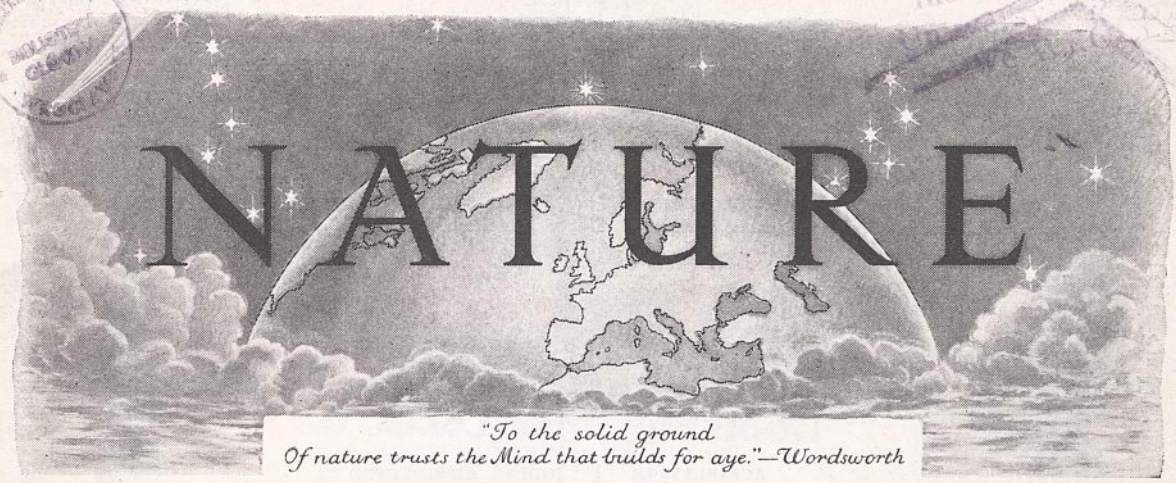

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INTERNATIONAL DEMOCRATIC UNITY

A DECLARATION of Union offered by the British Government was handed to the French Government by His Majesty's Ambassador on June 16. It is not necessary to reproduce here the complete Declaration, though a few phrases may well be emphasized.

"The two Governments declare that France and Great Britain shall no longer be two nations but one Franco-British Union. The constitution of the Union will provide for joint organs of defence, foreign, financial, and economic policies. . . . During the war there shall be a single war Cabinet, and all forces of Britain and France, whether on land, sea, or in the air, will be placed under its direction. . . . The Union appeals to the United States to fortify the economic resources of the Allies and to bring her powerful material aid to the common cause."

At the time of writing it is impossible to indicate French reaction to this great and valuable gesture of the British Government, neither is it possible at present to speculate on its implications or results. But men of science might well view with pride this political move as following very closely what has been going on in the world of science over a period of many years. Scientific collaboration has gradually been getting more intimate—a fact which will be apparent from an examination of the pages of the last score or so of volumes of NATURE. But such scientific collaboration was not confined to the democracies. Until comparatively recently, communications to the Editors arrived from all countries where scientific research was being pursued, that is, all civilized countries. It is true that, in the few years preceding this War, communications from the Totalitarian States, especially Germany, had been reduced almost to nil, whereas from the Democratic Powers and smaller Democracies, and especially from the U.S.S.R., there has been a decided increase.

In the Declaration, it is suggested that the "two Parliaments will be formally associated". International scientific parliaments in the form of congresses, conferences, symposia, etc., had already, until the outbreak of war, been more and more frequent and comprehensive.

But by the intensification of totalitarian policy, international scientific policy has been adversely affected. On several occasions international conferences have been postponed or cancelled. This has had the effect of forcing men of science of democratic, free countries into closer collaboration. Contact between British and American men of science has become more intimate during the past two or three years, as exemplified in many ways such as the closer relation between the British and American Associations for the Advancement of Science marked by the inauguration of the British and American Association Lecture in 1938. In present circumstances, we hope that British and American collaboration will not only continue but also become intensified.

Collaboration between the British and French Associations was developing before the outbreak of war ; but shortly after the start of hostilities, important moves were made to bring the men of science of these two great democracies into even closer union. We may now disclose the fact that a strong group of French scientific workers were inquiring into the possibility of publishing periodically in NATURE articles contributed by French men of science in the French language—a suggestion which was viewed favourably by the Editors. Whether such a scheme will now prove feasible remains to be seen.

But a comprehensive scheme for collaboration by means of the centralization of scientific knowledge was already developed by a French group in the early stages of the War, and its machinery set working at the beginning of this year. Faced with an output of research papers running into millions, the recording of existing knowledge is a problem as important and difficult as any connected with science. For this reason, a Service de Documentation, under the direction of Prof. Pierre Auger, was established by the French Government's Centre National de la Recherche Scientifique.

The Service de Documentation has begun the issue of a *Bulletin Analytique**, which contains the titles or very short abstracts of papers published in the chief journals of chemistry, physics, applied chemistry, technical physics, biochemistry, and some branches of biology (see also p. 965). It is hoped to publish the *Bulletin* in fortnightly parts, with quickness of publication as a particular aim, and to publish every abstract within a month of its preparation. This speed is obtained by brevity and good organization. The *Bulletin Analytique* is intended mainly to aid the specialist.

The Service has also organized an archive of original papers. It also offers to file a copy of any typescript paper acceptable to it, and include an abstract in the *Bulletin*. Such abstracts are given a special mark. Copies of the deposited typescript can be made by machine, and supplied to applicants.

Extensive use is to be made of microfilms. Negatives will be made of any paper abstracted in the *Bulletin*, and positives supplied to research workers in laboratories and institutes. The cost of these positives is astonishingly low. A strip of film bearing images of ten pages of a paper costs about one penny. Films of very long papers and typescripts containing large numbers of illustrations cost a few pence. The images on the film are 18 mm. × 24 mm. in size, and when magnified ten times make a page of normal size. The images of the pages may be read through a small eyepiece costing about 7*s*. 6*d*., or they may be projected in page size on to a horizontal screen by a simple projector which costs less than £3. A third instrument at an intermediate price has also been devised.

Bibliographies of special subjects are made by assembling sections of microfilm. The sections are 19 cm. long and contain images of ten pages. They are placed in a file 20 cm. in size. One file will hold a substantial bibliography, and a drawer of files can contain microfilms of thousands of original papers.

The head office of the Service was established in the rue Pierre Curie, Paris, but we trust that arrangements have been made for it to function elsewhere now that Paris is in enemy hands. Some of the chief members of the staff have been associated with the "Tables Annuelles", and they are assisted by about forty abstractors and translators. Besides preparing the *Bulletin* and supplying microfilms of desired papers, the staff undertake on request the preparation of indexes and dossiers on particular subjects. They also prepare translations of papers in the less widely known languages.

The Service is at present limited to France, Great Britain and their Dominions and Colonies. It has already received valuable aid from the Science Library in London. This is the type of collaboration between British and French institutions which should be extended and, above all, made permanent and extended to those of other countries.

One of the most interesting features of the Service is that it has been organized by an experimental physicist. It provides evidence of the administrative ability dormant among young men of science. The scientific worker has the great advantage as an administrator in his own field of knowing exactly what he is dealing with, and what he wants, and he can accordingly devise the most efficient organization for providing it. The non-scientific administrator, with the utmost good will, frequently fails to grasp the possibilities in scientific matters, and does not understand how to create the conditions in which science can be used most effectively.

The establishment of the Service de Documentation for the aid of scientific workers both in France and Great Britain emphasizes once more the need for improving communications between democratic countries, so that the best co-operative use can be made of their national institutions.

It is not possible at the time of writing to get in touch with Prof. Auger, and therefore we cannot know the present plight of this Service, which augured so well for the contribution of science to international democratic unity. Much less is it possible to foretell the immediate future of British and French scientific collaboration ; though of the ultimate future there can be no doubt.

* *Bulletin Analytique*, 1, Nos. 1–6, Janvier-Mars, and Nos. 7–8, Avril, 1940. (Hermann et Cie.)

CAMOUFLAGE IN MODERN WARFARE

AT times like the present, when the threat of aerial bombardment and the possibility of invasion broods over Great Britain, public interest is naturally aroused in the subject of camouflage and its role in modern warfare. In happier and more normal times camouflage has been of interest primarily to the naturalist, who sees in the coloration of different wild animals a variety of devices which render them extraordinarily difficult to detect in the field. The underlying optical principles which govern visual concealment and deception are biological principles, the discovery and description of which are mainly due to the observations of naturalists and sportsmen. These men, whose labour or leisure has brought them into intimate contact with wild creatures, claim no particular credit for their discoveries, which are essentially an exposition of principles beautifully demonstrated by Nature herself.

The general application of these principles for war purposes was first suggested to a Government Department by Prof. (now Sir John) Graham Kerr, who in September 1914 communicated to the First Lord of the Admiralty methods of rendering ships at sea less easily recognized—in particular, by means of countershading, and disruptive coloration or 'dazzle' as it was called later. More recently the problem of camouflage has been intensely studied by Dr. Hugh B. Cott, whose lecture to officers at Chatham (*Royal Engineers Journal*; Dec., 1938) summarized a subject which he has dealt with more fully in an important work on "Adaptive Coloration in Animals" just published*. Well-defined principles of camouflage, derived from research in biology and psychology, are now established; but authorities in the various Service Departments concerned have been slow to make the most of this available knowledge. Indeed, the history of war camouflage provides an extraordinarily convincing example of the ineptitude of the existing system where science is concerned.

In reply to a question by Mr. S. F. Markham, Sir John Anderson stated in the House of Commons on August 2, 1939, that he did not propose, "as at present advised", to attach a biologist to the Camouflage Research Station. He had, however, invited a biologist to serve on an Advisory Committee to which he proposed to refer questions of scientific principle affecting camouflage. After an interval of eleven weeks from its constitution, this Committee was summoned to meet for the first time on October 18, 1939. During its subsequent brief history, the scientific experts serving on this panel were kept to a great extent in ignorance of the camouflage policy and programme operating in the Service Departments; co-operation between the different departments and even within individual departments was lacking; insufficient attention was paid to research and to the advice of members of the panel; and there was evidence of slackness and lack of initiative and interest by officials concerned on the executive side. Before the end of March of this year, the chairman, and the two members of the committee possessing the requisite scientific and practieal qualifications, had resigned or expressed their desire to resign.

On April 18 last, the Secretary of State for the Home Department announced that after examining the question of camouflage in the light of the experience gained since the beginning of the War, he proposed some reconstruction of the present organization of this work in reference to war needs. In due course the advisory committee, now termed the Camouflage Committee, was reconstituted under a new chairman, so as to include, among others, responsible representatives of those branches of the three Service Departments and the Ministry of Supply which are concerned with camouflage work. It was hoped that these changes would result in greater co-ordination and more effective pooling of information. Such hopes have, however, proved groundless: we are informed that the Camouflage Committee has not yet held its first meeting.

An illuminating commentary upon the lack of progress—remarkable even for a Government Department in these stirring times—and upon the failure to make proper use of those best qualified to serve in this field, is provided by a question and reply given in the House of Commons so recently as June 5 last, when Sir John Graham Kerr asked the Home Secretary whether he was aware that the establishment of the scientific principles which determine the effectiveness of camouflage was the work of biological specialists in this subject; that one of the leading authorities

* Adaptive Coloration in Animals. By Dr. Hugh B. Cott. Pp. xxxii+508+49 plates. (London: Methuen and Co., Ltd., 1940.) 40*s*. net.

in this specialized branch of science was a British subject ; and whether steps had been or would be taken to ensure that his full-time services should be available to the country during the present emergency. The following reply was made by Sir John Anderson :

"I am aware that biological science has made an important contribution to the study of camouflage, and I have invited a British biologist to serve on the Camouflage Committee. He has accepted my invitation and will, I have no doubt, be ready to give to the matter as much of his time as may be required."

We believe that the Committee concerned has never met, so it would scarcely appear that the best possible use is being made of this biologist's knowledge and experience.

When we turn to the personnel engaged at the Civil Defence Camouflage Establishment, the prospect is scarcely reassuring. Of some sixty-five technical officers, all but four are either professional artists or, at the time of recruitment, were students at art schools. Not one member of the establishment is a qualified biologist. It appears, moreover, that none has attended a course in the science of camouflage, and indeed at the present time there does not exist any such course of instruction which they could attend.

When the fact is realized that camouflage research and application are at the present time largely dominated by artists, or in the hands of Civil Servants and Army officers, and in either case controlled by people lacking the necessary scientific training and with no knowledge of the fundamental biological and psychological principles involved, the failure to achieve effectiveness which one sees on every side is rather to be expected than wondered at. But it is not less deplorable on that account.

The general lack of appreciation of the scientific background of camouflage has led to the neglect, or misapplication, of such basic principles as countershading, disruption, coincident pattern and deflection. As a result, much contemporary effort at camouflage has failed utterly and is consistently failing to attain effectiveness.

A serious fallacy—though one which need cause little surprise when we remember the artistic qualifications of those concerned—is seen in the excessive reliance placed upon paint, as opposed to structural camouflage. Only rarely is pigment able to counteract the effects of light and shade, and of cast shadow, presented by vehicles, buildings and other solid bodies in the open. Still less is paint of value when it is put on, as it is being put on everywhere at present, in defiance of the well-established scientific principles of countershading and disruption.

An efficient way of rendering a solid object easily recognizable is to paint it all one colour. Continuity of surface, unbroken outline, and relief will then reveal to the eye its true nature without the interference of illusion or distraction. Now the type of camouflage seen, for example, on Service vehicles displays a ludicrous attempt at disruption which fails entirely since the colours used are of approximately equal tone. Mere differences in tint become invisible at a short range, and objects so coloured are virtually self-coloured and hence self-evident.

Another common misapplication of paint, again unfortunately understandable in an artist used to thinking in terms of pictorial representation, is seen in the attempt to camouflage large structures such as hangars with representations of trees done in paint. An extravagant example of this foolishness was the decoration of the cooling towers of a large works to represent a grove of tall trees. It should scarcely be necessary to point out that the result of light and shade is such as absolutely to kill this piece of stage scenery at bombing range. Such exhibitions are the more to be regretted since they tend to bring down ridicule upon the art of scientific camouflage.

The principle of countershading, whereby the appearance of relief (upon which the visual interpretation of form and solidity so largely depends) is obliterated, has an obvious application to all kinds of objects of importance in war—tanks, torpedo-tubes, guns, aircraft, and buildings. Indeed, in principle, all camouflage by mere paint should be worked out on a basis of countershading. But Thayer's principle is still ignored by the authorities in the Service Departments. Even the simplest case, that of a gun, has been consistently bungled, frequently by being divided into an upper dark and a lower light half, without any attempt at gradation between the two, a method which shows that the basic principle of obliterative shading has never been grasped by the authorities concerned. A glaring example of incompetence was a recent photograph in the daily Press showing a coastal defence gun painted in a manner which nullifies Thayer's principle. The same remark applies to the vast majority of 'camouflaged' Service vehicles on the roads to-day.

A hard case of official ignorance is presented by the use of cryptic paint on bus-tops. The roofs of many double-decked buses now have been treated with grey or green and brown ; but the front, back and sides—the parts most visible in oblique view from the air—are coloured a brilliant red—the very hue the chief attribute of which is its carrying power and conspicuousness. Similarly many buildings have the roof camouflaged and the side walls neglected.

When we turn to camouflage at sea, we find that by a reversal of evolution, disruption (or 'dazzle'), used with success towards the end of the War of 1914-18, has now been abandoned ; and abandoned because of its supposed unsuitability in view of the fact that ships are seen against constantly changing backgrounds of sea and sky. It is scarcely necessary to mention here that this fact is, of course, the very reason why disruption, rather than self-coloration as at present, should be used as the only effective way of hindering recognition at sea.

So long as the present unsatisfactory state of affairs lasts, injury will continue to be done to the nation's war effort. The matter is urgent. Camouflage is destined to play a great part in the struggle. To those who have only given the matter hasty thought, the problem of visual concealment may appear in a minor role. Biologists and others who fully realize its scope and possibilities take a very different view ; and among those who know most there is a growing sense of uneasiness. At no time in our history has camouflage been of such vital importance as it is to-day. Yet under the present system, the men who know best what should be done seem to be excluded from getting anything done. Unless, and until, the fundamental biological principles are understood and applied by the authorities, attempts at camouflage are merely ridiculous. Now, after all these months of muddling and waste, and at this eleventh hour, the Government Departments concerned—Navy, Army, Air and Civil—must be urged in the strongest possible manner to take up the question of camouflage seriously and to tackle it scientifically.

PROF. FRANZ BOAS

Race, Language and Culture

By Franz Boas. Pp. xx+647. (New York : The Macmillan Company, 1940.) 21*s*. net.

IN this volume Prof. Franz Boas, the doyen of anthropologists of the United States, has reprinted a selection of his briefer but not, therefore, less weighty contributions to anthropology in the course of his long career. The earliest is dated 1887, and deals characteristically with the methods and subject-matter of geography, more especially in its humanistic aspect. The essays are classified, as the title indicates, under three heads ; and the order is logical rather than chronological. This order is the more appropriate in that while naturally as knowledge and experience have grown they have brought with them clearer insight into the processes and possibilities of the science, yet from the very beginning Prof. Boas has been singularly consistent in his methods of approach to certain aspects of the study of man.

Throughout his career, but more especially in his later work, Prof. Boas has held fast to the conception, not so common in his earlier days, that the results of anthropological investigation are not merely concerned with the backward and primitive, but are applicable to the needs and problems of modern civilized communities. Hence in dealing, for example, with problems of race, he is not content to examine and analyse physical measurements as the sole basis of investigation, though allotting them their due share of significance, but envisages the sum total of the conditions, environment, psychological, social and the like, bearing upon the problem under consideration. In this respect he stands alone, without rival.

In this collection of reprinted pieces, representative examples will be found of much of the most original and lasting contribution by Prof. Boas to anthropological thought in general and the anthropology of the American continent. Here is his report on studies in the changes in bodily form of the descendants of immigrants, which has been the source of much controversy, as well as "Race and Progress", the presidential address to the American Association for the Advancement of Science in 1931, in which he challenged Sir Arthur Keith's dictum that racial antipathy was implanted in man by Nature in the interests of natural selection. In view of the causes underlying the present European conflict, and the population problems of the American continent, these studies are of both topical and abiding interest.

In the section dealing with cultural subjects are several papers which touch upon the culture of the Kwakiutl and other peoples of the North-West Coast. Prof. Boas has long been devoted to the study of this region, which has bulked large in the development of the American historical school of anthropologists, of which he is rightly regarded as the founder. In addition, he has also included some of his important contributions to the study of development of primitive art, which at the time of their first publication in 1903 and 1908 were little short of revolutionary in their effect upon the approach to the study of conventional design.

THE PRINCIPLES OF DEVELOPMENT

(1) Principles of Development
A Text in Experimental Embryology. By Paul Weiss. Pp. xx + 601. (New York: Henry Holt and Co., 1939.) 5 dollars.

(2) Les progrès récents de l'embryologie expérimentale
Par Prof. Maurice Caullery. (Bibliothèque de philosophie scientifique.) Pp. 236. (Paris: Ernest Flammarion, 1939.) 22 francs.

(1) PAUL WEISS'S "Principles of Development" is one of the most complete accounts of experimental morphogenesis to appear in recent years, and certainly deserves a welcome in a field not too well provided with general texts. It attempts to combine a text-book with a critical discussion of the theoretical principles on which our interpretation of developmental phenomena is based. The hybrid is a vigorous animal and will give any reader a good run for his money, in spite of the fact that while its main body is galloping rapidly forwards its intelligence is hampered by a nostalgia for yesterday's metaphysics.

As a text-book it contains several brilliant innovations. The introductory inventory of development, with its discussion of growth and of the gradual differentiation of cell-strains; the discussion of the methodology of embryological research; and the account of the development of the nervous system and behaviour, with its implicit admission that development is one of the dimensions of all biological phenomena, characterizing physiological functioning just as much as anatomical structure; all these sections are exceedingly well done. It is only in the middle section, where the emphasis is dictated by the type of analysis adopted, that doubts arise.

Even in this part it is only rarely that the theoretical weaknesses have led to actual mistakes, although one must regret the uncritical acceptance of the isolation experiments on the chick as providing evidence about the properties of the germ as a whole rather than of the organizer; nor is there any justification for omitting any reference to the existence, let alone the functions, of the endoderm. The important criticism is that Weiss seems to mistrust most of the analytical concepts to which causal significance can be attached. This is most obvious in the case of genes, which are dismissed with a footnote reference to text-books of genetics. But in the discussion of the organizer, which is at present the central principle of developmental mechanics, although Weiss follows the English school in making a distinction between the properties of producing an inducing stimulus and of controlling the arrangement of the resulting tissues, he is unwilling to pursue this line of thought beyond the comparatively superficial aspects of the phenomena. Thus he deals most inadequately with the connexion between morphogenesis and metabolism, and in this way underemphasizes a line of work which is being actively pursued by biochemists at the present day, and is perhaps the most likely to bring developmental phenomena into closer relations with the rest of experimental biology. On the other hand, the book contains a fine discussion of one of the other promising lines of causal analysis, namely the influence of fine-structures at the liquid crystal level. This is a field in which Weiss has himself made some of the most notable contributions, and his evaluation of it is excellent.

Weiss formulates development largely in 'field' terms; a process such as the formation of the neural plate is for him a resultant of "field pattern" and "field energy". He gives an admirable analysis of the field concept, for the introduction of which into embryology he was largely responsible. In this analysis he makes it quite clear that the field is a descriptive convenience, not a causal agent. But can one then be content to formulate an experimental science in purely descriptive terms?

(2) Prof. Caullery's little book is a straightforward account of recent work in experimental embryology. There is no need to discuss its theoretical basis, since it does not attempt to penetrate beneath the

generally accepted ideas. It provides a short, clear and remarkably complete summary of the newer developments, and is, an agreeable surprise in a French book, adequately illustrated, though it still suffers from the poverty of index which is another unfortunate national characteristic. If available, it should have a wide sale in Great Britain, since it is both cheaper than any other comparable text-book, and also provides the student with the essential information in a much shorter space than any of its competitors.

