which cannot be cancelled by any scientific interest. Next, there are the restrictions on the methods of research which are imposed by the claims of those whom they affect. Thirdly, there are limitations on scientific research imposed by the quality of the results which they are designed to secure." Bishop Henson's lecture received nothing like the attention it deserved, for he was concerned rather to provoke thought about such issues than to enunciate answers to the questions he raised.

The formulation of an international code of ethics for scientific men may yet be distant ; still more the political conditions under which it could be implemented effectively. But none the less, it must be remembered that the atomic bomb itself is the product of international scientific co-operation, and only international control can avert its widespread use. The future of humanity depends, as Prof. Mumford asserts, on the three Great Powers, not less than others, placing themselves strictly under the judgment and the surveillance of the rest of the world. To take the initiative in this matter is not merely their responsibility but also an act of prudence. Unless national sovereignty can be liquidated to that extent, the world organisation we have created will lack the authority to give security even to the United States, the U.S.S.R. or Great Britain.

"The authority of the United Nations must be unqualified and universal : every last laboratory and factory must be open to investigation by authorised international agents, responsible to the central world authority. The power to spread, limit or even outlaw scientific investigation must reside in such a body no less than the power to outlaw completely all national armies. Privacy, secrecy, sovereignty must be unconditionally surrendered to a common body whose prescribed powers must override all local administrative organs at every point that is necessary to ensure freedom from fear and freedom from unlawful aggression." This is Prof. Mumford's minimum price of security, and he recognizes clearly the great psychological change involved, rather than further knowledge ; though he points to the value of developing further the sciences and arts relating to human institutions and biology. He asks of the man of science that he transfer to wider areas of knowledge and activity his capacity for self-abnegation, his well-trained inhibitions, his rigorous respect for controls. Religion, too, Mr. Mumford would mobilize in the cause, for institutional change will be insufficient unless we bring to it a fully awakened and constantly renewed personality ; and he recognizes the high demand for self-discipline involved in the extension of the very processes of democracy to world organisation.

There are, in fact, questions here to which the United Nations Educational, Scientific and Cultural Organisation might well turn its attention at a later date. Meanwhile, apart from the particular problems of conduct which individual men of science may meet, it would be well for the scientific world to face the ethical considerations which are involved in the control of atomic energy, and indeed in the very prosecution of nuclear research.

"CANST THOU DRAW OUT LEVIATHAN WITH AN HOOK?"*

The Role of the Aged in Primitive Society

By Prof. Leo W. Simmons. Pp. viii + 317. (New Haven, Conn. : Yale University Press ; London : Oxford University Press, 1945.) 26*s.* 6*d.* net.

THIS study by Prof. Simmons of the treatment of the aged collects into a single volume, from a number of sources widely distributed in geography and representing varying types and stages of culture, a very large assortment of examples of the way in which old age is treated by primitive peoples. The author states in his introductory matter that a preliminary analysis of his comparative material revealed significant contrasts on the basis of sex, and that marked difference in the treatment of the aged appeared to be correlated to varying factors in the environment, economics, kinship system, or religion of the group treated. Correlations between the physical and cultural traits described, and the environmental or other circumstances apparently determining or affecting them, are examined accordingly, and an analysis is made of the traits examined : the relative importance of each trait in its culture setting is estimated and the results indicated by a coefficient of plus or minus to two decimal points.

In effect, all this is an attempt to apply the methods of an exact science to material which, as it exists at present, is not really of a proper nature to be so treated, and if Prof. Simmons's book had no other merit, it would be of importance as a demonstration that material collected by the most careful ethnographers is not really susceptible of this sort of treatment. It is perhaps unlikely that this method of dealing with sociological phenomena will ever become satisfactory, but its application to data

* *Job* xli, 1.

that were never collected with a view to such treatment is probably dangerous and certainly unconvincing. It is not to be inferred, of course, that the author does not reach certain valid deductions. The conclusion "may be safely ventured", he tells us, that aged women have generally found it harder to get young husbands than old men have to get young wives. No statistical analysis, no weighted comparison of culture traits is needed to give us that information ; nor is it an unexpected qualification that old women have found young husbands easiest to get in matrilineal societies—where, of course, they control the property. Indeed, one cannot avoid the suspicion that some of the conclusions reached are really rather the unconscious dictates of the author's preconceived ideas than the inevitable conclusions of any truly scientific process. Thus the payment of bride prices is, by the author's findings, expressly correlated in patrilineal societies to inferiority in the status of women. This is a view which is no doubt widely accepted, but, so far as many patrilineal societies are concerned, quite erroneously. No doubt but such payments are not found in matrilineal groups ; in some cases they appear actually to originate in compensation paid by patrilineal bridegrooms to matrilineal families for the privilege of depriving them of a daughter's children ; in any event they frequently occur where the bride is of higher social status than her groom. Where the converse holds and the father of the bride must pay a man to marry his daughter, her status will be found, in effect, to be inferior generally to that of her husband. This is a trait which the author does not seem to have examined; but if bride price be, as alleged, an indication of the bride's inferior status we are little better off for the knowledge, for it may be cause, or it may be effect, or it may be a remedy, since in many societies it certainly operates to secure consideration and regard for the bride. The truth is that the data are incomplete, and individual interpretations of them must almost inevitably differ. The mathematical method cannot really be applied to imponderable phenomena the values of which must be variously assessed by different individuals.

Nevertheless Prof. Simmons has collected a large number of illustrations of the various ways in which the aged are or have been treated, and if anyone wishes to know what sort of treatment is meted out to them by the races of man generally, here is the book to consult, albeit it might be better indexed. Nor does one come away with any confidence that the segregation of the aged poor in a civilized British 'workhouse', where the partners of a life-time may be separated, is really one whit more humane than the primitive Fijian practice of burying the aged and infirm alive with their own connivance and co-operation. There must be few of us who have not met with aged parties who no longer take pleasure in life, "which long for death, but it cometh not, which rejoice exceedingly, and are glad, when they can find the grave". Finally, to mention one aspect of the aged which the author passes over, it may be doubted whether any civilized method of disposing of one's aged parents can compete with the piety of the Massagetæ, of the Issidones, and of our Irish ancestors, who conquered their repugnance to cannibalism and devoured their dead parents mingled with a savoury stew that they might live again in their children, and whom Herodotus tells us were accounted righteous people on that account, while Strabo records it as a seemly deed.

J. H. Hutton

ELECTRICITY SUPPLY IN GREAT BRITAIN

The Organisation of Electricity Supply in Great Britain

By Dr. H. H. Ballin. Pp. xv + 323. (London : Electrical Press, Ltd.. 1946.) 21*s*. net.

ELECTRICITY supply occupies a prominent place in the mind of the public at present, because the demand for electricity frequently exceeds the generating capacity, and because nationalization of the industry appears to be inevitable.

Dr. Ballin has made a careful survey of the growth of the British electrical industry from its commencement in 1880 until the present. He treats his subject mainly from the economic and political aspects, but gives some indication of the main technical features of transmission and distribution which had an important influence on rate of development.

In this notice, the progress of electricity supply in Britain will be outlined on technical and personal lines.

From the commencement of public electricity undertakings in the early 'eighties until 1914, numerous systems of heterogeneous types—direct current, 25-, 40- and 50-cycle alternating current—were founded. Only a few of the more enterprising undertakings could compete successfully with large industrial power plants. As described by Dr. Ballin, the period appears rather dull, but in fact it was remarkably colourful, and British pioneers were not lacking in enterprise or novel ideas.

During the First World War, the advantages of bulk supplies became evident to industrialists, and there was rapid expansion of all electricity supply undertakings in industrial areas.

The need for standardizing voltages and frequency was recognized by many engineers, and in 1919 the Electricity Commission was founded. The Electricity Commissioners surveyed the condition of the supply industry and established a statistical system on the basis of which the progress of that industry could be properly regulated. They attempted to bring about voluntary coalitions of undertakings into joint electricity authorities, but with little success.

The period 1919–26 was marked by the construction of a few generating stations, such as Dalmarnock (Glasgow), Barton (Manchester) and North Tees (Newcastle Electric Power Co.). These were deemed to be large stations; but it is worthy of note that a single boiler in the Ford power plant at Detroit could generate more steam than could the whole of the boilers in Dalmarnock.

The real achievement of that period was the passing of the 1926 (Electricity Supply) Act, which had as main objectives co-ordination of generation by means of the Grid system, and standardization of frequency of supply at 50 cycles/second.

The Central Electricity Board, set up under the 1926 Act and directed with extraordinary energy by Sir Andrew Duncan, brought about the construction of the Grid and the standardization of frequency between 1927 and 1934. This major constructional work demonstrated, above all, the efficiency of the British electrical manufacturing industry—all the novel transformers, switchgear, cables and other equipment being produced with remarkably little delay, and without technical setbacks. Between 1934 and 1939 the Board acted as a trading concern under peace conditions. It developed the intricate technical procedure required for operating all the British

generating stations in parallel; and what is even more remarkable, secured adequate enthusiastic co-operation of all authorized undertakings through the medium of national and district consultative committees.

Exact information as to capital and operating costs, utilization of personnel and fuel consumption was obtained for every generating station. In 1939, the specific coal consumption for all electricity generated by public authorities had fallen to 1·48 lb. of coal per kWh., a figure about equal to that attained in the United States, the foremost country of the world in respect of generation and transmission of electricity.

During the War, the soundness of the Grid system was finally established, as supplies were afforded wherever required with few interruptions, although damage amounting to £10,000,000 was caused by enemy action and other war causes.

Dr. Ballin's references to the personalities of the electrical industry create an incorrect impression as to who was of real consequence. He gives undue prominence to jurists and government officials who made no contribution to progress. He resurrects the term 'arch-ohm' banteringly conferred on the late Mr. George Balfour. Mr. Balfour was one of the really dynamic personalities of the supply industry. He pioneered supply developments in Great Britain and abroad long before the planners had realized their possibilities. His last British ventures were in territories in north Scotland which had been rejected as uneconomic by established authorities, and the power systems he established there must have been of inestimable benefit to the Services during the War.

In the controversy as to the relative merits of company and municipal undertakings, Dr. Ballin inclines to favour the latter. Municipalities in general provide electricity at lower cost to the consumer than do companies, but the reason for this lies in the more concentrated load areas rather than in the type of organisation. Success also depends to a great extent on the personality of the individual managers, as can be verified strikingly by reference to the sudden impetus given to development of Belfast and Hull municipal concerns and the Central London Electricity Ltd. at certain stages.

Dr. Ballin is concerned at the relatively poor increase in use of electricity in Great Britain, and points to defective organisation and heterogeneous tariffs in explanation. In the reviewer's opinion the reasons are much more deep-seated. Sir John Orr's 40 per cent of undernourished cannot interest themselves deeply in electrical development until they are fed and properly accommodated. The better-paid artisans and middle classes are only now beginning to realize what an inexpensive boon electricity can be to them in their homes.

Wealthier people are being forced to use electricity because of lack of domestic help. Recent spectacular and embarrassing increases in the demand for electricity provide clear evidence of public awakening to its value.

In considering the possible effect of nationalization on electricity supply it is salutary to compare the cost and quality of the telephone service with that of the light and power service. A telephone call at a minimum of 2*d*. compares most unfavourably for value with a kilowatt at 1*d*. per hour. The G.P.O. engineering is efficient, so that it is natural to conclude that the high cost and indifferent service are due to bureaucratic control. It is to be hoped that no additional obstacles will be put in the way of the British electricity supply industry, which is now well on the way to becoming the most efficient national electrical organisation in the world.

Dr. Ballin's book contains much useful and interesting information. His suggestions for an overriding national electrical organisation are well worth examination, although they do little more than indicate the complexity of the economic, legal and political situation of the industry. In the event of a new edition being required, the index and bibliography could with advantage be extended. One work in particular is specially worthy of mention, namely, "The Development of the Generation and Distribution of Electric Power in the British Isles"*. It was justly described by the late Sir John Snell as "the best brief epitome of the history of electricity in Great Britain".

C. W. MARSHALL

* Institution of Civil Engineers. Institution Lecture to Students. Session 1928–29.

MODERN PROBLEMS OF COLONIAL LAND TENURE

Land Law and Custom in the Colonies

By Dr. C. K. Meek. Pp. xxvi+338. (London, New York and Toronto: Oxford University Press, 1946.) 21*s*. net.

TWENTY years ago discussions of Colonial land legislation and policy were focused on the question of the alienation of land to non-natives, particularly in Africa, and the adequacy of the provision made to safeguard the rights and interest of native peoples. The importance of securing to them areas of land sufficient for their existing and estimated future needs was considered so urgent that this was the subject of a special clause in the agreements placing African territories under mandate; and the question whether native populations had, in fact, been injured by the grant of land to settlers was a matter of bitter controversy in some British Dependencies.

To-day the emphasis has shifted. In most Colonies the days of large-scale alienation are over, and further white settlement, if it takes place, will be on land already allotted to this use. In Central Africa most of the concession area granted in the optimistic 1880's has reverted to the Crown, as it has become evident that there would be no demand for it from European farmers.

The damage done in the meantime through local overcrowding of native areas remains; but this is now seen as only one aspect of a much wider problem —the problem of the adjustment of native customary tenures to modern conceptions of the use of land. Dr. Meek has surveyed the bewildering diversity of the Colonial empire, described the special circumstances and legislation of a number of different territories, and underlined the main issues in a book which will be invaluable to administrators and sociologists alike.

The problems of present-day policy arise from the changes that are taking place in customary forms of land tenure with the change from a subsistence to a money economy. Land, over which the community, perhaps with a chief as its representative, formerly held an overriding right, is now coming to be the object of commercial transactions between individuals, in which the contingent rights of other members of the group are overlooked. There is a conflict

between the two aims, both desirable, of encouraging the progressive farmer and protecting his more conservative kinsmen from dispossession. The magic of freehold has been found to have its black side. It may enable the farmer to raise credit for improvements; it often allows him to incur debts for unproductive purposes and leads to the loss of his land. Nigeria has considered legislation which would allow the mortgaging of crops but not of land. Zanzibar controls mortgages and lays down that neither land nor its produce may be made attachable for debt. Dr. Meek urges the need to provide agricultural credit on a sound basis as an essential supplement to legislation of this kind.

Customary systems appropriate to a subsistence economy and to a rotation of food crops and fallow cease to apply when the land is more intensively used, and devoted to commercial as well as subsistence crops. Several African Governments have made provision for grants of land to individual native farmers who find tribal systems inimical to the adoption of new methods. In recent years re-settlement schemes have been set on foot, as part of measures against sleeping sickness or simply to reduce congestion; the latest proposal for groundnut cultivation in Tanganyika aims at killing several birds with one stone. In such schemes Governments dare not risk the ruin of the soil by unsound practices and must retain the right to insist on certain standards of cultivation. The type of individual right which to-day is generally regarded as most satisfactory is that described by Lord Hailey in his introduction as "a usufructuary occupancy which secures full enjoyment of the land to the holder and his successors during its beneficial use, but enables the community to resume possession of a holding when beneficial use ceases, or to terminate possession on payment of equitable compensation for improvements effected".

Most Colonies, however, have not yet made up their minds as to the exact nature of the limitations to be imposed on the free disposal of land. In addition, many of them have to handle an intermediate situation, where individual title is not yet widely sought, but types of transaction in land which customary law does not recognize are becoming common in practice. In Africa the rule-making power of native authorities can have a significant influence on future developments in this field.

One of the great merits of Dr. Meek's book is that it shows how widespread these problems are, and it enables the reader to look at any territory with which he may be familiar in the light of the treatment of similar situations elsewhere. Dr. Meek finds the happiest answer to a number of typical questions in the 1940 Native Land Trust Ordinance of Fiji. This provides for the grant of private rights, but makes them subordinate to the needs of rural development and the maintenance of soil fertility. It empowers the Government to intervene not only if a native group is in danger of alienating more land than it can afford, but also if it is withholding land from beneficial use, and provides for the redistribution of land in accordance with changes in the population of landowning groups. The provisions dealing with compensation for improvements are commended to the notice of other Governments. Another important innovation is the establishment of local agencies, representing both Fijians and Indians, to advise the trust board in which the control of native lands is vested.

Lucy P. Mair

BACKGROUND OF APPLIED SCIENCE

Les radiations

Par Prof. Charles Fabry. (Collection Armand Colin: Section de physique, No. 243.) Pp. iv + 220. (Paris: Armand Colin, 1946.) 60 francs.

Propagation de la chaleur

Par Prof. Charles Fabry. (Collection Armand Colin: Section de physique, No. 236.) Pp. 216. (Paris: Armand Colin, 1942.) n.p.

PROF. FABRY, who died in 1945, was well known throughout the world for his original work, and, in a smaller circle, for his skill as a lecturer and expositor. These two books, one published in 1942 and the other after his death, are therefore of special interest. They are of a type not common among English publications, being short treatments of very wide subjects which are neither popular books nor abbreviated technical publications. They are mainly concerned neither with fundamental science nor with technical applications, but with something intermediate. They deal with those theoretical considerations which lie immediately behind applied science. For example, in "Les Radiations" there is little about the wave theory or quantum theory of radiation. A considerable proportion of the space is given to the basic theory of the measurement of a radiation flux (spectral distribution curves of sources and sensitivity curves of measuring devices). Different types of measuring instruments are mentioned, but there is nothing about the technique of photometry and similar subjects. The reviewer understands, from inquiry, that these books were based on lectures given to people who would later have to use or to test scientific instruments (for example, engineering students and students who would later become technical assistants in testing and research laboratories). Such students need precisely what these books aim to give—not technical details which they will obtain elsewhere, nor fundamental theory which would appear to them far removed from their work, but some general ideas brought into immediate relation with their own work. The literature of science in English would be enriched by publications of this type.

Agreeing that the objective is good, we may reasonably ask how well the books fulfil their purpose. "Les Radiations" deals with the whole electromagnetic spectrum; but there is an uneven distribution of interest. One might indeed plot an 'intensity of interest' curve with a broad maximum in the visible spectrum, falling fairly steeply through the infra-red and ultra-violet, so that X-rays and radio waves are mentioned only occasionally. In addition to chapters on sources and receptors there are a chapter on the properties of materials (including transmission by metals as well as by insulators), and a discussion of chemical and biological effects of radiation. The reader need not have any mathematical knowledge beyond elementary algebra. Great skill has been used to compress the material into the space available under the handicap imposed by the virtual absence of equations. The total effect, however, is that of an overcrowded stage—a play in which too many actors appear to speak a few brief lines. One can only regret that M. Fabry had not twice the space at his disposal.

The second book, "Propagation de la chaleur", is

of the same length; but the subject is smaller and has been clearly delimited. The author is able to deal adequately with the processes of conduction, convection and radiation, and to give a brief but satisfactory treatment of such matters as the difference in temperature between the surface of a wall and the layer of air in contact with it. The reader is assumed to have a knowledge of calculus, including the simpler differential equations, but Bessel functions, etc., are not introduced. This book can be recommended to engineers and architects who may be concerned with the heating of buildings. It would also be helpful to honours students in physics, who may gain from it both a good summary of matters of theoretical interest and an understanding of the relation between laboratory work on heat and some problems of practical importance. A translation of this book would be very welcome. R. W. DITCHBURN

MATHEMATICAL THEORY OF ELASTICITY

Mathematical Theory of Elasticity

By Prof. I. S. Sokolnikoff, with the collaboration of Asst. Prof. R. D. Specht. Pp. xi+373. (New York and London: McGraw-Hill Book Co., Inc., 1946.) 22*s*. 6*d*.

THE appearance of a treatise in English upon the mathematical theory of elasticity is an event the potential importance of which may be judged by the fact that the author, in his frequent suggestions for collateral reading, refers to only three such, those of Southwell, Timoshenko, and Love. In spirit and content Sokolnikoff's book differs greatly from each and all of these. It may be described by a possible sub-title: "A pure mathematician surveys topics related to certain problems in the mathematical theory of elasticity". It is symptomatic of the change in outlook of American mathematics over the past few decades.

The book falls naturally into three sections. The first (Chapters 1–3, pp. 1–96) is devoted to analyses of stress and strain, the stress-strain relation, and the equations of equilibrium. The main feature of this section is the systematic use of the tensor notation. The second section (Chapter 4, pp. 97–276) is mostly concerned with the extension, torsion and flexure of beams, while the third section (Chapter 5, pp. 277–345) deals with variational and associated methods, illustrated mainly as applied to the torsion problem. Frequent suggestions for collateral reading and sets of exercises are excellent features, and the appendix —a collection of important formulæ—is very useful.

From the above it will be seen that this book contains matter not to be found in the other treatises already mentioned—but the converse is also true. Only a small group of elastic problems is solved, namely, those reducible to two-dimensional boundary problems for Laplace's or Poisson's equation. Biharmonic analysis does not find a place; but we are promised a companion volume containing a systematic treatment of plates and shells based on the fundamental differential equations.

In the first section the tensors are cartesian; the suffixes are all subscript and the ideas of covariance and contravariance do not occur. (Formulæ for polar co-ordinates are derived in Chapter 4, and are there given in extended notation.) Upon the conciseness of the tensor notation there can be no question. But it is open to question whether the physical ideas must first be grasped in a familiar notation before the more compact symbolism can be really useful, and also whether the difficulties of new ideas and new symbolism are likely to be simultaneously overcome by the average student. When one has mastered the ideas expressed in the extended notation, then the advantages in succinctness of the tensor notation become evident. The remainder of the volume is, however, independent of tensor notation, for, as the author realizes and indeed explicitly states, this symbolism loses its magic when confronted by specific problems.

The second section first covers much familiar ground using familiar notation, but includes also modern ideas, such as Stevenson's specification of the flexure functions, and the use of complex variable methods for solving torsion and flexure problems. In making available the work of the Russian school along the latter lines the author has rendered a service. The emphasis throughout this section is upon exact formal solutions as ends in themselves with little regard to their suitability for technical calculations.

In Chapter 5 the author concerns himself with approximate methods, both formal (like those of Rayleigh–Ritc) and numerical (the finite difference approximation). Although applications are limited to a few cases of the torsion problem, the survey is valuable, especially the account of methods of delimiting exact values between upper and lower bounds.

As has been implied already, the outlook is that of a mathematician, of a man of science rather than a technician. Emphasis is upon method rather than result—rightly so, in the sense that it is for methods that the technician consults the mathematician. But we fear that the technician will not find this book easy reading. Although the author from time to time makes a conscious effort to take the reader behind the scenes and show him how the mathematical effects are produced, he cannot entirely escape the mathematician's habit of asking one to 'consider the expression . . .' which appears rather like the rabbit out of the conjurer's hat. Again, the engineer may well ask how the mathematician knows which method to use upon any problem—and in particular why the complex variable method be not applied to the torsion or flexure of either the elliptic cylinder or the rectangular prism. In what should be one of the most telling sections of the book, where the complex variable method is applied to the cardioid section, the essential simplicity of the method is masked by analysis which seems clumsy and is not easy to follow.

There is much repetition, both in the text and in the references. In the text it may possibly be justified, but it is surely unnecessary and wasteful to give full bibliographic references to (for example) Love's "Treatise" every time it is mentioned, or, in two footnotes on the same page, to repeat title and reference in full to a paper cited. Choice of notation is not always happy, for example, the use of σ for a complex variable after its use for Poisson's ratio. Misprints are more frequent than one likes to see, although they should cause little trouble to an intelligent reader.

But it is clear that, although only a small field has been tilled, there is, for those who can winnow the grain from the chaff, a harvest to be reaped in this book. W. G. BICKLEY

ENGINEERING PROBLEMS OF FUTURE AIRCRAFT

A DISCUSSION arranged by the Royal Aeronautical Society was held in London on November 14, dealing with some of the engineering problems presented by future aircraft. The subject was divided into four main sections, each introduced by a paper, which covered the problems that are now appearing on the horizon in the world of aircraft design. They were, broadly speaking: engineering problems of large aircraft, tailless aircraft design, flying-boats with particular reference to their peculiar constructional problems, and power plant installations.

Engineering Problems of Large Aircraft

The most outstanding feature from this point of view is the fact that the increase in size brings with it complication and elaboration of detail that is the work of specialists, many of whom may not have had any interest in the smaller aircraft of the previous decade. It will need the co-operation of a team, not necessarily all aeronautical, who will develop their own products to suit the particular requirements of the aircraft. An obvious example of this is the movements of the control surfaces. The effort necessary for these will certainly demand some kind of power driving, coupled with an extremely delicate control of it, which may be done either by gyroscopic instruments or graded down so that the pilot can operate it by 'feel'. At present pneumatic, hydraulic, and electrical systems are available, and it will have to be determined which can be best developed to the larger sizes with the least added weight and bulk, and retain the most delicate yet reliable control of its workings. There is a good deal to be said in favour of electrical systems, as electric power has to be generated for lighting and radio purposes. Alternating current at a pressure of about 200 volts between phases seems to be the most promising, and its development for both reliability and safety may well be one of the problems in the next few years.

Size of aircraft is very dependent upon the route to be operated. The London–New York route appears to be the most difficult one envisaged for the immediate future. The great circle distance is 3,450 statute miles, but allowing for head winds and other eventualities a fuel load sufficient for 5,500 miles must be carried. Present-day knowledge, based on a 300,000 lb. aircraft, suggests that only about 8 per cent of this figure is available for paying load, increasing to 11 per cent with one intermediate stop or 13 per cent with two stops, using the type of passenger accommodation most suited to aerodynamic and structural requirements. A further complication arises in that it may be convenient to make the longer non-stop run at night, so that sleeping berths will have to be provided. The extra space for these governs the size and weight of the body, and through this the design of the whole machine. Aircraft on the shorter runs with intermediate stops may possibly not operate in this way; and, if travelling during day-time hours, will tend to develop into a machine of a different type.

