SUPPLEMENT : RECENT SCIENTIFIC and TECHNICAL BOOKS

NATURE

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

Vol. 153, No. 3895 SATURDAY, JUNE 24, 1944 ONE SHILLING & SIXPENCE

NATURE

No. 3895 SATURDAY, JUNE 24, 1944 Vol. 153

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ST. MARTIN'S STREET, LONDON, W.C.2.
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Telegrams : Phusis Lesquare London
Advertisements should be addressed to
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone : Temple Bar 1942
The annual subscription rate is £4 10 0, payable in advance, Inland or Abroad.

TRAINING OF METALLURGISTS

A CONSIDERABLE amount of attention is being given at the present time to the general problems of education and training in Great Britain, and various groups such as the physicists, chemists, etc., have been reviewing existing arrangements for their professions. Recently, the subject of the supply, training and status of metallurgists has been examined by the Council of the Iron and Steel Institute, and a report giving its conclusions has been issued*. Although the Iron and Steel Institute as a body is primarily concerned with ferrous metallurgy, many of the recommendations given in the report will be found to apply to metallurgists destined for the non-ferrous industry. The report is a comprehensive one, and will be of value to all those concerned with the recruitment of metallurgists and with their employment in industry.

A severe shortage of trained metallurgists is expected at the end of the War. Various factors have contributed to this. The science of metallurgy is relatively new ; one may recall that the primary principles involved in the heat-treatment of carbon steels were still a subject of debate at the close of the War of 1914–18, and it is only during the period between the Wars that the metallurgist, as distinct from the chemist, has won real status in industry. Coupled with this possible lack of appreciation, both the demand and the supply has been limited by the severe depressions to which the industry has been subjected. Meanwhile, great progress has been made in steel-making processes, in the development of new and stronger materials, etc., and changes in technique which involve the employment of more highly trained metallurgists. It is envisaged that continued technical development will be necessary if British industry is to thrive in the highly competitive markets of the post-war period, and thus a still higher proportion of trained men will be required.

To cope with the expected shortage, the following steps are recommended to stimulate recruitment : direct contact with schools, attractive initial salaries, good prospects, etc. It is surprising how little information the average schoolboy receives which in any way interests him in metallurgy, and consequently, except for the districts where metallurgical industries are located, a metallurgical career seldom receives consideration. Publicity of the right type will undoubtedly cure this ; but to produce permanent effects, remuneration and prospects will be expected comparable with those in other professions, and adequate to eliminate concern regarding the violent depressions suffered periodically by the industry.

The report considers the training of personnel under three main headings : university training, education below university standard, and adult training. For the university trained man, it recommends that the degree course should be divided into two parts. The first should be directed to higher study of the basic scientific subjects, physics,

* The Training of Metallurgists, with Special Reference to the Iron and Steel Industries. Pp. 32. (Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1, 1944.) 2*s*. 6*d*.

chemistry, some mathematics, and engineering, and the second to a continuance of study in these fields and to the particular study of metallurgy. This emphasis on a high standard in the basic sciences will no doubt be given appropriate consideration by the university authorities. Great importance is attached to early experience of industrial operations during a university career, and it is suggested that works courses during vacation should form part of every university course. Careful consideration will need to be given to the extent to which such courses can be instituted without leading to 'over training' of the undergraduate.

For the training of process metallurgists, the report concludes that existing facilities are inadequate; and it is suggested that Great Britain should legislate for training many of the men needed to develop our Empire resources. The primary metal-producing industries throughout the British Empire form a large potential market for British manufactured products, and the development and sale of such products will be facilitated if the personnel in control are British trained.

Once in the works, the training of a graduate should be continued for some years, through arrangements which permit him to work for periods in all the various departments in which he may be particularly interested. This will increase his experience, give him a grounding in the internal administration and enable his employers to form a good idea of any special aptitude he may have. Such training schemes are in progress in some of the larger organizations and are successful. Perhaps insufficient attention has been paid in the past to the latent possibilities in new employees; thus it sometimes happens that a man is taken on for a specific job, and although he may turn out ultimately to be not specially suited for the particular work concerned, he has to continue with it; in large organizations there are much greater possibilities for manœuvre in such matters. Employers are recommended to encourage their men to write papers, to join in discussions and pay visits, and generally to participate in the professional activities associated with their particular branch of industry. For the keen man such facilities are well worth while, since they lead to rapid development of a sound critical faculty.

The importance of postgraduate education is not sufficiently emphasized in the report. The report indeed urges the need for improved facilities, and suggests that each university should specialize in some subject appropriate to the local industry. Postgraduate research is likely to be more productive for the individual if it is carried out where there is an active 'school' of research. Under such conditions a man, merely by keeping in touch with his fellows, can get a wide knowledge of research methods, etc., in a very short time. Again, it is essential that the professor should be keenly interested in research and not weighed down with administrative duties and normal teaching. The whole subject of postgraduate research needs reviewing by the authorities, to ensure that research facilities and atmosphere are really satisfactory.

Many of the recruits to industry come direct from school, and will no doubt continue to do so for some time. Their subsequent education takes the form of part-time courses or evening classes, and suggestions for improvement are made, including the institution of courses leading to the award of a national certificate in metallurgy. Such an award would be a desirable objective for the student, and a useful qualification to the employer. The report suggests that industry should encourage part-time education and limit the attendance necessary at evening schools to the absolute minimum.

The position with regard to part-time training should be simplified when the proposal is implemented that all persons who show sufficient ability at school should automatically receive a university training. Then the amount and type of training appropriate to the remainder will be more limited in scope than at present, and may conceivably be carried out by the envisaged young people's colleges or similar institutions. It is most desirable that men with first-class ability should be saved from the onerous task of educating themselves through evening classes and of suffering from "an impoverishment of initiative and intellectual quality at a period of life critical for the full development of the powers and capacities of the individual"*. In the meantime, a broadminded attitude from industry and close collaboration with the universities and technical colleges are necessary to achieve the best results from the promising material that enters industry direct from school.

On the question of adult education, the report mentions the need for refresher courses on specialized subjects for managers and staff, and refers to short courses to be held at universities with residential facilities. The Bristol conferences on metals and the Cambridge crystallographic conferences are successful examples of such meetings held by physicists. Interchange of senior staff between university and industry is considered to be very beneficial; but no practical methods for achieving such an interchange have yet been put forward. There are obvious difficulties, and various substitutes, such as interchange lectures and visits, probably represent the extent to which such suggestions can be implemented.

The training of workmen either for posts of higher responsibility or to give them better insight into their normal work is considered, and reference made to the outstanding success of the educational efforts of the Sheffield Trades Technical Societies. This organization works in the closest co-operation with the University of Sheffield, where lecture courses are provided "to enable workers to study the commercial and technical side of their work and to receive the latest scientific information which may be applied to their trade". Similar organizations might well be set up in other large manufacturing centres.

Satisfactory operation of all these educational schemes depends to a very large extent on the existence of the requisite number of able teachers; and, especially in the case of part-time courses and

* See p. 8 of "Industry and Education—a Statement". From Nuffield College. (Oxford University Press, London, 1943.)

evening classes, teachers are required who can make their subject interesting. The report directs attention to an existing shortage of teachers, and suggests that both remuneration and status should be raised so that more men will become available.

Very little advice is offered regarding the selection of men to be trained. This subject should be given serious consideration. All will agree that educational arrangements should be such that every person has facilities readily available appropriate to his abilities. On the other hand, efforts made to train people beyond their capabilities are largely wasted. Many evening school candidates probably fall into this category, and some attempt should be made by means of psychological tests to restrict facilities in technical training to those persons who can benefit.

EDUCATION AND THE WORLD STATE

The World We Mean to Make

And the Part of Education in Making It. By Maxwell Garnett. Pp. 264. (London : Faber and Faber, Ltd., 1943.) 10*s*. 6*d*. net.

IN times of comparatively rapid social change, there tends to be more thinking about education than in periods of comparative quiescence. Those who seek to control the development of society, in whatever aspect of it they are interested, are apt at some stage in their thinking to see in education one of the main forces which can bring about the conditions they desire. This is natural, for one of the chief functions of education is to transmit to the young what the older members of society most value in their culture, as the basis of the new world in which the young will live. Dr. Maxwell Garnett is concerned with the world "during the next two generations", and he adopts Mr. R. A. Butler's dictum that "education is the main arm with which to win the next peace".

Dr. Garnett has a plan for education in England ; but to add another to the many plans which have been published during the last few years is not the primary purpose of his book. It has been a weakness of recent planning in education that the aims of education have not usually been thought about enough or expressed explicitly enough, and with the ends obscure it has been difficult to evaluate the means proposed. It is a great merit of Dr. Garnett's book that he presents a reasoned statement of the functions and processes of education as he sees them. His aims in education are an integral part of a philosophy, and the means he proposes take cognizance of political and social trends and the evidence of psychology. Not all will agree with his philosophy or with his view of the facts, but they do constitute reasoned position which is both tenable and arguable.

A few sentences may summarize Dr. Garnett's position, though it cannot do justice to the wide range of his information and his thinking. The War should be followed by a general settlement, based upon the Atlantic Charter and President Roosevelt's four freedoms, which should bring into being an international authority, the Commonwealth of United Nations. This Society of States should promote human welfare, and should maintain the rule of right by administering international law. It should have at its command the sanction of armed force. But the Commonwealth cannot be maintained merely by the fear of power : it must depend on the enlightened loyalty of its citizens and their will to serve its purposes. Enlightenment by itself will not serve : " 'The mere intellect', wrote Aristotle, 'has no motive power' ". Free will, "something from outside space and time", "a spirit which can alter the course of our lives", will play its part, but since such interventions are comparatively rare events we cannot rely too heavily on them. We must in the main depend on the development of a 'sentiment' of loyalty to the Commonwealth as the single wide interest which will move men to act in the ways required. But are the values which the Commonwealth enshrines and which are to command our loyalty true as well as good ? They appear in our inner world, "the ordered world pictured by the man with a single wide interest", as desirable ends : does our inner world correspond with the outer world, "the world as it really is, or as it is partially known to science", so that our ends can be regarded as not only good but also true ? We do not know. We can only believe, by adopting a hypothesis "beyond the so-called 'discoveries of human reason' ", which we may find among "the essentially similar 'divine revelations' ". Most of the seven or eight great religions of the world offer the hypothesis that the supreme good is also the supreme reality. The Commonwealth, which must depend on the loyalty of its citizens, should therefore foster religious education. In Great Britain this means Christian education. The aims of education in England may be summed up as Christian faith, political loyalty and economic efficiency.

This is not a novel position. Dr. Garnett himself relates his ideal to that of Dr. Arnold a hundred years ago, to train Christian gentlemen. It is probably the position of a majority of those in Great Britain who are articulate about education. The plan for education which Dr. Garnett bases on it is accordingly not a revolutionary one. It resembles in many of its details the proposals of the Education Bill, which itself represents the highest common factor in the attitudes of those who have power to legislate for education. Dr. Garnett wants, for example, grammar schools, technical schools and modern schools, with some experiments in multilateral schooling. He finds good reasons why compulsory attendance should cease at fifteen rather than sixteen. He wants attendance at young people's colleges on one day a week. His plan need cause no alarm or despondency among the supporters of preparatory schools, public schools, direct grant schools, or the Oxford and Cambridge open scholarship system. He does not hesitate to apply to the schools the hypothesis he has adopted about religious truth. For example, "Local education authorities or managers will have to choose the head teachers of their primary schools from among those members of the profession who are zealous for Christian education". He refers, of course, to rights of conscience. "This practice should not be enforced by law. This is eminently a case for Plato's 'victory of persuasion over force' ". The appointing body would merely ask the prospective head-teacher certain questions, and "A candidate who gave no adequate answers to these questions or to others of the same sort would not be appointed as head teacher". In certain directions, such as adult education and the regional organization of educational administration, Dr.

Garnett would go further than Mr. Butler in his agreed measure has proposed to do. But in general, Mr. Butler could congratulate himself on finding respectable philosophical warrant for his Bill in Dr. Garnett's book, and Dr. Garnett could reflect with satisfaction that his theory of education is capable of translation into the realistic terms of administrative legislation. Their new education will be cast in the image of the old, but will undoubtedly be in many respects an improved version.

It is well that those who hope to fashion the shape of things to come should in this way draw on the wisdom that tradition and their own experience have given them. They cannot do more. Dr. Garnett's book, with its orderly argument and copious use of evidence, will help them to see their own way ahead. New generations, however, will have new experience and will interpret it in their own way. The world we mean to make will not necessarily be the world the next generations will see fit to make.