C. H. WADDINGTON.

REGIONAL GEOLOGY OF THE EARTH

Regionale Geologie der Erde

Herausgegeben von K. Andrée, H. A. Brouwer und W. H. Bucher. Band 2: Palæozoische Tafeln und Gebirge. Abschnitt 2: Northwestern Europe Caledonides. By Prof. E. B. Bailey and Prof. Dr. O. Holtedahl. Pp. 84 + 2 plates. 14 gold marks. Abschnitt 3: Mittel- und Westeuropa. Von Prof. Dr. Hans Becker. Pp. 114. 14 gold marks. (Leipzig: Akademische Verlagsgesellschaft m.b.H., 1938.)

IN this new "Regional Geology of the Earth", of which two parts are noticed here, there is to be presented a summary of the geological history of the earth's surface in which emphasis is placed more on tectonic and magmatic events than on details of stratigraphy. The division into regions for description is based upon tectonic history but, at the cost of some overlapping, complete geological accounts are to be given of each region. The work is intended for the trained geologist, and attention is therefore to be directed as much to unsolved problems as to criticism of materials already assembled.

The complete work is projected to consist of three volumes, the first dealing with the Ancient Coigns, the second with the Palæozoic Plateaulands and Folded Belts, the third with the Later Orogenic Belts. The two parts considered here belong to volume 2, and are concerned respectively with the Caledonian and Variscan mountain-building in Western Europe.

(1) The first part provides a summary of the geological history of the Caledonian fringe of north-west Europe. It deals with the margins, contents and fate of the Lower Palæozoic geosyncline which stretched from Spitsbergen through Norway into the British Isles. Prof. O. Holtedahl is responsible for the sections dealing with the Spitsbergen and Scandinavian portion of the geosyncline, and Dr. Bailey for the British portion.

For British readers, Holtedahl's account of a modern Scandinavian view is of particular importance. He supplies two plates of great value. The first of these is a correlation of the sedimentary series belonging to the Caledonian cycle in the Arctic and Scandinavia, the second a geological map of the Scandinavian Caledonian zone on a scale of about 1 in 250,000. Amongst a multitude of interesting topics, two may be cited, namely, the importance of Eocambrian (Sparagmite) in the Caledonian zone, and the genetic connexion between high-grade metamorphism and Caledonian igneous activity.

Bailey's treatment of the British Isles is a marvel of compression, as it provides within some 30 pages a summary of British geological history from Lewisian to Pleistocene. This summary is embellished with excellent, if schematic, maps of Scotland, Ireland and North England and Wales. In so short an account it is necessary for the author to take sides in many controversial questions, but this is done fairly, especially in connexion with differences of opinion on Highland problems. Holtedahl's views on the importance of the sparagmite in Norway and on the Caledonian age of the metamorphism there are echoed by Bailey for Scotland, in that he suggests that the Dalradian may be sparagmite, and the Highland metamorphism Ordovician in age. These suggestions will be of great interest to Scottish geologists, who will doubtless reflect upon them.

References to literature are merely skeletal and there is no index—perhaps this latter is not needed for a 75-page account.

(2) Prof. Hans Becker deals with the Variscan and Saxon tectonics of Western Europe. He gives a summary of the pre-Variscan elements, the Variscan folds, Palæozoic magmatic history and the folding of Saxon style, and carries the geological history up to the present day. Whether one admits or not the justification of so compressed a summary as Becker gives, one is nevertheless rewarded by the last half-dozen pages of this part. Here brief mention is made of a series of interesting topics—the Variscan magmatic cycle, the meagreness of the Variscan geosyncline, the consequences of this and the source of the geosynclinal fill, some general criticism of the geosynclinal-orogenic doctrine, peculiarities of the movements of Saxon style, and so forth. One could wish that these topics had been made texts for the whole sermon.

H. H. READ.

THERMODYNAMICS AND THE LOWEST TEMPERATURES*

By Dr. C. G. Darwin, F.R.S.,
Director, National Physical Laboratory

Equipartition of Energy

THE subject of thermodynamics goes, of course, beyond the familiar principles of ordinary dynamics, and it is therefore natural that we must have an extra principle in order to be able to work it. This principle which I am going to use is the *equipartition of energy*. Suppose that we have a closed vessel containing a gas, say, oxygen. If we imagine that we knew the motion of all the molecules at some instant of time we could work out their kinetic energies, and adding them together we should have the total energy of the gas in the vessel; a perfect gas has no potential energy, and oxygen is nearly perfect. We could divide this total by the total number of molecules, and so get the average energy of a molecule. Moreover, since the collisions do not change the energy, the average will be constant as the time goes on. Now suppose that we take two gases together, mixing, say, hydrogen with the oxygen. The atoms of the two kinds can now collide with one another and interchange energy, and the question arises of what happens. The theorem of the equipartition of energy tells us the answer. It asserts that the average energy of a hydrogen molecule will be equal to that of an oxygen, and this no matter what the proportions of the two gases that may be mixed together. Since energy is proportional to the square of speed, and the oxygen molecule is sixteen times as heavy as the hydrogen, it follows that the hydrogen molecules are on the average moving four times as fast as the oxygen.

This is the simplest example of the theorem, simplest because we have taken perfect gases. But it is true in other cases, so that any part of any system that is capable of exchanging energy will take a share of the energy, and on the average will have exactly the same amount of kinetic energy as the molecule of the gas. Now when a number of things are intimately mixed together they are thereby compelled to come to the same temperature. We identify the average energy of equipartition with the temperature, and it may be shown that in fact it is identical with the temperature measured on Kelvin's absolute scale. The average energy of an atom of a monatomic gas is $\frac{3}{2}kT$, where k is a known very small constant. Here is a link with pure thermodynamics, but it is still an incomplete one, since thermodynamics makes great play with a second quantity, entropy. For a full consideration of statistical mechanics it is, of course, indispensable to fit entropy into the scheme, but for my present purposes I can do without it.

I have enunciated the theorem in its simplest case and have oversimplified it in so doing. In the first place, I said nothing about the rotations of the molecules, which will also share in the equipartition. Thus a monatomic gas takes three shares per molecule, each of $\frac{1}{2}kT$, one for each dimension of space, whereas a diatomic takes five, since it can turn about two directions in space. More complicated molecules may have six shares, but for most of them other effects enter which I shall not discuss. Each atom of a solid usually has six units, three for the components of kinetic energy and three for potential energy. But there is a much more important modification which must be described.

The rule of equipartition implies the celebrated law of Dulong and Petit, that the specific heats of equal numbers of atoms of different substances should be the same. This law holds for most substances, but long ago certain puzzling exceptions were known; for example, the diamond has a much smaller specific heat than it should have. Moreover, the law implies that just as much energy should be taken to raise a body from 1° K. to 2° K., as it does from the freezing point 273° K. to 274° K., whereas it was found at the end of last century that at these deep temperatures the specific heats of all substances become very small—the diamond only differs from the rest in that its specific heat has started dropping earlier. This mysterious fact was later fully explained by means of the quantum theory, and arises from the rule that energy cannot be taken up by the atoms in arbitrary amounts but only in definite units. The way the process works may be described by a metaphor. Imagine that we have a large town, the health of which is cared for by a number of medical men. The rich men's doctors charge large fees and get few patients, while the poor ones get many small fees. I shall suppose that no doctor is allowed to change the scale of his fees. Then, when the town is prosperous, on the whole the doctors may all earn about the same money. This is the state of equipartition. But now suppose that the town is hit by an economic depression. Everyone suffers, the doctors included, but not

* From the Kelvin Lecture delivered before the Institution of Electrical Engineers on April 25.

equally, for no one will have the money for a large fee, and so whereas all the doctors will be poorer than before, the Harley Street doctors, who are not allowed to lower their fees, will be put right out of business. Consequently the total income of the medical profession is diminished out of proportion to that of the rest of the community.

This is a metaphorical description of what happens at deep temperatures. The matter is made a little harder to appreciate because it is not the separate atoms that constitute the units on which the energy is placed; it is combinations of them in the form of elastic waves of vibration. The shorter waves that require large doses of energy are frozen out and get none, and the only ones that get energy are the longer ones, which can accept it in small quantities. It is this effect that causes the specific heat to be much less at low temperatures.

Paramagnetic Refrigeration

The first stages in the history of refrigeration were carried out by a variety of processes connected with the condensation of vapours. By such means all the permanent gases have been condensed, but at about 1° K. the potentialities of the method are exhausted. To go further a new method is called for, and this has been found by making use of magnetism. We must therefore briefly consider the theory of magnetism.

As is well known, materials may display any one of three different magnetic characters. The majority are diamagnetic. These are weakly repelled from a magnet, and their nature arises from an undamped eddy current induced in each atom as the field is put on and annihilated again when it is cut off. Diamagnetism is a phenomenon of each separate atom or molecule, and is independent of the temperature. Then there is ferromagnetism, the ordinary magnetism of iron and nickel. This is an enormously strong effect by comparison, and its theory is moderately well understood: it has interesting thermodynamical features, but they are mostly at high temperatures. The third effect is paramagnetism. In this the body is attracted by a magnet, as in ferromagnetism, but about a million times less, so that the weak attractive force is of about the strength of the repulsive diamagnetic force, or perhaps rather more. The enormous quantitative difference between para- and ferro-magnetism is due to a qualitative difference, for in paramagnetism it is the separate atoms that are responsible, whereas for ferromagnetism it is certain very intense interactions of the electrons in the atoms. Paramagnetic susceptibility is very much affected by temperature, and it is this that makes it of interest here.

Think of each atom as containing a little freely suspended bar magnet. These magnets possess energy and can rotate, and there are interactions between the rotations and the other heat movements of the atoms of the specimen. Therefore there is equipartition between them, and at ordinary temperatures we have to think of the little magnets mostly whirling round rather fast. On account of this whirling they point on the average equally in all directions and the specimen is unmagnetic. But now put it in a magnetic field. We are not concerned with the diamagnetic effect, though it will be present, but there is a second more important effect to consider. Each magnet will now no longer rotate uniformly, but will move like a flywheel a little out of balance. Some go fast, some can barely get over the dead centre, and some may happen to have so little energy that they oscillate instead of rotating. The outcome of this is that when an average is taken, the magnets tend to point slightly down the field, and thus the specimen acquires a slight magnetic moment, which agrees in direction with that of the field, and is usually strong enough to swamp the diamagnetic moment in the opposite direction. The paramagnetic moment, depending as it does on the energy of equipartition, will vary with temperature and is found to be inversely proportional to it, so that at low temperatures paramagnetics have greatly increased susceptibilities. If we could get down to the absolute zero, all the magnets would be at rest pointing down the field, and the specimen would be saturated, so that no increase of external field could increase its magnetization further. Effects of saturation are observed for some substances at the deepest temperatures, but I do not need to consider them here. It is sufficient to note that the magnetization in a given field will go up as the temperature goes down, since this suggests a method by which conversely we can alter the temperature.

The process was first proposed by Debye and independently by Giauque, and before explaining why it works we will see how the experiment is done. The first work was done with gadolinium sulphate for the reason that its paramagnetic behaviour is exceptionally well understood, but of late commoner substances, such as iron alum, have been more used. A specimen, usually in the form of a powder, is first cooled down with liquid helium. It is next placed in a strong magnetic field, as a consequence of which it begins to heat up again, but this heat is also absorbed by the liquid helium. The helium is next removed, so as to insulate the specimen, and then the magnetic field is cut off, and as a consequence the temperature drops immediately to a very low value. Technically the process is, of course, very difficult, but this drop in a single step to the lowest temperature is in some ways very much simpler than the

elaborate sequence of pumping and repumping of vapours that has to be done in the earlier stages of the refrigeration.

We must now try to understand why the process works. As it is a magnetic process, it will depend on somehow getting energy out of the little magnets. A magnet placed in a magnetic field oscillates with a certain frequency, and if the field is weakened the frequency diminishes so that it oscillates more slowly. That is easy, but it is by no means so easy to see what happens to the *amplitude* of the oscillation as the field changes. It is easier to see this by taking the analogy of a pendulum so arranged that its frequency can be grádually altered. To do this we tie a bob W to a long string and make the other end fast at A. The string passes through a hole B in a light frame, and the frame can be slid up and down a groove vertically below A. It is thus only the part BW that swings. If B is low the pendulum is short and swings with a high frequency, but if B is up near A the swing is slow. What happens when we give the bob a measured amplitude of swing with B at the top and then slowly lower B? The reaction on the frame at B is half the time to the right and half to the left, but whether the bob is to the right or the left the reaction is always slightly upwards, only ceasing to be so at the instants when the bob is vertically below A. If then B is slowly lowered, it is lowered against a force, and so does work, and the bob therefore acquires energy. Conversely, if it is raised, the frame absorbs work and the bob loses energy. The solution in detail shows that at every stage the energy of the pendulum is proportional to the frequency. The result is general; when a vibrating system has its frequency of vibration raised it acquires energy from outside, when slowed down it loses energy.

Applying this to our magnets, think of one of them which is doing a small oscillation in a weak magnetic field. If the field is increased the frequency of oscillation will increase, and therefore the energy of the magnet will also increase, the work for it being done by the external field. Conversely, if we start in a strong field and slowly weaken it, the magnet's energy will decrease. Thus when our paramagnetic is put into the strong field the little magnets get more energy than is justified by equipartition and this they share out, so that the specimen heats up. This heat is absorbed by the liquid helium, and the magnets are left with the equipartition energy of the liquid helium. When the field is weakened, the magnets lose most of their energy and so will have very much less than the equipartition amount. They try to restore equipartition by borrowing energy from the other parts of the system, and so the temperature is lowered.

The process works at any temperature for a paramagnetic, but is very feeble at room temperatures. It becomes effective at deep temperatures for two reasons. First, the magnetic susceptibility becomes much bigger, so that attainable magnetic fields become much more efficient, and secondly the specific heat becomes much smaller, so that a given extraction of energy changes the temperature much more. In this way it comes about that it only takes a single stage to lower temperature from about 2° K. to about 0·003° K.

Before passing on to the properties at these new temperatures, I ought to confess that in one respect I have rather simplified the statement. An atom is not so much like a bar magnet as like an electromagnet. We may liken it to a perfectly conducting ring carrying current. As the field changes, the plane of the ring changes too, and the same things happen to the energy as I have described, but they are rather more complicated because one has to consider a motion something like that of a top, and this is more troublesome to think about than that of a pendulum. I might also add that though the way I have used of watching the energy gives one an easier insight into the process, in most cases it is quite troublesome to apply, and the orthodox thermodynamic use of entropy is far simpler.

There have been several schools of workers in this field. Giauque in America was the first to apply it, and he has made a detailed study of the properties of matter round about 0·1° K. In such work as this, mere record breaking is not the main thing, and Giauque's work has been as useful as anyone's, even though others have gone much further. De Haas of Leyden has got down to about 0·003° K., and Simon of Oxford to about the same. In addition to getting to such temperatures, we want to know what they are on the absolute scale, and this calls for more elaborate work. Anyone who has studied the thermodynamics of ordinary temperatures will remember what a troublesome business it was to fix the scale by such methods as that of the Thomson-Joule experiment. As a matter of fact, the new problem has turned out to be rather easier, because heat losses at these low temperatures can be made very small, so that the system can be approximated much more easily to the ideal thermodynamic engine of Carnot, and hence the temperature can be measured directly. Even so, it is not easy work, and the lowest temperatures attained are still rather conjectural. Pre-eminent on this side of the problem has been the work of Simon and his collaborators, who have fixed the absolute temperature scale with considerable accuracy down to 0·01° K.

The properties of matter at these temperatures are interesting. First, there is to all intents no

vapour left at all ; it is this that makes the heat insulation so good. Then the specific heat becomes very nearly simply that of the magnets, since the other parts have so little that they scarcely count. But there are technically much more interesting features. In my description of paramagnetism I spoke of each little magnet as simply exposed to a controllable external magnetic field, but in fact it is of course also in the field of all the other little magnets. As the temperature drops, they all begin to line up and cumulatively to exert forces on one another. Each little magnet cannot be expected to know where the force on it comes from, but will react to the total field acting on it. The result is important, and was until very recently most puzzling. The old theory of these local fields was that of Lorentz, and for long it had been accepted without question. According to this theory the susceptibility should be inversely proportional not exactly to T but to $T-\theta$, where θ is a calculable temperature which for most things should be in the region of 1° K. Below this temperature the substance ought to be capable of becoming a permanent magnet ; in the old days the question had only an academic interest, but with the opening up of this new range of temperatures it was interesting to see whether it would. The experiments failed to find any permanent magnetism at the predicted temperature θ, but there is a faint and rather doubtful suggestion of it at a good deal lower temperature.

This subject is much more exciting than might appear at first sight, because a similar theory was applied for electricity as well as for magnetism, and there it led to such fantastic results that for long no one was willing to face the problem at all. Just as magnetic permeability is largely due to little magnets tending to point along the magnetic field, so the dielectric constant of a non-conductor is largely due to electric dipoles twisting round under the external electric force. In particular, the large dielectric constant of water is mostly due to the strong electric moment of the two H's that lie in directions roughly at right angles from the O. Now dielectric polarizabilities are mostly much larger than magnetic susceptibilities—something like ten thousand times as large—the consequence of which is that the critical temperature for them is very much higher. For water this temperature ought to be nearly 1000° C. This is a fantastic result, for it means that if we fill a hose with water and then bring the ends together, the water ought to become violently polarized with one end positively charged and the other negatively ; it would be a strong horse-shoe magnet, only electric and not magnetic. Until about four years ago, nobody knew at all why it did not do this, and the theoretical result was so contrary to the facts that anyone who realized the difficulty was frankly terrified of the whole problem. Happily we now know that Lorentz's theory is too simple, and an explanation has been found by various workers which removes the trouble by showing that the co-operation between adjacent magnets, or dipoles, needs more thorough discussion than in Lorentz's theory. No one even now knows the full answer, but it is quite clear that there is no reason to expect the onset of permanent magnetism at the critical temperature, and it is to be conjectured that it will not come at any point above the absolute zero. Reverting to the magnetic case, this same theory applies and it removes the expected trouble, but the whole subject is not even now very clear.

If it is so comparatively easy to get down to 0·003° K., what stops us there ? The answer is that for each substance there is a sort of barrier preventing further chilling. One can see that when all the magnets are pointing the same way it would not be possible to get any further chilling anyhow, but some time before this point, thermodynamics shows that there must inevitably be a large increase in the specific heat extending over a certain range of temperature. This rise of specific heat checks the temperature drop, and would make it very hard to get below it. The effect is really a convenience rather than the reverse because, once the specimen has got into the range, its temperature will stay nearly constant for some time in spite of the inevitable leakage of heat into it from the surroundings. The barrier temperature can be lowered by taking a more dilute crystal, for example by mixing the iron alum with some non-magnetic alum, but the process will break down in the same sort of way that occurs in the production of cold by vapours. The diluted crystal will have fewer little magnets available for giving up their energy, and so we should have to take a larger specimen or use a stronger magnet so as to get even the same temperature drop. To get much below 0·003° K. we should therefore have to take a great bulk of inefficient material in a strong magnetic field (and, of course, in a vacuum), and it simply cannot be done technically. The method of demagnetization by means of paramagnetism is exhausted at somewhere a little above a thousandth of a degree.

Nuclear Refrigeration

This is more or less how matters stand now, but it is not necessarily the end. Not long after the magnetic method had been shown to work, it was suggested that it would be possible to get a similar process starting at the present lowest temperature and going down again by the same sort of factor to something near a millionth of a degree. The effective system was to be the magnetism in the

nucleus of the atom. A good many atoms have magnetic nuclei, and their strengths are about a thousandth of those we have been discussing, and this is exactly what is wanted. The proposal was to take a diamagnetic salt of a metal of this character and work with that. The experiment was not going to be easy, because it was necessary to cool this specimen to the thousandth of a degree *in* a magnetic field by contact with a paramagnetic which had already been cooled so far by being taken *out* of the field; for this a long heat-conducting channel would be essential, and this channel, probably of liquid helium, must itself also be lowered to the temperature.

Theory, however, suggested a curious difficulty. For the process to work, it is not sufficient merely to get the energy out of the magnets, but these magnets must also be able to borrow the energy from the rest of the system so as to restore equipartition; for if they do not, we cannot say the temperature has really been lowered. It is true that at this stage there is scarcely any energy left except in the magnets themselves, but still there is some, and unless the right proportion of this is duly borrowed to restore equipartition, we cannot say that the temperature has really been lowered—for example, we could not chill a second body by placing it in contact. Now theory shows that the rate of this borrowing will depend enormously on the temperature. At 1° it is instantaneous, at a thousandth it takes seconds or minutes, but at a millionth it may easily take a million years. The heat insulation has, so to speak, become so good that different parts of the same molecule can be at different temperatures for a million years without the heat flowing from one to the other. But the same work that revealed this difficulty showed a way out. The structure of a metal is very different from that of a salt, in that, however low the temperature, there are always electrons moving about in it at high speeds—this does not contradict equipartition, but I must take that for granted. These electrons act as middle-men and succeed in bringing about equipartition quite rapidly. So it seems likely that perhaps in a few years, by the use of a metal in which the nuclei have a magnetic moment, it may be possible to reach temperatures down to perhaps a hundred thousandth, perhaps a millionth of a degree.

What will be the properties of matter there? Frankly, I do not think it likely that they will be very sensationally different from those already found at a thousandth. There are a few things we would like to know—for example, whether other metals become super-conductors besides those already found at 1°. It would also be nice to know whether the paramagnetics become permanent magnets, though I doubt if that is feasible because of the slow rate they would have in coming to equipartition with the cold body. But Simon has suggested another more remarkable idea about such temperatures, and this is that the whole idea of temperature itself fades away.