The proportion of paying load on this type of large machine being so small, it is obviously important to achieve the greatest possible efficiency in structural design in order to keep the weight of this part down to a minimum. This postulates an accurate knowledge of the externally applied aerodynamic forces and the resulting internal loads in the structure. The most critical parts of such loads are those due to dynamic effects arising from vibrations. This necessitates a study of the natural frequencies of the proposed structure, and the effect of gusts upon it. Undercarriage action also induces vibrations with a similar effect. The mathematics of these problems is long and laborious, and needs checking by actual tests. Existing equipment is too small for full-scale tests on such large machines, both from the point of view of size and the magnitude of the test loads to be applied. The design and construction of large test apparatus will constitute a research in itself, or alternatively the relationship between model and full-scale behaviour will have to be developed to a state of certainty in prediction, from both the mathematical and the physical outlook.

The correct use of materials gives another field of extremely interesting development. An aircraft designed to-day for production has to conform to the specifications of materials that are available in sufficient quantities, both as to physical properties and sizes. The designer of the large machine, regarded as a researcher into future design problems, may well consider it advisable to choose materials that give him the most efficient structure, thus in effect creating his own materials specifications, and giving a lead to the materials manufacturer. For example, in the case of a stressed metal skin, the joints between individual sheets give an appreciable additional weight, and another problem is to attain a good smooth outer surface. If sheets of double the present-day maximum dimensions were available, the area of the joints on an average aircraft skin would be reduced by about 40 per cent. Smaller tolerances in workshop production would allow much finer limits in stressing at the design stage and consequent saving of weight. This may call for changes in the materials manufacturer's workshop technique, or possibly the development of new alloys that are capable of more accurate finish in their manufacture.

Tailless Aircraft Design

There are aerodynamic reasons, outside the scope of this discussion, that dictate that the supersonic speed aircraft flying in the stratosphere will need to have wings with a pronounced 'sweep back', of at least the order of 25°. The tail surfaces that are necessary for control purposes may conceivably be carried on these wing tips, now far enough back for the purpose. This will give a useful saving in both drag and structure weight, as the long cantilever body, which serves little useful purpose other than to carry the tail, will not be necessary. This is really only a secondary effect, the principal problem of the future being that of the swept-back wing rather than the tailless aircraft. This problem resolves itself into three main sections: the aerodynamics of the question at lower speeds necessary for take-off and landing; compressibility effects; and 'aeroelastic' problems of dynamic loading as already discussed in the previous paper.

The outstanding problem to be investigated is the early stall, initiated at the wing tips. Their position relative to the line of flight alters the aerodynamics of the problem, and a combination of increase of local lift, reduced negative camber, outward drift of the boundary layer of air, and interference by a

forced outward flow of the air from beneath the wings, causes premature stalling and lack of efficiency of the original tail surfaces now placed there. Investigations so far carried out suggest that an entirely separate design of the wing tips will need to be undertaken. The present knowledge of the behaviour of such devices as slots, flaps, etc., used as lift assisters, may need to be extensively modified when fitted in this area. Taper plan form for a wing, efficient in many respects for normal wings, may be definitely bad with swept-back wings owing to their disruptive effect upon the boundary layer behaviour. The control of the boundary layer by suction and ejection of air flowing over the plane, and even the design of completely different aerofoil shapes, are possible avenues of research into this problem.

Compressibility effects at high speeds need perhaps the greatest research in the future. This lack of precise knowledge of the behaviour of the aircraft is not confined to swept-back wings, but the problem is a degree more complicated in these cases. The variation of aerodynamic characteristics, the precise effect of sweep-back, and the problem of the stall, all need re-attacking under these conditions. A mass of theoretical and experimental data is beginning to become available, and assimilation of it and co-ordination of effort is a necessity.

The problems of aero-elasticity are an extension of similar questions on more conventional aircraft, considerably complicated by the fact that the wings are swept back. Spar bending under external loads produces a change of incidence, whereas it does not have this effect in a straight wing. This sets critical limits to most of the manœuvres, the investigation of which is naturally complicated by the introduction of a second variable. The possible effects of aileron reversal upon lateral control and stability, and the chance of its inducing wing flutter all need investigation, both mathematically, experimentally, and in full-scale flight.

Flying-Boat Problems Related to Production and Pressurization

This discussion, although primarily on the large flying-boat, raised general problems of the relationship between design and production that apply equally well to all large aircraft. Up to the present, design has generally been the first consideration, as indeed it must be with anything in the experimental development stage. Light and efficient structures have often been achieved at the cost of complication, with its attendant cost and slow production. Designers have been loth to increase structural weight, with its attendant reduction in useful load carried, in order to assist production. If the production engineer is willing to regard aircraft production as a separate problem, needing its own technique, co-operation with the designer should produce aircraft that will reflect the advance in aeronautical knowledge without necessarily being a bad production proposition. A reduction of the total man-hours needed for the complete building of an aircraft is the same thing, whether it results in cheapness for commerce or quick production for war.

Planning for production is obviously dependent upon the question of possible modifications found necessary during normal use. The present-day practice of building a few prototypes is not good from this point of view, and now that the tempo of development can be somewhat slower, it is possible that an extremely active development department using a larger number of pre-production machines could ensure that the final tooling for production would not be subject to many further alterations. Another criterion from this point of view is that of keeping the number and variety of parts down to a minimum in the design stage. The Republican Aviation Corporation in the United States redesigned the Sea Bee, as its cost of production was more than twice what the manufacturers had envisaged. A radical alteration to the structure involved them in considerable design trouble, as many of the re-designed features were not amenable to accepted strength computation methods, but the manufacturing costs were finally reduced to the required figure. Changes in detail design methods that are in danger of becoming stereotyped are foreshadowed here.

Another problem that has arisen in the production of large flying-boats which will certainly be common to all large aircraft is that of the minimum degree of accuracy needed. Laminar flow in the boundary layer demands exceptional finish of surfaces, and interchangeability of parts sets a limit on working tolerances. Unnecessarily small limits in either of these are wasteful, and much more precise information on these is needed.

Pressurization of cabins for high-altitude flying now appears to be essential with the adoption of the gas turbine. This creates a fresh outlook on the body structure, which now has to be a pressure-tight shell, in addition to being of the required strength. Although a circular cross-section is the stiffest shape, it is uneconomical for passenger accommodation, especially when large enough to accommodate more than one deck. A cottage loaf or figure of eight cross-section appears to be promising. Another question to be investigated is whether the whole body, or only the cabins, need be pressure tight. This is not only a question of human life in the cabins. The pressure differential between the outside and inside will affect the structural strength needed, and although pressure may not matter, the effect of temperature and humidity may affect certain kinds of cargo.

Power Plant Installations

The most outstanding feature of the future under this heading will be the possible change in general outline of aircraft due to the introduction of the gas turbine. This will be caused not only by the different requirements of the power plant itself, but also by changes in aerodynamic layout due to higher speeds and high-altitude operation. Military aircraft may also be extended to rocket-propelled, pilotless projectiles, although the more conventional aircraft will still be required for transport, observation, and possibly interception and destruction of enemy aircraft. Civil aircraft will tend to develop into types governed by range. The high fuel consumption of jet propulsion means that propeller drive will continue for these, although possibly driven by gas turbines. Medium-range, say up to 1,000 miles, and shorter-range aircraft may possibly use the highest possible speeds with jet propulsion, as the relatively short journeys will allow a more intensive use of the machine on the turn-about principle. Freight aircraft may well develop into two types, the faster catering for the transport of perishable goods, when the extra costs of high speed may be justified. The

piston engine–propeller combination will probably remain at the lower end of this scale, with the turbine-jet at the other end.

The future development of power plants is obvious in its direction. The piston engine with propeller is efficient mechanically, at least up to speeds where compressibility effects are serious. It has reached a high state of development and does not appear to be likely to undergo any radical change that will enlarge its present application. The gas turbine with propeller gives an engine that is relatively new and capable of development, although its most obvious progress, namely, increase of power, will be limited by the propeller's ability to turn it into thrust, which cannot go much further. Reduction in vibration, noise, fire risks, and such secondary matters are more promising lines of improvement. The gas-turbine-jet combination is capable of unlimited development, so far as the aircraft is able to use its extra power, and the human element can stand the high accelerations inseparable from high speeds, assuming that research succeeds in improving the efficiency of jet propulsion and reducing the high fuel consumption, which up to the present limits the possible range.

THE MAGNITUDE OF MICROBIAL REACTIONS INVOLVING VITAMIN-LIKE COMPOUNDS

By HENRY McILWAIN

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CHANGES brought about by one or a few units of catalyst in each cell of a living organism are postulated in biochemical interpretations of genetics. The nature of the changes is unknown; but a favoured suggestion is that they may consist of participation in the formation of enzymes, or their 'shaping' from otherwise synthesized protein molecules[1]. This is a theoretical conception, and no reactions defined in terms of substrates or products, and studied by biochemical techniques, have previously been recognized as due to one or a few molecules of enzyme per cell. Reasons are given below for thinking that a certain class of reactions with vitamin-like substances in bacteria may be due to such enzymes.

Formation of Vitamin-like Substances by Bacteria

Authors have previously pointed out the relatively small quantities of known vitamins which are associated with individual cells. When expressed as molecules per cell, numbers of the order of 10^3 to 10^5 are found in the case of many bacteria[2,3] (*b*, Table 1). Consider now their rates of formation in growing bacteria. Cultures of the organisms of Table 1 for which data are available[2] doubled in population each hour. Thus, for example, some 5,000 molecules of aneurin were produced in an hour by (initially) one cell. Allowing for its growth by the factor $\log_e 2$, the rate of production becomes 3,500 molecules/cell of 10^{-13} gm. dry wt./hr., or about 1 molecule/cell/second. These rates (*c*, Table 1), are likely to give low estimates of the synthetic ability of bacteria, for the following reasons. (1) The vitamins are found also in the fluids in which the bacteria have grown. The values *d* of Table 1 take this into consideration. They are likely to be high if vitamin production has continued in the absence of growth, as can sometimes occur[4]. (2) The bacterial generation time of 1 hour, which was employed in calculation, is three times that typical of good conditions of growth. Rates treble those of column *d* (Table 1) give a range of values of 0·24 to 33 molecules/cell/sec., with exceptional upper values for pantothenic and nicotinic acids of 120 and 540 molecules/cell/sec., respectively. (3) The extent to which these rates represent metabolic reactions which are at all well defined needs independent demonstration. They may be the outcome of a balance between vitamin production and breakdown. Evidence in specific instances is considered later.

Rates of Enzyme Reactions

The velocities of several reactions catalysed by enzymes can be expressed in terms of the numbers of molecules of substrate which one molecule of enzyme causes to react per second. Such values—the turnover numbers of the enzymes—are usually determined under optimal or physiological conditions of temperature and *p*H, and with excess substrate. Values are given in Table 2. In general, they are seen to be greater than the numbers of molecules of

TABLE 1. QUANTITIES OF VITAMIN-LIKE SUBSTANCES FORMED BY BACTERIA[3], AND THEIR COMPUTED RATES OF PRODUCTION

Compound	Organism	Quantity associated with cells[3] (*a*) μmol./gm. dry wt.	Quantity associated with cells[3] (*b*) Molecules/cell of dry wt. 10^{-13} gm.	(*c*) Rate of production of vitamin of cell in culture doubling in size each hour (molecules/cell/sec.)	(*d*) Value corresponding to (*c*) but including vitamin of culture fluid. (molecules/cell/sec.)
Aneurin	*Aerobacter aerogenes*, aerobically	0·037	2200	0·4	0·8
	Aerobacter aerogenes, anaerobically	0·050	3000	0·6	1·0
	Serratia marcescens	0·090	5400	1·0	1·7
	Pseudomonas fluorescens	0·086	5200	1·0	2·8
	Proteus vulgaris	0·070	4200	0·8	0·8
	Clostridium butylicum	0·031	1900	0·4	1·5
Riboflavine	(above five bacteria)	0·12–0·18	7200–11,000	1·4–2	2·4–11
Nicotinic acid	" " "	1·6–2	96,000–120,000	18–23	31–180
Pantothenic acid	" " "	0·4–1·6	24,000–96,000	4·6–18	5·2–41
Pyridoxine	" " "	0·035–0·11	2100–6600	0·4–1·3	1·1–5·1
Biotin	" " "	0·007–0·029	420–1800	0·08–0·34	0·08–3·2
Folic acid	" " "	0·003–0·02	180–1200	0·03–0·25	0·25–1·2
p-Aminobenzoic acid[5]	*Aerobacter aerogenes*	0·120	7700	1·50	4·0
	Serratia marescens	0·048	3100	0·60	1·2
	Pseudomonas aerugenosa	0·073	4700	0·92	5·5
	Streptococcus hæmolyticus	0·060	3800	0·74	1·1
	Escherichia coli	0·270	17,000	3·32	3·9

TABLE 2. CATALYTIC ACTIVITIES OF SOME ENZYMES

Enzyme (source)	Coenzyme or prosthetic group	Substrates	Turnover number (mol./mol. enzyme/sec.)
Carboxylase (yeast)[6]	Aneurin pyrophosphate and Mg	pyruvic acid	22
Fumaric hydrogenase (yeast)[7]	flavin-adenine dinucleotide	fumaric acid and hydrogen donors	40–50
d-amino acid oxidase (pig kidney)[8]	,, ,, ,,	alanine and oxygen	33
Diaphorase (pig heart)[9]	,, ,, ,,	dihydro coenzymes I and II	130
Triosephosphate enzyme (yeast)[10]		3-phosphoglyceraldehyde and cozymase	300
Alcohol dehydrogenase (yeast)[11]		alcohol and cozymase	300
,, ,, [12]		acetaldehyde and dihydrocozymase	450
Laccase (*Rhus succedanea*)[13]	Cu	*p*-phenylene diamine	40
Polyphenol oxidase (mushroom)[13]	Cu	catechol	800
Phosphate-transferring enzyme of fermentation (yeast)[15]	Mg	3 phosphoglyceric acid and adenosine triphosphate	600
Phosphate-transferring enzyme of fermentation (yeast)[15]	Mg	1 : 3 diphosphoglyceric acid and adenosine diphosphate	5500
Hexokinase (yeast)[14]	Mg	glucose and adenosine triphosphate	230
Phosphorylase (muscle)[16]	adenylic acid	glucose-1-phosphate and glycogen	660
Carbonic anhydrase (beef erythrocytes)[17]	Zn	HCO_3^-	14
Yeast polypeptidase[18]		leucyldiglycine	17,000
Catalase (ox liver)[19]	Fe-porphyrin	hydrogen peroxide	44,000

vitamin-like substances with which one bacterial cell was computed to react in the same period of time.

Several instances are quoted in which enzymes from yeast cause reactions in compounds of Table 1, with high velocities. The turnover numbers of carboxylase, fumaric hydrogenase, hexokinase, a triosephosphate enzyme and alcohol dehydrogenase range from 22 to 450 mol./mol./sec. This implies that the derivatives of aneurin, riboflavin, and nicotinic acid which constitute their substrates, coenzymes or prosthetic groups are caused to undergo changes with that frequency. Corresponding numbers referring to these compounds, in column *d* of Table 1, range from 0·8 to 180. This justifies further consideration of the possibility that some stages in the syntheses of Table 1 may be due to one or a few enzyme molecules per cell.

The following factors render the above comparison indirect, but not invalid. (1) Turnover numbers have not been given for bacterial enzymes; but Table 2 includes values for enzymes of plant, animal, and microbial origin, without showing any marked trend in the values, dependent on the source of the systems. (2) Where most direct comparisons are available between Tables 1 and 2, the reactions concerned are in the first case the synthesis of coenzyme constituents, and in the second their behaviour as coenzymes or prosthetic groups in hydrogen transport. However, the group of enzymes concerned are not unusual in turnover number when compared with others of Table 2. Aneurin, riboflavin and nicotinamide are not unusual in comparison with other substances of Table 1. (3) As the quantities of vitamin-like substances associated with cells are relatively small, it appears likely that the enzymes concerned with them are not reacting at the velocities represented by their ordinary turnover numbers. If the quantities of vitamin-like substances associated with cells and quoted in Table 1 are expressed as molar concentrations in cells with assumed water-contents of 80 per cent, values of 5×10^{-6} to 5×10^{-4} *M* are obtained. These are maximum values for the concentrations of the substances concerned; compounds acting as intermediates in one or more reaction series would be expected to appear only transitorily and in very low concentrations. Experimental evidence on the effect of such factors is considered below. (4) Questions relating to cellular organisation are likely to present major difficulties in comparing reactions in living cells with those in isolated enzyme systems. The functioning of many enzymes, including certain ones causing reactions in vitamin-like compounds[4], is, however, independent of growth. Most of the instances of Table 1 concern syntheses within the cell of small quantities of vitamin-like substances from simple materials available in relatively large quantities, and used in relatively large quantities within the cells for general syntheses. Limitation through unfavourable permeability appears unlikely. Production of the vitamins of Table 1 presumably represents the outcome of many enzymes acting in parallel and in series, so that the overall rate would be limited by that of the slowest reaction. The rates of Table 1 may then be much slower than those of which most of the enzymes concerned are capable. Tending in the opposite direction is the fact that, whereas the values of Table 2 refer each to one enzyme, those of Table 1 may refer to the sums of more than one synthetic series; more than one derivative of nicotinic acid and of riboflavin are known to be catalysts. It is therefore desirable to have data more biochemically defined than that of Table 1.

TABLE 3. VELOCITIES OF DIRECTLY OBSERVED MICROBIAL REACTIONS WITH VITAMIN-LIKE COMPOUNDS

Organism	Reaction	Velocity, mμmol./gm./sec.	Velocity, molecules/10^{-13} gm./sec.
Proteus vulgaris[20]	Inactivation of nicotinamide (37°)	0·08	5·1
Hæmophilus parainfluenzæ[21]	Inactivation of cozymase (38°)	0·17	11
Yeast[20]	Inactivation and reactivation of cozymase (25°)	0·18–0·27	12–18
Yeast[21]	Interconversion of coenzymes I and II (30°)	0·12–0·15	8–10
Escherichia coli[4]	Synthesis of pantothenate from inorganic salts and glucose (37°)	0·78	50
,, ,,	As above, with added β-alanine (37°)	8·5	540
Pseudomonas aeruginosa[4]	Synthesis of pantothenate from inorganic salts and lactate, with or without β-alanine (37°)	0·14	9
,, ,,	As above, with added pantoic acid (37°)	0·47	30
Proteus morganii[4,21]	Inactivation of pantothenate (37°)	0·39–1·9	25–120
β-hæmolytic streptococci[4,22]	,, ,, ,,	0·36–0·64	23–41

Rates of More Specific Microbial Reactions with Vitamin-like Compounds

Table 3 represents the best approximation to such definition which it appears possible to give at present. The processes listed are mainly brought about by non-proliferating suspensions of bacteria or yeasts, but in no case are both their substrates and their immediate products known. The range of values for reaction velocities in this table is seen to be comparable with that computed from Table 1. Some processes will now be considered individually in an attempt to assess the extent to which they represent at all well-defined reactions.

Pantothenate. One of those examined most fully concerns the inactivation of pantothenate by hæmolytic streptococci[22], a process leading to unknown products which do not have the growth-promoting activities of pantothenate. Kinetic experiments with non-proliferating streptococcal suspensions showed rates of inactivation of 23 to 41 molecules/10^{-13} gm./sec. in the presence of excess pantothenate[23]. This is, therefore, an instance in which the reaction velocity is not likely to be limited through the vitamin-like compound which is acting as substrate being present in a suboptimal concentration. Also, pantothenate has been observed to have relatively free access to the system involved in its degradation : the process commenced without delay on mixing bacteria and pantothenate[23]. The rate of the reaction with a given batch of organisms was little affected by a wide variety of circumstances (including even the presence or absence of growth[4]) which might have been expected to disturb the rate of reaction if it were due to a balance between synthesis and breakdown. Pantothenate synthesis was not detected in the streptococci in any circumstances, even when the inactivation was inhibited. This could be done in a very specific manner, which suggested the inactivation to be due to a single and characteristic system[21,22]. Inactivation of a growth-factor serving as catalyst might be due to processes of attrition in functioning, not directly relevant to bacterial metabolism ; but the reaction in pantothenate is closely correlated with its functioning in growth. Thus, a series of compounds structurally related to pantothenate inhibited, to similar extents, both streptococcal growth and the inactivation of pantothenate ; and a given analogue inhibited in parallel both the inactivation and growth, in a series of bacteria of varying sensitivities[21]. Inactivation might also be a side reaction or minor activity on the part of enzymes which react much more rapidly with other substrates. The correlation between inactivation and functioning of pantothenate renders this also improbable.

An enzyme of turnover number 23–41 mol./mol./sec. would be among the less active ones of Table 2. A value for a turnover number of pantothenate in one of the organisms (*Pr. morganii*) of Table 3 is already available[24]. This concerns the increased carbon dioxide produced or oxygen absorbed during processes catalysed by pantothenate, and gives values of about 20 mols. (O_2 as H_2 equivalents)/mol. added pantothenate/sec.

Many of the reasons for querying the relevance of pantothenate inactivation to the present topic do not apply to its synthesis. This normally (Table 3) proceeds in *E. coli* and *Ps. aeruginosa* at rates comparable to those of the inactivation. The synthesis requires amide formation ; values reported for a yeast polypeptidase suggest the high value of 17,000 as turnover number. The highest rate of synthesis of pantothenate which has been found (Table 3) was that of 540 molecules/10^{-13} gm./sec., observed in the presence of relatively high concentrations of β-alanine. The effect of increasing concentrations of β-alanine was presumably to saturate the systems concerned in a late stage of pantothenate synthesis.

Nicotinic acid derivatives. Reactions of synthesis, inactivation and interconversion occur in nicotinic acid derivatives with velocities not far removed from 10 molecules/10^{-13} gm./sec. (Table 3). This itself suggests a group of defined reactions, and adds to the significance of the processes of inactivation. In the conversion of coenzyme I to II (Adler, Elliot and Elliot[20]), a large excess and relatively high concentration—about 10^{-3} *M*—of substrate was employed. In the inactivation of cozymase by apozymase (Lennerstrand[20]) the reaction velocity was little affected by variation in cozymase concentration over a 50-fold range which rose to 10^{-4} *M*. Similar systems responded rapidly to the coenzymes as catalysts, indicating that these substances had relatively free access to the cell interior. The velocity of interconversion or inactivation of the coenzymes is thus unlikely to be limited by the substances being present in suboptimal concentrations. The velocities may in certain cases be limited by the progress of concomitant reactions (McIlwain[20] ; see also below), but in the instances of Table 3 which are so conditioned, the concomitant reactions also were proceeding rapidly.

The number of molecules reacting per 10^{-13} gm. per second in the systems of Table 3 is again low in comparison with the change which can be brought about by one enzyme molecule, being a tenth to a fortieth of that which hydrogen transporting systems of Table 2 can bring about in cozymase in the same time[25]. The interconversions of coenzymes I and II in yeast preparations are among the most defined of the reactions of Table 3, and involve phosphate transfer. Of the reactions of Table 2, that between phosphoglyceric acids and adenine derivatives, catalysed by a purified enzyme from yeast, has turnover numbers of the order of 600–5,500 mol./mol./sec. Muscle phosphorylase and hexokinase also give numbers much above the 10 molecules/10^{-13} gm./sec. of Table 3.

General comparison of rates. As a whole, the values of Table 2 are much greater than those of Table 1 (columns *c* or *d*), and Table 3. To take a very crude measure, the average value in molecules/unit/sec. in Tables 1 and 3 (cell as unit) is about one-tenth that of Table 2 (molecule as unit)[26]. The main criterion in compiling the tables has been the availability of data, and close correlation is not to be expected. The difference in mean rates is, however, such as to emphasize the small probable number per cell of molecules of the relevant enzymes. At the same time, the difference is one which can be understood in terms of the preceding discussion. Supply of more immediate precursors increased the rate of pantothenate synthesis three-fold or ten-fold in *E. coli* and *Ps. aeruginosa* (Table 3).

Possible Significance of Enzymes which Occur to the Extent of only a few Molecules per Cell

Relation to the gene. Reactions such as those of Tables 1 and 3 can be affected in micro-organisms by irradiation, in a manner suggesting the disturbance to be due to changes in a single unit of inheritance[1,27], and suggesting such a gene to control one biochemical

step. The minimum activity required theoretically in the gene is reproduction of itself, and some further activity by which other cell-processes are affected. The further activity may also be a catalytic one[1], or may be a control of independently reproducing entities capable of catalysis[2,8]. The production of enzymes occurring to the extent of only one or a few molecules per cell needs special consideration in such schemes, which would require the production of one enzyme molecule per gene per 15 min. or so, and introduce the necessity of coupling accurately with cell division two processes each concerning individual molecules: the formation both of one gene and of the associated enzyme. Such difficulty would not arise in the case of an enzyme of which some hundreds of molecules occurred in each cell. But if stages in bacterial reactions with important cell-reagents, such as vitamin-like compounds, require only a few enzyme molecules per cell, it appears simplest to suppose that production of the enzyme concerned is in some way intimately associated with reproduction of the gene. One conclusion consistent with the present argument would be that the reactions concerned with vitamin-like compounds represent, themselves, the hetero-catalytic activities of genes. The suggestion that genes may exhibit enzyme action in the ordinary sense is not new, nor is the suggestion that critical processes may be carried out by one or a few enzyme molecules per cell[29]. But the possibility that such enzymes may be responsible for a particular group of already investigated reactions, in substances the biochemical role of which is of known importance, affords starting points for specific investigations and a defined set of working hypotheses.