R. A. C. OLIVER.

UTILITARIAN ASPECTS OF GEOLOGY

Geology in the Service of Man

By Prof. W. G. Fearnsides and Dr. O. M. B. Bulman. (Pelican Books, A.128.) Pp. 158+8 plates. (Harmondsworth and New York: Penguin Books, Ltd., 1944.) 9*d*. net.

NOT so very long ago, the layman who wanted a simply written and up-to-date book on geology would have had to be content with a students' primer not altogether suitable for his needs. Now some half-dozen small volumes, written especially for him, await his choice; and among them this new "Pelican" book takes a high place. The authors have set out to show how geology has been used in the service of man—when he has been wise enough to utilize such knowledge—and have made clear their purpose in writing the book by their introductory note: "It is regrettable that more geologists have not been professionally associated with the war effort; it will be a tragedy if geological knowledge is not co-ordinated and directly applied in post-war reconstruction".

The book is divided into two parts, the earlier being a brief account of geological principles, an acquaintance with which is necessary for the appreciation of the later part, which is a review of the economic aspects of the science. In Part 1 the manner of treatment followed by the authors is what might be termed the 'classical' method; that is, it begins with the consideration of the earth as a globe, and the composition and physical properties of its core and crust, as elucidated by geophysical and chemical investigations. Whether or not this is a better approach for a layman than one which begins with the phenomena and materials around him—and therefore more or less familiar—and leads him to the less familiar and unknown is obviously a matter of opinion. In the present instance, however, the course taken lands him, in about six pages, in a discussion of stability relationships of mineral constituents that may deter him from going farther—which would be a pity since the problem cannot be treated with sufficient accuracy and detail to satisfy the critics, and since it appears that at the moment work on these lines has proved of limited value in petrology. If the reader skims this chapter and passes to those on the building of continents, the development of scenery and the geological history of Britain, he should feel well repaid by following a fascinating story simply told.

A short chapter on the nature and construction of geological maps concludes Part 1. Here, just enough is said to titillate the curiosity of the intelligent reader and make him wish for more, but (most importantly) enough to show that there is a more or less simple geometrical arrangement of the rocks of the crust and not a higgledy-piggledy mess as the uninitiated still seem to think.

Part 2 contains seven chapters, each dealing with an important aspect of industrial geology, such as water supply, geology and soils, petroleum, engineering geology (foundations, reservoirs, tunnels, building materials and roadstones), mineral supplies for heavy industries (coal and iron ores), non-ferrous metals and chemical supplies, and gemstones. Here, indeed, is a wealth of information to satisfy the inquirer; and, considering the scope of the subject-matter, it is noteworthy that the treatment is accurate and up to date throughout.

It may be serviceable to direct attention to a small point of nomenclature. Whereas the terms 'well-graded' and 'well-sorted' were formerly synonymous in geological writing, the practice of engineers is now to apply the former expression to a sediment in which the grains are distributed fairly evenly throughout the grades (as defined by size-limits)—that is, 'well-graded' becomes just the reverse of 'well-sorted' (where most of the grains belong to one size grade). In the interests of conformity and in order to make effective use of two good words, it would be well (at least in my opinion) for geologists to follow the engineers' practice.

To compress a large part of a text-book of geology into a "Pelican" book of 150 pages is no mean achievement. Inevitably it has necessitated a condensed style, but clarity is helped by many diagrams and a number of photographic illustrations. We may hope that the subject-matter will not prove so solid as to be indigestible to the general reader; and, if we can judge from the popularity of other "Pelican" books, certainly not less condensed and even more technical, it should not do so. As it takes two to make a bargain, it would seem that the layman, as well as the man of science, is now playing his part in helping forward this method of disseminating knowledge.

P. G. H. BOSWELL.

WEATHER WISDOM

Weatherwise

England's Weather through the Past Thirty Years. By John H. Willis. Pp. 110+30 plates. (London: George Allen and Unwin, Ltd., 1944.) 7*s*. 6*d*. net.

MR. JOHN H. WILLIS is a member of the band of amateur meteorologists who co-operate with the Meteorological Office in maintaining local records of weather according to a fixed plan day by day and year by year. The climatology of Great Britain owes much to their efforts, which are purely voluntary. It will easily be realized that to carry out such a self-imposed duty successfully, a man must be an 'amateur' in the literal sense of the term. Observations must be made in all weathers; they must take priority over personal convenience, they must be made punctually and they must be meticulously

recorded. So much is stated in the official pamphlet of 'requirements'. Here we may go further and say that the observer must have a real love of Nature, as expressed in the changes of weather. The daily reading of the instruments must not be merely a task to be done; it must be something which he loves to do, and which he approaches with a sense of adventure.

Mr. Willis's pleasant little book is the product of this attitude of mind, a sort of cavalcade of the years and the seasons as they presented themselves during a period of thirty years to an interested onlooker. Starting with the year 1913, we have a summary, on the scale of four or five pages to each year, of what the weather was like at Southwell Lodge, Norwich, with such few actual figures as are necessary to give precision to the verbal picture. In style, the author inclines to the poetic rather than to the scientific, "—a queenly June ascended her throne, to banish from her realm a measure of the month's rainfall, and dower the period of her reign with an additional hour of daily sunshine" (1914). A trifle 'twopence coloured' perhaps, but it is well to remember that a sequence of 'penny plain' statements like "June was dry and sunny" can be deadly dull.

Here and there the story is interlarded with snippets of meteorological theory, not all of which will find favour among the professionals. There are some remarks, too, about popular weather maxims. One of these calls for comment. Speaking of February 1920, Mr. Willis says: "its negligible rains belied once again its cognomen of Filldyke February; . . . according to my own station's records, Filldyke February is the driest month of the year". The matter cannot be so casually dismissed. The cognomen is "fill dyke", not "fill raingauge", and the distinction is an important one. The water seen in a dyke represents drainage from the land, and this is determined not only by the rainfall, but also by evaporation and the state of the soil. The latter factor depends on past rainfall as well as present rainfall. Under the conditions of rainfall and evaporation normally prevailing in Great Britain, the flow of streams and the level of underground water reach a maximum in late winter. There is, in fact, no month of the year to which the cognomen 'filldyke' could be more justly applied than to February.

The text is followed by a very interesting collection of photographs. It was a singularly happy idea of Mr. Willis's to photograph the same clump of snowdrops on January 1 every year, as an index of the state of vegetation—and a plant is a good indicator of integrated weather. The procedure was extended to other plant subjects and other dates, and several series of photographs are here reproduced. It is interesting to look at these pictures in conjunction with the table of monthly mean temperature on p. 106. They illustrate the effect of warmth during winter and early spring very forcibly and graphically.

The chronological form of presentation gives this book a very definite value. In times of peace a vast mass of meteorological information is published, but it is not always easy for an inquirer to find what he wants. What was the year of the great Christmas snowstorm? What was the date of the famous display of the aurora a few years ago? Questions of this sort can be answered more readily by reference to Mr. Willis's book and its index than by any other means known to the present reviewer. If for no other reason than this, it is well worth possessing.

E. G. BILHAM.

ARABLE FARMING ON POOR LAND

The Economics of Poor Land Arable Farming

Based on Surveys of Difficult Farming Areas in the East Midlands. By Dr. S. M. Makings. Pp. viii+280. (London: Edward Arnold & Co., 1944.) 18*s*. net.

EVERYONE must have been aware that all was not well with farming in the years between the Wars, but while the complaints of farmers were widely heard, there were few even in agricultural circles who had access to the full facts of the situation. The main problem is to be found among those who are committed to the poorer soils. With this in view, Dr. Makings has made a special study of the economics of certain poor land areas in the East Midland Province of England. In his work in the Economics Department at the Midland Agricultural College, he had access to the records and, so far as they existed, the accounts of a large number of farms in depressed areas. This material forms the basis of the book; it has been sifted and tabulated to give a clear picture of the business aspect of a cross-section of poor land arable farming, and the picture is none too bright. The conclusion is that under the conditions prevailing before the War, and in spite of a measure of government assistance, many farmers in these chosen areas, and particularly those handling the smaller units, were losing money.

The three districts chosen for the survey each suffered from certain definite soil, climatic or special limitations that made for low level of output, and greatly increased the risks that are inherent in production based on living things. In the Sherwood Forest area of Nottinghamshire, hungry, acid sand and the incidence of spring droughts put a heavy handicap on arable farming; in the poor Wolds of Lincolnshire, the thin poor soil and its exposed situation were the dominating factors; while in the Lincolnshire Carrs of the Ancholme Valley, it was lack of drainage rather than soil poverty that put its stamp on farming. The reader derives a clear picture of farming in each of these districts, partly from apt little summaries of the layout and balance of a number of typical farms, and in more precise terms from financial data derived from groups of farms. The Forest and the Wold both depended on the classical four-course rotation which, so long as sheep and barley prices were maintained, was probably the best system for these lands, but in recent years it has become clear that some fundamental change was necessary, and the author sets out the financial results of some of the alternatives that have been forced on the occupiers of these depressed areas.

The question is not entirely one of soil, although it is shown that farmers on better land can intensify and diversify their enterprises much better than their less fortunate neighbours. All the factors that enter the problem are discussed—land tenure, capitalization, and the technical qualifications of the occupiers. Finally, there is the national aspect of the farming of marginal land, not so much as it exists in war-time, but as it will appear after the War with even more land in this uncertain position than we had before. Two preliminary chapters set out the economic background to the detailed study, and a final chapter presents the main conclusions. The book is a thoughtful contribution to an important subject.

THE LAWS OF NATURE*

By PROF. HERBERT DINGLE
Imperial College of Science and Technology

Contrast in Character of Motion and Temperature Laws

IT would, however, be premature to conclude that because the laws of temperature in this one respect follow more closely the outlines of bare experience, they are therefore necessarily purer or more worthy of preservation than the laws of motion. We must look more closely into the matter, for it may be that, when the necessary supplementary clauses, so to speak, have been added, the type of law which has been constructed to describe motions is, by its greater scope, more adaptable to further experiences than the type constructed to describe temperature changes.

To examine this point we may usefully return to our examples of a ball thrown into the air and bodies at different temperatures placed near one another, to see how the difference of description, not inherent in the essential experiences, is introduced in the chosen terms of expression. The ball, it will be remembered, could, and in fact did, reverse its path, while the temperatures of the two bodies moved only towards equality. How did this come about?

'Bare experience' would have required the ball only to fall, for its tendency is to move towards the earth. Hence something must have interfered with its natural behaviour, and, in fact, we did throw it up, thereby making it take a path it would not by itself have chosen. In order to describe its motion completely, therefore, we must state not only the law of motion but also the initial occurrence which set it moving. No importance is to be attached to the fact that this was a human interference with natural processes, for the same thing might have happened without human agency; for example, the ball might have been thrown up by a volcano. The essential fact is that the motion cannot be described by the law of motion alone, but needs the statement of the law of motion plus a particular event. According to the character of this event the motion can be in one direction or in the opposite one, and the law of motion by itself must therefore be broad enough to allow both possibilities if it is to cover all the motions that occur in Nature.

The same thing is true, of course, on the larger scale. The planets might have revolved round the sun in the opposite direction so far as the laws of motion are concerned. To explain why they move in the direction observed we must know something of the origin of the solar system. When the circumstances in which they became detached from the sun are known, their motion is completely determined by the laws of motion, and no room is left for the possibility that they might have moved differently. The laws of motion thus establish their freedom by shifting the onus of distinguishing between opposite courses on to the shoulders of a 'boundary condition'; and when we deal with something so vast and ancient as the universe, this boundary condition lies so far in the past that we are apt to forget that it is there. Consequently we think that the course of development of the universe has the same freedom as the untrammelled laws of motion. In that, however, we are wrong. So far from releasing us from difficulties concerning the origin of things, the laws of motion make it essential that we shall face those difficulties, for they are framed in such a way that otherwise their requirements are necessarily ambiguous.

Now so far as possibilities are concerned, temperature phenomena are in precisely the same boat as the phenomena of motion. In saying that the ball could move up or down whereas the two bodies could only tend towards equality of temperature, I was in fact making an incorrect statement, and if you did not notice it, that is only an indication of our extreme susceptibility to error through accepting laws of Nature as equivalent to bare experience. It is quite possible for the hot body to become hotter and the cold body colder if we choose our initial circumstances properly. For example, a gas expanding suddenly may cool and give its heat to another gas originally hotter. Such circumstances occur much less readily on the earth than do movements against gravity, and we are therefore liable to overlook their possibility. But in principle there is no difference at all in this respect between motion and temperature exchange, and there is no fundamental reason why laws of temperature should not have been constructed permitting a reversible exchange of temperature and requiring supplementary boundary conditions to determine what would happen in a particular case. If that had been done, there would have been no formal difference between the modes of treatment of the two phenomena, and I should have had to choose another subject for this lecture.