For temperature to have a practical meaning, one must be able to take the temperature of a body with a thermometer. Now this implies that the thermometer must be smaller than the body of which it is measuring the temperature, for otherwise it will itself disturb the body's heat. But there is now so little energy in the whole body that most of the time the thermometer will have none at all, and then occasionally will have much too much. To understand why this is so I may return to my metaphor of the doctors. The town is now so poor that its total capital only amounts to a few of the cheapest doctors' fees. Most of the time no one has enough money to pay a fee, but occasionally someone scrapes enough together and consults a doctor. Obviously we shall get a very different account of the health of the community according to whether we ask the fortunate doctor who has just got a fee, or one of the other members of his profession. The indefiniteness is, however, a matter of size. If we consider the health of a much larger town, or of a whole country, we shall find that there are a good many doctors who have got fees, and by averaging over them we could get an idea of the health of the community. So if we want to speak *usefully* of temperature at these very deep temperatures we must take a large body, and the colder the temperature the larger the body must be. Actually this region of indefiniteness is even now not at all far off. The first substance to show the effect would be a diamond, and it can be shown that a grain of diamond dust which is just visible will have a quite indefinite temperature at the temperatures already reached.

We seem to be ending on an anticlimax. Each successive stage in producing cold has called for greater efforts and has on the whole produced less results. In the first stage we leave all the rich variety of physical and chemical activity of ordinary temperatures—incidentally the activity that makes life possible—for the austere region of liquid helium. Here we have lost all chemistry, and have only found as compensation the interesting phenomenon of diminished specific heats and the startling fact of superconductivity. In the second stage, of paramagnetic demagnetization, there seems even less novelty, and the chief interest is in whether things will become permanent magnets. In the third stage, of nuclear demagnetization, we can not know what will happen, for it still lies in the future, but the most likely thing is that the target we are aiming at will simply fade away into indefiniteness before us.

THE ROYAL BOTANIC GARDEN, CALCUTTA

By Dr. K. Biswas,
Superintendent of the Garden

THE Royal Botanic Garden, Calcutta, situated on the bank of the River Hoogly only a few miles from Calcutta at Sibpur, offers a remarkable parallel to the Royal Botanic Gardens, Kew, which is situated on the bank of the Thames and is only a few miles from London. Both the gardens are of high scientific interest as well as of great æsthetic beauty. Both of them serve as a source of inspiration, education and research for their many visitors. To quote Sir Arthur Hill's words: "May they find in them both spiritual rest and refreshment and also that tree whose leaves were for the healing of nations".

But the Royal Botanic Garden, Calcutta, has a somewhat different origin from the Royal Botanic Gardens, Kew, which are younger than the Calcutta Garden by about fifty years. The latter started with a little more than three hundred acres of land. At present, it occupies an area of 273 acres.

Col. Robert Kyd of the Bengal Infantry, the then superintendent of the Honourable Company's dockyard and secretary to the Military Board of Fort William, a keen horticulturist, suggested on January 1, 1786, to the Governor-General, Sir John Macpherson, then officiating as Governor-General in the absence of Warren Hastings, the formation of a botanic garden in Calcutta. Without further delay effect was given to Kyd's proposal, and with the subsequent approval of the Court of Directors in England the present site, then measuring about 310 acres, immediately below Kyd's private gardens, was acquired. Col. Kyd very appropriately was also appointed as the honorary superintendent, and the work of developing this area into a botanic garden commenced with Kyd's valuable collection of exotic plants. The Garden was henceforth the property of the East India Company but under the control of the Governor-General-in-Council. This is the reason why the garden is still known among local people as the 'Company Bagan'. When the East India Company dissolved, all the rights, duties, and privileges were assumed by the Crown, and the garden became Her Majesty's Botanic Garden. Apparently on the constitution of the Province of Bengal in 1834, the control of the Garden passed on to the local government. The epithet 'Royal' came to be applied to it after the Queen's Proclamation of 1857. Kyd continued to perform the duties as superintendent until his death in 1793.

Dr. William Roxburgh, the Company's botanist in Madras, was appointed as the first official superintendent in 1794. He was the first to draw up a catalogue of 3,500 plants then growing in the Garden. This catalogue, "Hortus Bengalensis", in two parts, was published after Roxburgh's departure from India in 1813 by his friend Carey, the celebrated missionary. Roxburgh's "Flora Indica", his "Plantae Coromandelianae" composed of three volumes, and his magnificent large portfolio of coloured illustrations numbering 2,382, embodied in thirty-five volumes prepared during his period 1794–1814 with the help of Bengali artists, forms the basis of Hooker's flora of British India and many subsequent works on Indian plants. Roxburgh's work fully entitled him to the title of 'the father of Indian botany'. The famous scientific society under the title of the "United Brotherhood" was established at this time by Roxburgh's preceptor, John Gerard Koenig, a pupil of Linnæus, who was the guiding spirit of botanical studies in India.

In 1817, N. Wallich, an able and energetic botanist, was appointed and he held office until 1846. At his time the eastern portion of the Garden, measuring forty acres, including the teak plantation, was given up by the Government to the Lord Bishop of Calcutta (Dr. Middleton) as the site for a Christian College known as the Bishop's College. This college, since 1880, has been the Bengal Engineering College, Sibpur. In 1836, about two acres of land were allotted to the Agricultural and Horticultural Society of India, which was founded in 1820 by William Carey, its first president. This area expanded to about twenty-five acres, where the Society, in co-operation with the Garden officers, conducted the greater part of its work for about forty acres until 1872, when the Society's garden was transferred to its present site in Alipur.

Dr. Nathaniel Wallich undertook an extensive survey of a large part of the Indian Empire, particularly in the little-known regions of Kumaon, Nepal, Sylhet, Tenasserim, Penang and Singapore. His enormous collections were catalogued and named in Europe by himself, with the help of other botanists. They were then distributed to all the leading botanical institutions in Europe. A more or less complete set of this valuable collection, however, is still in the Calcutta Herbarium, together with Wallich's voluminous catalogue and his correspondence during 1794–1829, which were transferred to the Calcutta Herbarium from India House, London. Through the munificence of the East India Company, Dr. Wallich published his "Plantae

Asiaticae Rariores", three superb volumes of illustrated coloured figures.

Dr. Wallich, who was not only superintendent of the East India Company's gardens but also professor of botany at the Medical College, Calcutta, and superintendent-general of the Government Teak Plantation in Bengal, retired after thirty years of service in 1846 and died in 1854. He was followed by Hugh Falconer, a palæontologist, who held office until 1855. Early in 1848, during G. McClelland's officiating period, Sir Joseph Hooker visited the garden on his famous journey to Sikkim, and again on his return to Calcutta in 1850.

Falconer was succeeded by Dr. Thomas Thomson, a traveller and a botanist of much ability. Dr. Thomson was also president of the Agri-Horticultural Society (1859–1860), the coadjutor of Sir Joseph Hooker in the collection and distribution of an extensive and well-known herbarium of East Indian plants and the joint author of the first volume of the "Flora Indica". Thomson retired in 1861 and was succeeded by Dr. Thomas Anderson, whose untimely death in 1870 was caused by a disease contracted during his effort for the introduction of quinine-yielding cinchonas into the Sikkim Himalayas. Dr. Anderson was not only superintendent of the Royal Botanic Garden, Calcutta, and professor of botany but also the first conservator of forests for Bengal and in charge of the introduction and cultivation of cinchona in India.

In 1864 occurred the great cyclone of Calcutta. It was accompanied by a storm wave from the River Hoogly which laid the greater part of the Garden under water, in some places to a depth of six or seven feet, and carried two ships into the Garden with great violence. More than a thousand trees—at least one half of the total number in the Garden—and innumerable shrubs were prostrated. The survivors were much shattered, and scarcely a vestige of leaf, flower or fruit remained. Three years later a less severe but still very destructive cyclone, in which more than 760 of the surviving trees were blown down, completed the ruin. The removal of the wreckage occupied most of Anderson's remaining time in the Garden, but before he left in 1868 he had planned and begun to give effect to the planting of the Garden on a more or less formal systematic arrangement.

In 1871 Dr. (afterwards Sir) George King took charge of the Garden, which was not in a promising state. Sir George began the remaking of the Garden. The whole extent of the grounds was raised in level, the necessary soil having been obtained where large sheets of ornamental water have since been placed. These artificial lakes have been connected with each other by underground pipes, and a steam pump (and now an electric pump) has been supplied, by which the water in the whole system can be set at a high level by means of water pumped up from the river. Numerous wide roads have been made through the Garden. Many footpaths have also been made. The bamboo and mat erections which used to do duty as conservatories have been replaced by three large structures of iron. The valuable collection of dried plants has been suitably housed in a building designed by Mr. E. J. Martin, the Government architect. The internal arrangements of this building are adapted from those of the new Herbarium building at Kew.

PALMETUM OF THE ROYAL BOTANIC GARDEN, CALCUTTA.

King made remarkable contributions to Indian botany, and initiated the publication of the *Annals of the Royal Botanic Garden, Calcutta*, in 1887; vol. 14, Part 2 appeared this year. Sir George also moved at this time for the establishment of the Botanical Survey of India, which originated in 1890; the first record of the Botanical Survey of India appeared in 1893.

Lieut.-Colonel (now Sir David) Prain, who was first appointed as curator of the Herbarium, succeeded Sir George King, who after twenty-six years of meritorious service retired in 1897 and became the director of the Royal Botanic Gardens, Kew. Before Sir David left India in 1904 he sketched out a geographical

plan of garden divisions in accordance with which future plantings were to be regulated. Sir David Prain's plan, with slight modifications, has continued to be carried on by his successors as opportunity allowed up to the present day. Sir David retired on July 30, 1906, and took over the directorship of the Royal Botanic Gardens, Kew.

Lieut.-Colonel A. T. Gage was also first appointed as curator of the Herbarium and then succeeded Sir David in 1906. A catalogue of non-herbaceous phanerogams cultivated in the Royal Botanic Garden, Calcutta, prepared during Gage's time was published with the object of facilitating the exchange with other botanical institutions of plants, seeds, or materials for systematic, anatomical, physiological or chemical investigation. Gage was also professor of botany in the Medical College, Calcutta. He retired in 1923. During his absence on leave in 1908 Mr. W. W. Smith, now Sir William Wright Smith, keeper of the Royal Botanic Gardens, Edinburgh, and professor of botany in the University, who was then the curator of the Herbarium, officiated as the superintendent. Afterwards Mr. C. C. Calder was appointed as curator of the Herbarium after Smith. Mr. Calder succeeded Gage in 1923 and retired in December last year.

In the open garden there are about 15,000 trees and shrubs. In addition to these there are several thousand herbaceous species in the palm houses, orchid-houses and ferneries. The Garden, however, is by no means so rich in species as it might be, the total number of species in the open probably not exceeding 2,500.

The scheme adopted thirty-four years ago was to treat the Garden as a map of the world on Mercator's projection representing the tropical floras. The plants of India and Burma are to occupy the central triangular area of the large western part of the Garden, this area being again subdivided in accordance with the geographical subdivisions of the Indian Empire. To the west and south-west of the large central Indian area are the divisions for north-west Asia, Europe, then America, Africa, and Madagascar, and to the east of it the divisions for north-east Asia, China, Japan, the Philippines, Thailand (Siam) and Annam, the Malaya Peninsula and Archipelago, and Australasia, the last five being separated from the large central Indian divisions by the special collections of palms, screw-pines, and bamboos. Scattered throughout the Garden are twenty-six irregular lakes, some of which are of large extent with islands. Altogether the lakes comprise about one-ninth of the total area of the Garden. Most of them were designed by King with such skilful diversity of outline and surroundings as to enhance very greatly the beauty of the garden.

The work of both the Herbarium and the Garden is dependent to a considerable extent on botanical explorations. For this reason, the Botanical Survey of India evolved from the Botanical Garden. The work of the Botanical Survey of India and of the Garden with its Herbarium are so much interdependent that since the inception of the Survey in 1890 the superintendent of the Royal Botanic Garden has been the *ex-officio* director of the Botanical Survey of India. Botanical exploration is essential for utilizing the vegetable resources of the country and maintaining the vitality of the Herbarium and the Garden. A glance at a map of India showing the explored and unexplored regions will indicate what an enormous amount of work in this direction remains to be done.

The Herbarium and the Library have been developed since the foundation of the Garden in 1786. The present damp-proof and fire-proof building, especially designed to house nearly two and a half million sheets of herbarium specimens which form the basis of all botanical and allied investigation, was erected in 1883. In this Herbarium are a very complete collection of the dried materials of plants of the whole of the Indian Empire and also fair collections of those of Asia

OREODOXA AVENUE IN FRONT OF THE RIVER GATE OF THE ROYAL BOTANIC GARDEN, CALCUTTA, BEING THE KYD MONUMENT.

outside India, of Europe and Australia. Plants of Africa and America are far less perfectly represented. The Herbarium is an essential adjunct to a botanical garden of this standard.

Introduction of quinine, rubber, ipecacuanha, various timber trees, fibre- and oil-yielding plants and other plants of great economic value is mainly due to exploration by the scientific officers of the Garden. Almost all the road-side trees and ornamental garden plants now found widely growing throughout India and Burma were first acclimatized in this Royal Botanic Garden. They were then distributed all over India and abroad. Of recent introduction is the tung oil tree, which is a source of considerable revenue in China. Experiments at this Garden indicate possibilities of cultivation of tung oil in suitable areas of Bengal in the drier lower ranges of the Himalayas at 2,000–5,000 ft. There is no reason why India should not be made self-supporting with regard to the supply of this oil, so useful for various purposes. The Garden distributes seeds to various parts of India.

The garden roads were never intended for the heavy traffic that daily passes over them. In this sense the Calcutta Gardens must be unique. In most Gardens of similar dimensions and with similar objects the visitor passes on foot ; the restrictions placed upon him read very much alike wherever one goes. Custom and long precedent have allowed greater latitude to the visitor to Sibpur. Except in some of the nursery plant houses he can wander where he likes ; he picnics anywhere and he even lights fires in approved spots when he wishes to cook his food. It is all to the benefit of the Garden, in that greater public enjoyment and therefore support is ensured, and on the whole it must be said advantage is not taken of the latitude allowed.

OBITUARIES

Mr. H. J. Carter

BY the death of Herbert James Carter on April 16, Australia has lost one who had taken a prominent part in both educational and scientific affairs. He was born at Marlborough, Wilts., on April 23, 1858, the son of James Carter, and was educated at Aldenham School and the University of Cambridge, where he was a scholar of Jesus College. He was a mathematics master at Sydney Grammar School during 1881–1901 and was principal of Ascham Girls School from then until 1914. He was president of the Linnean Society of New South Wales during 1925–26, and a member of its Council from 1920 until 1939 ; also a fellow of the Royal Entomological Society of London. For many years he was honorary entomologist to the Australian Museum. He was science editor of the "Encyclopædia of Australia" published in 1926, and author of "Gulliver in the Bush" in which he related many of his experiences in pursuit of his scientific work.

Carter's special work was with the Australian Coleoptera, especially the families Tenebrionidæ, Buprestidæ, Cistelidæ, and Dryopidæ. In addition to descriptions of large numbers of new species, he paid particular attention to matters of synonymy, and published a number of check-lists of the families, and revisions of the Australian species of various genera. He did not shirk the drudgery of the work on synonymy, but often deplored the practice of some European colleagues who, on what he considered inadequate evidence, described large numbers of Australian species as new, and so added to the difficulties of Australian coleopterists.

His papers appear in a number of scientific journals from 1905 onwards, chiefly those of the Linnean Society of New South Wales, the Royal Zoological Society of New South Wales, and the Royal Society of South Australia. His last completed work was a short note on Dryopidæ, handed to the Linnean Society of New South Wales only a few days before his death, with the comment that he found such small objects trying to his sight and that this would probably be his last contribution on the family. His fine collection of Australian Coleoptera, including many types, will go to the Division of Economic Entomology of the Council for Scientific and Industrial Research at Canberra. A charming personality, he left a host of friends in his scientific colleagues and in his former pupils now scattered throughout Australia.

Prof. C. L. Boulenger

PROF. CHARLES L. BOULENGER, who died on May 21, aged fifty-five, will be remembered as a successful professor, an authority on freshwater medusæ and the trainer in helminthology of a large band of biologists who were scattered through the East for disease diagnosis in the War of 1914–18.

His father was G. A. Boulenger, F.R.S., a Belgian who became a great authority on reptiles and fish at the British Museum (Natural History). The son was a scholar of St. Paul's School and entered King's College, Cambridge, in 1903 as Lawrence Saunders scholar. He obtained first classes in the Natural Sciences Tripos and in 1906–7 occupied his University's table at the Stazione Zoologica, Naples, for the study of medusæ. He then visited Birket el Qurun (the remains of Lake Moeris) to investigate its medusa, discovering that its stinging cells are formed in the endoderm of the manubrium and in the ectoderm of the swellings at the bases of the tentacles

before migrating to accumulate in surface batteries in the manubrium and tentacles respectively. This work was followed up by nine reports on medusæ from Tanganyika, Rhodesia, the Limpopo and the Caspian, chiefly concerned with their development and meristic and genetical variation.

After a year's demonstrating at Oxford, Boulenger returned to Cambridge in connexion with the museum, also demonstrating, particularly taking charge of Sir Arthur Shipley's advanced classes on the flat-worms, nematodes and other parasites. In 1910 he went to Birmingham as lecturer and three years later was appointed reader in agricultural zoology. This was preceded by important work on the Myzostomida, external parasites of starfish, of which he received 170 specimens collected by Crossland from the Red Sea, this collection about doubling the known specimens. They were referred to six species with a full account of their anatomy. A report on a sheep's nematode (Nematodirus) followed, important for the development of cultural methods that enabled him to present its full life-history.

In 1915–16, Boulenger, under the Royal Society's scheme, lectured and demonstrated at Cambridge on the higher parasites of man. He then proceeded to Basra (Captain R.A.M.C.), where he acted as referee for worm parasites while making routine examinations for amœbic dysentery. He tabulated the stools of 1,180 patients, finding the British (about a third) quite free, while of the whole number 18·5 per cent had hookworm, 5·2 per cent Ascaris and 5 per cent Trichiurus, not large numbers, since Turkish prisoners proved to have four times these infestations. Unfortunately, he contracted amœbic dysentery, but in 1920 returned to India as professor at Lahore, working in the Punjab Veterinary Laboratory and specializing in the strongylid parasites of camels and horses. In 1921 he was appointed professor at the Bedford College for Women. To this he gave all his powers, fighting ill-health, for he never recovered from his Mesopotamian breakdown. He never married.

As a student Boulenger was very competent, but shyness caused him to be a solitary person and to build up a life within himself, ceramics and mezzotints then attracting him. This character he never lost, and perhaps it is the key to his life, if coupled with a strict obedience to duty. His lectures were models of clarity and balance, relieved by a marked touch of humour. He kept a high standard before his students, but was singularly understanding of their difficulties and always helpful; as an examiner he was remarkable for his judgment and appreciation of originality. With Prof. D. Mackinnon he effectively collaborated in providing a course in parasitology for the University of London. Every year he sent one of his students to Plymouth, providing anonymously the necessary funds by means of a prize. He was an admirable colleague, his views on college policy sound and strongly held. As he grew older his health became worse and he only found relief in the 'long' vacations at Algeria and Tangiers where he almost lived in the sea. In the winters he had his ticket for Covent Garden and gave play to his collector's instincts, especially in philately and oriental jewellery. J. S. G.

Prof. Michael Siedlecki

PROF. MICHAEL SIEDLECKI, who, during the occupation of Cracow by the Germans in November 1939 was imprisoned with the majority of the professors of the Jagellonian University, and transferred to the concentration camp in Oranienburg near Berlin, died there in January 1940.

Prof. Siedlecki was professor of zoology and director of the Zoological Laboratory and Museum of the Jagellonian University of Cracow, member of the Polish Academy of Sciences, honorary doctor of the University of Strasbourg, and member of many Polish and foreign scientific societies, including the Zoological Society of London. He was born in Cracow in 1873, and having taken the Ph.D. of the University of Cracow in 1895, he spent some years abroad completing his studies in zoology in the Universities of Berlin and Paris and at the Zoological Station in Naples. After his return to Cracow he continued zoological research in the University, first as an assistant, then as a lecturer in 1900, and finally as a professor without a chair. During 1908–9 he made a scientific expedition to Java and in 1912 succeeded Prof. Antoni Wierzejski in the chair of general and systematic zoology at the Jagellonian University.

In 1919, Siedlecki went to Vilna, to organize the new Polish university there, and remained until 1921, as the first rector of the University. He then returned to Cracow, to his former post as professor of zoology. Since 1923, Prof. Siedlecki represented the Polish Government on the Conseil Pérmanent International pour l'Exploration de la Mer in Copenhagen. He devoted much time to the organization of the Polish fisheries in the Baltic, and in the North Sea. He also organized the scientific investigation of the Baltic adjacent to the Polish sea-coast. Thanks to his efforts the marine stations at Hel and Gdynia were formed as the centre of scientific research of marine biology in Poland.

Most of Prof. Siedlecki's scientific researches concerned protozoology, especially the parasitic protozoans of the groups Sporozoa and Flagellata. He discovered and described a number of new and very important facts concerning the structure and development and reproduction in these groups, which are frequently cited in treatises and text-books on zoology. He was also interested in many other problems of animal biology, as is evidenced by his studies on tropical insects and amphibians. In the last years of his life his research was devoted almost entirely to marine biology, particularly to the biology of fishes inhabiting the North and Baltic Seas.

Prof. Siedlecki also took a great and active interest in the preservation of wild life. He organized the Polish Section of the International Committee for Bird Preservation, and was its chairman until 1937,

when, though still taking a prominent part in the work, he relinquished his position to Prof. Count Kasimerz Wodzicki. He was a member of the sub-committee appointed by the International Committee for Bird Preservation to examine and co-ordinate the proposals put forward by the National Sections of Europe for the Revision of the International Convention for the Protection of Birds (Paris 1902), and presided over many of its deliberations. He represented the Polish Government at the International Ornithological Congresses in Amsterdam in 1930 and in Oxford in 1934. Prof. Siedlecki's knowledge of international affairs, his diplomacy and his personal charm were of inestimable value at the many international meetings he attended; he was deeply respected by everyone with whom he came in contact, of whatever nationality, and those who had the privilege of working with him will always remember him with a lasting affection. Prof. Siedlecki was a man to whom the word 'cultured' could be applied to its utmost meaning, from his great knowledge of art, literature, architecture and history to his gentleness and courtly manner. But above all Siedlecki was a patriot, and his burning love for his country was an inspiration.

WE regret to announce the following deaths:

Prof. L. S. Bagster, professor of chemistry in the University of Queensland, Brisbane, aged fifty-three.