It will be observed that if systems concerned in the metabolism of pantothenate and *p*-aminobenzoate are fairly closely related to genes, so also are the actions of their competitive inhibitors, pantoyltaurine and sulphanilamide.

Metabolic interrelationships. Reactions such as those of Table 3 which proceed at the speed of some mμmol./gm. dry weight of organism/sec. have been termed reactions of mμmol. order[30]. Several of them show connexions with other cell processes which are of additional interest, if they are brought about by entities closely related to genes. Thus, pantothenate not only has a catalytic role, probably in pyruvate metabolism[24], but also the inactivation of pantothenate requires a concomitant reaction such as glycolysis[21,22] (of some μmol./gm./sec. or μmol. order). Coenzymes I and II are not only required in carbohydrate degradation, but also their synthesis and breakdown are conditioned by the occurrence of such reactions[20]. A control by the more ordinary cell processes of μmol. order is thus imposed on the activities of certain enzymes concerned with mμmol. reactions. Considering the potential effect in the opposite direction, it will be seen that if an enzyme conditioning a mμmol. process is operating with a turnover number of some 50 mol./mol./sec., then in the 20 min. of a bacterial generation it could have controlled the production of 6×10^4 molecules, for example, of a coenzyme capable of acting with a similar turnover number. The effect of the initial enzyme molecule could thus extend to $\frac{1}{2}(6 \times 10^4)^2$ or $1{\cdot}8 \times 10^9$ molecules (if of glucose, to $5{\cdot}4 \times 10^{-13}$ gm., or several times the typical bacterial mass), in this time.

The concentration of many enzymes (such as those concerned in μmol. reactions) even in bacteria involves the occurrence of large numbers of their molecules in each cell. Their relationship to genes is thus of the type in which one gene influences the production of large numbers of enzyme molecules. One might suppose in bacteria different series of genes, some concerned with the enzymes required in μmol. processes and others concerned with the coenzymes or prosthetic groups. If the first series conditions protein formation, the second would control reactions of mμmol. order in vitamin-like compounds. Enzyme and prosthetic groups would then be formed in roughly comparable molar quantities, the varying turnover numbers of different enzymes (Table 2) allowing considerable elasticity in such a scheme. The turnover numbers themselves are presumably biologically conditioned by the need for biochemical balance within the cell[33].

If one third of the dry weight of a bacterium of 10^{-13} gm. consists of protein, this would suffice for 2×10^5 molecules of molecular weight 10^5, which is a magnitude frequently found in enzyme molecules; several of those of Table 2 are of this order. There are at least 250 genes in a bacterium such as *Escherichia coli*[27], and these appear to be of about 12 mμ in diameter or molecular weight about 750,000. Their number is not apparently likely to be more than, say, five times the value of 250; the much more complex *Drosophila* has only some 800 genes in its *X*-chromosome[27], and probably about 3,000 in all. In the bacterium the genes may thus constitute 0·1–1 per cent of the protein molecules. This is consistent with the balance suggested above between μmol. and mμmol. reactions.

Although the subject can be approached only tentatively, there is a further aspect of bacterial metabolism which requires assessing in relation to the suggested number of genes in a bacterial cell, and to the probability that a gene controls one biochemical step. A rough estimate of the number of reactions involved in autotrophic organisms in carbohydrate metabolism, synthesis of the amino-acids, simple peptides, lipoids, nucleic acids, and their constituents, and the vitamin-like compounds which are already known, gives a value of some 300 reactions. This makes no allowance for compounds as yet unidentified or not yet known to be general bacterial constituents; for the synthesis of specific proteins; or for arrangements necessary for assimilation and the avoidance of confusion between various intermediates in synthesis. Perhaps it may be supposed that many of the synthetic problems can be answered by suitable associations of the enzymes concerned, and that a reasonable proportion—say half—of bacterial constituents other than proteins are known. Then it still remains true that the number of reactions required for the purposes enumerated above, in nutritionally exacting organisms such as the β-hæmolytic streptococci, is less than that required in a non-exacting organism by a very considerable fraction. This makes understandable the development of nutritional needs in suitable environments, and the characterization of substances as vitamins[31].

Bacteria and other organisms. The degree to which the present suggestions concerning mμmol. processes can be extended to organisms other than bacteria is limited by the available data. Yeast cells and fungal spores are of some 50 to 250 $\times 10^{-13}$ gm. dry wt., but their rates of growth are slower than those of bacteria. With generation times of 3–6 hours, production of cells of similar vitamin content, but by means of the same number of enzyme molecules as in bacteria, would require the enzymes to exhibit 3 to 25 times the activity of those of the bacteria.

The difference between the rates of the reactions of Table 2 and those of Tables 1 and 3 suggest—though with much less security than in the case of bacteria—that certain such reactions may be due to only one or a few enzyme molecules per cell. Organisms such as Amœbæ or Paramecia, of 10^3 to 10^6 the volume of bacteria, are clearly beyond the scope of the present observations, even when the multiple nature of the nuclei of certain of them is taken into consideration. Indeed, differences in organisation would be expected to exist between organisms differing several thousandfold in magnitude. The present considerations suggest that these differences include the extension, to reactions with vitamin-like substances, of a mechanism by which one gene controls many enzyme molecules. One may query whether the relative simplicity and typical size of bacteria are related to the proportion of reactions they can carry out by enzymes which occur to the extent of one or a few molecules per cell, and which are closely related to the unit of inheritance.

Several reactions with vitamin-like compounds are carried out even by bacteria at high velocities; for example, the decomposition of nicotinic acid by a soil organism which derived its main energy and material from the compound[32]. This, if anything, serves to emphasize the similarity existing in the group of mμmol. reactions. The more rapid reactions, presumably involving control of many enzyme molecules by a given gene, are frequently adaptive, and suggest bacteria to possess the ability to transform a reaction of mμmol. to one of μmol. order, conceivably by proliferation comparable to that ascribed to the plasmagene. It must be emphasized in conclusion that to examine this and many other possibilities, much more information is required concerning the metabolism of vitamin-like compounds in bacteria.

Summary

Reactions in bacteria which take place at the rate of some mμmol./gm. dry wt./sec. may be due to one or a few molecules of catalyst per bacterial cell. They include some stages in the synthesis, breakdown and interconversion of many vitamin-like substances. Entities catalysing such reactions are likely to be closely related to the unit of inheritance. Many of these reactions are required for the progress of the more rapid cell reactions, such as respiration or fermentation, which proceed at the rate of some μmol./gm./sec. Also, progress of the first reactions can be conditioned by the occurrence of reactions of the second group. Reciprocal connexion is thus afforded between the sparsely distributed enzyme (and possibly the gene) and the synthesis of cell substance.

I have greatly appreciated the comments of Dr. D. G. Catcheside, Dr. M. Dixon, Prof. J. B. S. Haldane, and Prof. H. A. Krebs in the course of preparing this account.

[1] See symposium, *Ann. Missouri Bot. Garden*, **32**, 107 (1945), and Beadle, G. W., *Chem. Rev.*, **37**, 15 (1945).

[2] Data (unless otherwise indicated) from Thompson, R. C., Univ. Texas Pub. No. 4237, 87 (1943), who grew the organisms at 33° in a medium containing glucose, a casein hydrolysate and inorganic salts.

[3] 10^{-13} gm. has been taken as a typical bacterial dry weight, based on the following values (derived from data of Bergey, D. H., "Handbook of Determinative Bacteriology" (Baillière, Tindall and Cox, London); Topley, W. W. C., and Wilson, G. S., "Principles of Bacteriology and Immunity" (Arnold, London, 1946); Buchanan, R. E., and Fulmer, E. I., "Physiology and Biochemistry of Bacteria" (Baillière, Tindall and Cox, London, 1928)) for organisms of Tables 1–3: *Aerobacter aerogenes*, 0·4–2; *Escherichia coli*, 1·1–1·7; *Proteus vulgaris*, 0·7–1·4; *Pseudomonas aeruginosa*, 0·6–1·2; *Hæmophilus parainfluenzæ*, 0·15–0·4; *Serratia marcescens*, 0·5–0·8; *Streptococcus pyogenes*, $0{\cdot}15–0{\cdot}45 \times 10^{-13}$ gm. The probably multinuclear nature of certain of the organisms of the tables (cf. Robinow, C. F., in Dubos, R. J.: "The Bacterial Cell" (Harvard University Press, 1945)) favours the conclusions of the present article.

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[13] At 20°; Keilin, D., and Mann, T., *Proc. Roy. Soc.*, B, **125**, 187 (1938).

[14] At 30°, *p*H 7·5; Berger, L., Slein, M. W., Colowick, S. P., and Cori, C. F., *J. Gen. Physiol.*, **23**, 379 (1946); Kunitz, M., and McDonald, M. R., *J. Gen. Physiol.*, **29**, 393 (1946).

[15] At 25°; assumed molecular weight, 10^5; Bücher, T., quoted from the printer's proof (received privately) of a paper sent for publication in the *Biochem. Z.*, on June 29, 1944.

[16] At 25°; Cori, C. F., Cori, G. T., and Green, A. A., *J. Biol. Chem.*, **151**, 39 (1943).

[17] At 15°; calculated from activity and molecular weight given by Peterman, M. L., and Hakala, N. V., *J. Biol. Chem.*, **145**, 701 (1942), and the rate of the non-catalysed reaction derived from Meldrum, N. V., and Roughton, F. J. W., *J. Physiol.*, **80**, 113 (1933) and Brinkman, R., Margiara, R., and Roughton, F. J. W., *Phil. Trans. Roy. Soc.*, A, **232**, 65 (1933–34).

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[19] At 0°; Keilin, D., and Hartree, E. F., *Proc. Roy. Soc.*, B, **121**, 173 (1936).

[20] Computed, with some assumptions which are given in detail by McIlwain, H., "Advances in Enzymology", **7** (1947), from data of: Morel, M., *Ann. Inst. Pasteur*, **67**, 285 (1941); Lwoff, A., and Lwoff M., *Proc. Roy. Soc.*, B, **1 2**, 360 (1937); Lennerstrand, A., *Arkiv. Kemi, Min., Geol.*, **14A**, No. 16 (1941); Adler, E., Elliot, S., and Elliot, L., *Enzymologia* **8** 80, (1940); Euler, H. von, and Adler, E., *Hoppe Seyl. Z.*, **252**, 41 (1938).

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[23] McIlwain, H., *Biochem. J.*, **39**, 279 (1945).

[24] At 37°; data from Hills, G. M., *Biochem. J.*, **37**, 418 (1943); for calculation see ref. 20.

[25] Turnover numbers for nicotinic acid derivatives during hydrogen transport by *H. parainfluenzæ* and *Pr. vulgaris* can be calculated from data of Lwoff, A., and Lwoff, M., and of Morel, M. (see ref. 20), and yield values of 1 to 5 mol. H_2/mol. nicotinic acid derivative/sec. Lwoff and Lwoff, however, consider experimental circumstances to render the bacterial activity artificially low.

[26] Average from Table 1 calculated by taking the mean value for each vitamin-like substance with different organisms, and averaging these values. This gives a value of 19 mol./mol./sec. with one hour as mean generation time; if this is supposed to be 20 min., the figure becomes 57 mol./mol./sec. Average from Table 3, 65 mol./mol./sec. From Table 2, a simple average but excluding catalase and yeast polypeptidase: 560 mol./mol./sec.

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[29] Haldane, J. B. S., "Enzymes" (Longmans, Green, London, 1930); essay in "Perspectives in Biochemistry" (University Press, Cambridge, 1937).

[30] McIlwain, H., ref. 20. The rates are there expressed in mμmol./mgm dry wt./hr. and the values thus differ from those of Table 3 by a factor of 3·6. Of the units available for expressing metabolic coefficients, the latter would seem preferable in being derived from the gram-mol., gram, and second, especially in calculations of the present type which involve comparison with turnover numbers already expressed with the minute or second as time-unit.

[31] cf. Fildes, P., *Proc. Roy. Soc. Med.*, **28**, 79 (1934); Knight, B. C. J. G., Med. Res. Council Special Rep. Ser. No. 210 (1936); Lwoff, A., "L'Evolution Physiologique" (Paris, 1944).

[32] Allinson, M. J. C., *J. Biol. Chem.*, **147**, 785 (1943).

[33] The present considerations are relevant to only a few of the problems concerning the relative abundance of enzymes in cells. Pontecorvo (*Nature*, **157**, 95; 1946; and private communication) suggests that in most organism, all genes produce during the life-period of a cell a few molecules only of their primary products. The primary products of the genes are then considered to be capable of self-reproduction at rates specific to them, and so to condition the turnover per cell of reactions controlled by the genes. Enzymes occurring to the extent of only a few molecules per cell may then be regarded as an extreme case derived from products with very low rates of self-reproduction. This more general scheme tends to obscure the possibility that enzymes performing mμmol. reactions in bacteria may represent a simpler genetic process than those obtaining in other cases.

ISING'S THEORY OF BIRD ORIENTATION

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THE orientation of birds on migratory and homing flights still poses such baffling problems that the publication of an entirely new theory is a matter of exceptional importance to ornithologists. Critical experimental work on the homing of wild birds under conditions such that all guidance by previous knowledge of topography is ruled out, is still all too sparse. Nevertheless, evidence has for a long time been slowly accumulating that some species at any rate must possess powers of orientation independent of any terrestrial landmarks (see Griffin, 1944; review[1]); and more recently Rüppell[2] has added a further substantial piece of evidence for some 'sense of direction'. But what sensory mechanism could enable the bird to estimate correctly experimental displacement and maintain direction? For clearly any sensory equipment which is to meet fully the needs of the homing or migrating bird under adverse conditions, as when familiar landmarks are absent or obscured, must at least provide information with regard both to direction and latitude.

Prof. G. Ising, a distinguished Swedish geophysicist, has recently put forward[3] a new and highly original hypothesis on the sensory basis of direction-finding in animals, with special reference to problems of bird migration and homing. After pointing out the lack of evidence for, and the difficulties confronting, any magnetic theory of bird direction-finding, he proceeds to discuss the possibility that the perception of a Coriolis force, generated by the rotation of the earth, might provide the basis for an explanation. The Coriolis force may be described as follows. If a body is accelerated relative to the surface of the earth, the force per unit mass acting on it is not, as might be expected, numerically equal to the sum of this acceleration and the centrifugal acceleration due to the rotation of the earth, but contains a term in addition to these two. This term is equal to twice the product of the velocity relative to the surface of the earth, the angular velocity of the earth, and the sine of the angle between the direction of motion and the earth's spin axis. This 'extra' force is called the Coriolis force and is seen to vanish for zero velocity of motion over the earth's surface or if the body moves parallel to the earth's spin axis. For a full discussion of Coriolis forces see A. G. Webster's "Dynamics", 2nd edition, p. 317.

Prof. Ising has investigated theoretically the behaviour of liquid contained in a ring-shaped tube which is capable of being rotated relative to the spin axis of the earth. He shows that the Coriolis force produces two effects on the ring: first, a streaming movement in the fluid; and secondly, a couple acting on the ring. Both these effects have been verified in a semi-quantitative way in the laboratory with an apparatus having the ring 20 cm. in diameter. The energy involved in the two effects is of the same order. Ising's thesis is that these effects, alone or in combination, enable birds to determine their direction of flight and latitude; and he suggests that the semi-circular canals of the inner ear and their associated sense organs might be the structures by which the forces are perceived. Both effects are similarly dependent on latitude and on flight direction, but it is theoretically quite possible for the flying bird to disentangle these effects by periodic swinging movements of the head. From the physical point of view, therefore, there seems no great theoretical difficulty in regarding Coriolis forces as the basis for a latitudinal and directional sense in birds and other vertebrate animals.

Before, however, the theory can be accepted even provisionally, there remain to be considered practical and biological difficulties. The most important questions are: What is the magnitude of the forces involved, and what means has a bird of perceiving them? Ising shows that with a ring 1 cm. in diameter and 1 sq. mm. in cross-section, containing fluid of density 1 and zero viscosity, turning through 5·7° in the most favourable orientation will cause the fluid in the tube to gain a Coriolis energy of 2×10^{-13} ergs.

The bird would detect the motion by causing the kinetic energy of the liquid to be transmitted to some detecting apparatus such as the hairs of the crista or to the cupula (Lowenstein and Sand, 1940[4]). One must remember that each such hair has its own 2×10^{-14} ergs of Brownian agitation energy, per degree of freedom, and that there is, in Prof. Ising's model, a total of ten times this amount for distribution among the hairs per turning motion, even assuming a completely efficient energy transfer.

This crude picture of competition between the Coriolis energy and the Brownian energy needs modification in view of the fact that the bird can control to some extent the frequency spectrum of the Coriolis energy by changing the speed and nature of the head turning. So if the bird is differentially sensitive to the frequency of the displacement energy of the hair, the competition will not be between all the Coriolis energy and all the Brownian energy, but between those portions of them lying in the sensitive region. The bird may further gain by repetition of the swinging motion at a frequency lying in the sensitive region. Against all this we must set the fact that the most efficient transfer of energy from fluid to hair would take place when a large concentration of the Coriolis energy was in the frequencies near the natural frequencies of the hair, but that it is in these frequencies also that the greatest concentration of Brownian energy takes place. The net gain from these considerations cannot be estimated without accurate knowledge of the construction and elastic moduli of the hair; but it is improbable that it is high.

We must also inquire into the effect of changing the scale of the apparatus. It seems that the energy generated in the second effect is proportional to the seventh power of the linear dimensions of the ring, while in the first effect it is proportional to the sixth power. In consequence, a reduction in size by a factor of two would result in a hundredfold loss of energy generated. Thus if one were to take as criterion that the Coriolis energy must at least equal the Brownian agitation energy, the theory looks very unplausible for birds the semi-circular canals of which are smaller than 1 cm. in diameter, although the detection of energy increments

smaller than the Brownian energy is not impossible in principle.

The relative motion between the lymph and the wall of the canal, due, on the motion of the head, to the inertia and finite elastic properties of the system, cannot be estimated from the data at present available. But it must be borne in mind that this might well be of at least the same order as the motion due to the Coriolis forces.

Now, obviously, if this theory is indeed the basis of bird direction-finding, one would expect larger birds with larger semi-circular canals to be more efficient at long migration and homing flights than smaller birds. There is no suggestion that this is the case, though our present information on homing flights is too scanty to be of much value. Again, if the theory is true, one would expect the semi-circular canals of birds to be conspicuously large relative to the body size, compared with many other vertebrates; and moreover the canals should be relatively larger in small birds than in large ones. Here again the evidence is meagre, but the work of Retzius[5] gives a few readily accessible facts to go upon. Retzius describes and figures semi-circular canals of eleven species of birds. The accompanying table shows the maximum diameter in each case, expressed in cm., together with the weight in kgm. and wing-length in cm. of the female as given by O. Heinroth[6] and Witherby *et al.*[7] respectively.

It will be seen that while, as is the case with mammals (Prof. G. R. de Beer, personal communication), the canals of the smaller species are relatively larger than those of large species, the majority of birds have the canals well below 1 cm. in diameter; and many small birds which are far-flying migrants and expert homers obviously must have canals smaller still.

	Maximum diameter of semi-circular canals (cm.)	Body-weight, ♀ (kgm.)	Wing-length, ♀ (cm.)	Ratio of wing-length to canal diameter
Anser domesticus ..	0·82	3·0–3·5	41·6–46·8	55
Mergus merganser L. ..	0·79	1·40	25·0–26·7	32·7
Vanellus vulgaris, Bechst.	0·64	0·20	21·6–23·0	34·2
Scolopax rusticola L. ..	0·64	0·27	18·4–20·8	30·6
Columba domestica ..	0·59	0·30	21·0–22·2	36·6
Gallus domestica ..	0·64	1·50	—	—
Turdus musicus ..	0·465	0·07	11·1–12·1	24·3
Cypselus apus	0·43	0·04	16·4–17·9	39·9
Nucifraga caryocatactes L.	0·64	—	17·5–19·0	28·4
Bubo ignavus, Forst. ..	1·42	2·5–3·0	45·0–49·5	33·6
Haliætus albicilla ..	1·29	5·0	61·0–68·5	50·0

In view of all these circumstances, we cannot avoid the conclusion that, sound and ingenious as the theory is from the point of view of the physicist, it encounters very great practical and biological difficulties. It does, however, serve to emphasize the need for repetition and extension of long-distance homing experiments critically controlled and on a much larger scale than hitherto. The design of many past homing experiments has been open to criticism in one way or another, but there seems little doubt that it should be possible to plan experiments which would put Ising's theory to the test.

[1] Griffin, D. R., *Quart. Rev. Biol.*, **19**, 15 (1944).
[2] Rüppell, *J. Orn. Lpz.*, **92**, 106 (1944); see *Ibis*, **88**, 262 (1944).
[3] Ising, G., *Ark. Matematik, Astronomi och Fysik*, **32A**, N. 18, 1 (1945).
[4] Lowenstein, O., and Sand, A., *Proc. Roy. Soc.*, B, **129**, 256 (1940).
[5] Retzius, "Das Gehörorgan der Wirbelthiere", **2** (Stockholm, 1885).
[6] Heinroth, O., *J. Orn. Lpz.*, **70**, 172 (1922).
[7] Witherby, H. F., *et al.*, "Handbook of British Birds" (1938–42).

OBITUARIES

Prof. Pierre Weiss

ALTHOUGH Prof. P. Weiss died so long ago as November 1940, there has been a lengthy interruption of the flow of scientific news from France. Tribute to the great teacher and experimenter, whose influence dominated Continental magnetism for forty years, must of necessity be a little tardy.

Weiss was a true son of Alsace, being born at Mulhouse in 1865. Doubtless influenced by family connexions with industry, he began a four-years engineering course at Zurich in 1883. After this he entered the École Normale Supérieure, Paris, becoming *preparateur-assistant* there on the completion of his studies. Interest in magnetic problems had already been aroused by the work of Ewing. In 1895 Weiss took a lectureship at Rennes; and in the following year he presented his doctor's thesis at the Sorbonne, dealing with the properties of magnetite; then followed a move to Lyons, and in 1903 his appointment to the chair of physics at the Federal Polytechnic, Zurich. Already he had produced some twenty or so papers, including the classic ones on pyrrhotine.

The next few years, up to 1914, were Weiss's most productive, and accounted for more than sixty papers. In 1907, the fertile hypothesis of the molecular field and spontaneous magnetization was put forward. With Beck he investigated the relation between specific heat and molecular field for ferromagnetics. In 1910, Weiss spent a period in the laboratories of Kamerlingh Onnes; the influence of this period on the subsequent work of Weiss and his students is most apparent. In 1911 began the lengthy series of measurements of atomic magnetic moments leading to the introduction of a new unit, the Weiss or experimental magneton. Bohr's magneton is a fundamental unit with theoretical justification and, to within a fraction of 1 per cent, five times the Weiss unit. It is a measure of Weiss's enormous prestige that his experimental unit appears to have been preferred on the Continent up to the outbreak of the Second World War. Zurich before the First World War must have been particularly stimulating, with Einstein, Schrödinger, Ehrenfest, Debye, Piccard and Weiss shared between the University and Hochschule. Weiss always took pride in the fact that he was one of the small group that founded the Société Suisse de Physique, and that he was president up to 1914.

During the War, for about a year, Weiss was attached to the Direction des Inventions, Paris. With Cotton he devised a sound-ranging system for locating enemy artillery batteries. During 1916–18 he returned to his Zurich chair.

In 1918 came the call to assist with the building up again of the University of Strasbourg. No finer choice could have been made. In the Institut de Physique, electric light and central heating were quickly installed, the director's apartments were converted into laboratories, part of the basement was given over to accumulators, charging plant and switchgear. The building was wired to provide current for the electromagnets that the workshops made in addition to quantities of galvanometers, potentiometers and other apparatus. (Weiss's design of electromagnet is now standard equipment, and the Paris cyclotron magnet owes much to his interest and advice.)

The research programme of the Institute was divided up, magneto-optics to Ollivier, ferromagnetism to Forrer, paramagnetism to Foëx, X-radiography to Hocart, mathematical physics to Bauer, high-frequency work to Ribaud, to all of whom Weiss conveyed his enthusiasm. Every Monday all the research workers met for a session of "questions de l'ordre du jour". Weiss went to endless trouble at these meetings to help a worker finding honest difficulties; he went to similar trouble in rebuking a worker doing slovenly work or presenting it badly if he or she should have known better. Of particular joy to Weiss was the formation of a Strasbourg section of the Société de Physique française—the first of the provincial sections. There was but one choice for president. In the 1919–39 period Weiss continued his practice of shutting himself in the laboratory one or two days a week and being available to no one. Rather more than forty papers were produced in these years.

Large numbers of foreign workers came to the Institute, and Weiss was always most helpful and kindly to them, going out of his way to assure himself that they were comfortably housed, had sufficient money, and that all was well at their homes. The number of British students was small, but Rumanians and Poles came in plenty. Many of the workers were mature, being schoolmasters to whom the French *lycée* teaching programme afforded plenty of leisure. Weiss was a charming host, and there were many happy receptions held in the long wide corridor of the Institut de Physique following scientific meetings. Everyone met everyone, and not the least charming feature was the manner in which the other members of the Weiss family devoted themselves to putting everyone at ease. Weiss could chat readily in German (including Swiss, Alsatian and Mulhouse patois), Dutch and English besides his native French. Happy, and believing in the value of the work being accomplished in Alsace, Weiss declined advancement in Paris; in 1926 he had been elected a member of the Academy of Sciences. He was also doctor *honoris causa* of Geneva.