It has not been done, however. Perhaps owing in some measure to the fact that in everyday experience the temporary flow of heat against a temperature gradient generally needs the establishment of highly artificial conditions, while the temporary movement of bodies against gravitation is a very common occurrence, a different approach to the problem has been made; and instead of describing a thermal phenomenon in terms of the rate of change of temperature with time, as we describe a kinematical phenomenon in terms of the rate of change of position with time, we describe it in terms of a new conception, *entropy*, which has no analogue in the present formulation of mechanical laws. The characteristic of entropy is that, no matter whether heat flows from the hot to the cold or from the cold to the hot body, the entropy at the end is always greater than the entropy at the beginning. (There is, it is true, a theoretical possibility that the entropy may remain unchanged, but in practice that can be ignored, and even theoretically it is impossible for the entropy to decrease.) This statement is true only if the *total* entropy is taken into account—the entropy of the hot and cold bodies and of any other body or system which has any influence at all on the process.

By this device we give direct and immediate expression to the one-way tendency of bare experience. We do not need first to give phenomena a round-trip ticket, and then to limit its validity to one direction only according to the ticket office at which it is presented. Whatever happens, whether bodies tread the natural path of temperature equalization or by violence are forced along the opposite course, the entropy of the whole system increases.

No such function as entropy, I have said, exists in the laws of motion, but there seems no fundamental reason why it should not be derivable. Every incidental motion in the universe contributes in its own measure to the grand one-way march of bare experi-

* *Continued from p. 736.*

ence, and should not be inherently incapable of representation in terms of an ever-increasing (or ever-decreasing, it does not matter which) function which for the purpose of reference we may call 'motion-entropy'. Motion-entropy would increase when an apple fell to the ground, and it would also increase when we threw our ball upwards—provided, of course, we took into account its change in ourselves and in the earth on which we pressed more heavily when we threw, as well as its change in the ball. If motion-entropy were formulated, we could destroy the formal difference between the laws of motion and those of temperature exchange in another way, by bringing the former into line with the latter, instead of by the reverse process.

On the face of it, this would seem the more desirable thing to do, for a direct expression of experience seems preferable to an indirect one. There is a penalty to pay, however. The conception of entropy is such that it has meaning only with reference to equilibrium conditions. Consider our two bodies again, and let us suppose that at the beginning their temperatures, though different, are steady. We can then evaluate their entropy—relative to an arbitrary zero, it is true, but that is of no importance here. Now let them interact with one another. After the lapse of a certain time their temperatures will have become equal, and then they will remain steady again. We can now again evaluate their entropy, and we find, according to the law, that it is greater than it was before. And that is all that the law can tell us. During the interval between the two steady states we cannot say that the entropy has steadily increased; we cannot, in fact, say anything at all about it, for the conditions essential to its significance do not exist. And since, in actuality, things are never in equilibrium, it follows that, in strict truth, we can never assign a precise entropy value to any actual system of bodies, let alone the whole universe. That is one reason why, as we saw, we could not apply our temperature laws to any system not enclosed within a boundary, for a boundary is necessary, though not sufficient, for equilibrium. Our assumption that our two bodies were originally at steady temperatures was an illegitimate one; there is no known process for keeping them so.

It should be understood that equilibrium here has a perfectly definite meaning, and is not subject to the arbitrariness arising from the possibility of changing our terms of expression. I mentioned earlier that a body at constant temperature could be regarded as an inert mass or as constantly interchanging energy with its surroundings, and that we could choose which form of expression we liked. That is true, but the laws of temperature I am speaking about now—in particular the law that entropy always increases—are framed after we have made our choice, and the choice is such that a state of constant temperature is a state of equilibrium so far as temperature is concerned, and a state of varying temperature is not a state of equilibrium. We cannot satisfy the condition for the significance of entropy by conceptually petrifying into equilibrium whatever state we may be confronted with.

The case again is not improved by the adoption of some physical picture of entropy, such as the very common and very convenient though very dangerous one which relates it to 'organization'. That representation was adopted after the discovery of the significance of entropy, and its validity is entirely dependent on its faithful conformity to the characteristics of entropy regarded as a simple mathematical function of certain thermal quantities. 'Organization' is a term of expression of a term of expression, and as such it has aspects which have no connexion with the facts of experience; it allows us, for example, to assign a precise measure of probability to occurrences which we have no reason to suppose are even possible. We can attach no weight to long-distance extrapolations of a process of disorganization which could not be reached also by extrapolations based on the original meaning of entropy, and we shall therefore not concern ourselves with them.

Strictly speaking, then, the entropy of an actual system can never be determined, but in practice we can often arrange to isolate a system sufficiently well for it to appear to be in equilibrium for a finite length of time, and we can then calculate its entropy. In such cases, in spite of its strict meaninglessness, the conception is extremely useful. We always find that the combined entropy of the system and its surroundings is increased when a change occurs, and our assumption that the entropy of the universe is continuously increasing is based on this fact. Such a conclusion, however, I must repeat, is rigorously a meaningless statement, and can only by courtesy be called an unprovable assumption.

The laws of motion do not suffer from this disability. They enable us to follow our ball throughout the whole duration of its flight, whether it is moving upwards or downwards, and make no demand that the system shall be in equilibrium. They have therefore much to compensate them for their excessive latitudinarianism, and make up by attention to detail what they lack in self-sufficiency.

The result of our analysis, then, is this. Our experience, both of the motions and of the temperature changes of bodies, shows that at present the processes going on in the universe tend in a certain direction and not in the opposite one. We describe this tendency for purposes of precise calculation by choosing terms of expression which form the alphabet of physical laws, and since time is included among these terms of expression, the laws allow us to extrapolate to the distant past and the distant future. The terms we choose for motion, however, differ in character from those which we choose for temperature, in that they lead to a different type of law. The former lead to reversible laws, which describe every detail of the changing process, but leave to an unknown 'original state' the task of determining why the process goes in one direction rather than the opposite one. The temperature laws, on the other hand, indicate the direction of the process without reference to an original state, but cannot be applied unless we can contrive or assume that the system in which we are interested is brought to a condition of equilibrium on two successive occasions: they then require that a certain quantity is greater on the second occasion than on the first, but can tell us nothing about the course from the first to the second condition of equilibrium.

Historical Aspect of the Laws of Temperature

Neither type of law affords grounds for dogmatizing about the distant past or future of the universe, and it is perhaps not altogether profitless to have achieved a realization of even that modest result. It is a matter of some interest to inquire why, when the bare experiences follow such similar lines, we should have chosen laws of such different types for describing them. I suggest the following explanation.

The earliest progress in science was naturally concerned with motion, for that is the phenomenon most easily examined with precise measuring instruments. Our theoretical scale of time measurement, for example, was chosen by assuming a body moving freely in space, and defining equal times as those in which it covered equal distances. A radiating body, such as the sun, might have been chosen instead of a moving body, and equal times defined as those in which it melted equal masses of ice, say, but the practical difficulties would have been greater. A kinematical measure was therefore chosen, *and then applied universally*—in particular, to the description of temperature phenomena when they came to be examined. Temperature thus, from the beginning, inherited terms of expression chosen originally for the analysis of motions instead of developing along its own intrinsic lines.

This procedure was further established by practical needs. We required to know how *work* (a concept belonging to mechanics, the science of motions) could be obtained from heat before we were very far advanced in the study of temperature phenomena themselves, and accordingly the additional terms of expression chosen for the laws of temperature were those found to be best adapted to the description of the transformation of heat into work, and not those best fitted for the study of heat for its own sake. The theoretical temperature scale, for example, was based on the amount of work obtainable from heat, and not on simple thermal effects alone. The result of this unnatural union between the representatives of motion and temperature was the birth of entropy, a quantity which was conceived in order to afford a measure of the availability of heat for transformation into work. Nothing parallel to this, of course, existed in the science of motion, and so no corresponding concept was created there.

It may be argued that this was a fortunate circumstance, and that the thermodynamic conceptions thus originated are more favourable for rapid and permanent progress than pure thermal conceptions would have been. From the point of view of the understanding, apart from the exploitation, of Nature, however, this seems to me very unlikely. Certainly our ultimate aim is to unite the sciences of mechanics and heat, but I think the soundest basis for a satisfactory union would lie in the existence of two strong independent sciences established on similar lines. We have brought about a union long before the science of heat has reached maturity, and so forced on it an unnatural development. The incompatibility between the motion and temperature laws is a result of this, and is not a happy augury for future connubial bliss. I venture to propose a return to first principles, and the creation of an independent science of heat, with concepts and laws of its own.

The obvious starting point is the phenomenon of radiation, for of all the modes of temperature exchange that occur, this is overwhelmingly the most important in the universe as a whole. It is indeed impossible to express how utterly insignificant all other temperature phenomena become when compared with it. To take a single example, the sun, a dwarf star, radiates some 4×10^{33} ergs of energy every second to space. On the other hand, the energy available, through all terrestrial processes—production of fuel, human and animal metabolism, etc.—for transformation into work does not exceed 5×10^{19} ergs per second, and if we suppose one tenth of this to be so converted, we see that the radiation from one dwarf star is about 10^{15}—a thousand million million—times the total terrestrial transformation of heat into work in the same time*. How many times the number of stars equivalent to the sun exceeds the number of planets on which work is artificially produced from heat we do not, of course, know; but, whatever it may be, when we consider that the terms of expression and laws of temperature phenomena have been shaped by this terrestrial 'gnat' and then foisted on the multillions of stellar 'camels' throughout the universe, we begin to realize something of the anomaly which has occurred.

Thermal Relativity

There is, however, another reason why we should —indeed, I would go further and say why we *must*— reform our present treatment of radiation. Progress in the study of motion has in the last generation brought to light a fundamental principle which, it is generally acknowledged, is valid throughout the whole of scientific inquiry, and this principle is violated in our present theory of radiation. I refer to the fundamental justification of the theory of relativity, namely, the principle that our theories should not imply the possibility of observing what is, in fact, inherently unobservable. It was this principle that destroyed the materialistic ether doctrine of the nineteenth century. Motion through the ether eluded observation so consistently as to force acknowledgment of the idea that it was inherently unobservable, whereupon the whole science of kinematics was reformed in such a way as to require that any experiment made to observe such motion must necessarily fail. The only observable motion is motion of one body with respect to another, and accordingly the word 'motion' now carries with it the quality of relativity, so that we cannot speak of it without implying the existence of some locatable frame of reference.

Now absolute radiation is unobservable in precisely the same way as is absolute motion, but while we have dismissed the latter from the terms of expression of motions, we still retain the former among the terms of expression of radiation phenomena. Consider two bodies relatively at rest. We used to say that each had an absolute velocity, v, and that they were relatively at rest because their absolute velocities were equal. We have now discarded the idea of absolute velocities, and associate no motion with the bodies. But consider two bodies at the same temperature. We used to say, and we still say, that each has an absolute temperature, θ, as a result of which it radiates a certain definite amount of energy, and that we do not observe any effects of the radiation because each receives from the other the same amount of energy that it radiates. But this absolute radiation, just like absolute velocity, is essentially unobservable. We should, then, in accordance with our principle, cease to employ it in our theories, and express the laws of radiation in such a form that it has no significance.

This, of course, means a radical reform of the laws of radiation, but I can see no escape from its necessity unless we deny the basic justification of the theory of relativity. When we reflect on the matter, we see other points of resemblance between the sciences of motion and radiation, which, indeed, is not surprising in view of the fundamental parallelism of the bare experiences already pointed out. For example, the

* I am indebted to Sir Alfred Egerton for the data concerning terrestrial processes.

development of the mechanical theory of relativity showed that gravitational and inertial mass, two quantities which, according to the former view, just happened always to be equal, were, in fact, essentially the same thing. In the theory of radiation we have likewise two quantities, radiative power and absorptive power, which similarly just happen always to be equal. We might expect that these two quantities, in a reformulation of the theory of radiation, would also be revealed as the same thing. Again, there is in temperature, as in motion, a limit approachable only asymptotically by material bodies; we call one the absolute zero of temperature and the other the velocity of light. The fact that in temperature there is only a lower limit, whereas the velocity of light is a limiting velocity for motion in all directions, is merely a characteristic of our method of measurement. We have already seen that a measurement of velocity in terms of the Doppler effect would have given us a finite limit in one direction and an infinite one in the other, and we could equally well choose a scheme of temperature measurement (Kelvin, in fact, at one time proposed such a scheme for his 'absolute' scale) which would place the 'absolute zero' at 'minus infinity'.