Sir Arthur Harden, F.R.S., emeritus professor of biochemistry in the University of London, formerly head of the Department of Biochemistry in the Lister Institute, on June 17, aged seventy-five.

Prof. Samuel Klein, professor of the historical geography of Palestine in the Hebrew University, Jerusalem.

Dr. G. A. Loveland, formerly chief meteorologist of the Boston Weather Bureau, on March 30, aged seventy-six.

Dr. E. F. Northrup, vice-president and technical adviser of the Ajax Electrothermic Corporation, formerly assistant professor of physics in Princeton University, on April 29, aged seventy-four.

Prof. F. H. Probert, dean of the College of Mines, University of California, on May 9, aged sixty-four.

Prof. R. H. True, emeritus professor of botany in the University of Pennsylvania and director of the Morris Arboretum, who was known for his work in plant physiology, on April 8, aged seventy-three.

NEWS AND VIEWS

Commemorative Stamps to American Science

A NEW one-cent stamp in honour of Audubon was issued in St. Framisville, Louisiana, on April 8. J. J. Audubon (1785–1851), the well-known naturalist son of a Frenchman, worked almost solely on American animals, his greatest work being "Birds of America". This work contained 435 hand-coloured plates with 1,065 life-sized figures of 489 distinct species of birds. Audubon was the pioneer in the portrayal of birds in their natural positions and environment. The three-cent stamp in honour of Burbank was issued in Santa Rosa, California, on April 17. Luther Burbank (1849–1926) was the famous American plant breeder. Most of his work was carried out at Santa Rosa, which he described as "the chosen spot of all this earth as far as Nature is concerned". His most important early work, in 1872, was that of the development of the Burbank potato. Later, he worked successfully on the plant genera Rubus and Prunus.

Dr. Crawford Long (1815–1878), in whose memory a two-cent stamp was issued in Jefferson, Georgia, on April 8, was a pioneer in the use of ether as an anæsthetic. He administered ether for the first time in surgical history on March 30, 1842, in an operation for the removal of a tumour from the neck. The first account of his discovery was published in 1849. Dr. Walter Reed (1851–1902), the American bacteriologist attached to the army, disproved the then prevalent theories of the transmission of yellow fever and finally succeeded in showing that the parasite was transmitted by the mosquito *Stegomyia fasciata*. He also showed that the bite was effective only under certain conditions. A commemorative stamp to the value of five cents was released in Washington on April 17. A ten-cent stamp in honour of Jane Addams, the American sociologist, has also been released. Her greatest achievement was the establishment of the well-known social settlement, Hull House, in Chicago.

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The *Bulletin Analytique*

THE *Bulletin Analytique* is a journal of abstracts, issued by the French Government's new Service de Documentation (see p. 947). The director of the Service is Prof. P. Auger, and the chief editor of the *Bulletin* is Dr. N. Thon. The Bulletin was to have been issued in fortnightly parts. The first six parts, for January–March of this year, have been published in one fascicule. Nos. 7–8 appeared in April and No. 9 is dated May. The size of the page is about 6¼ in. × 9½ in. It is hoped that a complete annual volume will contain about one thousand pages. The abstracts are classified under eighteen subjects, which are: mathematical physics; corpuscular physics; structure of solids and liquids; mechanics and heat; radiation and optics; electricity and magnetism; astrophysics and geophysics; thermodynamics and chemical statics and dynamics; electrochemistry, photochemistry, radio chemistry, and photography; colloids and adsorption; chemistry of minerals, mineralogical chemistry and geochemistry; organic chemistry; metallurgy; industrial chemistry and materials; agricultural chemistry; biological chemistry; agriculture; physiology. The titles of all papers and all abstracts are given in French, with the name of the author, the place where the research has been done, the journal in which it has appeared and the language of the original. Abstracts of unpublished papers in the Service's archives are given a special mark.

Emile Duclaux

PROF. PIERRE EMILE DUCLAUX, the well-known chemist and bacteriologist, was born at Aurillac, capital of the Cantal Departement of France, on June 24, 1840. In 1857 he went to Paris, where he was educated at the Lycée Saint Louis. Two years later he passed the entrance examination not only at the Ecole Polytechnique but also at the Ecole Normale Supérieure, where Pasteur, with whom he became closely associated, was sub-director of scientific studies. In 1862 he became an *agrégé* and assisted Pasteur in his investigation of the disease of silkworms which was then prevalent in several departments of France. In 1865 he was appointed professor of chemistry at Tours, from which he was transferred in a similar capacity to Clermont-Ferrand, where he had about a hundred pupils, most of whom were medical students, including Emile Roux, his successor at the Pasteur Institute. From Clermont-Ferrand he went to Lyons, where he remained five years as professor of physics. Finally he settled in Paris in 1878 as professor of physics and meteorology in the Agronomic Institute.

In 1886, Duclaux was appointed professor of biological chemistry at the Sorbonne and held this position until his death. In 1888 he was elected a member of the Academy of Sciences in the section of rural economy, and in 1894 he became a member of the Academy of Medicine. In 1895 he was appointed Pasteur's successor in the Institute in the Rue Dutot. In the words of Prof. H. Roger, "Duclaux possessed all the essential qualities of a professor—erudition, critical sense, a lucid style and a taste for polemics". He was a remarkably prolific writer. In addition to more than eighty articles dealing with molecular physics, chemistry, meteorology, enzymes, physiology of digestion, vegetable physiology, bacteriology, etc., he was the author of a number of books, including "Ferments et maladies" (1882), "Le Microbe et la maladie" (1885), "Pasteur, Histoire d'un esprit" (1896), which was translated into English in 1920, "Traité de Microbiologie" (1898–1901) and "L'hygiène sociale" (1902). He was also founder in 1887 of *Annales de l'Institut Pasteur*. He died on May 3, 1904.

Huxley's Teaching at Edinburgh

DURING the four years when the *Challenger* was sailing the oceans of the world, Sir Wyville Thomson left his natural history class-room in the University of Edinburgh to lead the expedition. The vacancy was filled temporarily by two naturalists of European fame—Julius Victor Carus, of Leipzig, who conducted the zoology courses in the summer sessions of 1873 and 1874, and Thomas Henry Huxley in 1875 and 1876. An account of their tenure of the natural history chair, by Prof. James Ritchie, appears in the summer number of the *University of Edinburgh Journal* (pp. 206–212), the information about Huxley being gathered mainly from the class roll-books, and from a small notebook of Huxley's dealing with "Lectures, Edinboro", in the Huxley Library of the Imperial College of Science and Technology. Huxley drew a crowded audience for his introductory lecture on "The Crocodile"—it was a free lecture—and he laments that many parsons were present who "came to curse and didn't remain to pay". His course proper, covering twelve weeks, traversed the whole animal kingdom from Protozoa to Mammalia, and was predominantly morphological and classificatory, although generally some reference was made to development and to the fossil record of a group.

It was a heavy programme, and Huxley as well as the students felt the rush and strain. Joseph Thomson, student in 1876, who became one of the greatest of the geographical pioneers in Africa, wrote, "Huxley's usual lectures are something awful to listen to . . . to master his language is something dreadful", and yet "I would not miss them . . . they are something glorious, sublime". Huxley's own impression of the course was equally definite. "I . . . positively polished off the Animal Kingdom in fifty-four lectures. French without a master in twelve lessons is nothing to this feat." The class roll-books show that a practical class in zoology was first held in 1872 under Wyville Thomson, but except for a short record in the University Calendar there is no record of the scope of the work of the earliest practical classes. Huxley's notebook indicates that the class, conducted by the assistant under the professor's supervision, examined fourteen different types, and Prof. Ritchie points out the curious fact that the practical class appears to have traversed the animal kingdom from Vertebrates to Infusoria almost in the reverse order from that adopted in the lectures.

The Religion of the Future

IN an article "Brave New World Planning" in the *Quarterly Review* of April, W. J. Blyton stresses the importance of such values as freedom with discipline, personal character, room for spontaneity and the spiritual as a basis for a new world order. Character and not mechanisms must come first, and only a better and stronger religion will overthrow the passionate and evil religions which at present menace the world. Without that, democracy will not be enough, and Mr. Blyton argues that the League of Nations failed because its foundations were legalist, secular and without spiritual appeal, moral authority, or imaginative hold on the stormy wills of men. No future order, he urges, will last unless it is viewed as sacred by a vast majority who have to live under it. It must be loved and valued as England (or other *patria*) now is ; as one's religion is ; or one's family, personality and liberty. A wave of moral conviction and spiritual vision must pass over many nations, and the comprehensive order will grow out of close, friendly but not firmly defined relations. The entire mundane political business hinges on virtue, which can be analysed into conscientiousness, sympathy, self-discipline and moral insight, and great and good achievements are not officially inspired by law, resolution, or orders. Education in the limited materialist, utilitarian sense of the word is nought. To roll back the tide of Belial and Moloch we must oppose a true religion, instinct with love, works of mercy, the new life, the inescapable mysteries of life and death.

Culture, Diet and Teeth

WHILE the excellence of the teeth of primitive peoples, in the sense of an absence of caries, even though the teeth may be much worn by rough or coarse food, has been a subject of frequent reference by travellers and anthropologists, it is infrequent that direct evidence is available of the relation of diet and state of the teeth to which this character in the people is referred, usually in quite general terms. Yet obviously the question is one of considerable importance in evaluating the sum total of the effects of changes in culture which have recently taken place and are continuing among peoples of backward civilization in their contacts with Europeans.

A valuable observation of the mechanism of dental deterioration through cultural change is afforded by the field observations of Dr. Helen Mellanby of the University Field Laboratories, Sheffield, on the teeth of a number of Finnish Lapp children, reference to which is made on p. 978. Among these children a remarkable degree of dental hypoplasia appears and, as was to be anticipated, this was accompanied by an equally high percentage of carious affection. The interest and significance of the observations, however, was enhanced by a fortunate opportunity for comparing a part of this material with teeth from skulls from the same group of Lapps, dating back from fifty to two hundred years, in the Helsinki Museum. As compared with the teeth from this source, the teeth of the modern children showed a marked deterioration in structure, and a similar impression was conveyed by the teeth of the adult skulls, as compared with the teeth of the modern adult population, though no exact observations were made.

It has been shown that the structure of the teeth is dependent to a large extent on diet, and in attempting to account for this very evident deterioration in the structure of the teeth of modern Inari Lapp children, Dr. Mellanby puts forward the suggestion that while Inari Lapp culture has suffered less change than that among any other body of Lapps, their diet, which formerly was based upon a reindeer cultural economy and was almost entirely carnivorous without bread, has now become one based on mixed farming with reindeer keeping, in which the diet depends upon 'civilized' substitutes with large quantities of cereals. Comparative figures from Greenland quoted by Dr. Mellanby may be interpreted in like manner as emphasizing the effect of cultural change in an alteration of diet as affecting the character and health of the teeth. While the teeth of the children of the remote parts of East Greenland are probably the least carious of any (excluding the tropics), those of West Greenlanders, who are 'civilized', are slightly worse than those of children of the Danish elementary schools, among whom defects of 31 per cent for deciduous and 34 per cent for permanent teeth have been recorded.

Plant Foods of Australian Aborigines

IN a reference to a publication made some time ago by Mrs. I. W. Dadswell (*Austral. J. Exp. Biol. and Med. Sci.*, **12**, 13 (1934), Sir James Barrett points out that all the useful plants and animals now established in Australia were imported. The criticism that the aborigines never cultivated a plant nor domesticated an animal as a source of food is equally applicable to Europeans, in so far as the indigenous flora and fauna are concerned. Yet the aborigines, whom we are accustomed to regard as an uncivilized vestige of the Stone Age, have adapted themselves to their environment so as to be able to live and thrive where Europeans would starve. Thus, Governor Phillip had to ration the first settlement at Sydney Cove in 1788 ; and white men lost in the bush have usually perished unless helped by aborigines.

Mrs. Dadswell, working in the Department of Biochemistry of the University of Melbourne, found that certain vegetable foods eaten by the natives of Central Australia, and collected near Mt. Liebig in the Alice Springs region, do not differ greatly from corresponding cultivated foods in their organic composition, and that the necessary inorganic constituents, with the exception of phosphorus, are plentifully supplied in these foods. Thus, the fruit of *Solanum ellipticum* is bracketed with the tomato, the root of *Portulaca oleracea* with the carrot, parsnip and turnip, the tuber of *Ipomœa* sp. with the sweet potato, and the leaves of *Celendrinia balonnensis* with cabbage, lettuce and spinach. The moisture content of the fresh native foods was lower than that of similar cultivated foods ; the total ash was higher ; calcium, magnesium and iron were abundant. In

further investigations of the kind, which are contemplated, it would be of interest to include a reference to the vitamins of these native foods, and also to record any occurrence of sugars. According to the late Mr. H. G. Smith, of the Sydney Technological Museum, sugar in any form was a great attraction to the aborigines, who prized highly such sweet rarities as "Eucalyptus manna" (raffinose from certain punctured eucalypts) and "lerp" (a protective secretion of Psyllideæ).

Conservation in Canada

WRITING in the second issue of *Canadian Nature* (Whittemore Publishing Co., Toronto), Mr. Alan F. Coventry deals at length with an interesting experiment in conservation made on 88,000 acres at King Township, near Toronto. A survey of natural resources found the human population to be 4,600, and since 1840 the wild-life has decreased through human interference. The only large mammals left are deer on Holland Marsh ; the imported European hare is one of the most abundant, first appearing in 1925, and the area seems to be the northern limit for winter survival of the imported ring-necked pheasant. Depletion of natural water supplies and need for reafforestation are also noted. It is pointed out that the findings of the survey are applicable to a large part of southern Ontario, and similar surveys to the King Township investigation are recommended for other regions, so that the information gained can be used for conservation and for remedies to overcome increasing tendency towards flood and drought dangers. In no more than a century, about 2,500 acres have been abandoned as no longer fit for cultivation.

Conservation apparently plays a large part in the purpose of *Canadian Nature*, but there is no superabundance of sentimentality which deters the scientific naturalist from so many publications related to wild-life. An account is given of the Federation of Ontario Naturalists' Summer School at Camp Franklin, Parry Sound, and Prof. J. R. Dymond, of Ontario Museum, writes the "guest editorial", which is apparently to be a feature by notable authorities.

Primitive Insects of South Australia

UNDER this title Mr. H. Womersley, entomologist at the South Australian Museum, in Adelaide, contributes a useful handbook (dated 1939) on the lower insects, or Apterygota, of the country named. Recognizing the need for a wider diffusion of accurate knowledge of the fauna and flora of this region, a committee, under the South Australian Branch of the British Science Guild, has undertaken the issuing of a series of handbooks. The absence of suitable reference manuals has been a real handicap to the progress of Australian biology, and those which have already been planned, or issued, are prepared gratuitously by South Australian biologists and geologists : they are printed and published by the State Government and are available for sale at low prices. Some fifteen of these handbooks have now been issued and others are in course of preparation. Mr. Womersley's work is the first of the series to deal with the Insecta and comprises accounts of the orders Thysanura, Collembola and Protura. Well printed and arranged, its numerous clear and mostly original illustrations form a special feature that greatly enhances the value of this handbook. Increase in knowledge of these primitive insects has been rapid : thus in 1932 no Protura had been recorded from Australia, whereas eight species are now known. In 1926 only about forty species of Collembola were recorded from Australia, but now Mr. Womersley accounts for more than two hundred species. The handbook is set up by the Government Printer, Adelaide, and is good value for its price, 7*s*. 6*d*.

The National Physical Laboratory

THE report for 1939 of the National Physical Laboratory covers 100 pages (London : H.M. Stationery Office. 2*s*. 6*d*. net). During the year there has been no great falling off in the experimental work done for, and the advice given to, industry both for immediate purposes and for long-range projects for opening up new possibilities, or in the testing of instruments or the maintenance of exact standards of measurement. But the War has raised new problems for solution which have come from the Services and the civil defence departments. Changes of staff to and from industry, to the Admiralty, the Air Ministry and the Forces have been more numerous than usual. Among the investigations of the year may be mentioned those on the physical properties of carbon steels, light aluminium and magnesium alloys, ship propellers, new aircraft, the reduction of sound transmission in buildings, electrical insulating materials and the propagation of ultra-short radio waves. Members of the staff have continued to give lectures on the work of the Laboratory at provincial centres, to serve on technical committees at home, and to attend international conferences on scientific and technical questions abroad.

Life Expectancy in the Philippines

IN a recent communication (*Acta med. Philippina*, 1, 217 ; 1940) emanating from the Institute of Hygiene of the University of the Philippines, A. G. Sison, H. Lara, M. M. Herbosa and A. A. Lozano have compiled an instructive paper illustrated by 25 tables and 12 graphs of the life expectancy in the Philippines in 1902 and 1918. Their conclusions are as follows. The average expectation of life for both sexes in 1918 was 26·5 years, as compared with 17·91 years in 1902, which meant an improvement of approximately 9 years. For males the average expectation of life was 17·56 years in 1902 and 27·15 years in 1918, the corresponding increase being approximately 10 years. In 1902 the average expectation of life for females was 18·67 years and in 1918 26·38 years, an improvement of approximately 8 years. The complete expectation of life in the Philippines at birth for males was 11·54 years in 1902 and 25·17 years in 1918, an approximate increase of 14 years. For females the complete expectation of life at birth was 13·92 years in 1902 and 26·07 years in 1918, the increase being 12·15

years. The complete expectation of life at birth for both sexes was 12·24 years in 1902 and 25·64 years in 1918, in other words, the average length of life remaining to each child born alive in 1918 was more than double that of 1902.

Raymond Sabouraud

THE specialist research worker in a limited field is not usually accorded a large share of public fame, even though his contributions be enlightened and fundamental. Raymond Sabouraud performed a surprising amount of original investigation, at the Pasteur Institute, Paris, into the fungi which cause skin diseases of animals. A paper by Dr. L. Grigoraki (*Mycopathologia*, **2**, Fasc. 3, 171–200; March 1940) indicates the historical setting of Sabouraud's activities, and shows how greatly the science of dermatology is indebted to him. Many of the skin diseases are caused by species of fungi belonging to the genus Trichophyton. No fewer than twenty-five species of this genus are from Sabouraud's original description, and his studies embraced the disease and its prevention, in addition to the causal parasite; X-ray therapy developed into a cure at his hands, with the help of his associates. Most eloquent of all, however, is the citation of Sabouraud's published works, which occupy twenty-four pages in the paper under review, and provide the only monument which their author appeared to desire.

Pest Infestation of Produce

THE Secretary of the Department of Scientific and Industrial Research announces that H.M. Government has gratefully accepted the offer of the Governing Body of the Imperial College of Science and Technology to place at the Department's disposal for the period of the War all the accommodation of the Biological Field Station at Slough that is required for the purposes of the Department's work on the infestation of produce by insects. The Department has now taken into its own employment the staff of the Imperial College hitherto engaged on the Department's work in this field, and with the consent of the Governing Body of the College has secured the services of Prof. J. W. Munro as consultant. All correspondence intended for the Department on the infestation of produce by insects should be addressed to the Officer-in-Charge, Pest Infestation Laboratory, Biological Field Station, Slough, Bucks.

Announcements

PROF. W. L. BRAGG will deliver the Norman Lockyer Lecture of the British Association at Hull on June 24.

PROF. S. S. BHATNAGAR, professor of chemistry at the University of Lahore, has been lent for two years to the Government of India as director of scientific and industrial research. Prof. Bhatnagar carried out research work at University College, London, under Prof. F. G. Donnan during the years 1919–21, and obtained the D.Sc. degree of the University of London. Since then he has built up a most successful school of research at the University of Lahore, and has himself made contributions to magneto-chemistry and other branches of modern physical chemistry, besides doing a great deal of important technical work.

ROBERT D. POTTER, news editor and staff writer in physics and chemistry for Science Service since 1934, has been appointed science editor of the *American Weekly*, a large magazine supplement distributed by many American newspapers in their Sunday editions. Mr. Potter received his B.S. degree from the University of Buffalo in physics in 1927. During 1928–32, he was a graduate assistant in the department of physics at the Washington Square College, New York University, and later became the science editor of the *New York Herald Tribune*.

THE Trustees of the Lady Tata Memorial Fund announce that, on the recommendation of the Scientific Advisory Committee, they have agreed, if circumstances permit, to make the following awards for research in blood diseases, with special reference to leukæmia, in the academic year beginning on October 1, 1940: grants for research expenses to Dr. M. P. J. Guérin (Paris), Prof. K. Jármai (Budapest), Prof. E. L. Opie and Dr. J. Furth (New York), and Dr. A. H. T. Robb-Smith (Oxford); part-time personal grant and grant for research expenses to Dr. Werner Jacobson (Cambridge).

THE Franqui Prize of half a million francs has recently been awarded by the Franqui Foundation Committee to Dr. Pierre Nolf, professor of pathology and therapeutics at Liège and member of the Belgian Royal Academy of Medicine, for his contributions to science. The former Franqui prizemen are Prof. Henri Pirenne, professor at Louvain, Franz Cumont, member of the Royal Academy of Science, and Jacques Errera, professor in the University of Brussels.

DURING 1939, 91 miners were certified to have died of silicosis and 355 certified to have been disabled by the disease in the South Wales coalfield.

A NEW institute for experimental hygiene has recently been founded at Montevideo, and will probably be connected with the Clinic for Infectious Diseases.

ACCORDING to Sir William MacArthur, Director-General of Army Medical Services, in spite of the severe winter there have been relatively few cases of serious illness among the troops and a very light incidence of acute infectious diseases.

THE number of road accidents in the Union of South Africa in 1939 was lower than for 1938 and 1937 despite the increased number of vehicles. The number of people killed was less than in any year since 1935, and in 18 chief towns it was the lowest for five years. The number of accidents was 43,205 in 1939 compared with 43,868 in 1938 and 45,947 in 1937.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. They cannot undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.*

IN THE PRESENT CIRCUMSTANCES, PROOFS OF "LETTERS" WILL NOT BE SUBMITTED TO CORRESPONDENTS OUTSIDE GREAT BRITAIN.

NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 977.