Weiss retired from the post of director at Strasbourg in October 1936, but continued to direct the magnetic laboratories until 1939, when the University was dispersed. Weiss himself went to Lyons, and, despite serious heart trouble, worked hard editing and translating papers presented to the International Magnetism Congress held in Strasbourg four months before the outbreak of war. In November 1940 he died in his seventy-sixth year.

I am indebted to Prof. G. Foëx, director of the Institut de Physique at Strasbourg, for furnishing me with some of the details mentioned.

C. R. S. Manders

We regret to announce the following deaths:

Mr. F. W. Frohawk, well known for his illustrations of bird and insect life, on December 10, aged eighty-five.

Brigadier H. St. J. L. Winterbotham, C.B., C.M.G., D.S.O., formerly director-general of the Ordnance Survey, and recently general secretary of the International Geodetic and Geophysical Union, on December 10, aged sixty-eight.

NEWS and VIEWS

Crystallization of Synthetic Penicillin

The recent announcement in *Science* (104, 431; November 8, 1946) that du Vigneaud, Carpenter, Holley, Livermore and Rachele have isolated the crystalline triethylammonium salt of synthetic penicillin-II, identical in all respects with the optically active triethylammonium salt of natural penicillin, has solved one more of the extraordinarily difficult series of problems that this remarkable substance has set. Readers will recall the statement on penicillin chemistry which appeared in *Nature* of December 29, 1945, p. 761, wherein an account was given of the co-operative effort of British and American chemists working under the auspices of the Medical Research Council (London) and of the Committee on Medical Research (Washington), and which will appear shortly in monograph form. During this highly successful essay in trans-Atlantic co-operation, chemists in the United States and in Britain were able to show that in the reaction between certain oxazolones bearing a potential aldehyde group and *d*-penicillamine, antibiotic activity corresponding to a 0·03 per cent yield of penicillin could be produced with regularity, and this could be raised to a 0·22 per cent yield under better conditions. This product, moreover, had a 'bacterial spectrum' similar to that of natural penicillin, and when isotopic 'tracer' technique was applied to the problem by use of penicillamine containing radioactive sulphur, the added natural penicillin was isolated as a triethylammonium salt which could be recrystallized repeatedly without sensible variation of its radioactive sulphur content. In addition, the presence of penicillin in the synthetic mixture was shown by its destruction by the enzyme penicillinase.

The use of partition chromatography by an American firm on the synthetic reaction mixture led to an active material containing 2·6 per cent of penicillin, while an application of the 'counter-current distribution' principle of Craig to this problem by du Vigneaud and his colleagues has raised the yield in one case to more than 16 per cent. The innate instability of penicillin frustrated efforts to fractionate such products, and it was only when the one-stage condensation process was modified to a two-stage process that a readily reproducible yield of activity could be obtained which proved thoroughly amenable to fractionation by the 'counter-current distribution' method. Eventually crystals of triethylammonium penicillin-II were obtained, identical in all respects with the corresponding salt of the natural product. Although use of *l*-penicillamine in the synthesis apparently leads to biologically inactive material, du Vigneaud and his colleagues have found that *d*-penicillamine can be replaced by *d*-cysteine, the thiolthreonines and β-mercaptoleucine with production of new penicillins which may possess different 'bacterial spectra'. It cannot yet be said that "what was only a path is now made a high-road", but the knowledge that is now being garnered with regard to the mechanism of the reaction involved in the two-stage synthesis may one day make it possible for synthetic penicillins to compete with the natural products.

Engineering at the City and Guilds College: Prof. E. F. D. Witchell

In conferring the title of emeritus professor in mechanical engineering upon Edward Frank Dalby Witchell, the Senate of the University of London has signified its appreciation of a distinguished career in academic circles. His retirement severs a long and valued connexion with the University and with the City and Guilds College. After attending the City and Guilds College during 1898–1901 as a student in the Department of Mechanical Engineering, Witchell joined the staff of the College and eventually was appointed assistant professor and reader. His election as a member of the Institution of Mechanical Engineers and as president of the Association of University Teachers was followed by his appointment as professor in 1931, election as a fellow of the City and Guilds of London Institute in 1934 and appointment as deputy vice-chancellor of the University of London for 1945–46. His ability in debate and intimate knowledge of University procedure inevitably destined him to serve on the numerous academic boards, including the Board of the Faculty of Engineering, the Board of Studies in Civil and Mechanical Engineering and as its secretary for thirty-two years, the Academic Council and the Senate.

As a teacher, Witchell will long be remembered by many old students of the City and Guilds College for his clear and concise treatment of the subjects under discussion; his apparently effortless ability to explain fundamental principles, his fund of wit and sense of humour gave to his lectures a freshness that is rarely met in lecture theatres. It is among Old Centralians, perhaps, that his versatile qualities have been most freely displayed, and no small debt of gratitude is owed to him for the part he has taken in promoting social life between students, past and present, and inspiring the loyalty and devotion to the College that is characteristic of the Old Centralians.

Division of Colloid Chemistry, American Chemical Society — Prof. C. Edmund Marshall

Prof. C. Edmund Marshall, professor of soils at the University of Missouri, has been elected chairman of the Division of Colloid Chemistry of the American Chemical Society, in succession to Dr. Geoffrey E. Cunningham of the Dollinger Corporation, Rochester, N.Y. Other new officers of the Division are: Dr. Robert D. Vold (vice-chairman), of the University of Southern California; Dr. W. O. Milligan (secretary-treasurer), of the Rice Institute, Houston, Texas; Dr. E. A. Hauser, Massachusetts Institute of Technology; Dr. M. W. Tamele, of the Shell Development Company, Emeryville, Calif.; and Dr. J. W. Williams (chairman of the Symposium Committee), of the University of Wisconsin, Madison.

Prof. Marshall was born at Bredbury, Cheshire, on January 9, 1903, graduated from the University of Manchester and received the degree of M.Sc. for work on colloid chemistry. He was awarded a three-year research scholarship by the Ministry of Agriculture, and spent two years investigating the chemistry of humus at Rothamsted Experimental Station. The following year was spent in Prof. C. Wiegner's laboratory at Zurich, studying colloid chemistry and mineralogy. In 1928, he was appointed assistant lecturer in agricultural chemistry at the University of Leeds, where he started research in the colloid chemistry and mineralogy of soils and clays, which he has continued up to the present. In 1936, Dr. Marshall was invited to become visiting associate professor of soils at the University of Missouri; he decided to remain there, and in 1941 was appointed professor of soils. He was elected president of the Soil Science Society of America this year.

Tycho Brahe Celebrations

The University of Copenhagen celebrated the four hundredth anniversary on December 14 of the birth of Tycho Brahe (see *Nature*, December 14, p. 856), and honorary degrees were conferred on twelve astronomers from Denmark, Great Britain, Holland, Norway, Sweden, the United States and the U.S.S.R. The British representatives were Sir Harold Spencer Jones, Astronomer Royal, and Prof. F. J. M. Stratton, professor of astrophysics in the University of Cambridge.

A Century of Chemistry in Britain

As part of the centenary celebrations of the Chemical Society, an exhibition illustrating the achievements of British chemistry during the past century and the part which chemistry plays to-day in everyday life, organised by the Chemical Society and the Department of Scientific and Industrial Research, is to be held at the Science Museum, South Kensington, during July and August 1947. The Chemical Society is preparing the first part of the exhibition, which is to be historical in character, illustrating the great advances that have taken place during the hundred years of the Society's existence. How great are those advances will be noted when it is realized that, at the foundation of the Society, Dalton's atomic theory was but thirty years old; and the study of organic chemistry was in its infancy. Each branch of chemistry is under the care of a panel of experts who are now engaged in preparing an account of the progress in the past hundred years which this exhibition serves to illustrate. The Department of Scientific and Industrial Research is preparing a modern section dealing with the applications of chemistry to everyday life. Between the two parts of the exhibition there will be a linking section which will explain the processes by which the chemical engineer turns raw materials into the products which are familiar in the day-to-day life of every citizen. This will lead on to sub-sections dealing with such themes as textiles, agriculture, homes and buildings, roads and transport, fuel and power, health and food. The Department is having the co-operation of the Agricultural Research Council, various research associations and other organisations in the preparation of these exhibits; and the Central Office of Information is to be responsible for the design and layout of this part of the exhibition.

Aristotle's Views on Falling Bodies

Alvaro-Alberto has published an article (*An. Acad. Brasil. Ciencias*, 18, No. 1, March 31, 1946) which emphasizes a misunderstanding regarding the teaching of Aristotle on the velocities attained by falling bodies of different masses. It is often assumed that he taught that the velocity was proportional to the weight of the body, and that Galileo was the first to show the falsity of this assumption. A letter from J. F. Hardcastle which appeared in *Nature*, 92, 584, January 22, 1914, pointed out that Aristotle was referring to motion in a resisting medium, and that the velocity which he was considering was the

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The Faraday Society

A GENERAL DISCUSSION
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will be held at the University, Manchester
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on Wednesday, 9th of April, and Thursday, 10th of April, 1947.

It will comprise a theoretical section (including wave-mechanical, thermodynamical and kinetic treatments) and an experimental section dealing with

(a) the deposition and dissolution of metals, and

(b) anodic, and other electrode processes.

Those who wish to submit contributions are invited to send titles of their papers (together with a brief summary in duplicate) to the Editor not later than December 31st, 1946

G. S. W. MARLOW,
Hon. Secretary and Editor,
Faraday Society,
6, Gray's Inn Square,
London, W.C.1

ESSEX EDUCATION COMMITTEE

South-East Essex Technical College and School of Art, Longbridge Road, Dagenham

Head of Department of Chemistry and Biology

Applications are invited for the above post, rendered vacant by the appointment of the present holder to the Headship of the Chemistry Department at Chelsea Polytechnic. The salary is in accordance with Grade II scale for heads of departments, viz., £750 by £25 to £850, together with London allowance and training allowance. The department provides a considerable amount of special honours degree work in chemistry, and the biology side is also important. Duties will begin on April 1, 1947, or as soon thereafter as possible.

Application forms, which should be returned not later than January 13, 1947, may be obtained from the undersigned on receipt of a stamped addressed envelope.

Department of Chemistry and Biology

Applications are invited for the full-time appointment of Lecturer in Chemistry. Candidates should be honours graduates in chemistry. Industrial or research experience will be an additional qualification. Duties, which will begin as soon as possible after January 1, will involve instruction of classes in chemistry up to general and special degree standard. The salary will be in accordance with the Burnham technical scale, plus London allowance.

Forms of application and further particulars are to be obtained by sending a stamped addressed envelope to the Clerk to the Governors at the College, Longbridge Road, Dagenham, Essex, and should be returned to him not later than January 6, 1947.

CITY OF LEEDS

Public Health Department

DEPUTY CITY ANALYST

Applications are invited for the post of Deputy to the City Analyst under the Leeds Corporation. The person appointed will be required to devote the whole of his time to the work, under the direction of the City Analyst, and will not be allowed to engage in private practice. Applicants must hold the qualification F.R.I.C. (Branch E).

Salary £700 per annum, rising subject to satisfactory service to a maximum of £800 per annum. A cost-of-living bonus (at present amounting to £59 16s. per annum) is also payable.

Subject to the approval of the Ministry of Health and the Ministry of Agriculture, the person appointed will be called upon to act as Additional Public Analyst and Deputy Agricultural Analyst. He will be required to pass a medical examination and to contribute to the Superannuation Fund established under the Local Government and Other Officers Superannuation Act, 1937. The appointment will be subject to termination by three months' notice on either side.

Applications, giving details of age, qualifications, and experience, together with copies of not more than three testimonials, and endorsed "Deputy City Analyst," must be delivered at my office not later than 10 a.m. Friday, January 3, 1947. Canvassing in any form, either directly or indirectly, will be a disqualification.

J. JOHNSTONE JERVIS,
Medical Officer of Health.

METROPOLITAN WATER BOARD

SENIOR CHEMIST

The Metropolitan Water Board invite applications for the position of Senior Chemist (male). Candidates must hold a degree in chemistry from a recognized university, must produce evidence of experience in the chemical examination of water in all stages of purification, and should be under forty-five years of age. The appointment is whole-time and the duties will consist in organizing and assisting in the routine work of the chemical section and in carrying out research or other work as required from time to time by the Director of Water Examination. Basic salary £970 per annum, rising by annual increments of £50 to £1,120 per annum, plus cost-of-living bonus (at present £80 per annum). The successful candidate will be required to pass a medical examination by the Board's Chief Medical Officer, and to undertake in writing to join the Board's Superannuation and Provident Fund. Applications, stating applicant's age, present position and salary, qualifications and experience, accompanied by copies of not more than three testimonials, must be delivered to the undersigned, endorsed "Senior Chemist," not later than 10 a.m. on Friday, January 31, 1947. Canvassing, directly or indirectly, is prohibited, and candidates should state in their applications whether, in their knowledge, they are related to any member of, or the holder of any office, under the Board.

C. W. STOKER,
Clerk of the Board.

Offices of the Board,
New River Head, Rosebery Avenue, E.C.1.

NEW ZEALAND GOVERNMENT

Vacancies for PROFESSIONAL FORESTERS in the New Zealand State Forest Service

Applications from Professional Foresters are invited for vacancies in the New Zealand State Forest Service. Salaries range from £(N.Z.)435 to £(N.Z.)710 per annum, according to previous experience and qualifications.

Applicants are required to be graduated in forestry or possess equivalent qualifications. The applications should include full details of the age, nationality, marital status, academic career, and practical experience of the applicant, and be supported by copies only of recent testimonials.

The State Forest Service is expanding and requires additional qualified staff immediately, not only for general forestry duties and research, but also to fill tutorial vacancies at Staff Training Centres. There will be prospects of further advancement for officers of courage, initiative, and administrative ability.

Fares of successful applicants and their families will be paid from country of residence to New Zealand provided an undertaking is given to remain in the service of the New Zealand Government for a period of three years. Salary will commence from the date of taking up duty in New Zealand, and accommodation allowance will be paid for a short period to meet excessive expenditure before permanent accommodation is secured.

Applications, accompanied by testimonials, are to be addressed to the High Commissioner for New Zealand, 415, Strand, London, W.C.2, and should be lodged not later than January 12, 1947.

ST. HELENS EDUCATION COMMITTEE

Municipal Technical College

Principal: J. R. Petrie, B.Sc., M.I.Mech.E.

Applications are invited for the following permanent full-time teaching posts:

Lecturer in Mining and Allied Subjects. Applicants should be graduates in mining or possess equivalent qualifications. A first-class (Colliery Managers') Certificate of Competency, together with practical experience in mining, is essential. Teaching experience with part-time day students would be an advantage. Salary in accordance with Burnham technical scale. Commencing rate will include increments for approved experience in industry, etc., after the age of 21 years.

Lecturer in Electrical Engineering subjects. Applicants should hold an honours degree, have had good industrial and teaching experience, and be capable of taking classes to Higher National Certificate standard. Salary in accordance with Burnham technical scale. The post will be recognized as one of special responsibility with an additional allowance. Commencing rate will include increments for approved experience in industry, etc., after the age of 21 years.

Application forms (obtainable by sending stamped addressed foolscap envelope) should be returned not later than December 31, 1946.

N. F. NEWBURY,
Director of Education.

Education Office,
St. Helens.

UNIVERSITY OF SHEFFIELD

Vice-Chancellor:
J. I. O. Masson, M.B.E., D.Sc., F.R.S.

DEPARTMENT OF BACTERIOLOGY

Professor:
C. P. Beattie, M.A., M.B., Ch.B., D.P.H.

Applications are invited for a post as Lecturer in Bacteriology. Salary £550, rising by £25 every year to £650, and then if the appointment is renewed £700. In the case of a medically qualified candidate of outstanding attainment, consideration may be given to making the appointment as a Senior Lecturer, at a salary of £750, rising by £50 every two years to £1,000. In either case there will be superannuation provision under the Federated Superannuation Scheme for Universities, and family allowance.

Applications (three copies), including the names and addresses of referees and, if desired, copies of testimonials, should be sent to the undersigned (from whom further particulars may be obtained) by February 15, 1947.

If a referee named by a candidate is abroad, the candidate may ask the referee to send a confidential report direct to the Professor without waiting for an inquiry from the university.

A. W. CHAPMAN,
Registrar.

ROYAL TECHNICAL COLLEGE, GLASGOW

Department of Chemistry

Applications invited for a Grade I Lectureship, salary £450 by £15 to £700. Applicants should possess special qualifications in organic chemistry. Further particulars and form of application may be obtained from the Secretary. Applications to be submitted by January 18, 1947.

CITY OF BIRMINGHAM

Selly Oak Hospital

SENIOR LABORATORY TECHNICIAN

Applications are invited for the post of Senior Laboratory Technician, Selly Oak Hospital, with salary according to the Joint Committee on Salaries and Wages (Hospital Staffs), £390 by £15 to £420 per annum. Previous experience may be taken into consideration in determining the commencing salary. Possession of the Fellowship of the Institute of Laboratory Technology will be of advantage. Including the Biochemical Department, the total number of assistant technicians is eleven.

The present duties of the technician appointed will be mainly histological and haematological. The appointment will be subject to the provisions of the Local Government Superannuation Act, 1937, and the successful candidate will be required to pass a medical examination. The post will be subject to one month's notice on either side.

Further particulars of the appointment may be obtained from the Medical Superintendent of the hospital. Applications, stating age, qualifications, and experience, and enclosing copies of three testimonials, should be forwarded to the Medical Superintendent, Selly Oak Hospital, as soon as possible.

NATIONAL MILK TESTING SERVICE

Applications are invited for the following posts in a temporary capacity in the Cambridge province under the Ministry of Agriculture and Fisheries:

1. Provincial Supervisor to exercise general supervision of the service in the province. Applicants should possess a degree in science or the equivalent, and should have had sound training in dairy bacteriology and experience in dairying. The salary scales are as follows: men £300 to £400 per annum, women £240 to £320 per annum. A consolidation addition is also payable.

2. Area Supervisor to supervise the work of the service in North Norfolk and Holland (Lincs). Applicants should possess a degree in science or N.D.D., and should have had experience in dairy bacteriology and dairying. Salary scales are as follows: men £200-£300 per annum, women £200-£275 per annum. A consolidation addition is also payable.

Further particulars of the above posts can be obtained from the Advisory Bacteriologist, 75/77, Regent Street, Cambridge, to whom applications should be forwarded not later than January 7, 1947.

UNIVERSITY OF DURHAM

King's College, Newcastle-upon-Tyne

The Council of King's College invite applications for the post of Statistician to the Nuffield Department of Industrial Health. Applicants should have preferably a mathematical or biological background. The duties will consist of: (a) co-operating with the medical staff in the carrying out of surveys of morbidity and accidents in industrial populations, (b) advising upon the design of the laboratory experiments and the analysis of their results. There will also be some elementary statistical teaching. The salary will be fixed at a point between £400 and £1,000 per annum, depending upon experience.

Ten copies of application, together with the names of three persons to whom reference can be made, should be submitted to the Professor of Industrial Health, from whom any further particulars may be obtained, not later than Friday, January 31, 1947.

G. R. HANSON.
Registrar of King's College.

COUNTY BOROUGH OF WEST HAM

West Ham Municipal College, Romford Road, Stratford, E.15

Principal: E. A. Rudge, Ph.D., M.Sc., F.R.I.C., A.M.I.Chem.E.

Applications are invited for the post of Assistant Curator at the Essex Museum of Natural History, Romford Road, West Ham, E.15. Applicants should have some museum experience, and a university degree is desirable, but not essential. A good knowledge of photography is essential. The successful applicant would occasionally be required to act as Guide Lecturer.

Salary £285, rising by annual increments of £15 to £330, plus bonus, at present £59 16s. per annum.

Application forms, with full particulars, can be obtained on application to the Principal, West Ham Municipal College, and should be returned to him not later than January 31, 1947.

IRVINE G. JARDINE,
Education Officer.

Education Department,
95, The Grove, E.15.

ROYAL VETERINARY COLLEGE AND HOSPITAL

Applications are invited for the post of Lecturer in the Department of Animal Husbandry from candidates who are members of the Royal College of Veterinary Surgeons. Some experience of general veterinary practice, especially among farm animals, is desirable. Salary will be on the scale £500 a year, rising by annual increments of £25 to £850 a year, together with benefits under the Federated Superannuation System for Universities. Pay of the appointee will be fixed within this scale according to age, experience, and qualifications. Applications, giving the names of three persons to whom reference may be made, should be sent not later than January 11, 1947, to the Bursar and Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1.

ROYAL VETERINARY COLLEGE AND HOSPITAL

Applications are invited for the post of Lecturer in Biochemistry in the Department of Animal Husbandry. Preference will be given to candidates with experience of work relating to animal nutrition. Salary will be on the scale £500 a year, rising by annual increments of £25 to £850 a year, together with benefits under the Federated Superannuation System for Universities. Pay of the appointee will be fixed within this scale according to age, experience, and qualifications. Applications, giving the names of three persons to whom reference may be made, should be sent not later than January 11, 1947, to the Bursar and Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1.

UNION OF SOUTH AFRICA

FISHERIES RESEARCH

Applications are invited for the post of Director of the South African Fisheries Research Institute in Cape Town, to be responsible for the administration and management of the Institute under a Board of Control, and to direct the research programme. The minimum qualifications required are a university degree, plus a knowledge of the fishing industry and of the technology of the processing of fish products, together with administrative experience. The salary scale is £1,200-£1,500.

Applicants are requested to write in the first instance to the Scientific Liaison Officer, South Africa House, Trafalgar Square, London, W.C.2, for further information and application forms, which list the details required.

ROYAL INSTITUTION

AWARD OF GRADUATE MEMBERSHIPS

Notice is given that the Managers of the Royal Institution will shortly proceed to award three Graduate Memberships of the Institution for the year 1947. Graduates of either sex, of any university of the British Empire, who have graduated during 1946 with first- or second-class honours in any scientific subject, are eligible for these awards. The Memberships entitle the holders to the full privileges of the Institution for a period of three years, except that of voting at meetings of the Members.

Full particulars and forms of application can be obtained from the General Secretary, Royal Institution, 21, Albemarle Street, London, W.1. Completed applications must be received by January 15, 1947.

BRADFORD EDUCATION COMMITTEE

Technical College, Bradford

Applications are invited for appointment as Assistant Lecturer (woman) with qualifications in chemistry, physics, or mathematics. The Assistant Lecturer will also supervise generally the women students of the College.

Basic salary according to the Burnham scale, which is from £270 to £420 per annum. Commencing salary according to qualifications and experience, and the post will, subject to approval, be a special post under the Burnham award, with an additional allowance of £40 net per annum.

Further particulars of the appointment and forms of application may be obtained from the Director of Education, Town Hall, Bradford, and completed forms should be returned to the Principal of the College within two weeks from the date of publication of this advertisement.

THOS. BOYCE,
Director of Education.

UNIVERSITY OF LONDON

The Senate invite applications for the Chair of Mathematics tenable at the Imperial College of Science and Technology (salary £1,500). Applications must be received not later than February 6, 1947, by the Academic Registrar, University of London, Senate House, W.C.1, from whom further particulars should be obtained.

WEST OF SCOTLAND AGRICULTURAL COLLEGE

POST OF PRINCIPAL

The Governors invite applications for the post of Principal, which has been vacant since the retiral of Principal W. G. R. Paterson on September 30, 1944.

Applicants, who should be graduates of a university within the British Empire, should possess a sound knowledge of agriculture and have had wide experience in the organization of agricultural education, research and advisory work.

The salary offered is £1,650 per annum. Conditions of the appointment are obtainable from the undersigned, with whom applications should be lodged not later than February 28, 1947.

N. B. BAIN,
Secretary.
6, Blythswood Square,
Glasgow.

CITY OF LEICESTER EDUCATION COMMITTEE

Leicester College of Technology
The Newarke

Applications are invited for the post of Head of the School of Chemistry. Candidates should have suitable academic qualifications, together with teaching and administrative experience in a technical college, and industrial or research experience. The department is Grade I, with a salary scale £600 by £25 to £750, to which scale is added the usual training allowance.

Applications, together with three recent testimonials and the names and addresses of three referees, should be sent on the special form to the Principal within two weeks of the appearance of the advertisement.

ELFED THOMAS.
Education Department, Director of Education.
Newarke Street, Leicester.

CITY OF LEICESTER EDUCATION COMMITTEE

Leicester College of Technology
The Newarke

Applications are invited for the position of full-time Lecturer in the Department of Biology.

Applicants should possess a good honours degree in zoology or botany or a good general degree in both subjects. Ability to teach botany or zoology to degree standard is essential, and experience in physiology or an applied branch of biology would be an additional qualification.

Salary in accordance with the Burnham scale for technical colleges.

Forms of application and particulars of the post may be obtained from the Principal, to whom completed applications should be returned as soon as possible.

ELFED THOMAS.
Education Department, Director of Education.
Newarke Street, Leicester.

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

There will shortly be a vacancy for a metallurgist as Chief Officer of the Liaison and Technical Service Department. Candidates, who must be British subjects, should hold a university degree or its equivalent and have had some years' experience in the non-ferrous metals industry. Salary up to £1,000 per annum, depending on age, qualifications, and experience. Applications should reach the Secretary, British Non-ferrous Metals Research Association, 81-91, Euston Street, London, N.W.1, not later than January 11, 1947.