I have attempted[4] a re-expression of the phenomena of radiation, along the lines of the relativity treatment of the phenomena of motion, in which temperature is measured in terms of the rate of change with time of some observable characteristic of the radiating body, just as velocity is measured in terms of the rate of change with time of the spatial position of the moving body. The 'observable characteristic' could be the energy radiated by the body, expressed in terms of the readings of a suitably defined instrument, but I have found it more convenient to choose an instrument which records something analogous to the entropy change of the body; I will denote it by the Greek letter η. That, however, is a detail; the important thing for our present purpose is that temperature is measured in terms of a temporal process instead of by the reading of a thermometer in equilibrium, and the measurement of time involved is made by a thermal clock instead of a mechanical clock.

To understand the character of a thermal clock, let us look for a moment at the character of a mechanical clock. Here some specified body moves over a dial on which equal spaces are marked out, and equal times are those in which equal numbers of spaces are covered by the moving body. The fundamental clock is that in which the 'specified body' is a beam of light (this, of course, is only another way of expressing the familiar 'postulate of the constancy of the velocity of light' familiar to students of the theory of relativity), and clocks for practical purposes are constructed so as to give the same scale more conveniently. The time-scale suitable for the description of motion is thus one in which equal times are defined in terms of equal spaces, conformably with the measurement of motion by velocity defined as the rate of change of space with time. Similarly, the time-scale suitable for the description of radiation is one in which equal times are defined in terms of equal amounts of η, conformably with the measurement of radiation by temperature defined as the rate of change of η with time. Instead of the strictly specified body (a 'hand') moving over a space-scale (a 'dial'), we have a strictly specified body radiating to an η-measuring instrument, and equal times are those in which equal quantities of η are recorded by the instrument. We have to wind up the mechanical clock to keep its specified body moving continuously, and similarly we have, of course, to supply heat to keep the specified radiating body radiating continuously. In other respects also the two procedures are perfectly analogous.

In this way we provide a set of concepts, or terms of expression, for the description of radiation, which are intrinsic to the subject itself and not imported into it from without. The result is that just as mechanics has turned to advantage its choice of time measurement in terms of space by forming a unified conception of space-time, so the study of radiation along the lines suggested can turn to advantage its choice of time measurement in terms of η by forming a unified conception of η-time. To see the analogy, let us recall that in the ordinary theory of relativity the 'interval' between two events in the history of a moving particle is made up by combining a space increment with a time increment, and the relative magnitudes of these two components vary with the velocity of the co-ordinate system—that is, the velocity of the measuring instruments. When the co-ordinate system moves with the body, the interval consists entirely of the time increment, but for other velocities it is partly a time increment and partly a space increment. A similar thing is true of radiation. If we examine the radiation of a body with an η-measuring instrument and a thermal clock at the same temperature as the body, the former instrument records nothing and the thermal interval is wholly thermal time; but if we use instruments at a temperature different from that of the radiating body, they both give finite records, and the transformation equations connecting the readings at one temperature with those at another (the thermal 'Lorentz equations') are such that a total thermal interval exists which is the same for all temperatures of the instruments.

The concept of η-time thus arrived at can be given a geometrical interpretation corresponding to that given to space-time by Minkowski. The null geodesic in space-time corresponds to motion with a velocity of $\pm c$, and that for η-time corresponds to radiation at a temperature of the absolute zero or infinity. There is the difference, however, that whereas space-time is 4-dimensional since space has three dimensions, η-time is 2-dimensional; but, on the other hand, while the co-ordinate expression for the space-time interval is quadratic, that for the η-time interval is quartic. The geometries applicable to the two cases are thus different, and I have so far not been able to proceed beyond what I may call the 'special' theory, in which only constant temperatures are considered, just as in the special theory of mechanical relativity only constant velocities are considered. Constant velocities are appropriate to motions in a world of zero masses, and, similarly, constant temperatures are appropriate to radiation by bodies of infinite heat capacity. There is throughout a close parallelism between the new thermal and the current mechanical terms of expression, and we have an earnest of the possibility of ultimate amalgamation into a much more natural thermodynamics than the existing science of that name in the fact that thermal and mechanical time, though quite differently defined, give identical scales, and at any fixed temperature and velocity could be given the same unit. This is a necessary consequence, of course, of the experimental fact that a body at constant temperature radiates at a uniform rate according to our ordinary mechanical clocks.

The special theory of thermal relativity describes the same facts of experience as the current theory of radiation, but uses fundamentally different concepts for the purpose. So far as I can see, it entails nothing new in the field of observation, and in this respect it differs from the special theory of mechanical relativity which, when it superseded the earlier ideas based on absolute space and time, led to such discoveries as the dependence of mass on velocity, the equivalence of mass and energy, and other important relations. There are, however, two reasons for this. In the first place, pre-relativity mechanics was almost entirely concerned with velocities far from that of light, and the new requirements of the relativity theory thus related to conditions of which no experience had been obtained. The current absolute theory of radiation, however, is based on a relatively much wider range of experience, including that of phenomena at temperatures approaching the absolute zero. It has accordingly already adapted itself to the regions where anomalous results would be expected, so that the new theory is robbed of its chance of springing a surprise. Secondly, the general field of validity of the special theory of mechanical relativity —namely, the region of phenomena which can be discussed without considering the accelerating effects of gravitation—is a very large one, giving scope for many applications of the new principles. The special theory of thermal relativity, however, has scarcely any scope, for in all ordinary phenomena the effect of radiation is to lower the temperature of the radiating body very rapidly, and so to give variations of the radiation, the neglect of which is out of the question. Only bodies of very large heat capacity, like stars, come within its power, and we cannot make experiments with stars. New discoveries would therefore be expected to await the formulation of the general theory. But for our present purpose that is of little moment, for we are concerned more with the character and terms of expression of the laws than with the facts they represent, and these are as well exhibited in the special as in the general theory.

Whatever, then, may be the value of a thermal relativity theory from the heuristic point of view, it does, I think, show conclusively that it is possible to express the facts of radiation in terms totally different from the traditional ones, and so to preserve in our laws of motion and temperature the similarity of character inherent in the bare experiences. Each set of phenomena employs only concepts peculiar to itself—in mechanics, space and 'mechanical' time, and in temperature, η and 'thermal' time—and the measurements of the associated quantities are carried out by independent instruments. The connecting link is time, which, whether measured by the space covered by a moving body or by the η received from a radiating body, gives the same scale in the ideal cases of 'constant' velocity and 'constant' temperature. We can thus confirm the location of the rift in current physical theory in the arbitrary terms of expression chosen for our laws, leaving bare experience, if not necessarily quite homogeneous, at least sufficiently so to encourage the hope that a single scheme of law for all phenomena is a possible objective.

The One-Way Evolution of the Universe

Let us, in conclusion, look at the problem of the infinitely distant past and future from the point of view we have reached. We can say, first of all, that in so far as the problem arises from an extrapolation of existing laws, it is not a fundamental one. We can change the laws without violating experience. If they lead us into difficulties it may be necessary to do so, and if they lead us into contradictions or impossible situations we *must* do so. The fundamental difficulties are those which result from the trend of bare experience itself. If that leads us to an impossible situation, we must either fall back on the almost desperate expedient of trying to correlate our experiences without arranging them in a time order at all, or else capitulate and say that the universe is essentially irrational or (perhaps the same thing) beyond comprehension by human reason. I do not think, however, that we are yet reduced to that extremity.

In both its motion and temperature aspects the universe at present appears to be taking a one-way course. Its motions show a process of local consolidation and large-scale diffusion. This offers no problem for the future, for the diffusion can continue indefinitely and the consolidation tend asymptotically towards an eternally steady state. Working backwards to the past, however, we come by way of a large-scale consolidation and local diffusion to the idea of a single homogeneous mass, and, according to our present time-scale, this state would be located at a not infinitely remote epoch. The present discrepancy between the dates of this epoch yielded by the local and large-scale processes is a characteristic of our theories which can be ignored in our present considerations. What happened before this ? There is nothing that I can see to prevent that state having been reached by a gradual condensation of an originally infinitely diffused mass the rate of contraction of which, infinitely slow at first, accelerated until it culminated in a state of maximum density. After this a large-scale expansion could have proceeded, begun either by a rebound of a continuous mass from a state of compression, or by separate bodies simply continuing on their one-way journey after having made their closest approach to one another. Such a course of cosmic history would involve no problem of the distant past or distant future so far as motions are concerned.

What about temperatures ? The present trend is somewhat ambiguous. Our experience is so brief that we can detect no change in the temperatures of the stars, and any theories we may have on the matter are based on laws which we are now leaving out of account. Certainly there is a tendency towards equalization of temperature, shown by the fact of radiation from hot to cold bodies, but the probability is, nevertheless, that as we go backwards to remote times, the hottest bodies, the stars, become colder rather than hotter. I think it is in accord with present indications, so far as we can read them, to say that when we reach the time of maximum density of the universe, the stars, if they then existed, were cooler than now, and the temperature of the whole universe was more homogeneous. The tendency to local consolidation since that time has raised temperatures locally, and the large-scale expansion has checked the process of equalization. As we recede further into the past we contemplate a homogeneous mass of matter falling gradually in temperature step by step with its decrease in density, and there is no greater difficulty here than there is with the succession of motions. In the reverse direction, as we go from the present time towards the future, we presumably find the stars getting hotter up to a maximum temperature and then cooling, while all the time the

tendency towards equalization of temperatures by radiation goes on inexorably until ultimately the universe approaches asymptotically a state of uniform temperature.

We may sum up this picture of cosmic history, then, as follows. In the infinitely distant past the universe consisted of an infinitely diffuse, homogeneous mass at uniform temperature. With the passage of time the mass became denser and hotter until a state of maximum density was reached, and perhaps about this time the mass broke up into units. Thereafter a process of expansion went on, with the units getting hotter at varying rates but tending by radiation to come to a state of common temperature again. Ultimately they will reach and pass a maximum temperature, tending finally to a universe consisting of a number of aggregations of units at a common temperature performing eternally unchanging motions.

It should not be necessary to say that this is not intended to be in the slightest degree a theory of cosmogony. My purpose has been simply to give a conceivable course of development not inconsistent with the present trend of our experience, and involving no contradictions or insuperable difficulties in the distant past or the distant future. There may be a thousand such possible courses, and I am not concerned with the task of choosing between them. What I have tried to show is that not only does our present dilemma concerning the origin of things arise from our arbitrary laws, but also no such dilemma exists in the requirements of experience itself. The practice of 'induction of principles from phenomena', the origination of which Halley saw and did so much to facilitate, is still an endeavour worthy of our utmost effort.

[4] In course of publication.

TRANSFORMATION OF PNEUMOCOCCAL TYPES

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GRIFFITH[1] was the first to show that an attenuated and non-encapsulated 'rough' (*R*) variant of one specific type of Pneumococcus could be transformed into a virulent and encapsulated 'smooth' (*S*) form of another specific type. The transformation was accomplished *in vivo* by injecting subcutaneously a small amount of living *R* culture of Pneumococcus Type II together with a relatively large inoculum of heat-killed organisms derived from a fully virulent *S* strain of Pneumococcus Type I or III. The living *R* strain alone failed to kill mice, whereas the addition of the heat-killed Type I or III organism caused a fatal bacteriæmia. The organism isolated from the heart's blood of the infected animals, however, was not a virulent Type II organism, but a virulent encapsulated Type I or III pneumococcus according to the type of the heat-killed *S* vaccine employed. The importance of this observation was soon recognized, and Griffith's findings were confirmed by Neufeld and Levinthal[2], Baurhenn[3] and Dawson[4]. Some time later, Dawson and Sia[5] succeeded in carrying out the transformation of *R* Type II pneumococci into a virulent *S* Type III organism by an *in tivro* procedure.

In order to bring about this change, it is essential that the *R* variant should be in a reactive phase, since it is only when in this condition that an *R* culture is found to respond to the transforming stimulus. Once the organisms have assumed the type-specific *S* characters, they remain true to form through serial transfers in ordinary media and through repeated animal passage. In this work the greatest care was taken that the *S* vaccines employed contained no viable organisms.