Optical Sensitizing of Silver Halides by Dyes

IN a recent communication[1] we indicated the importance of planarity of dye molecules for the absorption of light and for photographic sensitizing. A further survey of cyanine dyes has shown this to be general; moreover, we find that dyes capable of planar form, but having strain on bond angles, show a *negative* temperature coefficient of absorption in solution. Increase of rotational-vibrational energy in the molecule overcomes the strain and relaxes the structure to a non-planar form. The activation heat can be equated to the potential energy of strain which is removed.

Using the same isomeric cyanine dyes previously described[1] we now have found that the planar isomers adsorbed to pure silver bromide (no gelatin) produce a normal photolysis (photo-chemical production of silver) on illumination in their absorption bands. But no photolysis was effected by the non-planar isomers, although they were equivalently adsorbed, that is, to an adsorption density corresponding to the area occupied per molecule—or molecular ion—in edge-on orthogonal orientation[2].

It appears that there is something fundamental and essential for optical sensitizing in this edge-on adsorption of *planar* dye molecules. In such molecules, the resonance and the electronic transition occurring on absorption of a light quantum are polarized in the plane of the molecule. In fact, in a great number of cases, the molecule may be regarded as a linear oscillator, so that, in consequence of the orthogonal orientation of the planar molecule to an octahedral (110) plane of the crystal, the electronic transit is polarized parallel to such a plane and in an azimuth normal thereto.

Optical sensitizing of silver halide can be shown now to exhibit some interesting analogies—perhaps close affinities—with the well-known 'selective' (external) photo-electric effect. This is an *external* effect, the electrons measured being those that pass the surface potential barrier, whereas the dye sensitizes an *inner* photo-electric process, namely, elevation of electrons from filled zones to conducting zones in the crystal. These internally liberated electrons may: (1) consummate photolysis by uniting with silver ions[2]; (2) spill over into contiguous silver metal-producing photo-voltaic effects[3]; (3) give actual photo-conductance[4] . . . in all cases for light absorbed by the adsorbed dye.

The similarities and differences between optical sensitizing and the selective photo-electric effect will be discussed in the fuller publication. The essential fact which we have brought out is that optical sensitizing not only involves a selective band (electronic transition) absorption of light, but also therewith selective polarization of the absorbed photon. The necessary and sufficient conditions for a dye to act as an optical sensitizer of silver halide appear to be:

(1) Oriented edge-on adsorption, orthogonal to a (110) plane of crystal;

(2) Planar configuration of dye molecule, respectively, of adsorbed dye ion;

(3) Electronic transition in dye ion on absorption of photon, polarized in an azimuth defined by (1) and (2).

We may suppose that the electrons of the filled (strongly shielded) zone (atomistically the Br^- ions of a 110 plane) have a vector, E_a in the 110 plane. This component may undergo partial coupling with a parallel component of the resonance energy of the adsorbed dye molecule polarized in the same azimuth. This corresponds to the displacement of the light absorption of the adsorbed dye molecule to lower frequencies than in the free, gaseous state. There is a corresponding enhancement of this component for an electron of the filled level, which becomes $E_a + h\Delta\nu$. On absorption of a quantum, $h\nu$, of light by the adsorbed dye, the coupling advances to the taking over of this whole increment of electronic oscillation, polarized in the same azimuth, by a partially coupled electron of the filled zone; the total kinetic energy of this electron in the given plane becomes $E_a + h\Delta\nu + h\nu \doteq h\nu_0$, where $h\nu_0$ is the energy necessary to raise an electron to the conductance zone of the crystal. The condition becomes equivalent to that deduced by A. von Hippel[5] for dielectric breakdown in alkali halide lattices, in which it was shown that in these (cubic) crystals the electrons prefer to move through the lattice in the 110 plane.

Essentially, what is postulated is a sufficiently large coplanar component of the otherwise strongly shielded electronic energy of the filled zone to make up the energy necessary to free the electron on coupling with a photon absorbed by the dye molecule. We have shown that optical sensitizing is limited to precisely the most favourable conditions for this. The relation of the suggested mechanism to so-called metastable levels and disturbed lattice points will be discussed in the fuller publication, as also the interesting suggestion of J. Eggert[6] that in ordinary latent formation by ultra- and blue-violet light the more perfect lattice regions are acting as 'optical sensitizers' for perturbed or imperfect regions. The foregoing conclusions, derived for planar cyanine dye molecules, and 'molecular' sensitizing, are equally consistent with 'aggregate' sensitizing[2]. It has been shown that the adsorbed molecular aggregates are parallel-piled edgewise adsorbed ensembles of planar dye ions[2]. Also, it has been shown by E. E. Jelley[7] and by G. Scheibe[8] that filaments or packets of these parallel piled ions constitute a mesomorphic (initially nematic) phase of ionic miscelles. The new—and

strongly shielded—electronic transition (shown in absorption, in fluorescence, and in optical sensitizing) proper to these ensembles is polarized in a direction perpendicular to the plane of the component molecular ions, that is, parallel to the axis of the packet or micelle—and, therefore, to a 110 plane of the crystal. The coupling of this with the azimuthal component of the electronic energy of a filled zone could proceed, therefore, as for an adsorbed molecule. In this connexion, it is significant that we find that non-planar cyanine dyes do not aggregate in the nematic state, while their planar isomers do so.

The considerations advanced are equally applicable to acid sensitizing dyes, for example, erythrosin, etc., of the xanthene type. These also are adsorbed edgewise and orthogonally to an octahedral surface, though of silver ions[2]. The molecules of these dyes are also planar, and *a fortiori*, because having a fused polycyclic skeleton.

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April 25.

[1] NATURE, **145**, 386 (1940).
[2] Sheppard, S. E., Lambert, R. H., and Walker, R. D., *J. Chem. Phys.*, **7**, 265, 426 (1939).
[3] Sheppard, S. E., Vanselow, W., and Happ, G. P., *J. Phys. Chem.*, **44**, 411 (1940).
[4] Kameyama, N., and Fukumoto, T., *J. Soc. Chem. Ind.* (Japan), **42**, 489 (1939).
[5] von Hippel, A., *Z. Phys.*, **67**, 707; **68**, 309 (1931); **75**, 145 (1932).
[6] Eggert, J., and Biltz, M., *Trans. Farad. Soc.*, **34**, 892 (1938).
[7] Jelley, E. E., NATURE, **139**, 631 (1937).
[8] Scheibe, G., *Kolloid. Z.*, **82**, 1 (1938).

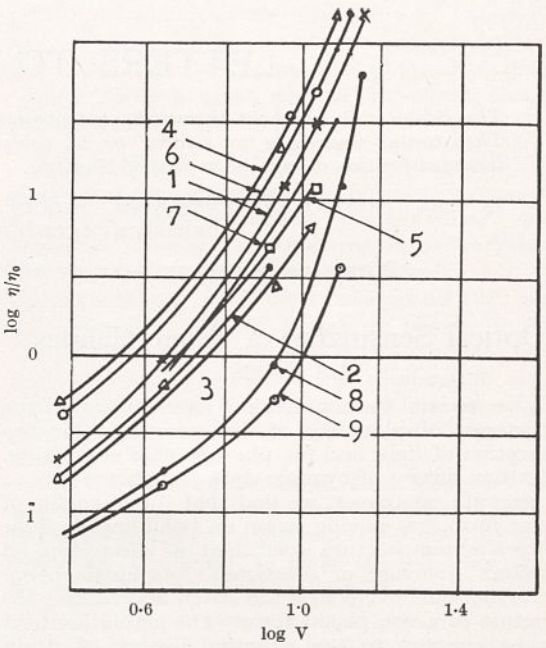
Viscosity of Suspensions and the Einstein Equation

THE Einstein equation $\eta = \eta_0 (1 + 2{\cdot}5\, V)$ relating the viscosity η of a suspension of solid spheres and η_0 the viscosity of the dispersion medium, V being the volume in parts of a cubic centimetre occupied by the dispersed solid, has been used as a basis for determining the molecular structure of proteins and other colloidal substances[1].

It is of interest in this connexion that the viscosity ratio η/η_0 is dependent, among other things, on temperature, the ratio being affected by the viscosity of the dispersion medium. The following data for (*a*) 16·7 per cent volume of graphite in a mineral lubricating oil and (*b*) 14·8 per cent volume kaolin in meta cresol, for example, illustrate this.

(*a*) Temp. ° C.	η	η/η_0	(*b*) Temp. ° C.	η	η/η_0
30	3·7	3·6	13·5	1·21	7·7
40	1·9	3·4	22	0·15	7·2
45	1·5	3·1	45	0·05	6·7

That the effect is not entirely due to disaggregation is indicated by using dispersion media of different viscosity. In the accompanying graphs, values of log $(\eta/\eta_0 - 1)$ and log percentage volume are plotted for powdered silica in various liquids, and it will be seen that the curves are roughly in order of the viscosity of the liquids, the viscosity ratios being least for normal hexane and greatest with glycerol. The source of the variation is presumably due to the spinning motion of the particles or their aggregates,



1, MINERAL LUBRICATING OIL; 2, RICINOLEIC ACID; 3, LIGHT MINERAL LUBRICATING OIL; 4, GLYCEROL (91%); 5, POPPY SEED OIL; 6, RAW LINSEED OIL; 7, TRIACETIN; 8, CARBON TETRACHLORIDE; 9, NORMAL HEXANE.

less time being required in the thinner liquids for the dispersed phase to take up positions of streamline flow.

It was found under isoviscometric conditions that the specific character of the dispersion medium affects the viscosity ratio; thus, for example, with kaolin, 5 per cent volume, a viscosity ratio of 2·15 was found in a light mineral oil, but in oleic acid the ratio was 1·3 and in benzyl alcohol 1·45.

It is possible that in very dilute suspension these effects may be minimized, but in the systems examined at lower concentrations the variations were observed.

The viscosity measurements were made in a simple form of plastometer, low rates of shear being avoided.

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April 29.

[1] "Viscosity and Molecular Structure", by H. Mark and R. Simha, NATURE, **145**, 571 (April 13, 1940).

Cohesion of Liquids

THE recent interesting letters of Profs. M. Born and R. Fürth, published in NATURE of May 11, on the strength of solids, lead me to think that experiments which I am now carrying out on the strength of liquids under hydrostatic tension may be of interest to physicists working in this field. Liquids, owing to their homogeneity and absence of rigidity, possess certain advantages over solids for the study of cohesion. In my view, measurements of the greatest tension which can be applied to liquids under various

conditions have been rather neglected by physicists, particularly in recent years.

In my experiments, a form of apparatus has been devised in which a metallic bellows, closed by a needle valve, contains the gas-free liquid under test, and the possibility of inward leakage of atmospheric air is avoided by completely surrounding the bellows and valve by the same liquid. The needle valve being closed, tension is gradually applied to the liquid by slowly filling a suspended can by means of a small jet of water. The water flow is turned off the moment a sudden downward movement of the can indicates that the liquid has broken. The can is then weighed complete with the contained water, and the tension which existed in the liquid immediately prior to breaking is calculated from the known effective cross-section of the bellows.

The liquids so far examined by this method are alcohol, ether and lubricating oil. It would be premature to quote results in detail at the present stage. However, it appears that the maximum tension which the above liquids will withstand for long periods under the conditions described is simply related to their surface tensions and vapour pressures. The maximum tension increases as the temperature is lowered, and this increase can be largely explained by the changes in surface tension and vapour pressure.

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Crystal Structure of Phosphorus Pentabromide

IT has been shown[1] that phosphorus pentachloride has an ionic type of crystal structure which is tetragonal and contains $[PCl_4]^+$ and $[PCl_6]^-$ groups. Phosphorus pentabromide is entirely different in crystalline form. It is orthorhombic, and X-ray investigations give for the unit cell $a = 5{\cdot}6$, $b = 16{\cdot}9$, $c = 8{\cdot}3$ A., with four molecules per unit cell. The space group is *Pbcm* and the four phosphorus atoms are therefore necessarily equivalent crystallographically and chemically. The possibility of a structure containing two different complexes similar to those in phosphorus pentachloride does not arise in this case. It is impossible to fit in four molecules of PBr_5 of the trigonal bipyramidal form, and the appearance of the diffraction patterns is entirely unlike that of a molecular compound. Patterson and Fourier methods were used to elucidate the structure. It was found that the structure contains tetrahedral $[PBr_4]^+$ groups located so that a plane of symmetry passes through each, and the fifth bromine is present as a bromide ion removed from the phosphorus at a distance about twice that of the four covalently linked atoms. It is natural to expect the stability of the octahedral complex to diminish with increasing radius of the halogen atoms so that the change-over from the constitution $[PCl_4]^+ [PCl_6]^-$ to $[PBr_4]^+ Br^-$ is not surprising.

H. M. POWELL.
D. CLARK.

Department of Mineralogy,
University Museum,
Oxford.
April 30.

[1] Powell, Clark and Wells, NATURE, **145**, 149 (1940).

Formation of Aggregates and Structures in Dilute Solutions of Hydrogen Bentonites

A YIELD value is noticeable in hydrogen bentonites at a concentration lower than that at which thixotropy first appears. This seems to happen generally with bentonites. Some natural calcium bentonites show coacervation[1]. Coacervation of fine subfractions of a natural bentonite has been reported[2] at concentrations above the thixotropic range. Hydrogen bentonites, however, show coacervation over a wide range and even below the thixotropic range of concentrations. Near about the concentration at which yield value becomes noticeable a sharp change in several properties has been observed. The cataphoretic velocity rapidly increases and tends to a maximum. The conductivity, Λ, per gram of colloid can be calculated from the relation $\Lambda = 1000\ (\lambda_c - \lambda_u)/C$, where λ_c is the specific conductivity at a concentration of C grams per litre and λ_u that of its ultra-filtrate; it passes through a minimum if plotted against C or $\sqrt{C}$.

Aggregation during coagulation is often associated with an increase in the cataphoretic velocity[3]. Also the mobility of 'monomeric ions' of 'colloidal electrolytes' has been found to increase when they associate to form 'micelle ions' and pass through a maximum, whereas the equivalent conductivity of the electrolyte as a whole passes through a minimum[4]. The hydrogen ion activity of hydrogen bentonite changes almost proportionally with concentration. The total acidity calculated from the inflexion point[5] in the sodium hydroxide titration curve does not generally vary with concentration, though a variation has been observed for one subfraction of a hydrogen bentonite[6].

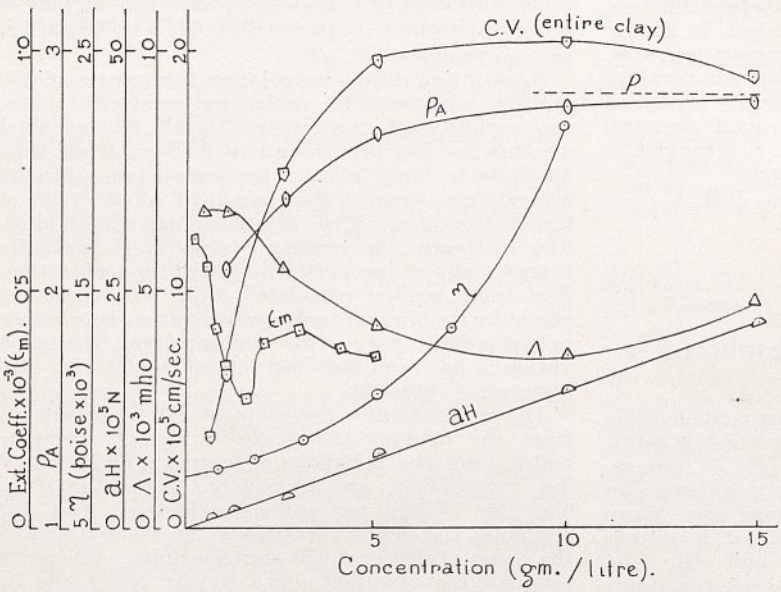
The conductivities per gram of colloid calculated from the relation $\Lambda' = a_H\ (l_H + l_{coll})/C$, where l_H and l_{coll} are the mobilities of hydrogen and 'colloid' ion respectively, are appreciably greater than Λ. The free charge per particle calculated from a_H, assuming the activity coefficient to be unity, is of the order of 500 or 1,000 electron units. Onsager's conductivity equation[7] for a similar electrolyte in true solution is inadequate to explain the form of the Λ, $\sqrt{C}$ curve.

The special features of these titration curves[5] and the discrepancy between observed and calculated conductivities per gram colloid are, however, met with in hydrogen clays and other similar colloidal systems[8] but are not of immediate interest. The sols have strong absorption. Interpretation of the measurements of extinction coefficient is difficult. The latter decreases with the concentration and passes through a minimum. Somewhat similar changes have been observed with colloidal dyes[9] and ascribed to aggregate formation. The 'true viscosity' increases with C at a rate much greater than that corresponding to a linear relationship.

Neither Einstein's equation nor Smoluchowski's modification of it can account for the high viscosity or its variation with concentration. Also the high viscosity cannot be fully accounted for by the anisometry of the particles. Hauser and LeBeau[10] observed that the apparent specific gravity, ρA, of subfractions of a natural bentonite increases with concentration and approaches a limiting value. However, ρA observed by them in the most dilute solutions is definitely less than the true specific

gravity, ρ, of bentonites recorded in the literature, while ρA for the higher concentrations has a definitely larger value and is also greater the finer the subfraction. Hydration cannot explain how ρA can fall below ρ. We find that the limiting value of ρA shows a fair agreement with the specific gravity of the material dried at 110° C. and immersed in toluene.

Air-dried hydrogen bentonite *en masse* has been observed to have the same specific gravity[11] in both water (2·248) and toluene (2·249). The diminution of density and not an increase requires an explanation. The precise manner in which this takes place has to be clarified by further experiments. However, clay minerals of the montmorillonite group show strong swelling in water as a result of the penetration of water molecules into the lattice. If the resulting free space in the lattice is not completely filled by water molecules the apparent specific gravity of the particles will decrease. It appears that with increase of concentration aggregates are first formed and then some sort of a structure develops and a yield value results.



Thixotropy comes next. Coacervation shows itself generally after the development of the yield value but may appear before or after thixotropy develops. Results of measurements obtained with a particular subfraction of a hydrogen bentonite (average effective radius about 12·5–25 mμ) are shown in the figure.

These investigations have been carried out with the aid of a grant from the Assam Oil Co., Ltd.

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April 18.

* Research scholar appointed by the Assam Oil Co., Ltd.

[1] Private communications from Mr. A. Reid.
[2] Langmuir, *J. Chem. Phys.*, **6**, 373 (1938).
[3] Mukherjee, Chaudhuri and Ghosh, *Trans. Nat. Inst. Sci. India*, 1, No. 4, 47 (1935).
[4] Hartley, *Kolloid Z.*, **88**, 22 (1939).
[5] Mukherjee, Mitra and Mukherjee, *Trans. Nat. Inst. Sci. India*, 1, No. 10, 227 (1937).
[6] Unpublished results by Dr. R. P. Mitra and Mr. S. Roy.
[7] Onsager, *Trans. Farad. Soc.*, **23**, 341 (1927).
[8] Mukherjee, *Kolloid Z.*, **62**, 257 (1933); **63**, 36; **65**, 72.
[9] Körtüm, *Z. phys. Chem.*, B, **34**, 255 (1936).
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[11] Woodman, *J. Soc. Chem. Ind.*, **51**, T, 327 (1932).

Total Energy Absorption in Biological Objects

THE total energy absorbed in a biological system when irradiated by a beam of X- or gamma-rays is a quantity of both theoretical and practical interest. The letter by Dr. Happey[1] indicates one method of attempting to solve such a problem, but it seems that the matter may be carried much further. When a beam of X- or gamma-rays is sent into a scattering medium such as a block of tissues, the distribution of radiation absorbed within the tissues may be conveniently represented by constructing 'isodose surfaces'. During the last two years we have carefully studied these surfaces, and they seem to afford the best method of attacking the total energy absorption problem. If the isodose surfaces have an axis of rotation, the volume of tissue between any two surfaces representing given dosage levels may readily be determined, so that by multiplication of volume (or more accurately mass of substance) and average dose we obtain the 'integral dose'. In this way we have studied the integral dose over a wide range of clinical conditions. An indication of the kind of results obtained is given in the accompanying table. The most striking feature is the very large variation in integral dose (always taken to the 10 per cent isodose surface) which exists between the different techniques. The results may be correlated with the very varying constitutional effects produced in the patients by the treatments.

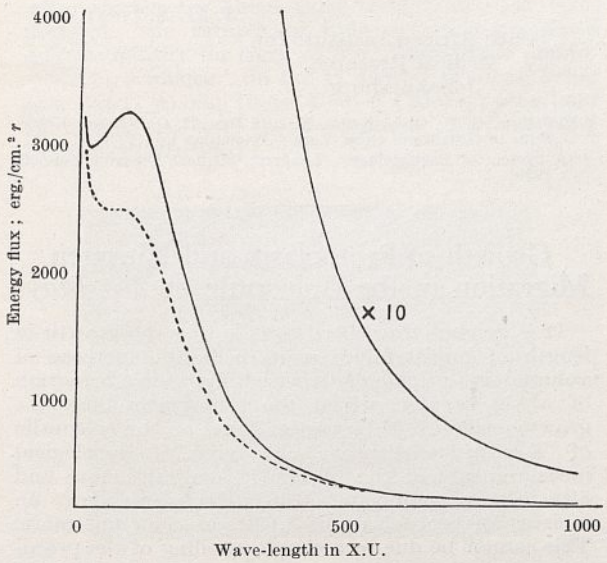
We have also developed semi-empirical formulæ very similar to those of Happey and compared the results of such calculations with the more elaborate isodose surface investigations. The table shows that although there is fair agreement between the two methods there are occasionally wide divergencies.