GOUROCK ROPEWORK CO., LTD.

Applications are invited for the position of Chief Chemist to take charge of the Research and Works Laboratories. Responsibilities include direction of original research connected with the processing of all classes of vegetable and synthetic fibres from spinning to finishing, with special reference to dyeing and proofing. Applicants of F.R.I.C. standard must have had good practical experience in textiles. Applications, in confidence, stating age and qualifications, and giving full particulars of experience, to be addressed to the Technical Director, the Gourock Ropework Co., Ltd., Port Glasgow.

UNIVERSITY COLLEGE OF SWANSEA

The Council of the College invites applications for the posts of Assistant Lecturer in Mathematics, Assistant Lecturer in Physics, and Assistant Lecturer in Chemistry. Present salary in each case £400 per annum.

Further particulars concerning the posts may be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications must be received on or before December 27, 1946.

BRITISH BAKING INDUSTRIES' RESEARCH ASSOCIATION

Applications are invited for the post of Director of Research to this recently formed Association. The initial salary offered is not less than £2,000 per annum, with superannuation. The actual starting salary will depend on the qualifications and experience of the individual appointed. High scientific qualifications are required, together with experience of directing research and of administration. Each application should be accompanied by the names of two persons to whom reference may be made. Further particulars are obtainable from the Secretary, at Wellington House, 125/130, Strand, London, W.C.2, with whom applications should be lodged before January 15.

UNIVERSITY OF READING

Faculty of Agriculture and Horticulture

The Council of the University will shortly appoint a Professor of Agricultural Chemistry to succeed Professor H. A. D. Neville, who retires on September 29, 1947. Salary £1,450 per annum. Applications should be received by the Vice-Chancellor not later than Monday, March 17, 1947. Further particulars may be obtained from the Registrar.

SOUTH-WEST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART

Forest Road, Walthamstow, E.17.

The Governors invite applications for the post of Lecturer in Biology. Applicants should be qualified to teach botany and zoology to Intermediate B.Sc. standard.

Salary according to the Burnham scale, with London allowance. Applications should be made immediately by letter to the Acting Clerk to the Governors at the College.

B. E. LAWRENCE,
Chief Education Officer.
County Offices,
Chelmsford.

BRITISH IRON AND STEEL RESEARCH ASSOCIATION

Assistant Technical Secretary (male) required by the Iron Making Division of the above Association. University degree in chemistry or physics essential. Candidate must be prepared to devote most of his time to paper work. Good command of English important. Knowledge of German an asset.

The vacancy is in the Scientific Officer grade, age range 22-27. Salary £350-£500 per annum, according to age, qualifications, and experience.

Written applications only, quoting "Iron Making Division" and stating full curriculum vitae, to the Personnel Officer, British Iron and Steel Research Association, 11, Park Lane, W.1, by Saturday, January 11, 1947.

GLASGOW ROYAL CANCER HOSPITAL

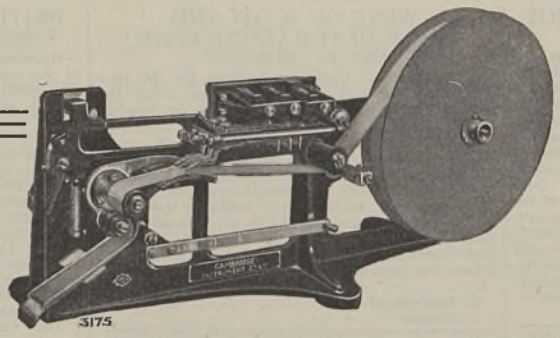
Senior Steward wanted soon, to take charge animal house, research department. Two assistants kept. Breeding and experimental work. Forty-hour week. Commencing salary £4 to £5 per week, according to experience. Full details to Secretary, Research Department, 132, Hill Street, Glasgow, C3.

APPLICATIONS ARE INVITED FOR THE post of Assistant in Anatomy (with medical qualifications) for Cape Town University. Some experience of teaching and working at anatomy and an interest in the scientific side of anatomy are essential, one who wishes to become an anatomist with a reasonable tenure of office. Salary scale £500 by £50 to £650 per annum, plus a temporary cost-of-living allowance, at present for a married man £75 per annum (and £12 per annum for each child under 18 years), for an unmarried officer £44 per annum.

Written applications (in duplicate, with copies of testimonials), giving date of birth, full details of qualifications and experience, and of posts held including dates, should be addressed to the Appointments Officer, Ministry of Labour and National Service, quoting reference No. F.A.1083 (from whom a memorandum giving the conditions of appointment is obtainable), by December 23. Only candidates selected for interview will be advised.

METALLURGIST REQUIRED FOR LARGE oil refinery in the North West. Candidates must have first- or second-class honours degree (or equivalent) and aged not over 30. Sound knowledge of corrosion and alloy metals essential. Some previous industrial experience desirable, but not essential. Salary according to age, qualification, and experience, details of which please supply, also when available, to Box 765, T. G. Scott & Son, Ltd., 9, Arundel Street, London, W.C.2.

(Continued on page ccxxx)



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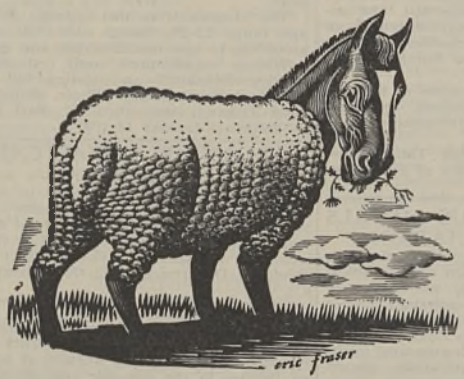

SHEEP WITH HORSE-SENSE

MINERAL deficiency diseases are common among our hill-grazing sheep due to soil deficiency. To restore the land is usually impractical. It was suggested that test flocks be fed with iodized mineral supplement. Wise men shook their heads and said that sheep would never eat prepared foods. But they did—and came back for more. The malnutrition was checked.

This dramatic example of the successful use of iodine in maintaining animal health is but one of many. Iodine plays an equally important part in industry and medicine.

All that is known about the uses and potentialities of iodine has been recorded and collated by the Iodine Educational Bureau, whose qualified consultant staff is ready to assist with professional, research and development problems. There is no charge.

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terminal velocity. This velocity is attained when the force of resistance in the medium in which the body is moving is equal to the weight of the body. Greenhill had also a letter in the same issue, and in the following week Sir William Ramsay and Sir Oliver Lodge had letters which supported the point of view of Hardcastle and Greenhill. Hardcastle quotes from St. Thomas Aquinas's "Opera Omnia" (Leonine edition), which shows quite clearly that different media were considered by Aristotle—earth, air or water or other things—and if air is twice as 'subtile' as water, then for an equal distance the time of translation in water will be twice that in air. It may be added that the story, so often repeated, about Galileo dropping the weights from the Leaning Tower of Pisa close to the professors' heads as they came out from their lectures is now admitted, like some other stories about Galileo, to be apocryphal. Among these must be included the story that Galileo was the first to disprove the alleged statement of Aristotle about the velocities attained by falling bodies of different weights.

Lunar Auroras

Sky and Telescope of September contains a short note on this subject which deals with a suggestion made by Prof. Mohd. A. R. Khan, Hyderabad, in *Popular Astronomy* of June. This suggestion is that auroral phenomena would occur on the portion of the moon's surface that is lighted up by earthshine, should there be any appreciable atmosphere on our satellite. While it would not be possible to observe the auroral streamers, he suggests that a study of the spectrum of the earthshine on the moon might reveal the presence of the stronger of the forbidden lines of oxygen and nitrogen which are characteristic of auroras. Simultaneous spectra of neighbouring regions of the sky should also be obtained to avoid confusion between lunar and terrestrial auroral light. Prof. J. Kaplan, University of California, not only supports the suggestion but also enlarges upon it. He points out that direct photographs made with infra-red sensitive plates and filters would record the auroral band at 15,000 A. due to ionized nitrogen. Variations in such photographs would reveal the presence of the aurora ; they would require shorter exposure times, and would also be easier to obtain than the corresponding spectra.

The New Anatomy

Classical anatomy, the study of visible structure for structure's sake, has long since exhausted itself (and others). But a new generation of anatomists is showing us that, when morphological observations are correlated with parallel biochemical and biophysical analyses and with considerations of function, profitable advances may result, and that, handled in this way, anatomy has still much to contribute to biological science. Prof. J. Z. Young, in his inaugural lecture as professor of anatomy at University College, London, developed this theme and put forward some stimulating suggestions for future progress in anatomical research. He deplored the rigid departmental segregation of anatomists, physiologists, biochemists, pharmacologists and so on, which so usually exists in medical schools, and urged that all should regard themselves primarily as human biologists. Each worker must necessarily practise his own specialized technique; but he should endeavour to correlate his findings with those derived from other, and often widely differing, techniques, and so view his problem from all possible angles. Prof. Young's own work on the degeneration and regeneration of nerve, in which a correlation of histological with physico-chemical findings led to an entirely new concept of the nerve fibre, is a case in point. He gives a timely warning to biologists against a too mechanistic interpretation of their subject. Living structures show an organisation or pattern on a higher level than that ordinarily regarded as physical or chemical ; consequently a purely physical or chemical approach is generally inadequate for the total handling of a biological problem.

Another fact, often overlooked in our preoccupation with seeking to relate cause and effect, is that living systems exhibit a continuous and spontaneous activity of their own, which is the very essence of being 'alive', quite apart from any response which they may make to external stimuli or experimental manipulations. This is well seen in the case of the nervous system, where the concept of reflex action, which appeals so much to the 'cause and effect' mentality, has singularly failed to account for the more important features of higher nervous activity. In this connexion Prof. Young makes the interesting suggestion that the overall pattern of organisation of the neuropil, rather than the detailed point connexions of the individual fibres, might have some significance in the interpretation of higher nervous functions. The title of Prof. Young's address was "Patterns of Substance and Activity in the Nervous System" (London : H. K. Lewis and Co., Ltd., 1946. 1*s*. 6*d*. net). Following the tradition of his distinguished predecessors at University College, he is primarily interested in the nervous system, and he chose to illustrate his theme in that context ; but the theme is applicable to all biological inquiry, and his stimulating and thoughtful address will be widely welcomed, particularly by medical men of science.

Faculty of Science, Fouad I University

The annual report for 1944–45 of the Faculty of Science, Fouad I University, Cairo, gives a brief indication of research work in progress, with lists of papers published and titles of theses for which degrees in science were awarded. In the Department of Applied Mathematics, R. H. Makkar has completed a thesis on "Series of Polynomials", and M. Tolba is investigating the question of two points expansion of functions, while in the Department of Applied Mathematics, Prof. M. A. Omara is engaged on determining the velocity potential of the fluid motion induced by a cylinder moving in an infinite mass of compressible fluid, and Dr. Hammad is still investigating the passage of sunlight through the atmosphere. In the Department of Physics, Prof. Fahmy has continued his work on the relativity of the electron and proton, in addition to supervising investigations on molecular polarization of vapours at different temperatures, electron polarization, electron diffraction and the viscosity of gases. Other work, under Dr. Mokhtar, has covered the scattering of supersonics, the measurement of absorption coefficients by acoustic materials and the tone qualities of musical instruments. The Meteorological Section has investigated matters connected with rainfall, sea-breezes, thunderstorms, floods in Egypt and north-east winds in the Nile Delta, while the Electronics Section has studied secondary emission, electron reflexion, X-ray analysis and Young's modulus.

In the Department of Botany, work on the anatomical determination of Pharaonic plant remains, carbohydrate and nitrogen metabolism, plant reactions to colchicine and β-indolylacetic acid, the effect of environmental factors on stomatal movements, the bacteriostatic effect of fungal metabolic products and organic chemicals and the ecology of Lake Edku are continuing; other investigations include a substitute colouring matter in butter, and the autecology of certain organisms. In the Department of Zoology, Prof. K. Mansour continued his study of some of the morphological and physiological aspects of the Lamellibrachiata (some of which have been reported in *Nature*), Prof. A. Naef his studies of the primitive Chordata, Dr. M. Waly his work of the Reptilia of Egypt and the fishes of the Nile, and Dr. F. Khalil the physiological investigation of the metabolism and excretion in some desert reptiles. Other investigations have covered the effect of triphenylchloroethylene on the development of the gonads of the frog, Egyptian spiders, the tympanic region of the Egyptian Insectivora, Chiroptera and Rodentia, yolk formation in the eggs of Mollusca, the chick embryo, etc. Work in the Department of Entomology has dealt with the biology of Egyptian insects, ecological studies of the insect fauna of freshwater ponds in the region of Cairo, and a biological and ecological survey of the Asterolecaninæ. A note on the Library states that exchange activity with other universities and learned societies has now been resumed.

Francis Amory Septennial Prize of the American Academy of Arts and Sciences

Under the terms of a gift in the will of the late Francis Amory of Beverly, Massachusetts, the American Academy of Arts and Sciences offers a substantial prize for outstanding work on the alleviation or cure of diseases affecting the human reproductive organs. The gift provides a fund, the income of which may be awarded at seven-year intervals "as a prize and gold medal, or other token of honor or merit", to any individual or individuals for work of "extraordinary or exceptional merit" in this field. The next award is to be made in 1947. No formal applications and no essays or treatises from individuals are solicited; but suggestions will be welcome from any appropriate source that will be of aid to the Committee in making a wise selection. Recommendations may be addressed to Secretary, Amory Fund Committee, American Academy of Arts and Sciences, 28 Newbury Street, Boston, Massachusetts, U.S.A.

Institution of Civil Engineers: Awards

The following medal, premiums and prizes of the Institution of Civil Engineers have been awarded for the papers mentioned, which have been discussed, or published without oral discussion, during the session 1945–46. *Baker Gold Medal:* G. L. Groves, in recognition of his work in connexion with the Ilford Tube. *Coopers Hill War Memorial Prize:* G. A. Maunsell, "Menai Bridge Reconstruction". *Telford Premiums:* K. C. Appleyard and G. Curry, "Opencast Coal Production in Wartime"; R. F. Wileman and H. W. Clark, "The Measurement of the Discharges of the River-basins of the White Nile (Sudan) and Nene (Great Britain)"; M. R. James, "Renewal and Extension of Pumping Machinery for the Metropolitan Water Board"; A. E. Reid and F. W. Sully, "The Construction of the King Feisal Bridge and the King Ghazi Bridge over the River Tigris at Baghdad"; J. N. McFeeters, "Concrete Runways"; J. K. Fisher, Alfred Goode and C. E. Docker, "Some Problems in the Design and Construction of Large Airfields"; J. D. Atkinson and George Cardiacos, "The Reconstruction of the Diyala Weir"; Robert Struthers and J. W. Lovatt, "Construction of a Heavy-Duty Concrete Runway"; Rudolph Glossop and A. W. Skempton, "Particle-size in Silts and Sands"; C. H. Dobbie, "Some Sea Defence Works for Reclaimed Lands". *Manby Premium:* Rowland Nicholas, "Highway Planning, with Particular Reference to Traffic Capacities". *Crampton Prize:* C. T. Mitchell, "Some Economical Aspects of Modern Earthmoving Equipment"; George Graham and F. R. Martin, "Heathrow. The Construction of High-grade Quality Concrete Paving for Modern Transport Aircraft". *Trevithick Premiums:* James Lorimer, "Some Uses of Explosives in Civil Engineering"; A. H. Toms, "Repairs to Railway Viaduct over London Road, Brighton, after Damage by Enemy Action in May 1943". *Indian Premiums:* Sir Claude Inglis, "Training Works constructed in the Rupnarain River in Bengal—after Model Experiments—to Prevent Further Bank Erosion endangering the Bengal–Nagpur Railway Line Linking Calcutta with Bombay and Madras"; C. G. Sexton, "The Construction of the Coronation Bridge over the Tista River, North Bengal, India"; Philip Claxton, "The Still-Water Pocket Principle".

The following Medal and Prizes have been awarded to students for papers read before local associations. *James Forest Medal and a Miller Prize:* O. H. Senogles, "The Superficial Geological Deposits of the Manchester Area" (North-Western Association, Manchester). *Miller Prizes:* F. N. Kirby, "The Development of the Parsons Steam-Turbine" (Newcastle-on-Tyne and District Association); J. A. Williams, "A Survey of Current Practice on the Design of Storm-water Overflow Works" (Newcastle-on-Tyne and District Association); Wilfred Eastwood, "Surface Water Drainage from Roads and under British Conditions" (Yorkshire Association); G. S. Glendinning, "Distribution of Rainfall and Run-off from Catchment Areas" (Edinburgh and District Association); T. E. H. Williams, "Bridge Construction with Special Reference to Foundations" (Birmingham and District Association); R. W. Winkler, "Repairs to an Early Nineteenth Century Sea Wall" (Edinburgh and District Association); G. F. Clark, "Timber Bridges—Various Types and Their Construction" (Edinburgh and District Association); D. D. Treharne, "Opencast Coal Production" (South Wales and Monmouthshire Association).

Announcements

The honorary degree of D.Sc. has been conferred by the University of Oxford on Prof. H. C. Urey, professor of chemistry and director of nuclear research in the University of Chicago.

Dr. F. Dixey, director of geological surveys, Nigeria, has been appointed director of Colonial Geological Surveys, in which position he will be adviser on all geological matters to the Secretary of State for the Colonies.

Dr. Augustin E. Riggi has been appointed director of the Argentine (Bernardino Rivadavia) Museum of Natural Sciences at Buenos Aires.

LETTERS TO THE EDITORS

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

Activation of Metallic Copper by Oxidation and Reduction

THE activation of copper by repeated oxidation and reduction is ascribed by previous authors to an increase in surface area[1], and our experiments have confirmed this conclusion. In the activated state, as measured by the interference colours produced during oxidation, the area is at least five to ten times as great as the measured area.

Copper oxide films on active metal, when reduced by hydrogen at 300° C., gradually lighten in colour as the reaction proceeds, but do not show interference colours. The reduction is evidently not simply a reversal of the process of oxidation. A marked feature of the reduction is an induction period during which the decrease in pressure of hydrogen is proportional to the square of the time. This indicates that metallic nuclei are produced at a number of active points and increase in diameter as the first power of the time. Separate nuclei cannot be seen, so that their number must be considerable. The extent of the growth of these nuclei is limited, probably because the film is finely subdivided by gaps in the material. Before the whole of the oxide is completely converted to metal, a second type of nucleation appears which is visible. These nuclei increase in diameter linearly with time, and this is believed to be due to the recrystallization of small copper nuclei by a process analogous to sintering, and also to those processes observed by Kornfeld[2] in the recrystallization of stretched aluminium wire. The recrystallization of the copper in a mixture of crystals of metallic copper and oxide may lead to the formation of inclusions of oxide in the resultant metal, and the phenomena observed by Ransley[3] during the reduction of oxide inclusions in metallic copper might be expected to occur.

Ransley showed that in the reduction of oxide inclusions in massive copper by hydrogen at 700–800° C., hydrogen diffused through the metal to the oxide, and water was produced at such high pressures that its escape caused cracks and blistering of the surface, producing the well-known embrittlement. A similar blistering has been observed during the activation of copper. Reduction of the inclusions by carbon monoxide did not occur by the same mechanism, since this gas, being insoluble in copper, cannot diffuse to the oxide. The reduction in this case took place, without embrittlement, by the diffusion of oxygen, possibly as ions, from the inclusions to the surface, where it reacted with the carbon monoxide. This difference between the mechanisms of the reactions of carbon monoxide and hydrogen is paralleled by their behaviour in experiments on the activation of copper.

If, after a series of reductions with hydrogen, carbon monoxide is used to reduce copper oxide, the rate for the first reduction is very similar to that with hydrogen. A second reduction following oxidation in the normal manner is, however, very slow and erratic, and cannot be completed at 300° C. in a reasonable time. The oxidation and reduction with hydrogen must be repeated before the carbon monoxide reduction goes smoothly. During the first reduction with carbon monoxide, the activation produced by hydrogen is very largely destroyed.

In the reduction of the oxide with carbon monoxide, metallic nuclei are formed very rapidly and in large numbers. In general, patches of metallic copper are formed on the surface long before reduction is complete. Under certain conditions, a complete covering of metal is formed on the oxide within a few minutes. The metallic film formed on the surface during the first reduction with carbon monoxide must be very porous, and the reaction continues because gas can diffuse to the oxide down numerous cracks in the metal.

The following sequence of events probably occurs during the reduction and oxidation reactions. During the reduction of the oxide by hydrogen, oxide particles will be enclosed in the metal which is formed. The reduction of these inclusions leads to embrittlement and the formation of a cracked metal film. This, it is suggested, is the process whereby the film is activated. This film expands on oxidation and the cracks are partly healed; but sufficient capillary passages remain to facilitate a subsequent reduction by hydrogen. However, after a carbon monoxide reduction, the metal film is much more compact, because embrittlement of the metal will not have taken place. Hence, on oxidation an oxide film is formed which is more perfect than when hydrogen is used. If a second reduction with carbon monoxide be now attempted, the film, being relatively free from cracks, is impermeable to the reducing gas, and the reaction is brought to a standstill.

These results indicate that there is some specific action by hydrogen which is absent when carbon monoxide is used, and is responsible for the activation of copper. This may be an effect analogous to that causing the embrittlement of massive copper on reduction with hydrogen.

W. E. GARNER
F. S. STONE

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Nov. 14.

[1] Hinshelwood, *Proc. Roy. Soc.*, A, **102**, 318 (1922). Constable, *Proc. Roy. Soc.*, A, **115**, 570 (1927); A, **107**, 278 (1925).
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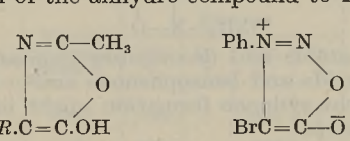
Structure of the Sydnones

THE communication from Prof. Wilson Baker and his collaborator[1] prompts us to intimate that we also have concerned ourselves with the sydnones, but from the point of view that their formation might be related to the racemization of α-acetylaminocarboxylic acids by acetic anhydride. Bergmann and Zervas[2] adduced evidence that this change depended on enolization of the anhydro-compound to I.



(I) (II)

Accordingly, we have resolved N-nitroso-N-phenyl alanin by means of brucine, and from the *brucine salt*, m.p. 147–149°, less soluble in acetone or benzene, have prepared the *dextro-rotatory form* of the acid,

$[\alpha]_D = +68{\cdot}3°$. This is converted by acetic anhydride into the optically inactive N-phenyl-C-methylsydnone described by Earl and Mackney[3]. Also the rates of racemization and of sydnone formation by acetic anhydride in ethereal solution at the ordinary temperature are parallel. Furthermore, N-phenylsydnone exhibits its relationship to enols in that it undergoes instantaneous bromination in glacial acetic acid solution, yielding a *monobromo derivative*, m.p. 134°.

The structure (II) of this product follows from the fact that whereas hydrolysis by hydrochloric acid yields phenyl hydrazine hydrochloride, alkaline hydrolysis furnishes sodium benzene diazotate, identified by conversion into benzene-azo-β-naphthol.

This experimental evidence justifies the analogy quoted above, and is in line with the ideas expressed by Prof. Wilson Baker and W. D. Ollis.

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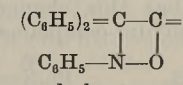
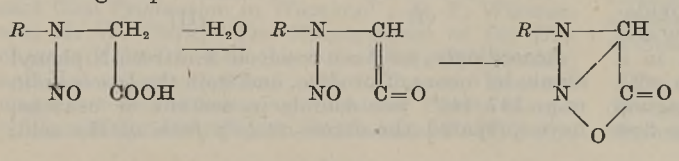
[1] *Nature*, 158, 703 (1946).
[2] *Biochem. Z.*, 203, 280 (1928); compare Du Vigneaud and others, *J. Biol. Chem.*, 96, 511 (1932); 98, 295 (1932); 99, 143 (1932).
[3] *J. Chem. Soc.*, 899 (1935).

The fused-ring structure for the sydnones is as unacceptable to Prof. Wilson Baker and his colleague[1] as to Mr. Eade and myself. They suggest that since a reasonable structure of the classical type cannot be assigned to these substances, they are probably hybrids of some of the possible extreme dipolar structures, but they give no experimental evidence. The subject having been raised, it might be as well to indicate the lines on which we have done further experimental work.

N-Phenyl-C-phenyl-sydnone can be prepared by the action of acetic anhydride on a benzene solution of N-nitroso-α-anilinophenylacetic acid. If one of the optically active forms of the acid is used, the sydnone is inactive and identical with that prepared from the inactive acid. This was expected, but it is conceivable that racemization might not have occurred in building up the fused-ring structure. Further experimental evidence is available from the ready decomposition of N-phenylsydnone in boiling aqueous solution when a little sodium carbonate or sodium acetate is added. There is a rapid evolution of carbon dioxide and the formation of resinous products. This suggests an analogy with the decomposition of the products obtained when nitroso-compounds condense with ketenes. One of the two products formed from nitrosobenzene and diphenylketene

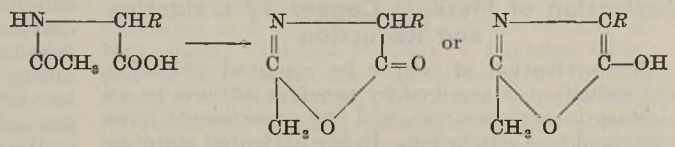


is very unstable and decomposes spontaneously to carbon dioxide and benzophenone anil[2]. It is conceivable that sydnone formation might involve the following steps



again leading to the unlikely bicyclic structure.