The earlier work of Dawson and Avery[6] and Dawson[4] showed that the conversion of *R* pneumococci to the *S* form of the same type could frequently be accomplished by growing the organism in anti-*R* serum. In effecting this transformation of type *in vitro*, anti-*R* serum is generally added to the culture medium, although it is recorded that the transformation can frequently be achieved in the absence of *R* antibodies. It is now known that to obtain repeatable results, sulphonamide inhibitors must be removed from the nutrient broth used as culture medium. The transformation has never been observed to occur in the absence of serum, and failure to induce the conversion of resting cells seems to indicate that transformation takes place only during the active reproduction of the cells. Attempts to use solutions of the *S* organisms, obtained by freezing and thawing and afterwards heating at 60°, in place of whole bacteria, were mostly without success. Alloway[7], using extracts of virulent Types I and III pneumococci, was successful in effecting the transformation of an *R* Type II culture into fully virulent Type I and III organisms respectively. The conversion of *R* Type II into *S* Type I was more difficult and usually required several sub-cultures before the conversion was finally established. Alloway showed that serum from the sheep, rabbit, guinea pig, horse or man could be employed irrespective of its content of anti-*R* immune-body, thus indicating that some property in serum other than the anti-*R* component is essential if transformation of type is to occur. The presence of the specific polysaccharide of a heterologous type failed to induce the conversion of *R* Type II organisms into the heterologous *S* form.

The transformation of *R* pneumococci into a virulent *S* form means that the organism has acquired the property of producing the specific capsular substance, which for the Type III pneumococcus has been shown to be a polysaccharide built up from 4-β-glucuronosidoglucose units[8]. It would appear, therefore, that in the presence of a specific factor contained in an extract of the *S* Type III organism, the *R* Type II pneumococcus develops the capacity to elaborate the Type III specific material. In a later paper, Alloway[7] showed that potent extracts, as active as the original *S* vaccine in causing the $R \rightarrow S$ transformation, were obtained by dissolving the *S* cells in sodium desoxycholate, and that the active factor could be freed from certain of the accompanying impurities by precipitation with alcohol, or by adsorption of the contaminating substances on charcoal.

After a lapse of rather more than ten years, progress on this subject has once again been brought to notice by the publication of a paper by Avery, MacLeod and McCarty[9] which describes the isolation and identification of the active transforming principle present in an extract of *S* pneumococci (Type III). The evidence of its nature is based on an examination by chemical, enzymatic and serological analysis, and by electrophoresis, ultracentrifugation and ultraviolet spectroscopy. Within the limits of the methods

employed, the active factor is shown to contain no protein, unbound lipid or serologically active polysaccharide. The material contains 34–35 per cent C, 3·7–3·8 per cent H, 14–15 per cent N and 8·5–9·0 per cent P, and these figures are in close agreement with those calculated on the basis of the theoretical structure of sodium desoxyribonucleate (tetranucleotide). It is probably no mere coincidence that it is this type of nucleic acid which is found as a constituent of nuclei and chromosomes and, as shown by Signer, Caspersson and Hammersten[10] and by Astbury and Bell[11], is the form of nucleic acid that can exist in a highly polymerized and reactive state.

Bacteria that give a positive Feulgen reaction[12], that is, bacteria that have the property of restoring the colour of a fuchsine solution decolorized by sulphurous acid, are generally considered to contain a nucleic acid of the desoxyribose type. Thompson and Dubos[13] found that after the removal of ribonucleic acid from pneumococci, the resulting Gram-negative organisms give a strong colour reaction with Feulgen's reagent. These workers were, however, unable to isolate desoxyribonucleic acid from pneumococci, whereas Schaffer, Folkoff and Bayne-Jones[14] working with *Escherichia coli* and Johnson and Brown[15] with tubercle bacilli obtained nucleic acids from these organisms that appeared to be essentially of the desoxyribose type. Avery, MacLeod and McCarty are the first workers to isolate a desoxyribonucleic acid from Type III pneumococci and to accomplish an *in vitro* transformation of *R* Type II pneumococci into the *S* form of the heterologous Type III organism by means of this substance.

It is of considerable significance that an *R* bacterial cell in the presence of a desoxyribonucleic acid is stimulated to produce the specific capsular polysaccharide characteristic of the heterologous pneumococcus from which the nucleic acid molecule was itself derived. Although the transformation described by these workers is limited to a single type of change, it seems probable from the observations of earlier investigators that the process is one of general application. If a similar type of substance derived from other *S* cultures is found to bring about *in vitro* transformations of this kind, then it will appear probable that the desoxyribonucleic acids possess different biological specificities, as distinct from serological specificity, and that these can be recognized according to the nature and specific character of the capsular polysaccharide formed. Up to the present, little is known concerning the immunological specificity of the nucleic acids. Recently, Lackman, Mudd, Sevag, Smolens and Wiener[16] have shown that both *d*-ribo- and *d*-2-desoxyribo-types of nucleic acid react irregularly and with considerable serological overlapping when examined with anti-pneumococcal serum. The specific reactivity of certain anti-pneumococcal sera for nucleic acids can be specifically inhibited not only by the purines present in the nucleic acid but also by the methyl-purines, caffeine and theophyllin. Precipitins of similar reactivity do not occur in normal sera, so that it would appear that the anti-nucleic acid component of the serum has been formed during immunization with the pneumococci. It may be, however, that significant changes are induced[17] in the highly polymerized and complex nucleic acid molecules during the isolation and purification procedures generally employed, and that little progress will be made in establishing a relationship between chemical constitution and immunological specificity in this group of substances until they can be recovered in the native condition from tissues and bacterial cells.

It appears probable from the work of Avery and his co-workers that there exists within all types of pneumococci an enzyme which passes into solution during autolysis and rapidly destroys the activity of the transforming agent. To obtain optimal conditions for the conversion it is essential, therefore, to employ young cultures during the logarithmic phase of growth, since under these conditions cell division is most active and autolysis minimal. Although there is as yet no definite evidence as to the exact nature of the biochemical processes that operate during the transformation, it seems certain that a co-ordinated series of enzymatic reactions results which finally leads to the formation of the specific capsular polysaccharide and of the transforming agent itself. Once initiated, the process of forming these newly acquired characters continues through innumerable transfers of the organism without the addition of further transforming agent. Avery, MacLeod and McCarty point out that the experimentally induced alterations are definitely correlated with the development of a new morphological structure—the capsular polysaccharide —and the consequent acquisition of new antigenic and invasive properties. The changes are predictable, type-specific and heritable, and indeed the inducing substance has already been considered to be gene-like and the capsular substance to be a gene product. If one assumes that the desoxyribonucleic acid and the transforming agent are one and the same substance—as the experimental evidence strongly indicates—then the transformation of *R* Type II pneumococci into *S* Type III pneumococci represents a change which is chemically induced and specifically directed by a known chemical substance.

The genetic implications of this work are considerable, for it would appear that the transformation is a gene mutation and that the $R \rightarrow S$ change induced is, in fact, an authentic example of the accomplishment of a controlled mutation by a specific chemical agent. Examples of similar changes with other biological material, such as the conversion of the virus of rabbit fibroma (Shope) into that of infectious myxoma (Sanarelli) by Berry and Dedrick[18] and Berry[19] have already been given, and many more will certainly be forthcoming. This type of research is fundamental in character and of outstanding importance.

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INVASION OF THE NEW WORLD BY *ANOPHELES GAMBIÆ*

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"ANOPHELES GAMBIÆ in Brazil" is the title of a recent book[1] by Fred L. Soper and D. Bruce Wilson, in which is related the story of the recent incursion, and defeat, of the African mosquito, *Anopheles gambiæ* Giles, into South America. The importance of this book is that it is the record of man's first whole-hearted deliberate attempt completely to eliminate a small insect vector of disease from a geographically large area.

Previous campaigns against insects have usually attempted the elimination of the species from an area of limited size, or the aim has been merely to 'control' the species. 'Control' implies keeping the population of the species down to a level at which the depredations of crop pests cease to be economically important, epidemics due to insect-borne disease cease, a pandemic is driven back into small endemic centres, or the incidence of the disease reduced to a figure that is considered satisfactory. Striking examples are the control of the coco-nut beetle (*Promecotheca reichei* Baly) in Fiji[2], the extermination of the Mediterranean fruit fly (*Ceratitis capitata* Wiedemann) in Florida, where it had gained a foothold[3], and the elimination of urban yellow fever in South American cities by the local eradication of the tiger mosquito (*Aedes* (*Stegomyia*) *ægypti* Linnæus)[4]. 'Control' has one great disadvantage over complete eradication of a species in that the control measures have to be continuous.

Anopheles gambiæ was a purely Old World mosquito widespread in the Ethiopian region. However, in March 1930, R. C. Shannon collected it at Natal, Rio Grande do Norte, Brazil[5]. It is thought that the fast surface-mail service established by the French between Dakar and Natal rather than aeroplanes was responsible for its introduction, since there had been only three Africa to Natal aeroplane arrivals before Shannon's discovery. The late Dr. Adolf Lutz, veteran entomologist of the Instituto Oswaldo Cruz, had surveyed the area around Natal in 1928 in connexion with proposed sites for a leper colony, and he had pointed out to the authorities the danger of mosquito importation from Africa consequent on the development of rapid trans-Atlantic transport[1,6].

Ecologically, the district around Natal was not particularly favourable to *A. gambiæ*, and, with luck, the mosquito might have failed to establish itself: the problem created by its arrival looked like being one of localized control, until the mosquito just died out. This being so, the Yellow Fever Service (a joint organization of the Brazilian Government and the International Health Division of the Rockefeller Foundation) undertook immediate measures against *A. gambiæ* around Natal. This optimistic attitude was, however, shattered when, in April 1931, severe epidemic malaria broke out in the surrounding districts. Malaria had been endemic in some of these districts, but the new epidemics were so bad that wholesale emigrations of the populace were taking place. These epidemics were due to the presence of *A. gambiæ*, acting as a vector; a year after being first discovered on South American soil, the mosquito had spread a distance of 182 km. from its first recorded foothold.

The locality of the initial infestation by *A. gambiæ* was a district where tidal flats had been transformed into 'freshwater hayfields' by the erection of dykes to exclude the tidal salt waters. *A. gambiæ* could have been eliminated at this stage by opening the dykes and admitting the salt water. This action was, in fact, recommended in May and September 1930, and again later, but it was only after the disastrous malaria epidemic of 1938 that it was done, the local health officers not having sufficient powers to overcome the opposition of the interests which stood to suffer loss by the opening of the dykes.

The localized work of the Yellow Fever Service cleaned up the situation around Natal, and the danger to the State capital having been removed the local authorities became disinterested in the matter though, fortunately, the workers of the Rockefeller Foundation continued to keep an eye on *A. gambiæ* in the outlying districts.

During 1932–37 *A. gambiæ* spread slowly, but little attention was paid to it until, in 1937, the mosquito was suspected of being responsible for localized epidemics of malaria, and in 1938 it was proved responsible for severe outbreaks of epidemic malaria in the coastal regions of Rio Grande do Norte, north of Natal and in the valley of the Jaguaribe River in the neighbouring State of Ceara. This epidemic wrought such havoc that tax-holidays had to be declared in certain localities and travelling representatives of business houses refused to enter the affected districts.

The State Governments appealed to the Federal Government, and in August 1938 the President of Brazil signed a decree creating the Anti-Malaria Service. This service was immediately organized under Dr. Mancel Ferreira, and a laboratory for research on *A. gambiæ*, as the species occurred in Brazil, was set up at Natal under Dr. Cesar Pinto of the Instituto Oswaldo Cruz[6]. The International Health Division of the Rockefeller Foundation, already actively co-operating with the Federal Government in the highly successful Yellow Fever Service, continued to keep an eye on the situation. In the course of preliminary discussions with the Brazilian Government it was concluded that if the spread of *A. gambiæ* was not stopped a major disaster threatened the Brazils, and no one could tell how many of the Americas would eventually be affected. It was therefore agreed that any programme of work should aim at the immediate eradication of the species.

In January 1939 arrangements were completed for collaboration between the Anti-Malaria Service of the Brazilian Government and the International Health Division of the Rockefeller Foundation in a new organization to be called the Malaria Service of the Northeast. This new body immediately set going a medical treatment campaign, commenced the systematic disinsectization of all vehicles, boats and aeroplanes proceeding from the infested region to clear areas, and made an immediate start on the actual attack on the mosquitoes themselves. At the peak of its activity the personnel employed exceeded 3,500, but the maximum number of medical men employed was forty-nine. During the period of its existence the Service used more than 6½ million tablets of atebrine and quinine. Some 11 million samples of water were examined for mosquito larvæ; more than 104 million collections of water were treated with anti-larval measures, 261,292 kgm. of Paris-green being used for this purpose; 720,906 litres of insecticide were used to disinfest houses,

vehicles, etc., of the adult mosquitoes. In 1940 alone 7,036,731 mosquito larvæ, of which 17,425 were *A. gambiæ*, and 972,248 adult mosquitoes, of which 56,780 were *A. gambiæ* were examined. The expenditure for for the whole period of the existence of the Malaria Service of the Northeast totalled 2,139,570.27 dollars.