The problem may, however, be attacked from a third, and perhaps more interesting, point of view. From the definition of the röntgen and the known absorption coefficients of air, it is possible to calculate the total energy flux per cm.^{2} per röntgen for different wave-lengths. The results are shown in the accompanying figure. We may, therefore, calculate the total energy which flows through the surface of the body during a radiation treatment. Many examples of these energy fluxes have been investigated by us, but to fix the order of magnitude we may state that for short wave-lengths ($\lambda = 0{\cdot}01$ A. to $\lambda = 0{\cdot}1$ A.) about half a gm. cal./cm.^{2} is absorbed for the normal therapeutic dose of 6,000 *r* on the skin. It may also be shown that when one röntgen is absorbed in one gram of air approximately 85 ergs are converted into energy of electronic motion. The amount of energy converted per electron per röntgen in other materials likely to occur in living tissues has been recently investigated[2]. We may, therefore, approximately convert the integral doses into total energy absorbed in ergs and compare the results obtained with the energy flux into the body. In this way we usually find that only about one third to one half of the energy poured in reappears as absorption in the

No. of radiation	Type of radiation	Type of technique	Potential in kv.	Filter	Mean wave-length (A.)	Focal distance	Diam. of field	Gram-röntgens to 10% contour	Integral dose from formulæ
1	X-rays	'Röntgen cautery'	45	Unfiltered. Tube only	0·90	2·0 cm.	1·0 cm.	71·5	68
2	X-rays	'Contact therapy'	60	Tube only. 0·2 mm. Ni equiv.	0·33	5·0 cm.	4·0 cm.	4,200	4,950
3	X-rays	'Deep therapy'	200	1 mm. Cu.	0·12	50 cm.	10·0 cm.	96,560	95,000
4	X-rays	'Super-voltage'	400 (peak)	4 mm. Cu.	0·069	50 cm.	10·0 cm.	110,000	107,000
5	γ-rays	One gm. unit	—	1 mm. Pt equiv.	0·014	5·0 cm.	5·0 cm.	14,593	11,200
6	γ-rays	Five gm. unit	—	1·4 mm. Pt equiv.	0·013	8·2 cm.	8·0 cm.	51,587	48,420

primary beam down to the 10 per cent isodose surface, the rest being scattered outwards or absorbed in parts of the body at low dosage-rates. Preliminary calculations indicate that this result is of a reasonable order of magnitude.

These considerations would also seem to have important consequences in relation to protection problems. For example, the 'tolerance' dose is defined as 0·2 *r* per day, and we may, therefore, calculate approximately the total energy absorption for a person of a definite weight exposed for a year to this dosage-rate. It is found that the order of energy absorption per year for gamma-rays at the tolerance dosage-rate is the same as that for one moderate-sized field (10 cm. diameter) during a course of high-voltage X-ray or gamma-ray therapy giving a surface dose of 3,000 *r*. This result may be taken as a warning or an excellent example of the importance of the 'time factor'. Again, if we consider a very small biological object constructed of approximately air-like material, then the dose in röntgens is an approximate measure of the energy absorbed in it whatever the wave-length. If, however, we consider an object sufficiently large wholly to absorb the energy falling on it, then the curve also represents the total energy absorbed per röntgen per cm.[2] of surface irradiated by a parallel beam. The energy absorbed per röntgen measured on the surface is now clearly very dependent upon the wave-length, and if there are constitutional effects depending upon the total energy absorbed in the organism, we might expect wave-length dependence.



CONTINUOUS LINE, IN AIR ; BROKEN LINE, WITH BACKSCATTER.

It will be seen, for example, that a given dose of gamma-rays would correspond to a very much larger energy absorption throughout the absorbing mass than for the same dose in röntgens of longer wave-length radiations such as scattered X-rays of wave-length 200 X.U. or diagnostic X-rays. Many animals and the human body would appear to be of such a size as to provide conditions intermediate between the two extremes, the magnitude of the effect depending upon the relative size of the absorbing mass and the 'mean free path' of quanta within $(1/\mu)$. Owing to the complexity of the circumstances it has not yet been possible to obtain accurate information though we have some data ; but it should be realized that there is some physical basis for expecting the tolerance dose to decrease with wave-length. The classical proofs of independence of biological effect with wave-length using very small biological objects would seem to have no necessary validity for large absorbing bodies.

Finally, we have been able to compare the energy flux during normal short wave-length X-ray or gamma radiation treatment with that occurring during ultra-violet light irradiation.

The whole subject has as yet scarcely become quantitative, and much more investigation is required, but it is clear that it offers important problems in biophysics. An account giving details of the physical and mathematical investigations carried out by us during the last few months has been submitted for publication elsewhere[3].

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Royal Cancer Hospital (Free),
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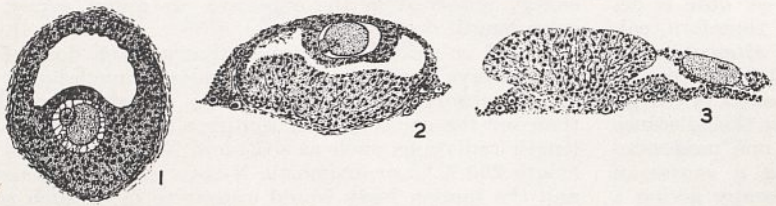
May 7.

[1] Happey, F., NATURE, **145**, 668 (1940).
[2] Mayneord, W. V., "Reports on Progress in Physics" *Phys. Soc.*, **5**, 284 (1939).
[3] Mayneord, W. V., *Brit. J. Rad.* (in the press).

Mechanism of Ovulation and Corpus Luteum Formation in Elephantulus

IN the course of an examination of serial sections of close on two hundred uteri and ovaries of *Elephantulus myurus jamesoni* in our studies on the menstrual and reproductive processes of this animal, we have had the opportunity of observing all phases of follicular and luteal growth in the ovary. This was facilitated by the fact that Elephantulus sheds up to sixty ova at a time from each ovary although only one embryo develops in each uterine horn. The corpus luteum does not commence to form *after* the extrusion of the ovum from the follicle, but rather before the ovum is extruded. In fact, the corpus luteum is responsible for ovulation (see accompanying illustration, 3).

The luteinizing granulosa cells proliferate at one pole of the follicle, encroach on the follicular cavity which is gradually obliterated, and the ovum is steadily pushed out of the follicle through the superficial layers of the ovary. During the process the theca interna proliferates, is vascularized and in turn invaginates the heaped-up luteal cells. By this method the original epithelium lining the follicular cavity is everted so that the free margin of the corpus luteum represents anatomically the lining epithelium of the original cavity, which now projects from the surface of the ovary, and the attached portion is vascularized by thecal vessels which extend radially towards the expanded free margin of the newly found corpus luteum.



1, RIPE GRAAFIAN FOLLICLE; 2, GRAAFIAN FOLLICLE ON THE SURFACE OF THE OVARY, PREPARATORY TO OVULATION; GRANULOSA CELLS ARE COMMENCING TO LUTEINIZE; 3, RECENTLY RUPTURED FOLLICLE WITH ATTACHED OVUM AND EVERTED CORPUS LUTEUM (×*c*.80).

Many theories have been invoked to explain the exact mechanism of ovulation, such as the increased tension produced by the secretion of the liquor folliculi, the contractions of smooth muscle and the action of enzymes[1].

While the method of corpus luteum formation in Elephantulus is unique and is so totally different from the accepted procedure in other animals, it nevertheless negates the above-mentioned theories of ovulation.

The findings in Elephantulus substantiate the claims that ovulation is a phase in the growth process controlled by the gonadotropic hormones, since there is most convincing evidence that pre-ovulatory differentiation occurs in the granulosa cells of the follicle.

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Department of Anatomy,
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[1] Hartman, Carl G., "Sex and Internal Secretions", pp. 629–651. Edited by Allen, Darnforth and Doisy (Williams and Wilkins, 1939).

Possible Relation between Ability to Synthesize Vitamin C and Reaction to Tubercle Bacillus

WE had occasion to write the following two lists within a few days of one another and were struck by the close similarity between them:

CLASSIFICATION OF ABILITY OF DIFFERENT MAMMALIA SPECIES

(A) TO SYNTHESIZE VITAMIN C (MCCOLLUM 1939)[1].	(B) TO RESIST INFECTION WITH HUMAN AND BOVINE TUBERCLE BACILLUS (M.R.C. 1930)[2].
1. Require vitamin C in their diet (that is, are unable to synthesize vitamin C themselves): Man. Monkey. Guinea pig.	1. Susceptible to infection by both bovine and human tubercle bacillus: Man. Monkey. Guinea pig.
2. Query require vitamin C in their diets (that is, authorities are in doubt as to their ability to synthesize vitamin C): Rabbit. Pig. Cattle Mouse.	2. Susceptible to bovine but resistant to human tubercle bacillus. Rabbit. Pig. Calf. Goat. Sheep. Horse.
3. Do not require vitamin C in their diet (that is, are known to be able to synthesize vitamin C) Dog. Rat.	3. Resistant to both bovine and human tubercle vacillus: Mouse. Dog. Rat.

We feel that this similarity is too close to be a pure coincidence and that there is possibly a relation, at present obscure, between the ability to synthesize vitamin C and the reaction to the tubercle bacillus. This is especially interesting in view of the number of papers appearing recently which suggest that the vitamin C metabolism is higher than normal in tubercular patients.

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J. H. S. GEAR.
South African Institute for
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[1] McCollum, E. V., Orent-Keiles, E., and Day, H. G., "Newer Knowledge of Nutrition" (New York: Macmillan Co., 1939).
[2] "A System of Bacteriology" (London: Medical Research Council, 1930).

Growth of Protoplasm and Nitrogen Migration in the Coleoptile of *Zea Mays*

IT is generally accepted that during the growth in length of meristematic plant cells the increase of volume is principally caused by the formation of a big vacuole, whilst the protoplasm does not grow considerably. Investigations[1] on the coleoptile of *Zea Mays* disprove this view. Cytological measurements of the plasmatic content before and after the phenomenon of cell stretching show an increase of protoplasm of 1,670 per cent and more. This cannot be due to a simple swelling of the protoplasm, as during this time the protein nitrogen of the cells increases as many as 9·5 times. Therefore

there is not so striking a difference between the behaviour of protoplasm in growing cells of plants and animals as is generally believed.

In the growing coleoptile considerable amounts of water-soluble and protein nitrogen migrate upwards, whilst the auxins migrate downwards. So long as the coleoptile is growing its content of total nitrogen is increasing. Only in the withering coleoptile a decrease of nitrogen does take place. But the coleoptile is not completely emptied of nitrogen before it dries. In this way every germ loses about 2 per cent of the nitrogen originally stored in the seed.

A. FREY-WYSSLING.
F. BLANK.

Laboratory of Plant Physiology,
Swiss Federal Institute of Technology,
Zurich.
May 9.

[1] *Ber. Schweiz. Bot. Ges.*, **50**b (1940).

Algæ in the Bed of the Dead Sea

THE presence of living micro-organisms—algæ and bacteria—in Dead Sea water was demonstrated by me some time ago.[1] It seemed, therefore, probable that life was also abundant in the sediment bed of the Dead Sea. To throw light on this point an investigation on a sample of sediment obtained from the sea bottom has been carried out.

The sediment sample was taken by means of a Fischer bottle at a point 23 km. west-south-west of the mouth of the Jordan and *c.* 8 km. off the east coast on December 28, 1939. The depth of the sea at this point is 350 m. The total salt concentration in the water near the sea bottom is 32 per cent. The specific gravity at 20° C. is 1·212. The percentage of different salt species in the sea water is as follows :

NaCl	9·42
KCl	1·42
$MgCl_2$	14·41
$CaCl_2$	4·78
Br	0·46

After storage for about three months at room temperature, the sample of sediment was examined microscopically for signs of life. These were abundantly in evidence. So far 17 species of algæ, living and dead, among them 4 or 5 Chlorophyceæ and 12 Diatomeæ, have been detected. The following have been identified :

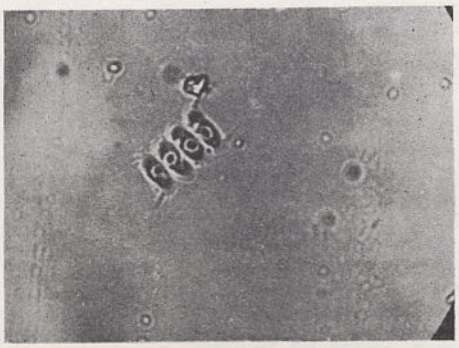

Fig. 1. × 900.

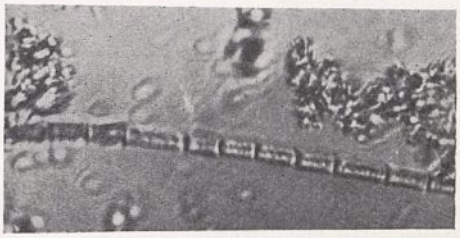

Fig. 2. × 900.

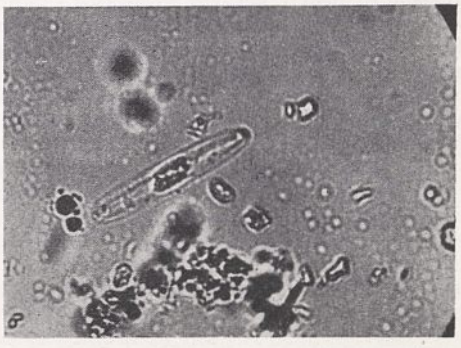

Fig. 3. × 900.

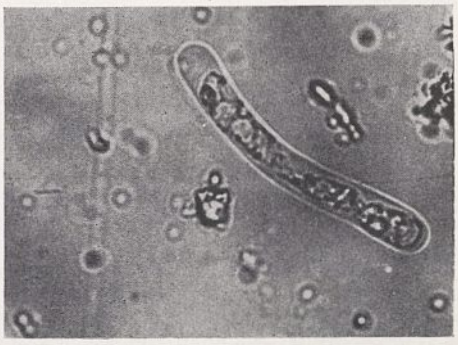

Fig. 4. × 900.

Chlorophyceæ : (1) *Scenedesmus quadricauda* (Fig. 1) ; (2) a filamentous alga of the order Ulothrichales (Fig. 2).

Diatomeæ : (1) Pennatæ, including Naviculoideæ (Fig. 3) ; (2) Centricæ, including Melosira.

A species of Chlorophyceæ most commonly observed was of an elongated type with a greenish-yellow chromatophore, occasionally seen in pairs (Fig. 4). In several diatoms the chromatophore was visible. It seems likely, therefore, that the diatoms found in the sea bed are at least in part alive.

A full description of the Dead Sea bed algæ will be published elsewhere.

Thanks are due to the Palestine Potash, Ltd., for submitting the sample and the water analysis.

B. ELAZARI-VOLCANI.

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Rehovoth, Palestine.
March 19.

[1] Wilkansky, B. (Elazari-Volcani), NATURE, **138**, 467 (1936). A full description will be published shortly.

Comparative Morphology and Evolutionary Trends in Trichoptera

THE internal anatomy of adult Trichoptera has been very little studied, especially on a comparative basis. A detailed attempt has been made in this direction and some interesting results have been obtained. In a study of the internal anatomy of six families of adult Trichoptera, the following significant conclusions have been drawn.

(1) There is a correlation between the structure of the systems and the habitat. It seems that the modification of Trichoptera has been associated with the invasion of poorly aerated waters as exemplified by the swift (flowing) stream-inhabiting *Rhyacophila dorsalis*, and slow stream-inhabiting *Mystacides longicornis*.

(2) Different systems in the same species do not evolve synchronously ; that is to say, there has been a differential intra-organic evolution.

(3) The trend of evolutionary development in adult Trichoptera has been towards reduction and simplification of structure, associated with a tendency towards non-feeding in the adult and the shortening of life.

It is hoped that the above results will shortly be published in detail.

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(University of Durham),
Newcastle-on-Tyne.
May 22.

Effect of the Severe Winter of 1939-40 on British Oyster Beds

PROF. ORTON has recently recorded[1] some details of the damage caused by the severe winter just past on the oyster beds of the Rivers Blackwater and Roach. As the result of an inspection of these and other beds during the period April 9–19, I am able to supplement the information given by him.

There is no doubt that the entire stocks of Brittany oysters (*Ostrea edulis*) relaid in the Blackwater and Roach Rivers have been destroyed. During a day's dredging on the River Roach no living Brittany oyster was found, while of the one or two per cent remaining alive in the Blackwater at the time of the survey nearly all were weak and contained mud in the mantle cavity, despite the fact that the water temperature had risen to 7·5° C. during the period between the surveys conducted by Orton and myself.

Oysters from Brittany are relaid at two other points on the East coast, namely, in the River Medway (Hoo Creek) and off Whitstable. In the Medway the mortality was 100 per cent. At Whitstable the mortality among Brittany relaid oysters was about 95 per cent and the survivors were still weak.

Brittany oysters relaid in the River Yealm, South Devon, have not suffered to the same extent, the mortality not exceeding 30 per cent, while in the Helford River, Cornwall, the losses were only slight.

Among native oysters the losses have not been so high, although the figures obtained in April were considerably higher than those recorded by Orton, showing that the losses had continued, as he had anticipated. In the Blackwater, 75–80 per cent of the native stocks have been destroyed, while in the River Roach 80 per cent of these oysters have died. In the River Colne and in Pyefleet the mortality among the stock of natives is estimated at 75 per cent and it is noticeable that here, as elsewhere, the larger oysters have suffered most severely. The survivors were still weak at the time of the survey. On the layings in the various creeks at West Mersea the mortality was somewhat variable, depending upon the amount of protection from silt driven in by easterly winds, but was nowhere less than about 50 per cent and reached 75 per cent or rather more in places.

In the River Crouch, which probably carried a larger stock of native oysters than any other river in the country, conditions were slightly better and the mortality did not exceed 50 per cent except in the upper reaches of the river. Of about a million oysters which had been collected in the storage pits when the frost set in, nearly 50 per cent have died and the survival of the remainder is doubtful.

At Whitstable native oysters have survived in considerable numbers, particularly those bred on the Whitstable Flats, and although precise figures are not yet available the mortality is not expected to reach 50 per cent. The losses among native oysters in Cornwall were slight, but the stocks were not high.

American oysters (*Ostrea virginica*) are laid down in the creeks at Brightlingsea and West Mersea, and by Christmas the stocks remaining on the layings were small ; the losses experienced vary between 25 and 50 per cent. Portuguese oysters (*Ostrea angulata*) are laid down at Brightlingsea, West Mersea and in the River Medway. The mortality varies somewhat from creek to creek. Estimates of the losses vary from 35 to 50 per cent.

Oysters bred on tiles in the experiment tanks at Conway, North Wales[2], and planted out in the Menai Straits, in situations where they are uncovered at spring tides, have suffered very little loss, despite several weeks of severe frost, and air temperatures down to −12° C. Similar tank-bred oysters in the River Yealm, South Devon, have also survived the winter without serious losses.

During the course of the survey of East coast oyster beds no evidence was found of any mortality among the slipper limpets (*Crepidula fornicata*) infesting these beds, other than a report of considerable deaths in the very shallow waters of Hoo Creek, River Medway. Elsewhere the clumps of slipper limpets were all tightly joined and no recently emptied shells were obtained in the dredge. The general weakness noted by Orton was nowhere apparent.

Recent samples of *Urosalpinx cinerea*, the American oyster drill, from the East coast beds contain only an occasional empty shell and show definitely that this pest has once again survived a severe winter without loss[3]. No living specimens of *Ocinebra* (*Murex*) *erinacea*, the British drill, have been noted in recent samples of drills from the River Blackwater, as contrasted with approximately 9 per cent in similar samples collected a year ago. It appears as if Urosalpinx has now almost completely replaced Ocinebra on the East coast beds.

H. A. COLE.

Fisheries Experiment Station,
Conway, N. Wales. May 20.

[1] Orton, J. H., NATURE, **145**, 708 (1940).
[2] Cole, H. A., *Min. Agric. and Fish., Fish Invest.*, Ser. 2, **15**, 4 (1939).
[3] Orton, J. H., and Lewis, H. M., *J. Mar. Biol. Assoc.*, **17**, 2 (1931).

Effect of X-Rays on Carboxypeptidase

IN a recent review[1] of the biological action of X- and gamma-rays, the conclusion is reached that only enormous doses of X-rays have an appreciable destructive effect on enzymes and that enzymes therefore play no important part in explaining the effect of X-rays on living tissues.

I have examined the effect of X-rays on crystallized carboxypeptidase[2] (substrate : edestine) with the following results.

The percentage destruction is a function of the concentration of the enzyme for a given dose of radiation. A definite amount of radiation energy absorbed corresponds to a constant amount of enzyme destroyed. In consequence, the percentage destruction increases as the concentration of the enzyme decreases : for example, if the concentration of the enzyme is 0·0080 (C.P.u) PDE per ml., 50,000 r. will destroy 21 per cent, 150,000 r. 50 per cent and 400,000 r. 65 per cent. However, if the concentration is 340 times lower, then 50 r. will destroy 29 per cent, 140 r. 50 per cent and 400 r. 70 per cent.

This shows that the concentration of enzymes has to be taken into account if statements regarding their radio-sensitivity are made. It shows, furthermore, that X-rays have a qualitatively uniform effect on the enzyme over the whole range of doses, from very small doses to doses a thousand times as large. This point is of importance in view of the opinion held by many that small doses act in an essentially different way from big doses.

Finally, I have found that X-rays have no effect at all on the enzyme carboxypeptidase when it is combined with its substrate during irradiation, whereas the enzyme simultaneously irradiated without its substrate showed 85 per cent destruction.

Details of the work will be published elsewhere.

W. M. DALE.

Christie Hospital and
Holt Radium Institute,
Manchester.
May 15.

[1] Scott, C. M., Medical Research Council, Special Report Series No. 223 (1937).

[2] Anson, M. L., *J. Gen. Physiol.*, **20**, 781 (1936–37).

"Books in War-Time"[1]

IN the libraries books are divided into two great classes : fiction and non-fiction. Nine tenths of the fiction published is of such poor quality that it could well be spared in war-time, whereas publications on non-fiction nearly always contain something of value. Good fiction is valuable and should not be discouraged, but a reduction of the present enormous volume of bad novels would give the few good ones a better chance of recognition. The Government might therefore consider whether the allotment of paper for fiction might not be cut by 90 per cent whilst allowing full supplies for non-fiction, which would be sufficiently handicapped by rising prices.

ARTHUR MARSHALL.

The Athenæum,
Pall Mall, S.W.1.
May 23.

[1] NATURE. **145**, 719 (1940).