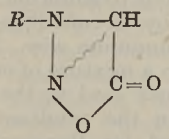
The similarity in behaviour of the carbonyl and nitroso groups suggests an analogy between the sydnones and the compounds formed by the action of excess of acetic anhydride on the α-acetylamino-carboxylic acids[3].



In this case there is no need to consider a possible bicyclic structure.

A further fact which must be considered in arriving at a satisfactory structure for the sydnones is the frequent occurrence of phenyl isocyanide among the decomposition products of N-phenyl-sydnone (for example, on its pyrolysis).

Taking all our present knowledge of the sydnones into consideration, I venture to suggest that we have in their structure a partly formed bond. There must always be a stage in the formation of a chemical bond between two reacting atoms in which they can be regarded as neither being uninfluenced by one another, nor in a state of complete and settled combination. It is usually not possible to arrest the process at this stage, but in the sydnones the five-membered ring controls the situation. The sydnones do not show any obvious dipolar characteristics, and if their structure is to be regarded as a hybrid of two dipolar structures, it may be merely one way of saying that there is present an incipient non-polar structure which one might write, *faute de mieux*,



the wavy line indicating an incipient link between the carbon and nitrogen. The same wavy line may have the further symbolism of indicating the doubt which must remain in our minds on this structural question until considerably more experimental evidence is forthcoming.

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Nov. 21.

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[2] Staudinger, "Die Ketene" (1912).
[3] Bergmann and Zervas, *Biochem. Z.*, 203, 280 (1928).

Colorimetric Estimation of Penicillin II

The Kapeller-Adler[1] method for the estimation of phenylalanine depends on the nitration of phenylalanine to give 3 : 4-dinitrophenylalanine; this is then reduced by alkaline hydroxylamine to a coloured nitroso derivative. It appeared probable that, by virtue of its phenylacetic radical, penicillin II (G) might be estimated in the same way and in the presence of penicillin I (F).

Unfortunately, nitrated samples of penicillin II treated with hydroxylamine gave

colours varying from light straw to dark brown; these were unsuitable for colorimetric purposes. A trace of ethyl alcohol appeared to catalyse the nitration, but there was no improvement in the final colour. A modified procedure[2], in which the nitro derivative was reduced with powdered zinc and then coupled with sodium 1 : 2-naphthaquinone-4-sulphonate, gave no better results.

The most promising method was to combine the Kapeller-Adler nitration procedure with the diazotization technique introduced by Bratton and Marshall[3] for estimating sulphonamides. This depends on the nitration of the phenyl radical to a dinitro derivative, which is reduced with powdered zinc to form the corresponding diamine. After diazotization and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride, a mauve dye is formed and is suitable for colorimetric measurements. Preliminary experiments led to the adoption of the following procedure.

About 1 mgm. of sodium penicillin II was accurately weighed, placed in a small evaporating basin and treated with 2 ml. of a nitrating mixture (20 per cent potassium nitrate in concentrated sulphuric acid). The mixture was warmed on a steam bath for an hour and then diluted with 10 ml. of water. About 0·1 gm. of zinc was added and the heating continued for 15 min. more. After standing at room temperature for 15 min., the reduced solution was filtered through a No. 41 Whatman filter paper and made up to 20 ml. with distilled water. 3 ml. of this solution were shaken for 5 min. with 1 ml. of a 0·05 *M* solution of sodium nitrite and then mixed with 5 ml. of ethyl alcohol, followed by 1 ml. of 0·05 *M* N-(1-naphthyl)-ethylenediamine dihydrochloride. The coloured solution was made up to 10 ml. with distilled water and, after standing in the dark for 20 min., was examined on the Spekker photo-electric absorptiometer, using a No. 5 green filter (Chance Bros. O.G.1). A calibration curve was prepared by plotting the quantity of penicillin II used against the corresponding reading of the absorptiometer.

The calibration curves for phenylacetic acid and phenylalanine, which behaved in the same way as penicillin II, were approximately linear for quantities between 0·1 and 0·3 mgm.; over this range, the two curves could be almost superimposed on each other. The curve for sodium penicillin II was less steep and tended to flatten off much sooner. The coefficient of variation for the estimations was about 10 per cent.

As was to be expected, the reaction here described gives no colour when penicillin II is replaced by penicillin I. However, the method for penicillin II has only a limited field of application, for many aromatic compounds give a similar colour. Nevertheless, it is thought that the technique may be of value for estimation of penicillin II in 'purified' penicillin.

We wish to thank Mrs. A. C. T. Hickman for technical assistance.

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[1] Kapeller-Adler, R., *Biochem. Z.*, 252, 185 (1932).
[2] Hess, W. C., and Sullivan, M. X., *Arch. Biochem.*, 5, 165 (1944).
[3] Bratton, A. C., and Marshall, E. K., *J. Biol. Chem.*, 128, 537 (1939).

Test of a Cancerogenic Substance in Respect to the 'Non-disjunction' Frequency of the *X*-Chromosomes in *Drosophila*

Some tests have been made with cancerogenic substances on *Drosophila* in respect to mutation frequency[1,2]. The results showed that the mutation-rate does not increase under treatment with cancerogenic chemicals.

We investigated the effect of benzpyrene on the non-disjunction frequency of the *X*-chromosomes in *Drosophila* females. We found mixing benzpyrene crystals with their standard food to be a convenient method of treatment. In this way one can trace the presence of the substance throughout the complete life-cycle by fluorescence microscopy.

The cultures were kept in darkness. The primary non-disjunction was investigated. We used 'bar' males and 'white' females from two inbred stocks which were kept pure for five years, and so may be considered as well-balanced stocks from the point of view of modifying factors. In this standard arrangement the frequency of exceptions was 1 : 500, or 0·2 ± 0·05 per cent without benzpyrene.

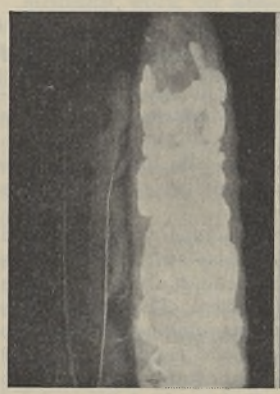

Fig. 1

Fig. 2

Fig. 1. Larvæ of *Drosophila* treated with benzpyrene under ultra-violet light. A control is slightly illuminated by its neighbour

Fig. 2. Eggs of *Drosophila* female maintained on food containing benzpyrene under ultra-violet light. In the middle are three dark controls

In the first test, the 'white/white' females were treated only during their larval life (Fig. 1). In this case benzpyrene was found in the ovaries of the females but not in the eggs when laid. There was not a significant difference between the control and the treated cultures in respect to the number of exceptional offspring.

In the succeeding test, the adult females were fed entirely on food containing benzpyrene, and in this

Treatment	Number of treated females	Offspring				Total ex. (per cent)
		Reg. ♀	Ex. ♀	Reg. ♂	Ex. ♂	
In larval life (I)	24	1190	2	1096	7	0·39+0·13
In adult life (II)	10	1235	–	998	–	
	15	1290	2	1167	–	
	25	2525	2	2165	–	0·04+0·03
Controls	24	1075	2	1049	3	
	10	1466	5	1188	1	
	15	1470	1	1200	3	
	49	4011	8	3437	7	0·2+0·05

case, using the fluorescence microscope, we were convinced of the presence of the benzpyrene also in the eggs when laid (Fig. 2). In this test the ratio of exceptions was 1 : 2,300, or 0·04 ± 0·03 per cent. The standard errors showed a statistically significant difference (0·16 ± 0·059) in the negative direction between controls and the second test. None of the treatments used gave any detectable increase in the non-disjunction frequency; but treatment with benzpyrene decreased the number of exceptional flies, that is, the mutation-rate. The reason for this is not known, but perhaps such chemical agents in the egg help in separating the synapsed *X*-chromosomes, whereas, on the other hand, it is known that colchicine causes an increase of exceptional flies[3].

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[3] Gelei, G., and Csik, L., *Biol. Z.*, **60**, 275.

Chemical Composition of *Rickettsia prowazeki*

The chemical composition of the causative organism of epidemic typhus fever, *Rickettsia prowazeki*, is quite obscure. A chemical study was therefore undertaken of *Rickettsia* cultivated in the lungs of white mice, purified suspensions of which are used for the preparation of vaccines[1].

A batch of mice (1–2 thousand) was sacrificed 3–4 days after intranasal inoculation. Those lungs in which the rickettsiæ were most abundant were selected after morphological control. The suspensions of minced lungs prepared in physiological saline were subjected to prolonged differential centrifugation at 4,000 rev. per min. until a sediment of pure rickettsiæ was obtained, which were then washed four times with distilled water. 250 mgm. rickettsiæ was prepared from the whole, and this mass was analysed for lipoids, proteins, nucleic acid, carbohydrates and ash according to the methods used in the study of viruses[2]. After three-fold successive extraction with acetone, alcohol and ether, and subsequent solution in chloroform, 113 mgm. lipoids (46·6 per cent) was obtained. The lipoids were divided into two fractions, namely, neutral fat (29·7 per cent) and phospholipids (15·8 per cent). A separate sample was subjected to 2-hour hydrolysis in 2 *N* hydrochloric acid; this yielded 4·1 per cent carbohydrates (by the Hagedorn–Jenssen method, computed in glucose terms). The ash content was 3 per cent. The residue after extraction of lipoids was used for determination of protein and separation of nucleic acid. Direct determination gave 30·2 per cent protein, and in the residue (77 mgm.) after extraction of nucleic acid, 34·7 per cent. After a two-fold precipitation the yield of nucleic acid was 29 mgm. or 12 per cent. Nucleic acid gave a positive Feulgen reaction (see table).

The above data are of interest from several points of view. It will be noted that rickettsiæ are rich in lipoids, approaching in this respect animal viruses. The high content of lipoids accounts for ether treatment of rickettsiæ as proposed by Craigie for the preparation of vaccines. As to the high content of nucleic acids (12 per cent), this brings rickettsiæ close to bacteria. The fact that nucleic acid of rickettsiæ belongs to the type of thymonucleic acid is of great theoretical importance in connexion with nucleic acid metabolism in intracellular infection. The comparison of the chemical composition of rickettsiæ with that of viruses and bacteria suggests that, in this respect and in their cultural and biological properties, rickettsiæ occupy an intermediate position between bacteria and viruses.

Chemical composition of *Rickettsia prowazeki* as compared with that of bacteria and viruses

	Proteus vulgaris[3]	*Sarcina lutea*[3]	*Sporangium* sp.[3]	*Gonococcus*[4]	*Ricket. Prow.*	Influenza virus[5]	Encephalomyelitis virus[3]
Lipoids	11·5			10–14	46·6	42–48	45
Phospholipids	4·2				15·8		35
Neutr. fat	7·2				29·7		10
Protein	47·2	67·6	37·4	71–83	34·7	52–84	49
Nucleic acid	13·0	10·5	12·6	14	12·0	3·5	4
Carbohydrates	14·2	8·5		3·5	4·1		4
Ash				6–10	3·0	5–6	

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Man's Reaction to Mosquito Bites

In reply to the query of Dr. Bristowe[1], variations in the attractiveness of different individuals to mosquitoes can be demonstrated in field experiments, which prove that whatever attracts mosquitoes can be measured quantitatively. Anophelines are readily deterred by minute quantities of pyrethrum[2], and in huts sprayed regularly random ingress is eliminated, and it then becomes possible to demonstrate their acute discrimination. In such huts I found that *c.* 250 per cent more females of *Anopheles funestus*, *A. gambiæ* and *A. melas* were attracted to three men than to one man, and by rotating sleeping duties I showed that over a period of three months one of the four men used was fairly consistently more attractive than any of the other three.

Of greater interest was the proof that there was considerable variation in the attractiveness of the same individual at different times. I obtained daily catches of *A. melas* from three Africans sleeping separately in experimental huts under close supervision. Individuals often became more attractive than their companions, and remained so every day for a

week or so, then to return to normal. For example, the least attractive of these three men suddenly became most attractive for eight days out of nine, and in this period attracted 186 ♀ *A. melas*, while his nearest rival attracted only 77 ; during two successive days at the beginning of this period he attracted five times as many mosquitoes as either rival. Statistical analysis shows that these results are significant. De Meillon[3] showed that thorough deodorization with soap and water considerably diminished attractiveness to *A. funestus*, but this factor seems insufficient to account for these results, which I consider to be due to variations in the physiological condition of the men.

It is likely that there are wide differences between the relative attractiveness of different individuals of different habits, but I know of no proved case of absolute immunity, and think that such claims are usually made by fortunate individuals who have escaped the more obvious consequences of mosquito bites and, therefore, erroneously concluded that they have never been bitten.

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[1] Bristowe, W. S., *Nature*, **158**, 750 (1946).
[2] Ribbands, C. R., *Bull. Ent. Res.*, **37**, 163 (1946).
[3] De Meillon, B., *Pub. S. Afr. Inst. Med. Res.*, **6**, 323 (1935).

Anopheline Mosquitoes as Natural Vectors of Equine Dermal Filariasis

Papadaniel[1] has reported, under the name of 'gâle microfilarienne', a dermatosis affecting horses and mules in Greece. The disease is associated with the presence of microfilariæ in the skin lesions. Analogy with filariasis elsewhere would suggest that the infection is insect-borne. From the available literature it appears that the natural vectors in Greece have not previously been described.

In the course of an investigation by members of this Laboratory on malaria transmission in eastern Macedonia, developmental forms of filarial larvæ were observed in *Anopheles sacharovi* (var. *elutus*) and in *A. maculipennis* (var. *typicus*). Between July 24 and August 27, 1946, the total of mosquitoes dissected was 456, of which the majority were *A. sacharovi* and the remainder *A. maculipennis*. Filarial larvæ were found in fourteen *A. sacharovi* and in one *A. maculipennis* (var. *typicus*). The infection-rate in *A. sacharovi* was 3 per cent. The larvæ were recovered from the musculature of the mosquito thorax or neck, in numbers varying from one to eight per mosquito. In the fresh preparation, the larvæ were actively motile. The length varied from 0·9 mm. to 2·3 mm. and the diameter from 25 μ to 55 μ.

In the same series of dissections high plasmodial sporozoite and oocyst rates were recorded. In two specimens of *A. sacharovi*, simultaneous infection with filarial larvæ and plasmodial oocysts was observed.

Local human inhabitants showed a high incidence of malaria but no clinical evidence of filariasis. Fresh blood preparations taken from 95 persons by day and from 69 persons by night showed no microfilariæ. In addition, 30 specimens of venous blood, examined by Fülleborn's concentration technique[2], gave negative results.

Local mules were found heavily infected with microfilariæ. In this part of our investigation we were fortunate to have the assistance of Major S. Papadaniel, of the Greek Army Veterinary Corps. Examination of the exudate from skin lesions showed microfilariæ in large numbers. The length of these forms varied from 150 μ to 170 μ and the diameter from 3 μ to 4 μ.

Investigations are proceeding. Full details of the work will be submitted for publication elsewhere. Our thanks are due to Major J. C. W. MacFarlane and Sgt. J. Tait for their help with the venous blood examinations.

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[2] Fülleborn, "Handbuch der Pathogenen Mikroorganismen", 8 (1928).

Division of Labour in Ants

Modern work on ant behaviour has shown that there is much greater individuality between one ant and another than was supposed. There is great variation in the individual psychology of ants : in their instincts, in their powers of learning, in their experience and their degrees of reaction to stimuli (see Schneirla, Chen, *et al.*[1]). This individuality reaches its highest development in the Formicinæ, where the social integration is also greatest—a fact which has appeared, to some people, surprising.

The basic integrating force of the ant community is that the offspring have experience of living mothers in their midst, while they themselves are sterile. The queens thus represent the shared fertility of the workers. This factor, coupled with the emotional bond of frequent mutual regurgitation, and the psychological and physiological similarity of the individual workers of the colony, leads to a most intimate mental and physical relationship.

Thus an ant reacts very quickly to the reaction of its neighbours ; and when one ant responds to a stimulus, the other ants in close proximity to it are stimulated to similar reaction unless they are already reacting to a stronger stimulus, or their response to that particular stimulus is already fully satisfied.

The gesticulatory antennal communication system is an entirely adequate method of communication for the working of this method of the division of labour. One ant feeling hunger will leave the nest and forage, exciting other workers which it meets to do the same ; another ant is stimulated to undertake the building operations required in another part of the nest, and similarly attracts other ants to that operation. These initial respondants to the stimuli are termed the 'excitement centres'[2].

The strength of the 'excitement centre' weakens as the operation nears completion or the reaction of the individual is satisfied, and eventually it fails completely. The operation will often be changed owing to the creation of a new stimulus : licking the larvæ may change to going out to forage if they show signs of hunger, or to moving them to a more humid chamber if they show signs of desiccation. The 'excitement centres' also function within the various operations causing the attraction and counter-attraction of ants between the various centres of activity.

Worker-polymorphism accounts for very little of the division of labour in ants, although the soldier reacts differently to stimuli from its fellow workers.

The mechanism of the division of labour depends on the reaction of the individual ant, and it is of considerable interest that in the ants the factors of individual variation in behaviour and social integration are complementary and not in conflict.

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[1] Schneirla, T. C., *J. Comp. Psychol.*, **15**, 243 (1933); **17**, 303 (1934); **32**, 41 (1941); **35**, 149 (1943); *J. New York Ent. Soc.*, **52**, 153 (1944) and other papers. Chen, S. C., *Physiol. Zool.*, **10**, 420, 437 (1938).

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Atmospheric Pressure Changes

THE pressure in the atmosphere at any point is determined by the weight of air above that point, so that pressure changes depend on the three-dimensional field of motion. The relation is normally expressed by the pressure-tendency equation:

$$\frac{\partial p}{\partial t} = -\int_z^\infty g \operatorname{div}(\rho \mathbf{v})\, dz,$$

where $\frac{\partial p}{\partial t}$ is the rate of change of pressure p at height z, g is the acceleration due to gravity, ρ the density, and $\mathbf{v}$ the wind vector.

It is customary to examine the pressure tendencies associated with certain theoretical approximations to the wind. The large divergence of the geostropic wind **J** when the latter has a north or south component has recently led Jeffreys[1] to recall the paradox that storms should move with a velocity comparable with that of sound unless they have a special, but unknown, kind of structure.

This is not the case, since there is in the atmosphere a natural brake mechanism which forces all pressure systems to move with relatively slow speeds. A good approximation to the wind is afforded by the gradient wind **G**, defined with its magnitude G by the equation

$$\mathbf{G}\left(1 - \frac{G\varkappa}{\lambda}\right) = \mathbf{J},$$

where $\varkappa$ is the curvature of the trajectory (positive in anticyclonic motion) and $\lambda = 2\omega \sin\varphi$, ω being the earth's angular velocity and φ the latitude. Making use of an expression due to Matthewman[2], the rate of change of pressure p associated with the gradient approximation is, very closely,

$$\frac{\partial p}{\partial t} = -\int_0^p \frac{1}{\lambda}\left\{\varkappa G\frac{\partial G}{\partial s} + G^2\frac{\partial \varkappa}{\partial s} - \frac{2\omega\cos\varphi}{r}v_G\right\} dp,$$

where $\frac{\partial}{\partial s}$ denotes space differentiation along the stream-line and v_G is the south-north component of **G**. r is the distance from the centre of the earth.

Each term on the right-hand side is potentially very large, and some further mechanism is required to explain why the observed pressure changes are invariably so small. In a non-steady pressure field, the trajectories of air particles differ from the instantaneous stream-lines. In order to show the mechanism of control, it is sufficient to represent this difference by

$$G(\varkappa - \varkappa_s) = C\varkappa_s \sin\theta$$

for a pressure system moving eastwards at speed C without distortion. The suffix s relates to the stream-line, and θ is the angle from which the gradient wind blows, measured clockwise from north.

The tendency equation then takes the form

$$\frac{\partial p}{\partial t} = -\frac{1}{\lambda}\int_0^p \left[G\varkappa_s\frac{\partial G}{\partial s} + G(G + C\sin\theta)\frac{\partial \varkappa_s}{\partial s} - C\varkappa_s^2 v_G - \frac{2\omega\cos\varphi}{r}v_G\right] dp.$$

Now C is dependent on the pressure tendency itself, being, in fact, proportional to its local value. $\frac{\partial p}{\partial t}$ is, therefore, implicit on the right-hand side of the equation as well as explicit on the left, and one may effectively transpose the terms containing C by writing

$$F\frac{\partial p}{\partial t} = -\frac{1}{\lambda}\int_0^p \left(G\varkappa_s\frac{\partial G}{\partial s} + G^2\frac{\partial \varkappa_s}{\partial s} - \frac{2\omega\cos\varphi}{r}v_G\right) dp.$$

It is possible to assess the magnitude of all terms, including F, from synoptic charts of the free atmosphere. Alternatively, one may carry the theoretical work a stage further by examining the typical upper pressure distributions associated with the commonly observed surface pressure systems. A more detailed account of the theoretical work will appear elsewhere, by courtesy of the Director of the Meteorological Office, London.

The equation has been applied to schematic models of warm-sector depressions, cold depressions, warm anti-cyclones, cold high-pressure ridges, developing secondary depressions and frontal waves, and to systems of straight north-south isobars. In each case F may be represented explicitly in terms of the (vertically integrated) parameters of the pressure and stream-line fields. Its value is normally between 10 and 50 in middle latitudes, though it can be even higher: it may therefore be regarded as a control factor, and only a fraction of the large pressure tendencies suggested by the terms on the right-hand side of the above equations can in practice ever be realized.

The braking mechanism in the movement of pressure systems thus lies in the distortion of the trajectory which the movement itself creates. The normal movement of systems can be explained on the basis of the gradient wind approximation. (A discussion of this approximation is appended to the full paper.) By a refinement of the theory it is further possible to discriminate between fast- and slow-moving systems, and to show how the method is capable of yielding information on the development as well as the translation of the pressure system. Since only a contribution of the order of $25 \times \frac{\partial p}{\partial t}$ need be sought in examining the field of divergence, a much more hopeful outlook on the synoptic problem of pressure changes should emerge.

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Whitecroft,
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Nov. 9.

[1] Jeffreys, H., *Quart. J. Roy. Met. Soc.*, 117 (Jan. 1946).

[2] Matthewman, A. G., *Phil. Mag.*, in the press.

Thickness Measurements of Thin Films

I READ with interest the description by Gunn and Scott[1] of their method of measuring the thickness of thin films. I have been using the same method for some time, but have found necessary a number of modifications and precautions which it may be helpful to record.

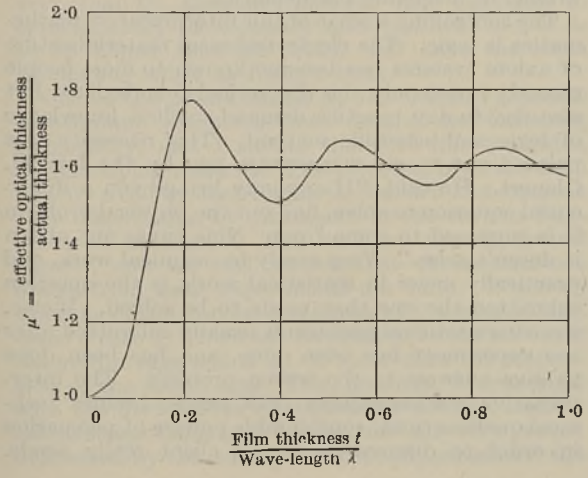
Gunn and Scott use multiple-beam wedge interference with monochromatic light between a reference surface and a slide on which the film is deposited. Silver is evaporated over the slide and the film, and at a film border the step corresponding to the film thickness gives rise to a displacement of the interference fringes. The method suffers from the slight disadvantage that in measuring the fringes with the travelling microscope a certain area of the slide is covered, and, therefore, if accurate figures are to be obtained the film must be uniform in thickness and the slide plane over this area. These requirements can be avoided if white light is used and the fringe system observed by means of a spectrometer. Other advantages, such as improved sharpness, of these 'fringes of equal chromatic order' are treated in detail by S. Tolansky[2] in another connexion.

The technique is to project an image of a line of the interference surfaces on to the slit of a spectrometer, the line crossing a film border. In this way the thickness at a single point of the film border is determined.

Inaccuracies in both methods arise due to the imperfect reflectivity of silver at visible wave-lengths. This causes the phase change upon reflexion to differ appreciably from 180°, and the equation governing interference must be written (normal incidence)

$$n\lambda = 2\mu t + 2\delta,$$

where δ takes account of the phase change. If a relative fringe displacement is to correspond to a change in optical thickness only, then δ must be constant. However, δ depends on the substance in front of the silver and, for semi-opaque silvering, also on the substance backing the silver. Therefore, in the case of interference with transmitted light an error will certainly be introduced due to the change in refractive index at the film border of the substance backing the silver; unless, indeed, the film under consideration has the same index as the glass supporting slide. Thus accurate measurement of film thickness is made possible only by having opaque silvering over glass and film, and using interference in reflexion rather than in transmission.



In measuring the optical thickness μt by depositing the film over the silvered glass slide, a similar error is introduced, of the order of 20 per cent in μ for a film 400 A. thick.

Another phenomenon in the measurement of refractive index is that the effective optical thickness, as determined by the interference method, is not μt for films less than about one wave-length thick but follows the curve shown, in which the effective refractive index $\mu' = \frac{\text{effective optical thickness}}{\text{actual thickness } t}$ is plotted against $\frac{\text{thickness } t}{\text{wave-length } \lambda}$ for a true refractive index of 1·6.

This curve has been deduced theoretically by the application of Maxwell's equations, but has also been verified by experiment.