The work of the first six months was not over-encouraging, but in the second six months localized eradications had been effected and the problem seemed to be resolving itself into one of administration. Early in April 1940, the vital experiment of stopping all control measures in an area that had previously harboured *A. gambiæ*, but which appeared to have been cleared of the mosquitoes, was made. *Anopheles gambiæ* did not reappear. The actual technique of destruction had proved simpler and more rapid than was at first anticipated, and faith in the ideal of complete and total eradication of the species began to grow by leaps and bounds. From this time anti-*gambiæ* work was stopped in any previously infested area after it had been found to be free from the mosquito for three months.

The clearance of areas allowed additional personnel to be concentrated on the less tractable districts, and this act was reflected in the rapidity with which the final stages of the elimination of *A. gambiæ* were accomplished. Less than two years from its inception, on November 14, 1940, the Malaria Service of the Northeast recorded the last evidence of infestation by *A. gambiæ* in Brazil, and in January 1941 all anti-*gambiæ* measures were suspended.

The evidence that *Anopheles gambiæ* has been eradicated from Brazil is all of a negative character, but Soper and Wilson[1] consider that it has, in fact, been effected. That reinfestation is possible has been shown by the recording by Soper and Wilson[1] of specimens of *A. gambiæ* found in aeroplanes arriving at Natal from Africa. In the future, vigilant disinsectization of aeroplanes must be insisted on.

The collaborative Malaria Service of the Northeast was brought to an end in the middle of 1942, having demonstrated that the goal of species eradication from a large area was attainable. Soper and Wilson[1] admit that there are features of the ecology of *A. gambiæ* which, related to the nature of the terrain invaded, favoured eradication. They also point out, however, that when species eradication is the goal aimed at, matters are simplified, compared with the institution of mere control measures, since the problem becomes a purely entomological one completely divorced from all medical and epidemological considerations. The test of success is not the reduction of any selected index relating to the disease to some predetermined, or hoped-for, figure, but simply the complete and continued absence of the species attacked after the campaign has ended. The Malaria Service of the Northeast was fortunate in having available for incorporation the trained personnel of the Yellow Fever Service.

No amount of argument will prove that species eradication, as a method of dealing with malaria and other insect- or arthropod-borne diseases, is not applicable elsewhere. Only the failure of properly organized and adequately financed attempts will do so. The cost may be high, but against this must be set the ever-recurrent losses due to the diseases and the annual cost of such control measures as are in vogue. These measures may cost enormous sums of money in the long run, but it is notorious that men, when organized as a society, tend to prefer annual recurrent small expenditures even though they may be far less effective and be far larger in the aggregate than the cost of a short intensive campaign promising finality. Soper and Wilson[1,4] do not claim that the method of species eradication is applicable everywhere or to any vector. They point out that in the first place the presence of the vector must be creating a public health problem sufficiently grave to justify the expenditure of time and money involved and the interference with the life and rights of the community necessary for the efficient application of the anti-vector measures. Secondly, the vector must be one which can be attacked successfully; that is, it must be possible to seek out and discover the vector with comparative ease, and methods of killing it in its breeding places must be available. Thirdly, it must be possible to clean up an isolated area unlikely to be reinfested, or the area to be cleared of the vector must be sufficiently large so that the peripheral region, where measures will have to be persisted in to prevent reinfestation, will be small in comparison with the area cleared.

Soper and Wilson[1], discussing the problem of *A. gambiæ* in Africa, point out that there the eradication would have to be centrifugal, while the campaign in Brazil was a centripetal one; they also point out that the problem in Africa would be complicated by the presence of *Anopheles funestus* Giles, a very efficient malaria vector, alongside of *A. gambiæ*. They point to the isolated malaria-ridden valleys of Peru, where a single species, *Anopheles pseudopunctipennis* Theobald, is the vector[7], and the islands of the Caribbean, as localities where species eradication would seem particularly feasible.

Soper and Wilson[1,4] have stressed the desirability of tackling any case of species eradication as an immediate problem without any postponement of the attack on the species pending the completion of some elaborate programme of detailed research on that species. It is, however, perhaps pertinent to point out that a considerable amount of basic research had been carried out on *A. gambiæ* in its Old World home before it reached Brazil; the results of these researches were, of course, available to those responsible for the campaign against the species in Brazil. There is probably a judicious mean between the two policies, though individuals may tend to lean toward one or the other extreme.

It might be well worth while to consider the place that species eradication campaigns might have in relation to the Colonial improvement programmes that are being mooted at the present time. The personnel problem should not prove intractable, since it is likely that, on the cessation of hostilities, many members of the Forces who have been engaged on anti-malarial or other related entomological work will be returning to civil life and might welcome an opportunity to continue such work. Such personnel might well be used to form the core of species-eradication organizations, and staff for routine operations could be recruited from the local populations.

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NEWS and VIEWS

Agricultural Research Council: Secretaryship

IT is announced that Mr. J. C. F. Fryer, director of the Plant Pathological Laboratory of the Ministry of Agriculture at Harpenden, has been appointed to succeed the late Prof. W. W. C. Topley as secretary of the Agricultural Research Council. Mr. Fryer is well known in scientific and official circles and his appointment to this responsible position is amply justified by his special qualifications. He has held his present post for a number of years and at one time it was combined with that of entomologist to the Ministry of Agriculture. Much of the improved technique applied in recent years to pest control has been the result of work initiated or fostered by Mr. Fryer in his official capacity. Educated at Cambridge, and for some time fellow of Gonville and Caius College, Mr. Fryer became Balfour student of the University. During his tenure of this studentship he carried out important researches on the genetics of butterflies in Ceylon and also investigated the fauna and physiography of Aldabra Island in the Indian Ocean. His subsequent career began with the Board of Agriculture and coming from a family well versed in farming experience he brought to his duties practical experience backed by scientific knowledge. His long and close association with this branch of Government service has left him comparatively little opportunity for other activities. Nevertheless, his name is among those who have occupied the presidential chairs of the Royal Entomological Society and of the Association of Applied Biologists. In the appointment of Mr. J. C. F. Fryer, the Agricultural Research Council has placed its secretaryship in exceptionally capable hands.

Stereoscopic Projection

ON June 17, at the Aldis Works, Birmingham, Mr. A. C. W. Aldis gave a demonstration of the stereoscopic projection. He employed special high-intensity projectors of his own design which gave a vivid impression of stereoscopic relief when viewed through the usual coloured anaglyphs. These projectors gave a remarkable efficiency with brilliant screen illumination in spite of the loss of brightness involved by the use of anaglyphs and coloured filters for the screen projections.

Mr. Aldis's approach was through the theory of stereoscopic vision. He invited his audience by suitable screen tests to determine their own stereoscopic appreciation, and produced by means of plane geometrical patterns projected from 50 ft. or more an impression, when viewed through anaglyphs, of a suspended luminous sphere which appeared to move towards the observer, meanwhile diminishing in size. The latter part of the demonstration showed the modern method of prospecting for minerals in jungle territory by means of stereoscopic photographs of the terrain, and was followed by scenes from the actual bomb damage in Germany including the Möhne Dam before and after the attack, the Eder Dam, the Herdicke Bridge and the damage to Mainz, Rostock, Düsseldorf and the Phillips Radio Factory at Eindhoven. These photographs, when viewed by stereoscopic vision, were particularly convincing, and the wealth of detail exhibited gave adequate testimony to the value of the method of projection which Messrs. Aldis have devised.

Penicillin Treatment of War Wounds

THE Medical Research Council's War Memorandum No. 12, entitled "The Use of Penicillin in Treating War Wounds" (H.M. Stationery Office, 1944. 3*d*. net), is a valuable publication embodying the instructions issued by the Penicillin Trials Committee of the Medical Research Council. There is a prospect, says the memorandum, that large quantities of penicillin may shortly be available and in particular it may be possible to treat a considerable number of casualties in forthcoming military operations. The memorandum is intended to be a guide for the treatment of battle casualties and for the laboratory control of such treatment, and it does not pretend to be a guide to all the clinical uses of penicillin (for a note on these see NATURE, April 29, p. 521; 1944). Further, its instructions are provisional, because experience of the treatment of wounds with penicillin is still relatively small. The properties of penicillin are briefly discussed, and a list is given of the bacteria which are susceptible and resistant to it. Other sections deal with the preparation of penicillin and with its local and systemic administration, with its uses for particular types of wounds, with failures of the treatment and with the laboratory procedures which are necessary for the control of the treatment (diagnosis of the bacteria present, titration of the penicillin content of the blood and of the potency of the penicillin). The memorandum concludes with a valuable list of selected publications and memoranda on penicillin.

Polish Medical Science

THE medical issue of "Polish Science and Learning" (London: Oxford University Press, 1944. 2*s*. 6*d*.), which is one of a series of booklets edited by the Association of Polish University Professors and Lecturers in Great Britain, is, its editors state, an attempt to lay a foundation for the future in collaboration with the scientific workers of other nations. The creation of the Polish Medical School and of the Paderewski Hospital in Edinburgh is, as Prof. Jurasz says in his article about them, a symbolic act, a practical demonstration of the determination of the Polish people to continue their national life in spite of all the sufferings of their country; and it demonstrates the existence of practical collaboration between two very different nations. It is perhaps difficult for some Englishmen to realize what hope and encouragement the creation of these two medical centres has meant to the Polish people. Already fifty-three students have graduated from the Polish Medical School. Many civilian students who are unfit for the Polish armed forces have joined it after leaving their schools in Great Britain, and others have got leave from the Army to continue their studies interrupted by the War, while some have gone there from the U.S.S.R. or after their escape from German prison camps. The Paderewski Hospital is devoted entirely to Polish patients and to the training of medical students and graduates. In addition to this hospital provision, valuable work has been done by a Polish sanatorium for tuberculous cases in Great Britain. Established at the end of 1942 at Gallowhill Hall, this sanatorium has now a capacity of one hundred beds and can carry out the best treatment. The majority of Polish cases of tuberculosis are, however, still distributed throughout British hospitals and Polish military hospitals. The percentage of tuberculosis, says Dr. Spitzer, is higher now among

Poles in exile than it was in Poland before the War, so that there is urgent need of the developments which are contemplated.

Something of what is happening in Poland now may be imagined by reading between the lines of the extract from a secret report on the condition of the Polish children which this journal publishes. At all ages the theoretical rations of Polish children are half the theoretical normal calorie value, while those of Nazi children are well above this norm. In practice, the writer of this report states, the quantity and quality of the food fluctuate; sometimes it is reduced to nil. In the Rodom district, for example, the children of the landworkers do not get any ration cards at all. Almost everywhere the distribution of milk to children under three has been suspended. The writer concludes that the rations show a deficiency of 90 per cent of fats, 80 per cent of albumins and 50–60 per cent of carbohydrates. It is not surprising that infectious diseases and "a frightening mortality", with a high percentage of tuberculosis, which is increasing, and of heart weakness are evident among Polish children. These conditions are, as recent articles in the *British Medical Journal* and *The Lancet* and discussions in the Houses of Lords and Commons have shown, reproduced in most of the occupied countries. It is easy to exaggerate them; but we should not commit the graver error of underestimating their consequences. The agricultural basis of European rehabilitation is clearly recognized, and Polish veterinarians have for long been co-operating with British veterinarians in the reconstruction of Polish veterinary medicine. An article on this, and others on the improvement of Polish milk hygiene and on the eradication of tuberculosis from Polish cattle, 25–50 per cent of which are, Dr. Mglej tells us, tuberculous, indicate that this aspect of the future is not being neglected.