Points from Foregoing Letters

S. E. Sheppard, R. H. Lambert and R. D. Walker find the necessary and sufficient conditions for optical sensitizing of silver halides by dyes to be : (1) planar configuration of dye molecule ; (2) edge-on adsorption of dye ion or dipole ; molecular plane orthogonal to a (110) plane of silver-halide crystal ; (3) electronic transition in dye ion or molecule on absorption of light polarized in azimuth, defined by (1) and (2).

A new apparatus has been used by R. S. Vincent for measurements on the cohesion of liquids. A metallic bellows is employed for applying tension to the liquids, and it has been found that the maximum tension which can be applied is simply related to surface tension and vapour pressure, and that the effect of temperature can be largely explained by the changes in these properties.

H. M. Powell and D. Clark show that phosphorus pentabromide has a crystal structure entirely different from the pentachloride. A constitution analogous to $[PCl_4]^+$ $[PCl_6]^-$ is no longer stable owing to the larger radius of the bromine but an ionic structure is formed containing $[PBr_4]^+$ and Br^- ions.

A study by J. N. Mukherjee and N. C. Sen Gupta of the variation of several properties of dilute solutions of hydrogen bentonites with concentration suggests that aggregate formation in bentonites begins at a very low concentration. At a somewhat higher concentration these aggregates form some sort of a structure and a yield value develops.

The total energy absorption of biological objects subjected to X- or gamma-rays has been investigated by the construction of 'isodose surfaces' for the tissue. W. V. Mayneord describes results that have been obtained.

B. Elazari-Volcani reports that he has found seventeen species of algæ in material obtained from sediment from the bottom of the Dead Sea. Photomicrographs are submitted.

P. J. Deoras, working on the internal anatomy of six families of adult Trichoptera, finds that the trend of evolutionary development has been towards reduction and simplification of structure associated with a tendency towards non-feeding in the adult and the shortening of life. Further, there has been a marked differential intra-organic evolution.

As the result of a survey of the damage caused by the severe winter just passed on British oyster beds, H. A. Cole has found that virtually the entire stocks of Brittany relaid oysters (*Ostrea edulis*) on the Essex and Kent beds, probably amounting to thirty millions all told, have been destroyed, while the stocks of native oysters have been reduced by about 75 per cent.

W. M. Dale has exposed solutions of the crystalline enzyme carboxypeptidase to X-radiation. He finds that the percentage destruction of the enzyme is a function of its concentration, increasing as the concentration decreases.

RESEARCH ITEMS

Teeth of Finnish Lapps

A DISCUSSION by Helen Mellanby (*Brit. Med. J.*, April 27, 1940) of dental deformation and caries among Finnish Lapps, and their relation to changes which have taken place in the national diet, is based upon observation of 1,253 teeth of seventy children between two and fourteen years of age, undertaken in June 1939. The teeth are charted for hypoplasia and caries. The teeth of both Inari and Skoltje Lapp children are of very imperfect structure. Only 25 per cent of the deciduous teeth, and in the permanent teeth only 6·7 per cent, were of good or normal structure; and even these figures may be too high in view of allowances for attrition. As might be anticipated from the poorness of structure, caries is rampant. All children over four years of age were affected, and out of the total of seventy only three were caries-free. Of deciduous teeth 55·3 per cent and of permanent teeth 44·5 per cent were carious. Among Eskimos of East Greenland, only 2–4 per cent of the deciduous teeth and 1–1·4 per cent of the permanent teeth in the ages 0–13 years were affected. In the cranial material, only a proportion of the teeth remained. Nevertheless, comparative examination shows a decided deterioration in structure and increase in carious affection in the modern material. There is evidence to suggest that deterioration set in about 1900 when Finns began to immigrate in numbers. Further, in the last century or more the diet of the Lapps has changed. Like that of the 'uncivilized' Eskimos, it was almost entirely carnivorous, a low calcium intake being made good by chewing bones. In the modern dietary there are important differences, notably cheap margarine, coffee, oatmeal, sugar and potatoes. Cereals are consumed in large quantities during the winter. If allowance is made for the anti-calcifying effect of a high cereal content of the diet, it may account for a deterioration in tooth structure which is correlated with a greater liability to caries.

Fishes of the John Murray Expedition

A MAGNIFICENT collection of fishes is described by J. R. Norman (John Murray Expedition 1933–34. *Sci. Rep.*, **17**, No. 1. Fishes. British Museum (Natural History), 1939). These were obtained from the Red Sea, Gulf of Aden, South Arabian coast, Gulf of Oman, Arabian Sea and in the Zanzibar and Maldive areas, chiefly from regions largely unexplored for deeper water fishes, and, as was to be expected, there are many which are new to science (28) and new to the British Museum collection (56). 276 species are represented altogether. Some of these deep-water species from the Zanzibar region and the Gulf of Aden were hitherto only known from the Philippines and adjacent seas, but the author is convinced that more extensive collecting in the intervening areas of the Indian Ocean would show that most of these forms have a wide range in this part of the world. Among the interesting finds is an egg capsule from the depth of 1,061–1,080 metres, of one of the Chimæridæ, probably Harriotta. A synopsis of the Oceanic genera of the Brotulidæ is included in the report and a key to these.

Biology of Rubus Aphides

G. H. L. DICKER (*J. Pom. and Hort. Sci.*, **18**, 1; 1940) has carried out a detailed investigation into the biology and morphology of four important pests of Rubus, *Macrosiphum rubiellum* Theo., *M. rubifolium* Theo., *Amphorophora rubi* (Kalt) and *Aphis idæi* van der Goot. Field observations were made to elucidate the life-histories, and statistical data obtained on seasonal fluctuations of the populations. It appears that Coccinelid larvæ are responsible for the decline in populations during August. A comprehensive list of host plants is given for each of the common aphides, and consideration of their origin shows that there is often a close correlation between the genetical constitution of the host and the species of aphides breeding on it. Thus, *M. rubiellum* shows definite preference for species of blackberry or blackberry crosses, whilst the raspberry and its hybrids are avoided. This selectivity narrows down the field of investigation of virus diseases transmitted by aphides. Notes are given on six other species of aphides recorded on Rubus in Great Britain, and one unnamed species related to *Aphis Urticaria* Kalt.

Spores of Bryophyta

Miss Knox has added to her experience of spore types by a survey of Bryophyte spores (*Trans. and Proc. Bot. Soc., Edin.*, **32**; 1939), with the view of identifying fossil spores in coal. The survey shows great variety among liverwort spores, as compared with considerable uniformity among those of mosses. The liverwort spores have a wide range in size and also in the type of wall sculpturing, and this is especially striking in the case of certain genera which are also characterized by other features of form and structure, such as Frullania. Evidence from various sources suggests that Bryophyta had reached a considerable degree of specialization by Carboniferous times, and it is probable that many of the spores found in the Fife coals may be of this origin. Though the author would not suggest that specific or even generic significance should be attached to them, the broad comparisons of spore types suggest that many of the living groups of Bryophyta were represented at that time. Certain characteristic spore forms, such as those of Frullania, Mastigolejeunia, Grimaldia, Targionia, and, among mosses, Breutelia, have not been recognized from the coals, whilst types closely resembling species of Anthoceros, Riccia, Moerkia and Fossombronia are present.

A Rhododendron Complex

THE beautiful *Rhododendron sanguineum*, regarded as a single species at the beginning of this century, has now become a taxonomic incubus of very numerous, intergrading forms. Activities of plant collectors in western China have contributed greatly to horticultural beauty, but have added to the difficulties of the plant systematist. John M. Cowan, in a most useful evaluation of the Sanguineum subseries (*Notes Roy. Bot. Gard. Edin.*, **20**, No. 97, pp. 55–91; February 1940), has shown that there are eight recognizable species, comprising 43 sub-species, in the group. The key and descriptions which are

given should provide an adequate taxonomic framework, and should bring order to this formerly chaotic section of botanical classification. Considerable restraint has been practised by the author to avoid unpractical 'splitting', and his conclusions are based upon the examination of several thousand living plants and herbarium specimens.

Position of Chiasmata

K. MATHER (*J. Genetics*, **39**, 205–223; 1940) has continued his studies on the determination of the position of crossing-over. The ratio of differential-interference-distances, that is, the distance between the centromere and the proximal chiasma and between the proximal and second chiasma may be used to describe the distribution of the chiasmata on the chromosome. Analysis of the cytological results in several species shows that the agreement between this ratio and the observed positions of chiasmata at metaphase and anaphase is close. Therefore the author suggests that the position of chiasmata at metaphase is the same as at chiasma formation; terminalization is an all or none process. Either all chiasmata terminalize or only the most distal ones move to the ends without reducing the frequency of chiasmata. This hypothesis therefore implies that chiasmata (*a*) tend to have determinate positions, and (*b*) no detectable change in these positions occurs after formation, unless potentially complete terminalization is also present.

Incompatibility in Cosmos

T. M. Little, J. H. Kantor and B. A. Robinson (*Genetics*, **25**, 150–156; 1940) show that *Cosmos bifurcatus* is completely self-sterile. As the result of intercrossing 25 plants they have found three intra-sterile interfertile groups with indications of two further groups. The behaviour is accounted for on East's hypothesis of incompatibility factors. The genetic constitution of the three groups is s_1s_3, s_1s_2, s_2s_3, while a further group contains s_4.

Pollination in Maize

MANGELSDORF had found that a gene sp_1 gives rise to small pollen grains. Only about 1 per cent of these achieve fertilization in competition with normal-sized pollen grains, but are fully functional when the normal pollen is eliminated by screening through sieves. W. R. Singleton (*Proc. Nat. Acad. Sci.*, **26**, 102–104; 1940) found that when the maize strains Purdue 39 and Connecticut 81 were crossed with heterozygous $SuSp_1/susp_1$ plants, 39 per cent and 17 per cent *su* seeds were produced although the cross-over percentage between *su* and sp_1 is 6. Further breeding confirmed that in these crosses the small pollen grains carrying sp_1 had functioned. The inbred strains Purdue 39 and Connecticut 81 have greatly increased the functioning of the small pollen grains. The reasons are unknown.

Earthquakes of Missouri

ROSS R. HEINRICH has examined lists of earthquakes of Missouri and states that most of these earthquakes originate in more or less definite seismic districts (*Trans. Amer. Geophys. Union*, 1938). Six such districts are suggested for Missouri; they are the New Madrid, St. Mary's, St. Louis, Hannibal, Springfield, and north-west Missouri seismic districts. Some of the earthquakes which have been felt in Missouri have apparently originated in seismic areas outside the State boundaries. Four such are the Centralia and Harrisburg districts in Illinois, the Anna district in Ohio, and the Kansas-Nebraska Nemaha Belt. About 85 per cent of all the seismicity of Missouri origin comes from two seismic areas; about 60 per cent from the New Madrid area, and about 25 per cent from the St. Mary's Fault Region. A tabulation of the earthquakes by intensities indicates that most of the activity of strong intensities also seems to originate in the south-eastern Missouri area, although only about $7\frac{1}{2}$ per cent of the total earthquakes recorded since the New Madrid series have been strong enough to endanger life.

Ionization Constants of Weak Acids

A NEW method of calculating ionization constants of weak acids from conductance (Λ) measurements (B. Saxton and L. S. Darken, *J. Amer. Chem. Soc.*, **62**, 846; 1940) depends on the following procedure. The degree of dissociation is $\alpha = \Lambda/\Lambda_\infty$, where Λ_∞ = conductance of completely dissociated acid at the same ionic concentration. Then $k = \alpha^2 c/(1-\alpha) = c_i^2/c_u$, where k is the mass action constant, c is total concentration, c_i and c_u are ionic concentration and concentration of undissociated acid. Now $\gamma^2 k = K$, where γ is mean ionic activity coefficient and K is thermodynamic equilibrium constant. The Debye–Hückel equation gives $\log \gamma = -A\sqrt{c_i}$, where A is a constant. Hence $\log K = \log k - 2A\sqrt{c_i}$. K is found by extrapolating to infinite dilution a plot of $\log k - 2A\sqrt{c_i}$ against c_u, this being found empirically to be linear up to a concentration of almost 1 *m*. The values of K at 25° for cyanoacetic, formic and butyric acids are calculated.

Reality of Periodicities

THE controversy as to the reality of the periodicities found by Fourier analysis of the observations of the solar constant (Abbot, *Smithsonian Misc. Coll.*, **94**, No. 10, 1935; Paranjpe, *Quart. J. Roy. Met. Soc.*, **64**, 459, 1938; Sterne, *Proc. Nat. Acad. Sci.*, **25**, 559, 1939) has been carried a stage further by Dr. H. R. Hulme (*Observatory*, **63**, 101; 1940), who approaches the subject from the statistical point of view. Hulme develops a test which, when applied to the amplitudes found for the periodicities, decides whether or not they are small enough to have arisen from statistical fluctuations. He points out that care must be taken that the observations are independent in the sense that the value of any one is unconnected with the values of neighbouring ones; this is conspicuously not the case with the 10-day means published by Abbot. It is found that random fluctuations active for a time comparable with a quarter of the length of the period in question are quite capable of producing illusory periodicities of the amplitudes actually found by Abbot for all his periodic variations. Sterne's method of assessing the reality of the periodicities by calculating the probable errors of their amplitudes also requires independence amongst the observations for its correct application; and Hulme regards his results as indicating not that the periodicities are real but that the fluctuations persist over a number of 10-day intervals. This is physically quite understandable, and such effects can evidently produce 'periodicities' of the observed order of magnitude. It is concluded that the periodicities should not be regarded as real until the more stringent test of successful prediction has been passed.

THE ROYAL OBSERVATORY, GREENWICH

ANNUAL REPORT OF THE ASTRONOMER ROYAL

THE annual report of the work of the Royal Observatory, Greenwich for the year ending May 1, 1940, was presented by the Astronomer Royal to the Board of Visitors on June 1. The following are among the chief items of the report.

Reversible Transit Circle. The observations for providing the foundations of a system of right ascensions have been continued. More than 3,500 transits were observed during the year besides a large number of observations for determining the collimation, level and azimuth of the instrument. The level error has proved to be subject to rapid diurnal variations due to changes of temperature and direction of wind. Experiments are being made to reduce these fluctuations to a minimum. Observations for the errors of the divisions of the fixed circle are progressing; already to date some 180,000 individual microscope readings have been made.

Small Transit Instrument. A small reversible transit instrument made by Cooke, Troughton and Simms has been purchased from the Crown Agents for the Colonies. The instrument is of more modern design than the small transit instruments made in 1874 hitherto in use at the Observatory for time determinations. It is hoped that observations made on the same night with (1) the new instrument, (2) the small transit in current use, (3) the large reversible transit circle, will give useful information concerning fluctuating errors of instrumental origin.

Total Eclipse of the Sun on October 1, 1940. An expedition from Great Britain had been planned to observe this eclipse in South Africa. On the outbreak of war, the plans for the Royal Observatory expedition were cancelled, but a part of the equipment, together with spectrographic instruments from the Solar Physics Observatory, Cambridge, has been sent to South Africa for use by a combined expedition from the Royal Observatory, Cape of Good Hope, and the Union Observatory, Johannesburg.

The Greenwich Equatorials. (*a*) 28-inch refractor, (*b*) 26-inch refractor, (*c*) 36-inch reflector (Yapp). Work on both (*a*) and (*b*) ceased on September 1–2, when the object glasses of the instruments were dismounted for safety. Up to that date, however, 402 plates suitable for parallax measurements had been taken with (*b*). Work with the slit-spectrograph on the Yapp reflector has been continued, and 49 ultra-violet spectra of 35 *F* to *M*-type giant stars have been obtained to test the possibility of the presence of high-temperature companions to those stars that are spectroscopic binaries.

Observations of Eros. The discussion of the material obtained at the 1931 opposition already to hand is in progress. It is clear that the final value of the solar parallax will be nearer 8·79″ than 8·80″, the latter value being that adopted in the *Nautical Almanac* and other natural ephemerides.

Solar Observations. The downward trend of the present 11-year cycle after a very high maximum in 1937–38 seems now established, although the sun has shown considerable activity throughout the year. Three of the numerous groups of sunspots recorded equalled or exceeded 2,000 millionths of the sun's hemisphere at their maximum development. The relationship between bright chromospheric eruptions and magnetic storms has been studied at Greenwich during the past year.

Time Service. Astronomical determinations of time were made on 121 nights with the small reversible transit. Star places based on the FK3 Catalogue have been used in the reductions since January 1. The universal adoption for the time determinations of the same fundamental system of star places will make the times determined at different observatories more directly comparable than hitherto. The principle of employing a 'mean clock' has been continued. Six Shortt clocks normally comprise this mean clock.

The quartz crystal controlled oscillator clock is running satisfactorily, but with rather a large rate, and the performance is not as good as it should be. At the completion of the present run, it may be necessary to have a fresh crystal cut; and the opportunity will be taken to use a fundamental frequency of 100 kilocycles per mean solar second instead of per mean sidereal second as at present. The usual service of rhythmic time signals radiated by the Post Office has been maintained. For about two months short-wave transmission was used. The B.B.C. six dots and hourly signals for controlling the 'talking clock' have also been transmitted regularly.

Nautical Almanac Office. The work of the Office has been mainly devoted to the routine calculation and proof reading involved in the preparation and publication of (1) the *Nautical Almanac*, (2) the *Abridged Nautical Almanac*, (3) the *Air Almanac*, (4) the *Astronomical Navigation Tables*, and for the first year (5) the *Apparent Places of Fundamental Stars*. Surveying this large output of material, the report adds that the Office is now responsible annually for the calculation and publication of about 5,500 large octavo pages of figures; there is probably no other institution of similar size that approaches this output.

Magnetic and Meteorological Observations. The variations of declination, horizontal force and vertical force have been continuously recorded photographically throughout the year at Abinger, absolute observations being made every weekday. The La Cour magnetographs installed during 1937–38 continue to give very satisfactory results. During the year, 30 magnetic storms were recorded of which 7 were 'great' storms. The disturbance on March 24 ranks among the greatest storms of the past ninety years.

Routine meteorology was commenced at Greenwich on November 9, 1840, and the Meteorological Department has thus now entered the hundredth year of its existence. The mean temperature for the past year was 49·1° F. (0·4° lower than the average of seventy-five years, 1841–1915). The highest temperature in the shade was 85·2° on June 7; the lowest, 12·4°, on January 20. Temperatures of freezing point or below were recorded on 66 days, of which 27 were in January. The total rainfall was 30·23 inches, which is 5·99 inches greater than the average.

The Astronomer Royal concluded his report as follows :

"In last year's Report, reference was made to the deterioration of the conditicns for astronomical observations at Greenwich and for the urgent need for the Observatory to be removed to a site where the conditions are favourable. At the same time the increasing magnetic disturbance at Abinger caused by the development of electric traction requires the removal of the magnetic observations to a site remote from railways, if high precision in the observations is to be attained and if the Observatory is to be secure for the future against further developments in railway electrification. A number of possible sites, both for the astronomical and for the magnetic observations, were examined during the year. The further consideration of the plans for the removal to new sites of the astronomical and magnetic observations has necessarily had to be deferred until after the conclusion of the War.

"The further improvement in accuracy of the time service provided by the Observatory has been under consideration. For purposes where high precision is needed, corrections to the time signals are published at approximately monthly intervals, after the errors of the mean clock have been satisfactorily determined from a large number of observations. The great developments in recent years in precision frequency standards and in their use have created a need, which is extending rapidly, for time signals of such precision that an interval of 24 hours can be measured to an accuracy of one thousandth of a second, without the application of corrections published after a considerable interval. This precision is not attainable with pendulum clocks, which are less accurate than the precision frequency standards themselves. The installation of a battery of quartz crystal oscillator clocks of the highest precision is required, in order that the frequency stability of modern frequency standards may be satisfactorily controlled. Conferences on this subject have been held with the Radio Section of the General Post Office and the Research Department of the British Broadcasting Corporation. The help and collaboration of these bodies and also of the National Physical Laboratory are greatly appreciated and should go far towards enabling a satisfactory scheme to be drawn up."

THE PHYLOGENY OF MAN

PROF. W. E. LE GROS CLARK, discussing recent additions to evidence bearing on the phylogeny of man (*Biol. Reviews*, **15**, 2, 1940), begins by passing in review the fossil man-like apes, commencing with the Eocene Tarsioids and the Anthropoidea, of which the earliest representative is Parapithecus from the Oligocene of Egypt. It has now become evident that at the beginning of the Miocene the main groups of the anthropoid apes which exist to-day were already undergoing separately their evolutionary definition. It is probable that the human line of descent became first differentiated at this period and that the initial appearance of the Hominidæ is to be sought in the palæontological records of this period.

The evidence for the fossil man-like apes, the Dryopithecidæ, though widespread, consists almost entirely of teeth. Nevertheless, it points to the existence of some twenty to thirty different species, indicating that differentiation from generalized ancestors had already begun. Some of these species already show marked resemblance in dentition to man, while others approximate to the orang. In the Brahmapithecus and Ramapithecus discovered in India the resemblance to man is even more emphatically marked—so much so, indeed, that question has been raised as to the propriety of including Ramapithecus in the Simiidæ rather than the Hominidæ. A comparison with the Pleistocene apes of South Africa, of which portions of the skull are available, leaves no doubt as to their Simian status.

The evidence relating to the Miocene apes, then, suggests that they may have included among their number the direct ancestry of man. The only evidence apart from teeth, relating to the Dryopithecine groups, consists of a femur and shaft of a humerus of somewhat uncertain identification. If as is probable they are to be accepted as belonging to Dryopithecus they suggest that Dryopithecus was a 'ground-ape'; and there is every reason to believe that the human line took its origin from a form adapted to a terrestrial life.

Of the extinct man-like fossil apes of South Africa, while there can be no reasonable doubt of the human characters of the milk dentition and palate of Australopithecus, the main difficulty of interpretation lies in the attempt to assess the characters of the adult from an immature individual. Of the recently discovered Paranthropus and Plesianthropus of R. Broom it may be accepted as an established fact that the teeth and palate in several respects are more human than those of any of the living anthropoid apes. The geological and faunal evidence alike debar them as too recent to stand in the direct line of human descent, but on the view that they derive from a dryopithecid ancestry of Miocene date, they support the conclusion that the dryopithecid stock was endowed with a potentiality of evolutionary development in the direction of the Hominidæ so far as teeth and palate are concerned.