It is seen that, owing to this effect and to the phase change on reflexion, large errors can be introduced in measurements on very thin films.

I am greatly indebted to K. Donaldson, a member of Dr. Tolansky's team at the University of Manchester, for introducing me to the technique and difficulties of multiple-beam interferometry.

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London.
Nov. 14.

[1] Gunn, A. F., and Scott, R. A., *Nature*, 158, 621 (1946).
[2] Tolansky, S., *J. Sci. Instr.*, 22, 161 (1945).

Choice of a 'Reality Index' for Suspected Cyclic Variations

THERE are natural phenomena which, without being purely periodical in character, show cyclic variations with maxima of different height, minima of different depth and varying intervals between consecutive maxima or minima. While in many cases the cyclic variations are so strongly marked that there can be no doubt as to their reality, in other cases it might be difficult to decide whether the variations appearing in a series of observed quantities are of real significance or not. In the latter cases it would be advantageous if we could find a 'reality index' which would indicate the degree of reality of suspected cyclic variations in a similar manner as, for example, in the calculus of correlation the correlation coefficient expresses the degree of relationship between two sets of observed quantities.

In an earlier communication[1], I reported on a function which could be used as criterion for the reality of cyclic variations. This function is really the probability that the number of extrema actually found is less than the number which would be expected if the terms of the series were distributed at random. This criterion, however, has the following disadvantage: it holds good only for long cycles, but not for short ones. If, for example, in a sufficiently long series of observed numbers large numbers always alternate with small ones, the existence of a short-cycle variation is very probable. Thus the reality index should, in this case, have a value near 1; the above function, however, is zero in this case.

A more suitable reality index can be found by making use of an interesting investigation by W. O. Kermack and A. G. McKendrick[2]. These authors pointed out that, in an infinitely long series of

quantities distributed at random, the mean length of a 'run' is 2·5, and that the standard deviation from this average is given by $S = \sqrt{\frac{3}{5r}}$, where r denotes the number of runs counted. By 'run' is meant either a sequence of decreasing terms beginning with a maximum and ending with a minimum, or a sequence of increasing terms beginning with a minimum and ending with a maximum; and by length of a run is meant the number of terms of which the run consists, the two extrema at the beginning and the end of the run being included. If the series is finite, the first run begins with the first term of the series and the last run ends with its last term, while all the other runs begin and end with extrema as stated above. In this case the mean length of a run (for random distribution) is less than 2·5; but if the series is not too short, the difference between 2·5 and the accurate mean length of a run can be neglected.

Consider a series of N observed quantities containing E extrema (that is, E terms which are either greater or less than both their neighbours). Then L, the observed average length of a run in this series, and r, the number of runs, obviously are given by $L = \frac{N+E}{E+1}$ and $r = E + 1$. If we put $D = L - 2{\cdot}5$, then, according to the results obtained by Kermack and McKendrick, a suitable reality index R should fulfil the following conditions:

(1) $R = 0$ for $D = 0$, (2) $R = 0{\cdot}5$ for $D = \pm S$,
(3) $R \to 1$ for $D \to \infty$, (4) $R \to 1$ for $S \to 0$ and $D \neq 0$.

Among all the functions satisfying these conditions it will, for practical purposes, be best to choose one for which the calculation is as easy as possible. I therefore propose to take

$$R = \frac{D^2}{D^2 + S^2},$$

as reality index for suspected cyclic variations. Then, values of R near 0 would refute the supposition of cyclic variations, values of R near 1 would point to their reality, while values of R near 0·5 would leave the question doubtful.

Sometimes it may happen that cyclic variations are covered by secondary fluctuations of an accidental character; these fluctuations may arise from errors of observation or may have their origin in the observed phenomenon itself. In this case it will be necessary to eliminate the secondary fluctuations by forming averages of the observed quantities in order to reveal the cyclic variations. An example will elucidate the application of the proposed reality index to a given series of observed quantities.

The heights of all sunspot maxima observed hitherto are characterized by the following Zurich numbers: 92·6, 86·5, 115·8, 158·5, 141·2, 49·2, 48·7, 71·7, 146·9, 131·6, 97·9, 140·5, 74·6, 87·9, 64·2, 105·4, 78·1, 119·2. This series consists of 18 terms, 11 of them being extrema. Thus we have $N = 18$ and $E = 11$; hence, $r = 12$, $S^2 = 0{\cdot}05$, $L = 2{\cdot}4$, $D = -0{\cdot}1$, $R = 0{\cdot}2$. (The value of R is given here only to one decimal place; for its more accurate calculation is impracticable because of the shortness of the series concerned.) The small value of R indicates no cyclic variation in the above series. This is interesting, because some authors have concluded from the sequence of seven alternating terms near the end of the series that high sunspot maxima generally alternate with low ones. This conclusion is incompatible with the small value of R.

Now take running averages of every four consecutive quantities of the above series. The resulting series is: 113·4, 125·5, 116·2, 99·4, 77·7, 79·1, 99·7, 112·0, 129·2, 111·2, 100·2, 91·8, 83·0, 83·9, 91·7. The number of terms has decreased to 15 and the number of extrema to 4. Thus $N = 15$ and $E = 4$; hence, $r = 5$, $S^2 = 0{\cdot}12$, $L = 3{\cdot}8$, $D = +1{\cdot}3$, $R = 0{\cdot}9$. This value of the reality index R is so near 1 that the existence of real cyclic variations is beyond question. But as the value of R for the original series was only 0·2, it is clear that the cyclic variations in the height of sunspot maxima are covered by secondary fluctuations.

I hope the reality index as proposed here will prove to be useful for the study of cyclic variations in many branches of science.

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Nov. 2.

[1] *Nature*, **157**, 663 (1946)
[2] *Proc. Roy. Soc. Edin.*, **57**, 228 (1936).

Mathematical Technology

The new synthesis in mathematics discussed by Erdélyi and Todd and in the leading article in *Nature* of November 16 has had a long wait for explicit recognition. Ignored or sniffed at by 'real' mathematicians and, because of his natural tendency to mathematical irredentism, a worry to departmentalized institutions, the mathematical interpreter has for too long lurked in a scientific and administrative underworld. For that matter, there is no such thing, officially, as a 'mathematician'; he has to be described either as a teacher, a physicist, or a statistician, even if none of them.

There is as much permanent beauty in this branch of mathematics as in any other, for those who can recognize it. Essentially this new synthesis centres about what may be termed 'mathematics of organisation', and thus draws from material scattered all over the conventional mathematical 'subjects', as well as from subjects, such as the design of office forms and filing systems, the mathematical content of which is not derived from the dynamics of material systems, and is therefore classed as 'recreations' or 'trivia' in academic mathematics.

The controlling science of this interpretative mathematics is logic. The electrotechnical materialization of axiom systems has become known to most people recently; not only the theoretical foundations, but also day-to-day practice demand explicit knowledge of logic and scientific method. This necessity was pointed out to me some years ago by the late H. Glauert. He said, "If anybody brings you a differential equation to solve, find out the physical problem it is supposed to come from. Nine times out of ten it doesn't arise." Very rarely in technical work, and practically never in statistical work, is the question submitted the one that needs to be solved. Worse, the computational problem is usually submitted after the experiment has been done, and has been done to give answers to the wrong problem. The interpretative mathematician thus needs, besides technical qualifications, considerable powers of persuasion in order to discover what his client really needs.

Also it is almost essential that he should have worked in a cognate field of research, not as a mathematician.

The trouble is that scientific workers are never explicitly taught scientific method and argument. Even statistical techniques are taught without this foundation, and, therefore, often degenerate into a modern Pythagorian mysticism. It is noteworthy that, in my experience, the best junior computors are, *ceteris paribus*, not science but librarianship students. The course for librarianship includes those essentials of logic and classification that are essential in the intelligent operation of computing schedules, calculating machines and strategic computing installations of the punched card and electronic type. (Use of highly trained scientific or mathematical workers for whole-time computation is a waste of valuable skill.)

Inasmuch as we train scientific men to answer questions but not to ask them, we cannot complain if strategical computors are described as 'electronic brains'. The interpretative mathematician, by devising machinery to answer questions, is, with his colleague the technologist who devises machinery to perform actions, making it possible for human beings to live like human beings, instead of like machines, especially in clerical activities. He needs no apology, but he does need opportunity and facilities.

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Establishment of Cytochemical Techniques

In 1936 there appeared an admirable book "Histochemie Animale", by L. Lison. In this book, Lison tried to teach chemistry to the histologists, and by the weight of his own reasoning he was forced to discard a great many time-honoured histological methods the validity of which had never been really investigated. Recently, in an article entitled "Establishment of Cytochemical Techniques"[1], J. F. Danielli endeavours to do a similar thing for cytochemistry, and, since some of his criticisms concern techniques which form the backbone of modern cytochemistry, it might, perhaps, be feared that his remarks will leave the cytochemist with a gloomy feeling of being suspended in mid-air without any reliable method to cling to. There is no doubt, however, that Dr. Danielli's plea for more exactness in cytochemistry is necessary and justified, and it is to be hoped that his article will have the same wholesome effect as Lison's book.

One of the points raised by Dr. Danielli concerns a technique which has been used at the Carlsberg Laboratory, and I should therefore like to add a few clarifying remarks. The principle involved is to stratify a cell by centrifugation, divide it and examine "the distribution of substances in the various fragments so obtained". This we have done in several cases[2,3], and we still believe that the conclusions drawn from these experiments are valid. Danielli's example of the untrustworthiness of the method concerns a case in which the respiration of the halves of sea-urchin eggs added up to more than the respiration of the intact egg. This, however, is concerned with the distribution of respiratory *activity*, and K. Linderstrøm-Lang and I have, for the very reason illustrated by this example, repeatedly stressed[4,5] the fact that the only conclusions to be drawn from experiments of this type are those based on the quantitative distribution of *substances*. In the case of an enzyme, as in our peptidase experiments, it is therefore necessary to kill the cell fragments, to remove diffusion difficulties by thorough cytolysis, to make sure of free contact between enzyme and substrate under conditions which are standardized for the enzyme determination, and to check that under these conditions the amount of enzyme found in the halves adds up to the value for the whole egg. If these provisions are made, we think that deductions are justified; but such deductions permit, of course, only *indirect* conclusions with regard to physiological activity.

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[1] Danielli, J. F., *Nature*, 157, 755 (1946).
[2] Philipson, T., *Compt. rend. Lab. Carlsberg*, 20, No. 4 (1933).
[3] Holter, H., *J. Cell. and Comp. Physiol.*, 8, 179 (1936).
[4] Linderstrøm-Lang, K., *Compt. rend. Lab. Carlsberg*, 19, No. 13 (1932).
[5] Linderstrøm-Lang, K., and Holter, H., *Ergeb. der Enzymforsch.*, 3, 309 (1934) (see p. 311).

It is most pleasing to read Dr. Holter's firm restatement of the basic principles which he and his colleagues at the Carlsberg Laboratory regard as essential in cytochemical studies by 'stratification' methods. We are completely in agreement on these points.

Most of the correspondence which has reached me on this matter has expressed agreement with the emphasis which I placed on the need for caution. Of the few dissentients, none has complained of feeling "suspended in mid-air"; nevertheless, I continue to hope that their position will ultimately become plain to them.

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Effect of Pressure on Crystal Growth

I have been greatly interested in the comments arising from my suggestion that the expansion of setting plaster-of-Paris might be due to the pressure exerted by crystals of gypsum growing non-isotropically in a not completely confined space[1]. The original suggestion was speculative, and it was made clear that it had no direct experimental confirmation. Undoubtedly, more direct proof would be required before it is accepted. But in pure water or in solutions of accelerators, in which expansion is greatest, the rate of growth parallel to the *c*-axis is some 10–20 times greater than that perpendicular to the *c*-axis, and a considerable relative increase in solubility would be required to make the rate of growth parallel to the *c*-axis negligible compared with that perpendicular to it. It is not possible to express this in quantitative terms, or translate it into a force; but while experimental proof is lacking, the suggestion cannot be dismissed *a priori*, and is at least a possible explanation of a phenomenon for which no reasonable alternative is available.

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[1] *Nature*, 158, 13, 584 (1946).

X-RAY ANALYSIS IN THE STEEL INDUSTRY

X-RAY analysis in the steel industry formed the subject of a conference organised by the X-Ray Analysis Group of the Institute of Physics, and held at Sheffield on November 8 and 9. Dr. W. H. Taylor presided over a well-attended meeting.

One of the main X-ray methods used in the study of the structure of steels and associated materials is that based on the Debye–Scherrer powder technique. The Conference opened appropriately with a paper by Dr. A. J. Bradley[1] on how to use this technique in problems requiring the highest possible accuracy in measurements of the intensity and position of the diffraction lines. Using specimens of thin annealed wires of platinum or copper in a powder camera of the Bradley–Jay type, he showed that it is possible to resolve the $K\alpha$ doublet for all lines of the diffraction pattern down to the smallest angle reflexions. With a good reflecting material, therefore, the technique is capable of giving very high standards of definition. Dr. Bradley then went on to consider the disturbing effects of such factors as height of the collimating slits, size and absorption of the specimen, and variations in the focal spot of the X-ray tube. He showed how they would influence the position and intensity of the diffraction lines, but gave formulæ for deducing the true values. He also drew comparisons between the photometer and the human eye as instruments for assessing the line positions and intensities. He finds that the photometric curve of a line is of the form $y = A/(B + x^2)$, when y is the height at a distance x from the peak; this, to a first approximation, gives a parabolic top to a line. He concludes that the blackening of a line as seen by eye is inversely proportional to the latus rectum of this parabola; also that the eye sees only the top and upper slopes of the lines, and sees the width of a line as the distance between those points where the curvature of the photometric record changes sign from the convex appearance at a peak to the concave appearance between peaks. He ended by showing how best to interpret both the visual and the photometric measurements.

Dr. G. W. Brindley, who opened a brief discussion, directed attention to the problem of estimating the proportions of materials in a mixture from the relative intensity of the lines from the individual constituents. He gave examples where the estimation could be very seriously in error because the particles were of different size and absorbing power.

The second paper was a contribution by Dr. W. A. Wood[2], on the application of X-rays to the study of internal stresses and deformation in iron and steel. The X-ray method for internal stresses, as first used, particularly in Germany, depended on measuring the lattice dimensions of a test piece in various directions, and treating the difference between these values and the normal unstressed lattice parameters as elastic strains, from which, with the aid of standard elasticity theory, the equivalent internal stresses could in principle be deduced. This early procedure was described at previous conferences. Dr. Wood therefore confined himself to a review of the method in the light of his work at the National Physical Laboratory on the changes in lattice dimensions and macrostructure of the metallic grain under known applied stresses. These researches showed that the early procedure must be used with caution. One reason is that the lattice stress-strain curves cease to follow Hooke's law when the primitive external elastic range of the steel is exceeded. This means that plastic deformation of itself results in permanent internal stresses which become superposed on the applied or macro-stress, and results in a residual lattice strain. Another reason is that the extent of this residual strain remaining on removal of the stress differs for different crystallographic planes; therefore the early procedures for stress determination could lead to a different answer according to the particular planes used for measurement. Finally, since the magnitude of the residual strain associated with a given lattice plane depends on the previously applied stress, the stress-strain ratios, or apparent elastic moduli, have not the fixed values required by the simple procedures. Dr. Wood attributed these effects to the conditions associated with breakdown of the perfect grains of the primitive elastic range into the smaller disoriented crystallites produced during plastic deformation, and the fact that the X-rays examine only certain selections of these orientations. The breakdown is shown by the peripheral spread of the reflexion spots into continuous arcs along the diffraction rings; a lower limit to the crystallite size this produces is shown by the fact that later radial broadening of the diffraction ring reaches a steady value. In conclusion, Dr. Wood pointed out that although the use of the X-ray method calls for new discrimination, in particular the desirability of confining measurements to planes showing minimum residual strain and longest elastic ranges, at the same time it has brought to light previously unknown properties of the metallic lattice.

Mr. G. B. Greenough, in discussion, indicated that he had repeated the work of Dr. Wood and confirmed the presence of the internal strains produced in the plastic range. He gave figures for the residual strains of various planes in aluminium and magnesium as well as iron, and emphasized the point that whereas mechanical measurements take an average over all the grains, X-ray methods select grains of certain orientations, thus taking account of anisotropy. He also directed attention to the theories of Masing and Heyn on the production of internal stresses as the result of the irregularity in deformation of differently oriented grains in polycrystalline aggregates.

The third paper, by Mr. H. J. Goldschmidt[3], dealt with the application of X-rays to the study of electro-deposited layers of chromium on steel. Mr. Goldschmidt had examined the structural conditions associated with layers of high hardness and wear-resistance, and found that these properties are decided largely by the base metal and the conditions at the interface. In a good deposit, the electrolytic hydrogen enters the steel surface in the initial stages of deposition and expands the lattice to a size favourable for linking with the chromium eventually deposited. The linkage is metastable; and, after plating is finished, the tendency of the steel and the chromium to revert to their natural lattice dimensions leads to marked internal strains. Mr. Goldschmidt considers that these strains are the essential cause of the great hardness and wear-resistance. He has found that in poor-quality deposits no such linkage occurs, the iron and chromium lattices being separate. Mr. Goldschmidt has also applied the X-ray method to the study of the structural changes on annealing the samples up to 1,000° C., and distinguishes between three classes of occluded hydrogen according

to the firmness of binding in the lattice. His points were illustrated by a number of interesting slides.

Dr. W. Betteridge, commenting on this paper, referred to results he has obtained in examination of thicker deposits of chromium. He believes that conditions at the interface would not influence the properties of the outer layers of a thick deposit. Dr. T. Ll. Richards considered that Goldschmidt's experiments explain the mechanism of adhesion rather than enhanced wear resistance and hardness. The explanation of these properties is not, however, one of the simpler problems confronting the X-ray worker.

The next paper introduced other difficult problems. This paper was by Dr. A. H. Jay[4] under the provocative title of his successes and failures in X-ray applications. He began with four failures. The first was lack of success in detecting the graphite in cast iron; this he attributed to the erosion of the graphite on preparing the cast iron surface and the formation of pits into which the incident X-rays did not sufficiently penetrate. The second was the failure to estimate the amount of silica in zircon flour to nearer than 2 per cent; a task, however, which, his hearers might have thought, would have been expected to be troublesome. The third was the difficulty of estimating quantitatively the constitution of iron ores, because some constituents, for example, goethite or limonite, gave such poor X-ray reflexions that they could be present to an appreciable amount and remain undetected. The fourth was the failure of X-rays to detect any difference of structure in a steel when it was in the tough condition and when it was in the 'temper brittle' condition. Dr. Jay then tempered the breeze by referring, though more briefly, to his successes. He quoted two: first, his establishing the difference in structure between steel in the tempered and the annealed condition, the former exhibiting partial recrystallization only of its constituents and the latter full recrystallization; secondly, a successful determination of the desirable chemical changes in refractory bricks during manufacture, and the light thrown on the mechanism of failure which might occur during firing. It is well known that he could have quoted others.

The Conference concluded with a paper by Prof. G. I. Finch on the rather different, but complementary, field of surface structure covered by electron diffraction. Prof. Finch[5] set out to show the type of problem to which this technique could be usefully applied, and illustrated his points by slides showing a fascinating series of electron diffraction patterns. He began by a group demonstrating the use of the technique for studying the degree of order of the atomic arrangement in a surface of thin film, the diffraction patterns ranging from the diffuse halo of the disordered state to the sharp rings or diffraction spots characteristic of crystallinity. He then illustrated his experiments on the Beilby layer associated with polished surfaces of metals and inorganic crystals, and demonstrated the interesting point that the amorphous layer, though undoubtedly produced during polishing, did not always persist as a disordered layer but might spontaneously crystallize to the structure of the substrate, particularly on well-defined cleavage planes. Prof. Finch ended by showing electron patterns obtained during his later researches on the mechanism of crystal growth and the manner in which minute crystals were influenced by the structure of the surface on which they were deposited. In conclusion, he certainly succeeded in making his hearers 'electron-diffraction conscious'.

W. A. Wood

[1] "The Intensity Relations of Debye–Scherrer Powder Diffraction Lines", A. J. Bradley.
[2] "The Application of X-Rays to Study of Internal Stresses and Deformation", W. A. Wood.
[3] "An X-Ray Investigation of Electrodeposited Chromium", H. J. Goldschmidt.
[4] "Some Successes and Failures in the Application of X-Rays to Industrial Problems", A. H. Jay.
[5] "The Surface Structure of Metals", G. I. Finch.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW ZEALAND

ANNUAL REPORT

THE twentieth annual report of the Department of Scientific and Industrial Research, New Zealand, covers the year 1945–46 (Wellington: Gov. Printer. 2*s*.). Mr. D. E. Sullivan, Minister responsible for the Department, refers in his introductory statement to the way in which the Department has kept abreast of scientific developments overseas during the later years of the War, instancing the use of radar to assist coastal navigation and of antibiotics to assist the control of plant and animal diseases. The necessity of maintaining close personal contact with laboratories and research stations in other countries has led to a policy of sending young men of science abroad for varying periods to gain experience and provide a reserve of trained personnel to meet the increasing demand for scientific services. The secretary's report refers to the grouping of the Department's activities into the Auckland Industrial Development Laboratories, which has made good progress during the year. It is hoped that new activities sponsored in the Laboratories may ultimately be taken over by units of industry and serviced therefrom, leaving the Laboratories to concentrate on further research and development, and to undertake only such specialized services as are essential to industry and yet unlikely to be provided in New Zealand by private firms. It is also anticipated that the policy and organisation in relation to secondary industries of the Dominion Physical Laboratory, the Auckland Industrial Development Laboratories and the Defence Development Section, Christchurch, will do much to strengthen the link between research and secondary industries. During the year the Radio Development Laboratory and other sections in Wellington have been absorbed into the Dominion Physical Laboratory, and the chemical, physical and engineering activities have been grouped to meet more readily the requirements of the secondary industries.

During the year the Soil Bureau, Grasslands Division and Botany Division have combined in investigations covering areas where soil erosion is in progress or threatens. Over considerable parts of the Dominion the decrease of soil fertility through erosion can now be measured, and means for checking the losses indicated. The Grasslands and Botany Divisions have carried out surveys and initiated investigations, on hill country in both Islands, designed to conserve soil fertility. Other work of the Soil Bureau has covered soil chemistry, physics

and biotics, while the Botany Division of the Plant Research Bureau has continued to investigate weed problems, some of which, such as nassella, constitute a serious threat to good pastoral land. The Grasslands Division continues to breed, test and multiply improved strains of grasses and clovers, while studies of the best utilization of these by the animal, direct and through conservation, as silage or hay, are proceeding. Similar investigations on arable supplementary fodder crops, both alone and in association with pastures, are in progress in the Agronomy Division, which also continues to produce high-quality seeds for certification. The Entomology Division has focused its attention on the grass-grub, the major insect pest affecting pastures, but has completed its study of the control of cheese-mites, in co-operation with the Dairy Research Institute, which established the value of dichloroethyl ether for this purpose. The Plant Diseases Division, in dealing with a wide range of diseases affecting crops, has included numerous trials of new insecticides such as D.D.T. and 'Gammexane' as well as investigations on proofing canvas, etc., against fungal attack and the control of moulds which stain plaster walls.

Much of the work of this Division has been carried out in collaboration with other divisions, for example, the Plant Chemistry Laboratory, where an investigation of the value of antibiotics for control of plant and animal diseases and the exploration of New Zealand flora for new strains has been initiated. The Plant Research Laboratory has also investigated hormone weed-killers such as 2 : 4-dichlorophenoxyacetic acid; while investigations by the Plant Diseases, Botany and Soil Survey Divisions of the yellow-leaf disease of *Phormium* (New Zealand 'flax') indicate that the disease occurs on soils where other plants suffer from mineral deficiency. The relation of phormium to shortages of trace elements is being examined, and the Botany Division has amassed much information on the management of phormium plantations which should be valuable in placing the industry on a sounder basis.

Work at the Wheat Research Institute has led to the breeding of a new high-protein wheat giving excellent baking quality, and the wheat and flour-testing services of the Institute have been used to keep damage to flour through unfavourable harvest conditions at a manageable level. A new milling machine devised by the Institute to give an 80 per cent extraction without loss of nutritive quality in the flour has proved satisfactory in commercial trials. Tobacco research has revealed a variety which possesses good resistance to black root-rot, a disease which is now appearing in certain types of soil, and promising results have been obtained in trials of a new type of curing-kiln conducted in collaboration with the Chemical Engineering Section of the Dominion Laboratory. Fertilizer experiments, nutritional studies and a soil survey of tobacco blends are other activities in this field.

Investigations under the Dairy Research Institute have included land-cress taint in cream and butter, the use of 'Parchfoil' and 'Pliofilm' for wrapping butter packed in *Pinus radiata* boxes, trials of a method of wrapping matured cheese in 'Pliofilm', the use of transparent wrapping materials for packing skim-milk powder and the formulation of a specification for parchment for wrapping butter. Final reports of the work on the effect of mastitis as indicated by the Hume modification of the bromthymol blue test on the composition and cheese-making properties of the milk have been forwarded for publication, and work on starters for cheese manufacture, the cleaning of milking machines and on dairy cow nutrition has continued. The Dairy Research Institute has also undertaken to compile, at the request of a committee on which the various other bodies, such as the Wheat Research Institute, the Dominion Laboratory, the Plant Chemistry Laboratory and the Otago Medical School, also concerned with research on food for human consumption, are represented, the information already in existence on the composition of the main classes of dairy produce. Fruit cold-storage research has continued on similar lines to those described in the previous report, and some notes are included on manurial investigations in the research orchard at Appleby, and other investigations under the Plant Diseases Division, Auckland, and the Cawthron Institute, Nelson.