Classification in Biology

THE question is often asked by students as to which is the 'right' classification of a group of animals. Mr. K. H. Chapman, lecturer in zoology, Rhodes University College, Grahamstown, South Africa, directs attention to certain ideas that must be kept in mind when considering schemes of classification from this point of view in a communication to the Editors which is summarized below. Although such conceptions have been put forward before, there persists so much misconception about the nature and purpose of systematics in biology, not only among students but also among biologists themselves, that it is necessary to re-emphasize these points. It is probable that no classification is right or definitive because there is no real classificatory system outside ourselves that it is only necessary for us to discover. In most groups it is obvious that we can only deal with survivors; and even where fossils do exist, they are unselected members of the group from this point of view. Thus it follows that natural classification is an unfortunate term. Living animals do not fall into true and equivalent groups even though we arbitrarily place them in such, and consequently we can only regard classification as a convenient tool with which to deal with a large mass of material, and it does not have a natural existence of itself. It is only necessary to compare the species, genera and other groups of insects with the similarly named categories in other phyla to realize their non-equivalence. The species, whatever it may be, also must be regarded as a dynamic and not a static unit, and any living group may, in the course of time, become something different. The question of polyphylletic origins also arises; for example, W. A. Herdman suggested that the compound ascidians are an assemblage of groups evolved from different groups of the simple ascidians which had independently assumed the colonial habit of growth. Any classification is to be regarded as an expression of a scale of values which indicates, in the opinion of its proposer, the relative nearness or farness of two or more groups with respect to one another.

The British Bryological Society

FEW associations of naturalists have been originated by advertisement, but such was the genesis of the Moss Exchange Club. The Rev. C. H. Waddell first advertised in *Science Gossip* in December 1895 and, from the twenty-three favourable replies, founded the Club in the following year, when 2,077 specimens were distributed. It remained an association depending very largely on postal contact until 1922, when the need for closer personal association in field meetings led to the formation of the British Bryological Society. Miss Eleonora Armitage has collated the annual reports of both Club and Society into a short pamphlet (Miss Armitage, Dadnor, Ross). She was president at the Society's last meeting in 1939, and this review should serve the purpose of sustaining the collective interests of bryologists until more stable times allow a resumption of their activities. Several census lists of British bryophytes have been published, from the York Catalogue, compiled by J. A. Wheldon in 1889, to the latest taxonomic indexes for mosses, compiled by J. B. Duncan in 1926, and for hepatics, by A. Wilson in 1930. The taxonomy of mosses and liverworts is now largely established, but many bryological matters still require elucidation. Perhaps the post-war period will provide opportunities for detailed ecological studies —the relation of a moss or liverwort to its substrate, its reactions with other plants, and particularly of its unique physiology, which allows a special phenology of reproduction not possessed by any other kind of plant.

Work of the League of Nations

THE report on the work of the League of Nations during 1942–43, submitted by the Acting Secretary-General, in addition to an introductory section giving a useful survey of proposals for future world organization, contains chapters on economic, financial and transit questions, on questions of a social and humanitarian character, on questions of a legal and administrative character and on the Library of the League. The work of the League on the first group of questions is reflected chiefly in a series of reports which have already been noticed; but in regard to the second group, the report affords strong evidence that whatever views may be held as to the continuance of the League as a co-ordinating machinery in political affairs, its technical organizations should be retained as part of the functional apparatus set up in any future world organization.

The Health Section has concentrated its attention during the year on the present food scarcity, and on malnutrition and the danger of epidemic outbreaks in Europe. A comprehensive study of the trend of morbidity and mortality of European countries in relation to food shortage is shortly to

appear in the *Bulletin of the Health Organisation*. The Organisation has also been requested to determine which food elements are most acutely lacking in the present dietary of enemy-occupied countries, so that foods prepared by the Allied Food Relief Organization should, in the form of adequate complement rations, compensate present deficiencies. Information on the health situation in Europe was summarized in a series of notes on the prevalence, trend and probable course of typhus fever, cerebro-spinal meningitis, enteric fever, scarlet fever, smallpox, poliomyelitis, etc., and typhus fever was also the subject of a special study. The Singapore Bureau functioned until less than a week before the occupation of Singapore by the Japanese in January 1942. The activities of the Health Information Service have been maintained, and a study on the significance of names of communicable diseases in various languages was amplified and extended to form the basis of a comprehensive glossary in twenty-four languages of the communicable diseases. Research has continued on several subjects on the agenda of the Permanent Commission on Biological Standardization, including the nature of the toxins produced by the tetanus germ and by *Bacillus perfringens*, one of the agents of gas gangrene.

In regard to the Control of the Drug Traffic, international supervision has been impaired by the deterioration of communications, and difficulties in obtaining the necessary supplies have in some South American countries led to plans to produce raw opium and to manufacture drugs. The report directs attention to the danger that an excess of manufacture over legitimate needs may follow, and to the importance of taking, as soon as possible, all necessary steps to restore the full measures of control as they existed before the War. Work has already commenced on a post-war planning programme in this field, which includes a study and review of present national and international systems of control, with the view of suggesting improvements, and a study has been made of the legal position of drug addicts and current methods for treatment of addiction. The collections of the Library comprised about 318,200 volumes at the end of 1942, and in view of the exceptional facilities for work which the documentary material available will offer after the War, the secretariat is studying the means by which a gradual return to normal conditions may be effected.

Smithsonian Institution : Annual Report

THE report of the Secretary of the Smithsonian Institution for the year ending June 30, 1943, includes the report of the secretary and the financial report of the executive committee of the Board of Regents, together with the usual reports of the United States National Museum, the National Gallery of Art, the National Collection of Fine Art, the Freer Gallery of Art, the Bureau of American Ethnology, the International Exchange Service, the Astrophysical Observatory and on the Library. The secretary's report points out that all personnel and facilities of the Institution and its branches were made available and extensively used in the prosecution of the War, although the normal activities were kept alive to the extent of continuing observations the cessation of which would leave permanent gaps in records essential for future investigations and of maintaining and caring for the national collections. All other research and exploratory projects not required for the orderly resumption of cultural activities after the War have been suspended, except those activities relating to closer cultural co-operation with the other American republics. Much of the Institution's contribution to the war effort is of an indirect nature. More than a thousand recorded inquiries had been answered up to the close of the fiscal year, and a list of selected examples tabulated by the War Committee shows not only the wide range of these questions but also the extent to which modern total war depends on scientific knowledge.

War research projects have also been concerned with many different branches of science, including anthropology, biology, geology, physics and meteorology, and these projects occupied almost the whole time of the instrument and mechanical shops of the Astrophysical Observatory, the Division of Radiation and Organisms and the Division of Engineering, as well as of numerous individual members of the scientific staff. With regard to inter-American co-operation, the report refers to the organization of an Inter-American Society of Geography and Anthropology, with membership open to scientific workers anywhere in the hemisphere. More than 700 members have already been enrolled. The first part of a check list of the coleopterous insects of Mexico, Central America, the West Indies and South America is now in the Press as a bulletin of the National Museum. A prediction of the march of solar variation during 1939–45 based on periodicities revealed by the solar-constant values published in vol. 6 of the *Annals of the Astrophysical Observatory* shows that the years 1940–47 will be the most important years to study the sun's variations since the early twenties, and for this reason every effort has been made to keep the three field observatories in Chile, California and New Mexico in operation. With regard to the international exchanges, the report records that the Office of Censorship lifted in January 1943 the ban imposed in April 1942 on sending abroad the *Congressional Record* and the *Federal Register*.

Office Organization in Engineering Works

A BOOKLET issued by the British Standards Institution, "Office Organisation and Practice" (B.S.1100 ; Part 10 ; 1943), states in some detail the underlying principles of good office management and clerical organization, and gives practical guidance as to the installation of a system and the technique of office and clerical organization. It is addressed primarily to engineering firms of 250–1,000 employees with offices of 20–100 clerks, but the large amount of basic information on office practice condensed and set out simply in this booklet should be equally valuable to smaller firms in all branches of industry. Sections are included on the planning of systems ; the design and use of forms ; the use and selection of machines and other devices, with an appendix listing suppliers ; accommodation, lay-out, lighting and heating requirements of offices ; personnel organization, including the grading of jobs and standards of performance and incentives ; training, selection, co-ordination and control of staff, and methods of inspection of work. Typing is dealt with in a separate section including both selection and training and the pool system, while a further section deals with communications, both inward and outward mail, the use of telephones and messengers. There is a short

section on filing and another on sales invoicing. A short bibliography and an index add to the value of the publication.

Institution of Electrical Engineers : Annual Report

ACCORDING to the report for the year 1943–44 of the Council of the Institution of Electrical Engineers, total membership on March 31, 1944, numbered 24,558, and of those there were 11,924 corporate members ; 2,944 elections to all classes of membership were made during the previous twelve months. During the year 562 meetings were held in London and at the local centres. The Wireless Section held fifteen meetings, the Measurements Section eight, the Transmission Section eight, the Installations Section seven, and there were six informal meetings. There are nine students sections. Post-war planning has received close attention at the hands of the committee appointed for the purpose, and reports have been published on "Education and Training for Engineers", the "Organization of Post-War Electrical Research", and on "Electricity Supply, Distribution and Installation." A report on "Electricity in Post-War Building" has been completed by the Electrical Installations Committee and is being published by H.M. Stationery Office. The Council's report also deals with various phases of the Institution's war effort, with technical investigations, joint activities with other institutions, and with the subject of education. The revised eleventh edition of the Regulations for the Electrical Equipment of Buildings has been issued during the year.

Monthly Astronomical Newsletter

BART J. BOK, Harvard Observatory, prepares a *Newsletter* each month for the American Astronomical Society which is intended to keep scientific societies informed about progress in various branches of astronomy during the disruption of exchange of information. Some of the notes are duplicated in other publications, such as *Sky and Telescope*, and by Science Service. The present issue, No. 17, contains brief references to papers and notices in *Harvard Announcement Cards*, the *Astrophysical Journal*, *Popular Astronomy*, etc. A considerable portion is devoted to a review of contributions by Dr. N. T. Bobrovnikoff and others on the physical properties of comets.

The Night Sky in July

FULL moon occurs on July 6d. 04h. 27m. U.T., and new moon on July 20d. 05h. 42m. The following conjunctions with the moon take place : July 18d. 08h., Saturn 1° N. ; July 22d. 01h., Mercury 0·7° S. ; July 22d. 20h., Jupiter 2° S. ; July 23d. 11h., Mars 2° S. The following conjunctions in addition to the above also take place : July 5d. 08h., Mars in conjunction with Jupiter, Mars 0·2° N. ; July 10d. 04h., Mars in conjunction with Regulus, Mars 0·7° N. ; July 20d. 12h., Jupiter in conjunction with Regulus, Jupiter 0·5° N. ; July 28d. 08h., Mercury in conjunction with Regulus, Mercury 0·01° N. ; July 29d. 17h., Mercury in conjunction with Jupiter, Mercury 0·7° S. Occultations of stars brighter than magnitude 6 are as follows : July 2d. 21h. 20·9m., θ Libr (*D*) ; July 30d. 21h. 57·7m., χ Ophi. (*D*). The times refer to the latitude of Greenwich and (*D*) means disappearance. Mercury is in inferior conjunction on July 1. At the middle of the month the planet sets 50m. after the sun and at almost the same interval at the end of July. Venus is too close to the sun to be conveniently observed until late in the month. On July 31 the planet sets less than half an hour after the sun. Mars, in the constellation of Leo, can still be observed as it sets 2h. after the sun at the beginning of July and 1h. 10m. after sunset on July 31. Jupiter, in the constellation of Leo, is drawing near the sun, setting only 50m. after sunset at the end of July. Saturn is no longer visible. The earth reaches aphelion on July 3 when its distance from the sun is 94,560,000 miles. An annular eclipse of the sun, invisible at Greenwich, takes place on July 20. At Bombay the magnitude of the eclipse is 0·95, at Hong Kong 0·90, and at Madras 0·80.

Announcements

THE following elections to the Royal Society have been made : fellow of the Royal Society under Statute 12 : the Right Hon. S. M. Bruce, High Commissioner for Australia in London. Foreign members : Dr. O. T. Avery, bacteriologist, member of the Rockefeller Institute, New York ; Prof. M. Lugeon, professor of general geology and stratigraphy in the University of Lausanne ; Prof. The Svedberg, professor of physical chemistry in the University of Uppsala ; Prof. N. E. Svedelius, professor of botany in the University of Uppsala ; Prof. S. Timoshenko, professor of engineering mechanics in the University of Michigan.

THE director of the Chinese National Central Library has offered to provide British scholars with Chinese material for specialist researches, and to arrange for its translation into English if this is desired. The Library will also forward lists of books available to interested institutions in Great Britain. The British Council has undertaken to act as intermediary on the British side ; all inquiries should be addressed to the Director, Books Department, British Council, 3 Hanover Street, London, W.1.

Two prizes of 200 dollars each, offered by Mr. A. Cressy Morrison, to be known as the A. Cressy Morrison Prizes in Natural Science, will be awarded in December 1944 by the New York Academy of Sciences. Papers, which must embody the results of original research not previously published, must be submitted on or before October 1, 1944, to the Executive Secretary of the New York Academy of Sciences, at the American Museum of Natural History, Central Park West at 79th Street, New York, N.Y.