Turning to the ape-like men, the recently discovered examples of Pithecanthropus, and especially the early infantile skull from Modjokerto, with which are here included the fossils from Choukoutien referred to the genus Sinanthropus, have served to confirm the Hominid status of the Pithecanthropus group. Despite many primitive features of the skull, brain and dentition, the limb bones are closely comparable with those of modern man. If the modern characters of the human limbs had already been acquired so early as the beginning of Pleistocene times, the point of divergence of the Hominidæ from the Simiidæ must have been correspondingly more remote.

The evolutionary origin of the Pithecanthropus group is entirely conjectural. Presumably it is derived from a dryopithecine ancestry; but here there is a conspicuous gap in the palæontological record.

In the classical examples of Neanderthal man, the skeleton shows the development of a number of somewhat specialized characters from which it is inferred that the type could scarcely have given rise to *Homo sapiens*. As no transition types of later date have been found, it is legitimate to assume that Neanderthal man became extinct. It is significant that typical Neanderthal forms belong to the later phase of the period, whereas the remains belonging to the earlier part of the Mousterian epoch, such as, for example, those found at Krapina in Croatia, are less typically Neanderthaloid. This agrees with the occurrence of pre-Mousterian types (for example, Ehringsdorf, Steinheim, Swanscombe) which show a close resemblance to *Homo sapiens*. There can be little doubt that they were the precursors of modern man.

The Pithecanthropus group then almost certainly provided the basis for the development of later types of man. Of these, one is represented by the rather specialized Neanderthal type of later Mousterian date—an aberrant line—and a second by types of early Mousterian and pre-Mousterian date which were less distinctively Neanderthaloid and more akin in their anatomical features to *Homo sapiens*.

DEVELOPMENTS IN ELECTRIC SURGE RECORDING

IN 1933 a considerable amount of investigation had already taken place, chiefly outside Great Britain, with the view of determining, by means of special devices called klydonographs, the effects of lightning discharges upon overhead lines. The klydonograph is an instrument in which an electric discharge takes place on to a photographic plate or film, the resulting impression affording a record of the characteristics of the discharge. The advent of the National Grid in Great Britain stimulated interest in the subject. Whilst it was seen that the published information from various countries could be usefully applied, it was also realized that, as the results were dependent on so many variables, this needed great care, and that a similar and independent investigation could with advantage be carried out in Britain.

This was undertaken by the British Electrical and Allied Industries Research Association, with the co-operation of the Central Electricity Board and the Yorkshire Electric Power Company. The complete investigation included the use of a high-voltage cathode ray oscillograph and magnetic links in addition in continuously recording klydonographs, but only the last mentioned are to be considered here. It was agreed that these instruments could not be regarded as accurate peak surge voltmeters, but that they were capable of indicating the approximate magnitudes, polarities and times of occurrence of voltage surges.

The investigation was begun in 1933, on an 11 kv. line owned by the Yorkshire Electric Power Co. Three klydonographs were coupled to the line by means of concentric-cylinder type capacitance 'potential-dividers'. It was soon found out that the klydonographs were not suitable for unattended use, and new ones containing many improvements were developed. Progressive elimination of defects resulted in trustworthy and satisfactory operation by May 1937, since when no noteworthy trouble has been experienced.

On April 5 J. L. Candler read a paper before the Institution of Electrical Engineers on developments in surge recording by means of the klydonograph. This paper is based on the E.R.A. report Ref. S/T 26, and is mainly concerned with the instruments and their auxiliaries. The principle of operation of the klydonograph is fairly simple. A high-voltage electrode is placed in front of and touching a photographic film. The momentary application of a high voltage across the electrode will produce a distinctive figure on the film after development. This figure is known as a photographic Lichtenburg figure or klydonogram, and from its size and type certain features of the voltage causing it can be deduced. By causing the film to slide between the electrodes at a known rate, the time of occurrence of the surge can be estimated. Generally two films and two pairs of electrodes are used. By comparing the two concurrent figures the polarity of the voltage producing them is definitely determined.

The complete instrument consists essentially of three parts: (1) a light-proof box containing the spools of unused films, the electrode system and the feed-control sprocket wheels; (2) a smaller light-proof box, containing spools on to which the used film is wound; and (3) a compartment containing two clock-work motors. Hundred foot reels of 35 mm. film are used and the travel rate is 1 inch an hour. Thus the films last for about seven weeks, but provision is made for cutting off the used film when desired, and two interchangeable take-up boxes are provided for each instrument.

In the latest type many improvements have been introduced and little trouble is now experienced. It is essential that in making tests on klydonographs the conditions should stimulate practical conditions as nearly as possible. For this reason a test hut was erected in the field behind the laboratory building. The requisite voltage is applied by a transformer either directly or through the potential divider. Experience since 1937 indicates that mechanically the devices have attained a very high standard of perfection, and that electrically the performance cannot be improved further with this type of instrument.

No surges considered to be due to lightning were recorded on the Rayleigh-Southend line, on the lines in South Scotland or at the (G.E.B.) Creekmouth transforming station. Recording on the Rotherham–Doncaster line and the Thornhill–Barugh line each yielded fifteen. Surges due to switching were numerous, but they are usually uni-directional and are approximately equally divided between the two polarities and limited to not more than twice the normal voltage.

MECHANISM OF PHOTOSYNTHESIS

IN a recent article (*New Phytol.*, **39**, 33; 1940) K. Wohl has presented a notable addition to the literature on the kinetics of photosynthesis in green plants, in which a model is put forward based largely on the results of Emerson, Warburg, and their collaborators. Assuming that the light-sensitive reaction requires 4 quanta/mol. carbon dioxide, as first demonstrated by Warburg and Negelein, the author suggests the following type of reaction:

$$X_0 \xrightarrow{h\nu} X_1 \xrightarrow{h\nu} X_2 \xrightarrow{h\nu} X_3 \xrightarrow{h\nu} X_4 \xrightarrow[+H_2O + CO_2]{-O_2-CH_2O} X_0 \quad . \quad (1)$$

Recent work on quantum efficiency is later reviewed in the paper. The high value of this efficiency and the shape of the rate/light-intensity curve indicate that none of the intermediate photoproducts is lost and that X_4 is also produced in an irreversible way. The carbon dioxide is therefore considered attached to a 'reducing centre' which is coupled, in an energetic respect, to a number of chlorophyll molecules. Absorbed quanta may then pass to the reducing centre which, together with its associated chlorophyll, may be referred to as a *functional* photosynthetic unit. Considerations are put forward which support the existence of such a unit, and a comparison is made with the *numerical* unit of Emerson and Arnold. Figures are presented both for the *functional* and the *numerical* units in a number of plants, calculated from experiments in continuous and in flashing light, and both kinetic and optical models are set up.

As regards the sequence of events figured in (1), experiments in flashing light indicate that the four light processes occur successively with no prolonged dark reaction between. The Blackman reaction $X_4 \rightarrow X_0$, unlike most physiological reactions, deviates widely from the simple Arrhenius reaction. One explanation is that the Blackman reaction occurs in a number of steps of reaction time τ_1, τ_2, τ_3. . . . Taking two reactions only, for simplicity, τ_1 is shown to belong to a reaction of high activation energy and is several orders of magnitude smaller than τ_2 which is coupled to a low activation energy. The two reactions are therefore of entirely different types. From the calculated values of $\tau_1^{(0)}$ and $\tau_2^{(0)}$ (hypothetical reaction times at infinitely high temperatures) the author shows that τ_1 relates to a monomolecular reaction and τ_2 to a bimolecular. The calculated value $1/\tau_1^{(0)}$ surpasses the theoretical figure even for a monomolecular reaction. This is accounted for by the introduction of an entropy factor $T\Delta S$, replacing the activation energy A_1 by the free energy $A_1 - T\Delta S$ in Arrhenius's equation. This gives a figure of the correct order of magnitude only if a considerable number of atomic bonds are broken during the reaction period τ_1.

It is suggested that at least six such breakages occur and that the six CH_2O groups produced combine immediately to, for example, a hexose. These six groups must be produced successively at the same reducing centre, and photosynthesis would then be a 24-quanta process. The bimolecular reaction is taken to be the formation of an oxygen molecule. Ninety-three references are given.

RAIN FOREST OF SOUTHERN NIGERIA

DR. P. W. RICHARDS, of the Botany School, Cambridge, in a recent paper, states that it forms the first part of the results of the Cambridge Botanical Expedition to Nigeria and it aims at being a description of a typical region of the West African Rain Forest—a chief object being to compare the rain forest of this area with those previously studied in British Guiana and Sarawak ("Ecological Studies on the Rain Forest of Southern Nigeria". (1) "The Structure and Floristic Composition of the Primary Forest", *J. Ecology*, **27**, 1; Feb. 1939. Univ. Press, Cambridge). The reasons for making such a comparison are not stated. The author states on more than one occasion that "the Rain Forest of the whole of South-Western Nigeria is situated near its climatic limits".

Discussing the remarkable uniformity of the forest attributed by Mildbraed to the great climatic changes the region has suffered in the past, causing great migrations of floras and levelling local peculiarities, the author says: "if this is so, it is easy to understand why regions on the extreme edge of the Rain Forest Area, such as South-Western Nigeria, should show a marked poverty in species". This insistence by the author is curious. Perhaps it is based on his statement that "it is generally admitted that the Cameroons is one of the richest regions of the African Rain Forest and is probably to be regarded as the chief centre of evolution of the Rain Forest flora". Yet the rain forest belt stretches to the west of Nigeria through the Gold Coast and through the French Ivory Coast, where it occupies extensive areas; which, in some parts, are claimed to be as fine examples and to produce as large a percentage of high-quality timber—mahoganies and so forth—as any other portion of the belt on the Coast.

The main differences in the author's comparison of the south-western Nigerian forest with that of British Guiana and Sarawak are: (1) that the first and second tree stories in Nigeria are more open, whilst the largest proportion of the third story is true third-story species; (2) the relative floristic poverty of the Nigerian forest; this poverty applying to all three stories of trees, to the shrub and herb layers, and to the climbers and epiphytes. In respect of single species dominance, the author considers the Nigerian rain forest as intermediate between British Guiana and Sarawak. Dr. Richards is of opinion that (1) and (2) above may be due to unfavourable climatic conditions, though with reference to (1) he quite correctly adds "though it is impossible to exclude human interference as a possible cause".

SEVENTY YEARS AGO

NATURE, vol. 2, June 23, 1870

The Unit of Length

"The battle of the Standards is over, and we may say the Metre has gained the victory. The need of a new system of weights and measures to amend the strange diversities which disfigure our practice being admitted, the question has once more been started—Should we once for all found our system on a natural basis ?" The seconds pendulum had been suggested but dismissed on account of the difficulty of ascertaining the real length of a normal pendulum. The advocates of the metre admit that greater accuracy is obtainable than that achieved by the French philosophers at the end of the eighteenth century, but point out that it is already a cosmopolitan unit, widely recognized, and in general use among many nations. Any slight error in its determination is more than counterbalanced by the extreme simplicity, symmetry and convenience of the metric system.

A Royal Commission which has considered the introduction of the metric system in Great Britain has recommended its legalization. "Since the complete substitution of the metric for the present practice is now practically certain, would it not be much better to prepare for the change and carry it into effect as speedily as possible ?"

Advertising

"WE have just seen a bill-head or order to which we think it necessary to call attention. On a scroll at the top is a name which, together with the address, which is on another scroll, we suppress. . . . In the centre is a coat of arms and crest surrounded by a garter, on which is printed *Fellow of the Chemical Society, London*. We have no wish to infer that this gentleman is not a most eminent chemist, but we do most emphatically protest against the membership of a learned society being turned to account for advertising purposes."

Museums of Natural History

"THERE is no doubt of the popularity of museums of natural history with the lower classes. That it is otherwise with more educated people is perhaps attributable to the fact that hardly any scientific knowledge is to be gained by a cursory inspection of crowded collections arranged with reference to economy of space rather than to the existing conditions of zoological science. It must not be forgotten that the sentiment of mere wonder . . . was satisfied, or at least blunted, in early childhood, in the case of those of us who have had access to well-illustrated books, and to the zoological gardens of great cities."

THE indifference of agriculturists to scientific research has been illustrated by the refusal of the Council of the Royal Agricultural Society to publish an account of the investigations which have established the truth of the old bucolic dogma, that berberries produce rust on wheat growing in their vicinity. There is now no doubt that the berberry-rust and the wheat-rust are two different stages in the genetic cycle of *Puccinia graminis*.

FORTHCOMING EVENTS

Monday, June 24

ROYAL GEOGRAPHICAL SOCIETY, at 3 p.m.—Annual General Meeting.

Tuesday, June 25

ROYAL ANTHROPOLOGICAL INSTITUTE, at 5 p.m.—Annual General Meeting.

Prof. A. R. Radcliffe Brown : "On Social Structure" (Presidential Address).

AUSTRIAN ACADEMY IN GREAT BRITAIN, at 5 p.m.—Prof. Dr. Max Neuburger : "The Contribution of the Vienna Medical School to Medical Science".

Friday, June 28

ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX (in the Lecture Hall of the Science Museum, South Kensington), at 5 p.m.—Miss E. W. Parker : "The ASLIB Register of Technical House Journals".

APPOINTMENTS VACANT

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

HEAD OF THE ENGINEERING DEPARTMENT of the Burnley Municipal College—The Director of Education, Education Offices, Burnley (June 26).

DIRECTOR OF EDUCATION for the Borough of Hyde—The Director of Education, Education Office, Union Street, Hyde (June 27).

LECTURER IN CHEMISTRY at the Rutherford Technical College, Newcastle-upon-Tyne—The Director of Education, City Education Office, Northumberland Road, Newcastle-upon-Tyne 2 (June 29).

EDUCATION OFFICER to the Community Service Council for Durham County, Ltd.—The Director, Hallgarth House, Durham (June 29).

ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Manchester 13 (June 30).

CHEMIST AND BACTERIOLOGIST to the Borough of Chelmsford Water Undertaking—The Town Clerk, Municipal Offices, Rainsford House, Chelmsford (endorsed 'Chemist and Bacteriologist') (July 1).

LECTURERS IN AGRICULTURE (two required)—Sudan Government London Office, Wellington House, Buckingham Gate, London, S.W.1 (quoting "Lecturer in Agriculture") (July 8).

COMMISSIONED ORDNANCE MECHANICAL ENGINEERS in the Indian Army Ordnance Corps—The Secretary, Military Department, India Office, London, S.W.1 (quoting "Ordnance Recruitment") (July 8).

TWO TEACHERS (men) OF ENGINEERING SUBJECTS—The Principal, South Dorset Technical College, Newstead Road, Weymouth (July 27).

ASSISTANT LECTURER FOR MINING—The Principal, County Secondary School and Cumberland Technical College, Workington.

REPORTS AND OTHER PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Empire Cotton Growing Corporation. Report of the Administrative Council of the Corporation submitted to the Nineteenth Annual General Meeting on May 28th, 1940. Pp. ii+46. (London : Empire Cotton Growing Corporation.) [305

Imperial Agricultural Bureaux. Joint Publication No. 3 : The Breeding of Herbage Plants in Scandinavia and Finland. Pp. 124. (Aberystwyth : Imperial Bureau of Pastures and Forage Crops ; Cambridge : Imperial Bureau of Plant Breeding and Genetics.) 4*s*. [305

Other Countries

Canada : Department of Mines and Resources : Mines and Geology Branch, Bureau of Mines. Comparative Tests of various Fuels when burned in a Domestic Hot-Water Boiler, 1925 to 1938. By C. E. Baltzer and E. S. Malloch. (No. 802.) Pp. v+23. (Ottawa : King's Printer.) 25 cents. [305

Newfoundland Government : Department of Natural Resources. Research Bulletin No. 7 : Investigations into the Life History of the Lobster (*Homarus americanus*) on the West Coast of Newfoundland, 1938. By Dr. W. Templeman. Pp. 52. (St. John's : Department of Natural Resources.) 20 cents. [305

Information

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(Professor J. Kenner, D.Sc., Ph.D., F.R.S.)

TEXTILE CHEMISTRY (Bleaching, Dyeing, Printing and Finishing; Paper Manufacture)
(F. Scholefield, M.Sc., F.I.C., F.T.I.)

TEXTILE TECHNOLOGY
(Professor W. E. Morton, M.Sc.Tech., F.T.I.)

BUILDING
(W. B. McKAY, M.Sc.Tech., M.I.Struct.E.)

INDUSTRIAL ADMINISTRATION (Post Graduate Certificate Course)
(K. G. Fenelon, M.A., Ph.D.)

The prospectuses of Part-time Courses give particulars of evening courses in Engineering, Mathematics, and Physics, leading to the external degrees of London University in Engineering and Science.

MATHEMATICS DEPARTMENT
(F. Bowman, M.A., M.Sc.Tech.)

PHYSICS DEPARTMENT
(W. H. Taylor, Ph.D., D.Sc.)

Prospectuses will be forwarded on application to the Registrar, College of Technology, Manchester, 1.

UNIVERSITY COLLEGE OF SWANSEA

(A CONSTITUENT COLLEGE OF THE UNIVERSITY OF WALES)

Principal: C. A. EDWARDS, D.Sc., F.R.S.

The twenty-first Session will open on October 1, 1940.

Courses of study are provided for—

(*a*) Degrees of the University of Wales in Arts, in Pure Science and in Applied Science (Metallurgy, Engineering and Metallurgical Engineering);

(*b*) Diplomas of the College in Metallurgy and in Engineering;

(*c*) The training of teachers for elementary and secondary schools;

(*d*) The first medical examination of the University of Wales

College courses in Pure Science are recognized by a number of medical licensing bodies as constituting a first year of medical study.

Persons who are not desirous of studying for degrees or diplomas may attend selected classes, provided they satisfy the authorities of the College that they are qualified to benefit by such classes.

Entrance scholarships are offered for competition in April of each year.

Particulars concerning admission to the College and of the entrance scholarships may be obtained from the undersigned.

Singleton Park, Swansea. EDWIN DREW, *Registrar.*

SUDAN GOVERNMENT

Two vacancies exist in the Department of Agriculture and Forests for two men who for the first few years are required as LECTURERS in the SCHOOL OF AGRICULTURE, four miles outside Khartoum, and who later might transfer to the Inspectorate staff of the Department.

They would be required to lecture in general agricultural subjects and might be called upon to perform any duties that accord with their qualifications. The preparation of suitable courses will involve some investigational work. A specialized knowledge of Agricultural Zoology, more particularly Entomology, would be an additional qualification for one of these posts and might result in appointment to the School as Lecturer in Agricultural Zoology at a salary rising to £E.1,080.

Candidates should be under the age of 27 and unmarried. The starting rate of pay is £E.480 per annum, rising to £E.936 after fifteen years' service. There are several posts in the Department with maxima up to £E.1,400, to which competition for promotion is possible. (£E.1=£1 0s. 6d.) After a probationary period the posts would be pensionable. 90 days' annual leave is normally granted.

The posts are to be filled between September 1940 and the end of 1941.

Application forms and further particulars of the conditions of service may be obtained from the Controller, Sudan Government London Office, Wellington House, Buckingham Gate, London, S.W.1, to whom applications should be submitted not later than July 8, 1940. Envelopes should be marked "Lecturer in Agriculture."

GOVERNMENT OF INDIA

Applications are invited for the appointment of Principal of the proposed Technical Institute at Delhi.

Candidates must be male British subjects, aged not more than 45 years on September 1, 1940, and must have a good honours degree in applied science or a technological subject (preferably engineering). Sound workshop training, experience in a British Technical College and of a Junior Technical School or Technical High School, and powers of initiative, organization and disciplinary control are essential.

Agreement for five years in first instance (including one year's probation). Pay Rs. 800 rising by annual increments of Rs. 40 to Rs. 1,000 a calendar month (Rupee=1s. 6d. approx.), plus Overseas Pay of £20 a month for an appointee of Non-Asiatic domicile, who will also be given free passage to India and return passage on satisfactory completion of agreement. Provident Fund.

Further particulars and forms of application may be obtained on request by postcard, quoting Appointment 1/11G, from the High Commissioner for India, General Department, India House, Aldwych, London, W.C.2. Last date for receipt of completed applications June 29, 1940.

NEWCASTLE-UPON-TYNE EDUCATION COMMITTEE

RUTHERFORD TECHNICAL COLLEGE

Principal: H. A. SCARBOROUGH, M.A., D.Sc.

Wanted, for September 1940, a Lecturer in Chemistry. Candidates should have a good honours degree, together with industrial and teaching experience with a bias towards Physical Chemistry.

Salary in accordance with the Burnham Technical Scale.

Forms of application, which will be sent on receipt of a stamped, addressed foolscap envelope, should be returned to the undersigned not later than Saturday, June 29, 1940.

THOS. WALLING,
Director of Education.

City Education Office,
Northumberland Road,
Newcastle-upon-Tyne, 2.

THE UNIVERSITY OF MANCHESTER

Applications are invited for the post of ASSISTANT LECTURER IN ENGINEERING (MECHANICAL). Stipend £300 per annum. Duties to commence September 29, 1940. Applications must be sent, not later than July 13, 1940, to the Registrar, The University, Manchester, 13, from whom further particulars may be obtained.

THE UNIVERSITY OF MANCHESTER

Applications are invited for the post of ASSISTANT LECTURER IN BOTANY. Stipend £300 per annum. Duties to commence September 29, 1940. Applications must be sent, not later than July 6, to the Registrar, The University, Manchester, 13, from whom further particulars may be obtained.

MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM
The Laboratory, Plymouth

The following animals can always be supplied, either living or preserved, by the best methods:

Sycon; Clava; Obelia; Sertularia; Actinia, Tealia, Caryophyllia, Alcyonium; Pleurobrachia (preserved); Leptoplana; Lineus, Amphiporus, Nereis, Aphrodite, Arenicola, Lanice, Terebella; Lepas, Balanus, Gammarus, Ligia Mysis, Nebalia, Carcinus; Patella, Buccinum, Eledone, Pectens, Bugula, Crisia, Pedicellina, Holothuria, Asterias, Echinus, Salpa (preserved), Scyllium, Raia, etc.

For prices and more detailed lists apply to:
Biological Laboratory, Plymouth. THE DIRECTOR.

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