The Industrial Psychology Division has completed its investigation into the attitudes and problems of the girl worker in industry, and a report is being published. Reports are also in preparation on social and welfare activities in industry and on an investigation on music in New Zealand factories. An investigation concerned with the personnel function of management in the smallish firms, with the view of ascertaining what techniques of management are meeting with success and the underlying attitudes of mind or philosophy, is in its initial stages. Surveys and investigations were carried out for nineteen firms and organisations, as well as vocational examinations involving the use of psychological tests for seven firms and one Government organisation. The New Zealand Leather and Shoe Research Association continued investigations on the quality of sole leather, the effect of perspiration on upper leather, and shoe comfort; and during the year a pilot drying plant suitable for the conveyor system of shoe manufacture was designed and erected. An investigation of the curing of calf-skins was commenced during the year.

The Manufacturers' Research Committee has no scientific or technical officers of its own, all industrial projects being carried out in departmental or research association laboratories, and as further trained staff and equipment become available it is hoped to extend the scientific services and testing organised under the Committee and available to the large number of small units in New Zealand which are unable to provide such facilities for themselves. In particular, it is hoped shortly to offer service in fuel technology. The Committee has during the year sponsored the formation of a research association for the pottery and ceramic industry. The Woollen Mills Research Association in its first year of work carried out many tests on unshrinkable finishes, and has studied laboratory methods of dyeing after-chrome blacks, as well as metachrome dye-baths in dye-houses, by means of *p*H measurements; it was discovered that under commercial conditions the use of ammonium sulphate was an unreliable method of neutralizing alkali in scoured wool or for controlling the *p*H of the dye-liquor. Tests have also been made of D.D.T. and 'Gammexane' for the protection of wool against carpet beetles.

In addition to the work of the Plant Research Bureau already noted, there may be mentioned its garden pea breeding work, maize-breeding project, linen flax investigations, studies of the toxicity to farm animals of indigenous and exotic plants, and on medicinal plants as well as seaweed investigations. Valuable work on different aspects of tomato pro-

duction and on the use of small applications of cobalt sulphate for the control of bush sickness has been carried out at the Cawthron Institute. Research work at the Canterbury Agricultural College on the control of house-flies, on sheep dips, the pre-emergence decay of peas and, at the Massey Agricultural College, on plant propagation, drainage and the improvement of mutton and wool, is also noted in the report, which reviews further the activities of the Dominion Laboratory in physical chemistry, ceramics, paint and building research, chemical engineering, metals and corrosion, oil, bitumen and tar and coal survey. The work of the Dominion Observatory in time service and seismology continued on the usual lines, and that of the Dominion Physical Laboratory has been replanned in accordance with post-war needs.

FORTHCOMING EVENTS

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

Saturday, December 28

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 3 p.m.—Prof. H. Hartridge, F.R.S.: "Colours and How We See Them" (Christmas Juvenile Lectures, 1).*

APPOINTMENTS VACANT

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

LECTURER IN FORENSIC MEDICINE AND TOXICOLOGY, and a LECTURER IN HYGIENE AND PUBLIC HEALTH—The Secretary, Charing Cross Hospital Medical School, 62 Chandos Place, London, W.C.2 (December 30).

ASSISTANT LECTURER (Grade IIb) IN MECHANICAL ENGINEERING—The Secretary, The University, Edmund Street, Birmingham 3 (December 31).

RESEARCH ASSISTANT, Milk Utilization Department, Auchincruive, Ayr—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow (December 31).

DIRECTOR OF A PUBLIC HEALTH LABORATORY in the Southern Rhodesia Government Service—The High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (December 31).

READERSHIP IN GEOGRAPHY, and the READERSHIP IN GEOLOGY, tenable at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (December 31).

EDUCATIONAL PSYCHOLOGIST in the Ipswich Education Department—The Chief Education Officer, 17 Tower Street, Ipswich (December 31).

ENTOMOLOGIST to carry out fundamental research on bees, and a BIOLOGIST to assist in the research work of the Bee Research Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (December 31).

PROVINCIAL SUPERVISOR of the National Milk Testing Service in the Bristol province under the Ministry of Agriculture and Fisheries—The Advisory Bacteriologist, 22 Berkeley Square, Bristol 8 (December 31).

SENIOR LABORATORY TECHNICIAN IN THE DEPARTMENT OF PATHOLOGY at Broadgreen Hospital, Edge Lane Drive, Liverpool—The Medical Officer of Health, Hospitals Department, Gordon House, Belmont Grove, Liverpool 6, endorsed 'Laboratory Technicians' (December 31).

DEPUTY CITY ANALYST—The Medical Officer of Health, Public Health Department, Leeds, endorsed 'Deputy City Analyst' (January 3).

HEAD OF THE DEPARTMENT OF CHEMISTRY AND BIOLOGY—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex (January 3).

LECTURER IN CHEMISTRY—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex (January 6).

LECTURER IN THE DEPARTMENT OF ANIMAL HUSBANDRY, and a LECTURER IN BIOCHEMISTRY—The Bursar and Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1 (January 11).

METALLURGIST as Chief Officer of the Liaison and Technical Service Department—The Secretary, British Non-Ferrous Metals Research Association, 81–91 Euston Street, London, N.W.1 (January 11).

PRINCIPAL SCIENTIFIC OFFICER in the Radar Research and Development Establishment of the Ministry of Supply—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 1721 (January 13).

CHAIR OF GEOGRAPHY, tenable at King's College—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 14).

SENIOR ASSISTANT OBSERVER—The Director, The Observatory, Cambridge (January 15).

RESEARCH OFFICER, and an ASSISTANT RESEARCH OFFICER, in the Personnel Research section of the Leather Industries Research Institute, Rhodes University College, Grahamstown, South Africa—The Secretary, Office of the High Commissioner for the Union of South Africa, South Africa House, Trafalgar Square, London, W.C.2 (January 17).

LECTURER (Grade I) IN THE DEPARTMENT OF CHEMISTRY—The Secretary, Royal Technical College, Glasgow (January 18).

CHAIR OF ELECTRICAL ENGINEERING, and a LECTURER IN MATHEMATICS, at Canterbury University College, Christchurch, New Zealand—The Secretary, Universities Bureau of the British Empire, 24 Gordon Square, London, W.C.1 (January 31).

LECTURER IN ARCHITECTURAL CONSTRUCTION at Auckland University College, Auckland, New Zealand—The Secretary, Universities Bureau of the British Empire, 24 Gordon Square, London, W.C.1 (January 31).

CHAIR OF MATHEMATICS tenable at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 6).

OFFICIAL FELLOWSHIP IN CHEMISTRY—The Rector, Lincoln College, Oxford (February 8).

CHAIR OF PHYSIOLOGY—The Bursar, Royal Veterinary College, Royal College Street, London, N.W.1 (March 1).

CHEMIST AND BACTERIOLOGIST—The Chief Engineer, Mid-Wessex Water Company, Frimley Green, Aldershot, endorsed 'Chemist and Bacteriologist'.

CHIEF LABORATORY TECHNICIAN—The Medical Superintendent, Selly Oak Hospital, Birmingham.

DIRECTOR OF THE SOUTH AFRICAN FISHERIES RESEARCH INSTITUTE in Cape Town—The Scientific Liaison Officer, South Africa House, Trafalgar Square, London, W.C.2.

LECTURER IN MECHANICAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne.

PLANT BREEDER in the Hop Research Department—The Secretary, Wye College, Wye, Ashford, Kent.

DIRECTOR OF RESEARCH—The Secretary, Institute of Brewing, Goring Hotel, Grosvenor Gardens, London, S.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

International Committee for Bird Preservation (British Section). Annual Report for 1941–1945. Pp. 36. (London: International Committee for Bird Preservation, c/o Zoological Society, 1946.) [17

Carnegie United Kingdom Trust. Thirty-second Annual Report, 1945. Pp. viii + 44. (Dunfermline: Carnegie United Kingdom Trust, 1946.) [17

Empire Cotton Growing Corporation. Report of the Administrative Council of the Corporation, submitted to the Twenty-fifth Annual General Meeting on June 25th, 1946. Pp. ii + 22. (London: Empire Cotton Growing Corporation, 1946.) [17

Memoirs of the Cotton Research Station, Trinidad. Series A: Genetics, No. 26; (i) The Genetics of 'Corky'—(1) The New World Alleles and their Possible Role as an Interspecific Isolating Mechanism, by S. G. Stephens; (ii) The Crinkled Dwarf Allelomorph Series in the New World Cottons, by J. B. Hutchinson; (iii) Evidence on Chromosome Homology and Gene Homology in the Amphidiploid New World Cottons, by R. A. Silow. Pp. 54. (London: Empire Cotton Growing Corporation, 1946.) 2*s.* 6*d.* [17

Imperial Bureau of Soil Science. Technical Communication No. 43: Land Classification for Land-Use Planning. By G. V. Jacks. Pp. iii + 90. (Harpenden: Imperial Bureau of Soil Science, 1946.) 4*s.* [17

The Effects of the Atomic Bombs at Hiroshima and Nagasaki: Report of the British Mission to Japan. (Published for the Home Office and the Air Ministry.) Pp. vi + 22 + 24 plates. (London: H.M. Stationery Office, 1946.) 1*s.* net. [27

Nuffield Foundation. Report of the Trustees for the Three Years ending 31 March 1946. Pp. 64. (London: Nuffield Foundation, 1946.) [27

Broadcasting Policy. (Cmd. 6852.) Pp. 28. (London: H.M. Stationery Office, 1946.) 6*d.* net. [47

Department of Scientific and Industrial Research: Fuel Research. Survey Paper No. 58: Rapid Survey of Coal Reserves and Production; a First Appraisal of Results. Pp. viii + 24. (London: H.M. Stationery Office, 1946.) 9*d.* net. [167

Ministry of Health. Salaries of Whole-time Public Health Medical Officers: Interim Report of Askwith Memorandum. Pp. 12. (London: H.M. Stationery Office, 1946.) 2*d.* net. [167

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 586, Vol. 232: Smoking and Tobacco Pipes in New Guinea. By A. C. Haddon. Pp. 278 + 7 plates. (London: Cambridge University Press, 1946.) 50*s.* [167

Imperial Bureau of Plant Breeding and Genetics. The New Genetics in the Soviet Union. By P. S. Hudson and R. H. Richens. Pp. 88. (Cambridge: Imperial Bureau of Plant Breeding and Genetics, School of Agriculture, 1946.) 6*s.* [167

Proceedings of the Royal Society of Edinburgh, Section B (Biology). Vol. 62, Part 2, No. 24: The Use of Rats for Pressor Assays of Pituitary Extracts, with a Note on Response to Histamine and Adrenaline. By F. W. Landgrebe, M. H. I. Macaulay and H. Waring. Pp. 202–210. 1*s.* 6*d.* Vol. 62, Part 2, No. 25: Chemically Induced Mosaicism in *Drosophila melanogaster*. By Charlotte Auerbach. Pp. 211–222. 2*s.* Vol. 62, Part 2, No. 26: Situs Inversus Viscerum in a White Rat (*Mus norvegicus*). By Dr. R. A. R. Gresson. Pp. 223–224 + 1 plate. 6*d.* (Edinburgh and London: Oliver and Boyd, 1946.) [167

Royal Society of Edinburgh. Plant Invaders. By Sir William Wright Smith. (Address of the President at the Annual Statutory Meeting, October 22, 1945.) Pp. 8. (Edinburgh and London: Oliver and Boyd, 1946.) 1*s.* 3*d.* [167

University of Cambridge: Department of Colloid Science. A List of Papers published during 1912–46 under the direction of Eric Keightley Rideal, F.R.S., presented to him on his Resignation from the John Humphrey Plummer Professorship of Colloid Science, June 1946. Pp. 46. (Cambridge: Department of Colloid Science, The University, 1946.) [177

John Innes Horticultural Institution. Thirty-sixth Annual Report, 1945. Pp. 28. (London: John Innes Horticultural Institution, 1946.) [177

Institute of Social Medicine, Oxford. First Annual Report, 1945. Pp. 20. (Oxford: Institute of Social Medicine, 1946.) [177

College of the Pharmaceutical Society of Great Britain. Annual Report for 1945 of the Research Departments. Pp. 20. (London: Pharmaceutical Society, 1946.) [177

List of Whole-time Awards for Scientific Research, other than Professorships, offered by Public and Private Bodies in Great Britain and Northern Ireland. Fourth issue. Pp. 36. (London: Royal Commission for the Exhibition of 1851, 1946.) 1*s*. [177

Other Countries

Skrifter udgivne af Kommissionen for Danmarks Fiskeri- og Havundersøgelser. No. 11: Om Limfjordens Torskebestand. Af Erik M. Poulsen. Pp. 136. 4.50 kr. No. 12: Fiskeri- og Havundersøgelser ved Faerøerne. Af Å. Vedel Tåning. Pp. 127. 5.50 kr. No. 13: Havets Planteverden i økologisk og produktionsbiologisk Belysning. Af E. Steemann Nielsen. Pp. 108. n.p. (København: C. A. Reitzels Forlag, 1942–1944.) [17

Danish Review of Game Biology. Edited by Jagtraadets vildtbiologiske Undersøgelser. Vol. 1, Part 1: The Species of Capillaria parasitic in the Digestive Tract of Danish Gallinaceous and Anatine Game Birds. By Holger Madsen. Pp. iii + 112. (Copenhagen: J. H. Schultz, Ltd., 1945.) [17

Meddelelser fra Kommissionen for Danmarks Fiskeri- og Havundersøgelser. Serie Hydrografi, Bind 3, Nr. 2: The Influence of the Currents in the Danish Waters on the Surface Temperature in Winter, and on the Winter Temperature of the Air. By Aage J. C. Jensen. Pp. 52. Serie Hydrografi, Bind 3, Nr. 3: The Hydrography of the West Greenland Fishing Banks. By A. Kiilerich. Pp. 45 + 7 plates. Serie Plankton, Bind 3, Nr. 4: Die Productionen bedingungen des Phytoplanktons im Übergangsgebiet zwischen der Nord- und Ostsee. Von E. Steemann Nielsen. Pp. 55. Serie Plankton, Bind 3, Nr. 5: Investigations on the Quantity and Distribution of Zooplankton in Icelandic Waters. By Poul Jespersen. Pp. 77. Serie Plankton, Bind 3, Nr. 6: Über das Frühlingsplankton bei Island und den Faröer-Inseln. Von E. Steemann Nielsen. Pp. 14. Serie Plankton, Bind 3, Nr. 7: Investigations on the Food of the Herring and of the Macroplankton in the Waters round the Faroes. By Poul Jespersen. Pp. 44. (København: C. A. Reitzels Forlag, 1940–1944.) [17

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Carlsberg Foundation's Oceanographical Expedition round the World 1928–30 and previous *Dana* Expeditions under the Leadership of the late Prof. Johannes Schmidt. *Dana* Report No. 18: Die Scyphomedusen. Von G. Stiasny. Pp. 29 + 2 plates. 3.50 kr.; 3*s*. *Dana* Report No. 19: Mysidacea–Lophogastrida, 1. Par Prof. Louis Fage. Pp. 52. 7.50 kr.; 6*s*. *Dana* Report No. 20: Les Gymnosomes, 1. Par A. Pruvot-Fol. Pp. 54. 7.50 kr.; 6*s*. *Dana* Report No. 21: A Study of a Collection of the Fish *Schindleria* from South Pacific Waters. By Anton Fr. Bruun. Pp. 12. 1.20 kr.; 1*s*. *Dana* Report No. 22: Indo-Pacific Leptocephalids of the Genus *Anguilla*; Systematic and Biological Studies. By Poul Jespersen. Pp. 128 + 4 plates. 24 kr.; 20*s*. (Copenhagen: C. A. Reitzels Forlag; London: Oxford University Press, 1940–1942.) [17

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Institute of Theoretical Astronomy of the Academy of Sciences of the U.S.S.R. Ephemerides for the Determination of Time Corrections by Equal Altitudes (Zinger's Method) for 1946. 21st Year. Pp. 101. (Moscow and Leningrad: Academy of Sciences Press, 1945.) 10.50 roubles. [167

Kungl. Svenska Vetenskapsakademiens Handlingar. Serien 3, Band 23, No. 3: On the Genus *Peltostega* Wiman and the Classification of the Triassic Stegocephaliens. By Tage Nilsson. Pp. 55. Serien 3, Band 23, No. 2: On the Proper Motions of Stars and the Absorption of Light in the Region of the Open Cluster Messier 52. By Arne Lundby. Pp. 63. (Stockholm: Almquist and Wiksells Boktryckeri A.-B.; London: H. K. Lewis and Co., Ltd., 1946.) [167

Ministério da Agricultura: Serviço florestal, Secção de botânica. Boletim No. 1: Chaves para a determinação de gêneros indígenas e exóticos das dicotiledôneas no Brasil. Vol. 1: 1217 gêneros de 152 famílias. Por Liberato Joaquim Barroso. 2a edição. Pp. 272 (27 plates.) (Rio de Janeiro: Ministério da Agricultura, 1946.) [167

Development and Welfare in the West Indies. Bulletin No. 21: The Fisheries of British Honduras. Report by Dr. Ernest F. Thompson. Pp. 32. (Bridgetown: Advocate Co., Ltd., 1946.) 10 cents. [167

State of Connecticut. Public Document No. 24: Sixty-fifth Report of the Connecticut Agricultural Experiment Station for the Year 1941. Pp. iii + 768 + 78. (New Haven, Conn.: Connecticut Agricultural Experiment Station, 1941). [177

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Connecticut Agricultural Experiment Station. Circular 143: Control of the Pear Psylla in Connecticut. By Philip Garman and J. F. Townsend. Pp. 12. Circular 144: Control of the European Corn Borer by Sprays and Dusts. By Neely Turner. Pp. 13–16. Circular 145: Control of the Apple Maggot. By Philip Garman. Pp. 17–26. Circular 146: Loams for Top-dressing. By Herbert A. Lunt. Pp. 27–34. Circular 147: Control of the European Corn Borer by Sprays and Dusts. By Neely Turner. Pp. 35–44. Circular 148: Sweet Corn Hybrids, Lexington, Lincoln and Lee. By W. R. Singleton and D. F. Jones. Pp. 45–52. Circular 149: Herbs and their Culture. By Ruth M. Hendrickson and Frances M. Johnson. Pp. 53–72. (New Haven, Conn.: Connecticut Agricultural Experiment Station, 1941.) [177

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Inadequate Diets, Deaths and Diseases and a Food Plan for Madras, by K. G. Sivaswamy; Nutritional Diseases, by Dr. M. P. Chacko; Food Hints, by Dr. S. Gurubatham. Pp. 84. (Royapettah, Madras: Servants of India Society, 1946.) 2 rupees. [177

Food Control and Nutrition Surveys, Malabar and S. Kanara, by K. G. Sivaswamy, the late V. R. Nayanar, Dr. R. G. Kakade and L. N. Rao; and Diet and Disease Surveys, by Eleven Doctors. Pp. ii + 75 + 84 + vii + 65. (Royapettah, Madras: Servants of India Society, 1946.) 4 rupees. [177

Cawthron Institute, Nelson, New Zealand. Silver Jubilee of the Cawthron Institute, 1920–1945. Pp. 16 + 1 plate. Silver Jubilee Commemoration Lecture, October 1945: The Contributions of the Cawthron Institute to Science and New Zealand Agriculture, with Bibliography of Scientific Papers and Reports. By Sir Theodore Rigg. Pp. 58 + 13 plates. (Nelson: Cawthron Institute, 1945.) [177

Indian Central Jute Committee. Technological Research 1938–44: Research Results recommended for Practical Application, being a Review of some of the Work done from the Inception of the Technological Research Scheme up to 31st October 1944. By C. R. Nodder. Pp. iv + 63. (Calcutta: Indian Central Jute Committee, 1946.) 14 annas; 1*s*. 3*d*. [177

Chicago Natural History Museum. Report of the Director to the Board of Trustees for the Year 1945. Pp. 135. (Chicago: Chicago Natural History Museum, 1946.) 1 dollar. [177

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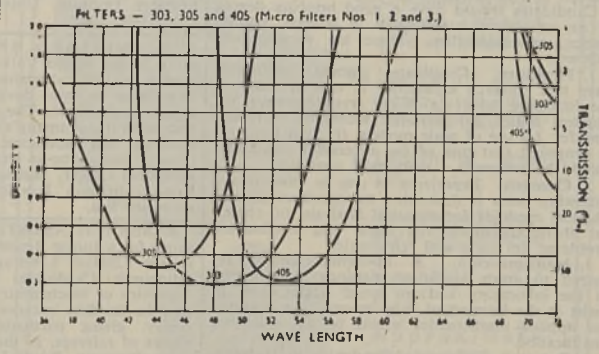

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(Continued from page iii of Supplement)

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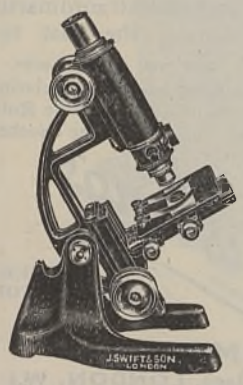

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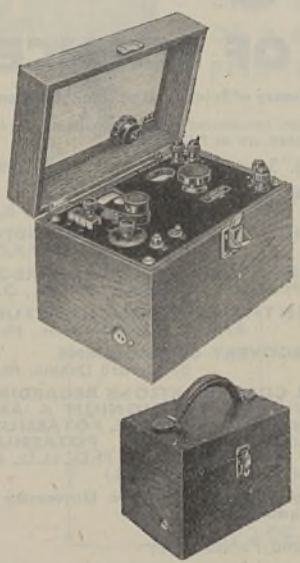

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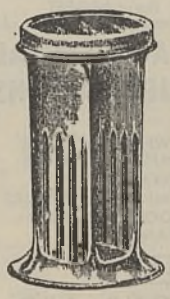

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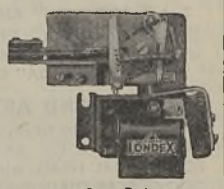

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JEAN MÉRY (1645-1722) AND HIS IDEAS ON THE FOETAL BLOOD FLOW
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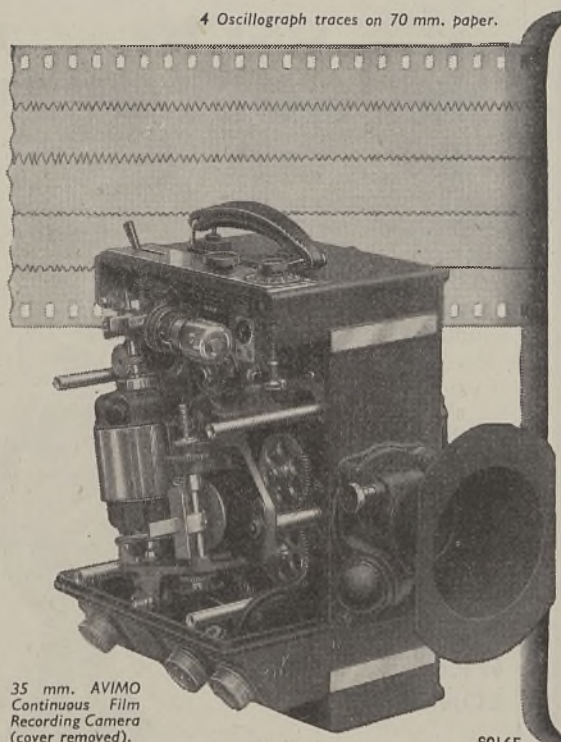

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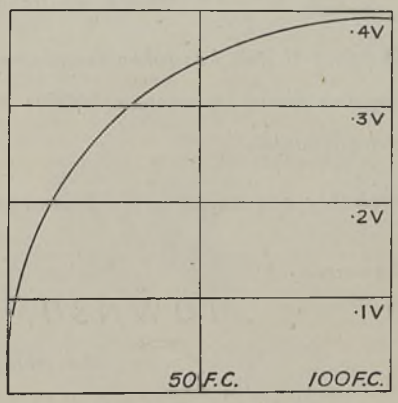

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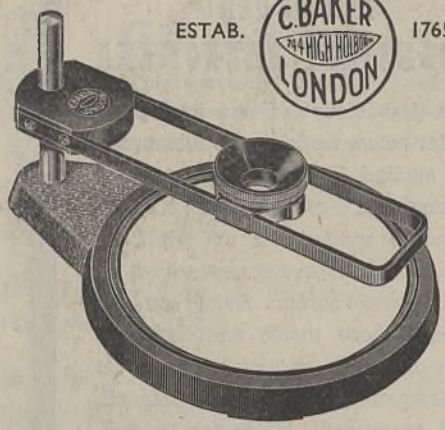

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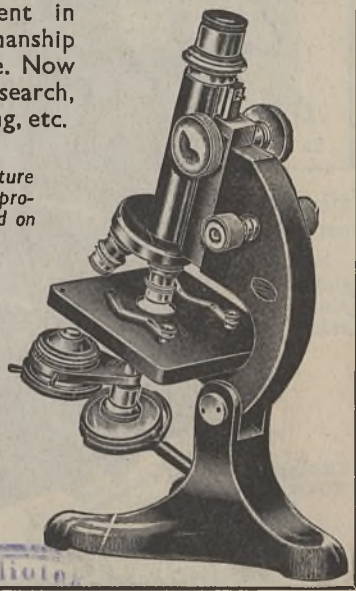

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