THE University of Birmingham is to award Anglo-American studentships to encourage research in some branch of petroleum technology. These studentships will normally be awarded for one year, but may be renewed for a second year, the value of the award being £225 for the first year and £250 for the second year, if renewed. They are open to graduates of the University of Birmingham and science graduates of other universities. Applications, which should include a statement of age, academic qualifications and career, should be submitted to the Registrar of the University of Birmingham by July 15. Applicants must also submit the names of two referees.

ERRATUM. In the communication "Thermal Fatigue in Metals" by W. Boas and R. W. K. Honeycombe printed in NATURE of April 22, p. 494, the illustration has been inverted : photomicrograph *d* should be *a* ; *c* should be *b* ; *b* should be *c* ; and *a* should be *d*.

LETTERS TO THE EDITORS

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

New Components of the Vitamin B Complex

AN attempt to prepare a concentrate of folic acid from liver by the method of Hutchings *et al.*[1] resulted, as already noted in a recent review[2], in the preparation of a fraction probably containing folic acid, together with another fraction soluble in chloroform, which likewise stimulated the growth of certain micro-organisms. A second chloroform-soluble fraction with similar properties has now been obtained. All three of these fractions stimulate the growth of *Lactobacillus helveticus* and *Streptococcus lactis* R 8082, but not that of *Lactobacillus arabinosus* 17/5. Although the growth-promoting properties of the chloroform-insoluble fraction are probably due to folic acid, the chloroform-soluble fractions are believed to contain new factors not previously described.

At first, an alcohol precipitate obtained as a by-product in the manufacture of commercial liver extracts was used as the starting material for the preparation of these fractions; but later, it was found more convenient to prepare the chloroform-soluble factors from the liver extract ('Examen') itself, manufactured according to the method of Laland and Klem[3]. This was subjected to the following fractionation procedure: extraction with chloroform at *p*H 3, concentration of the washed extract *in vacuo* to dryness; solution of the residue in water; adsorption on 'Decalso' at *p*H 4·5; elution with hot 10 per cent sodium chloride solution; extraction of the eluate with phenol at *p*H 3; and transference of the activity to water by addition of ether.

The eluate and the combined 'Decalso' filtrate and washings were each concentrated *in vacuo* to the original volume of the 'Examen'. In this way, two fractions were separated, an eluate and a filtrate factor.

Both concentrates stimulated the growth of *L. helveticus* and *S. lactis* R when added in place of a folic acid concentrate, but in different ways. With *L. helveticus*, the presence of both factors produced a synergistic effect, whereas with *S. lactis* R, the effect was additive. The concentrates were added at levels of 0·5, 1·0 and 2·0 and occasionally at 4 ml./10 ml. to a basal medium which was a modification of the basal medium described by Landy and Dicken[4]. At levels of 2–4 ml./10 ml. of medium, the filtrate factor alone appeared to be a complete substitute for folic acid for both organisms, but a mixture of the filtrate and eluate factors could replace folic acid at much lower levels (0·1–0·5 ml./10 ml. of medium). In the case of *S. lactis* R the effect appeared to be purely additive, but with *L. helveticus* the effect was greater than the sum of the growth-stimulating effect of each. Two typical results are given below, expressed as the amount of standard alkali necessary to neutralize the acid produced:

L. helveticus. Incubation for 48 hr. at 37°.

Chloroform-soluble filtrate factor

ml. concentrate in 10 ml. medium	Blank	0·5	1·0	2·0
ml. 0·1 *N* NaOH	0·1	2·1	4·5	6·8

Chloroform-soluble eluate factor

ml. concentrate in 10 ml. medium	Blank	0·5	1·0	2·0
ml. 0·1 *N* NaOH	0·1	0·9	0·9	0·9

Chloroform-soluble filtrate + eluate factors

ml. concentrates in 10 ml. medium	Blank	0·1 + 0·1	0·5 + 0·5
ml. 0·1 *N* NaOH	0·1	2·6	4·5
		1·0 + 1·0	2·0 + 2·0
		8·3	9·9

The synergistic effect of the two factors together is clear from these results.

S. lactis R incubated for 72 hr. at 30°.

Chloroform-soluble filtrate factor

ml. concentrate in 10 ml. medium	Blank	0·5	1·0	2·0
ml. 0·05 *N* NaOH	0·1	2·0	2·8	5·4

Chloroform-soluble eluate factor

ml. concentrate in 10 ml. medium	Blank	0·5	1·0	2·0
ml. 0·05 *N* NaOH	0·1	1·4	1·9	2·7

Chloroform-soluble filtrate + eluate factors

ml. concentrates in 10 ml. medium	Blank	0·1 + 0·1	0·5 + 0·5
ml. 0·05 *N* NaOH	0·1	2·1	3·2
		1·0 + 1·0	2·0 + 2·0
		6·3	8·2

Here the influence of the two factors is apparently additive.

Neither of the chloroform-soluble factors was destroyed by nitrous acid, by acetylation with acetic anhydride in sodium hydroxide solution (at room temperature), or by benzoylation with benzoyl chloride and sodium hydroxide solution.

The chloroform-soluble factors appear to be different from folic acid and indeed from other similar factors described in the literature, which are all reported to be insoluble in the common organic solvents, except glacial acetic acid.

The full experimental evidence will be published in due course.

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June 13.

[1] *J. Biol. Chem.*, **141**, 521 (1941).
[2] NATURE, **153**, 478 (1944).
[3] *Acta Med. Scand.*, **88**, 620 (1936).
[4] *J. Lab. Clin. Med.*, **27**, 1086 (1942).

An 'Incomplete' Antibody in Human Serum

A STUDY of the properties of mixtures of different types of human anti-*Rh* sera has led to the recognition of what appears to be an incomplete antibody. The research arose out of a suggestion by Prof. R. A. Fisher that this technique might throw some light on the problem of antibody absorption.

Human anti-*Rh* serum of the type called by Wiener "standard" agglutinates red cells of the gene Rh_1 and also those of Rh_2. 'Anti-Rh_1' serum agglutinates the former cells but not the latter[1,2]. If, however —and this was the observation that started the present work—cells of the genotype Rh_2Rh_2 or Rh_2rh are added to a mixture of these two sera, the expected agglutination due to the standard anti-*Rh* serum does not occur. It was then found that the sera need not be mixed, for if the Rh_2 cells are suspended in anti-Rh_1 serum—which causes no agglutination—and after a few minutes are separated from the serum, washed and re-suspended in saline, then these treated cells can no longer be agglutinated by standard anti-*Rh* serum.

In January of this year Fisher drew up the following formulation of the relationships found in the Rhesus factor, designed to distinguish the three categories, antigens, genes or allelomorphs and antibodies for which provision must be made in a satisfactory notation.

Name of serum:	Anti-Rh_1	*St*	Anti-*Rh* Standard	Anti-Rh_2	Not yet found	
Antibody present:	Γ	γ	Δ	*H*	δ	η
Genes						
Rh_z *CDE*	(+)	(—)	(+)	(+)		
Rh_1 *CDe*	+	—	+	—		
Rh_y *CdE*	(+)	—	(—)	+		
Rh′ Cde	+	—	—	—		
Rh_2 *cDE*	—	+	+	+		
Rh_0 *cDe*	—	+	+	—		
Rh″ cdE	—	+	—	+		
rh cde	—	+	—	—		

Those reactions not yet determined serologically are given in brackets.

The three forms of allelomorphic antigens are arbitrarily denoted by *C*, *c*, *D*, *d*, *E*, *e*, chosen to avoid confusion with any symbols so far used. The antibodies with which these react are denoted by corresponding Greek letters. These single letters refer to antigens and their corresponding antibodies only. Every gene of the system seems to be associated with a selection of three antigens from these three pairs. The system thus predicts an eighth allelomorph, Rh_z, which could not be recognized in a single individual, but could be identified in a favourable pedigree. It also suggests the possibility of two more antibodies not yet known reacting with *d* and *e* respectively.

Wiener[1] has supposed that the presence of the Rh_1 gene results in there being two "partial antigens" on the red cell (*C* and *D* of the table), and our recent work with *St* and other sera seems to make three parts necessary to the total antigen resulting from the Rh_2 gene, namely, *c*, *D* and *E*.

It is only one of these three antigens in the Rh_2 cells, called *D* in the table, which is being blocked by the anti-Rh_1 serum. *E* and *c* are left uncoated and ready for agglutination.

	Rh_2 cells untreated				Rh_2 cells coated with anti-Rh_1 serum			
Serum dilutions	1/1	1/2	1/4	1/8	1/1	1/2	1/4	1/8
Anti-Rh_1 serum (Γ)	—	—	—	—	—	—	—	—
Standard anti-*Rh* serum (Δ)	+	+	+	+	—	—	—	—
St serum (γ)	+	+	+	+	+	+	+	+
Anti-Rh_2 serum (*H*)	+	+	+	+	+	+	+	+

The coating of this same *D* antigen in Rh_1 cells can be demonstrated, but first it is necessary to remove the agglutinin (Γ) in the anti-Rh_1 serum for Rh_1 cells. This was done by absorption of the serum by *Rh′rh* cells which remove the agglutinin but not the coating factor, since these cells contain *C* but not the coatable antigen *D*. With the resulting absorbed serum, cells of the genotype Rh_1Rh_1 can be coated without agglutination confusing the result. There is no blocking of the antigen *C* in Rh_1 cells.

Absorption with untreated Rh_2 cells diminishes the agglutinin titre of standard anti-*Rh*, (Δ), anti-Rh_2 (*H*) and *St* (γ) sera. Absorption with coated Rh_2 cells diminishes the titre of anti-Rh_2 and *St* sera but not that of standard anti-*Rh* serum. Thus, absorption experiments confirm that in Rh_2 cells it is only the antigen *D* which is being blocked, *E* and *c* being left free.

The coating factor may be looked on as the standard anti-*Rh* serum antibody (Δ), which can combine with its appropriate antigen, but is defective in that it is not a suitable partner for the second stage of the antigen-antibody reaction which results in agglutination of the cells. It may be called an incomplete antibody (Δ′). Varying salt concentrations failed to produce agglutination of the coated cell suspensions, so did variations in the *p*H.

The incomplete standard anti-*Rh* antibody (Δ′) has been found in good strength in four anti-Rh_1 sera (from *Rh* negative mothers) and in a weak amount in our remaining anti-Rh_1 serum (from an *Rh* negative mother). With the removal of the incomplete antibody, these five sera gained no fresh agglutinating range; they did not, for example, then behave as anti-*Rh′* sera. In other words, there is no complete standard anti-*Rh* serum antibody present which is being masked by the presence of the incomplete form of this antibody.

One standard anti-*Rh* serum in our collection contains the incomplete antibody (Δ′) as well as the complete agglutinin (Δ). Titration results with this serum and Rh_1 or Rh_2 cells had previously given what was a puzzling and unique appearance—weak reactions, with intervening negatives, continuing up to a high dilution (1/1,000). Preliminary absorption with, say, Rh_2 cells removes the incomplete antibody leaving the normal antibody, which now gives strong reactions up to the same titre with more of the same Rh_2 cells. It seems as if the incomplete antibody wins the race for antigen.

Incomplete antibodies have been looked for but not found in three *St* sera, four anti-Rh_2 sera, one standard anti-*Rh* serum, two sera from normal *Rh* negative donors, and eleven sera from normal *Rh* positive donors. The appropriate antigen *D* in all cells so far tried has been coatable; the cells were Rh_1Rh_2 (1), Rh_1Rh_1 (3), Rh_1rh (3), Rh_2rh or Rh_2Rh_2 (6) and Rh_0rh (1). The incomplete antibody can be removed from serum by appropriate but not by inappropriate (for example, *rhrh*) cells, nor by saliva from an Rh_1Rh_1 A_1B secretor. Heating to 56° C. all the sera involved made no difference to the reactions.

I do not know of any similar phenomenon in hæmagglutination or hæmolysis. The inhibition by normal serum of the tissue hæmolysis of red cells recently reported by Magraeth, Findlay and Martin[3] is evidently of a very different nature. The inhibitor described by these workers was not species specific, whereas the incomplete antibody now being described is specific down to one antigen.

In bacterial agglutination a more striking resemblance is found in the agglutinoid phenomenon studied by Shibley[4]. The most obvious differences are that agglutinoid was made by partial heat denaturation of the serum and showed itself only as a zone of inhibition followed in higher dilutions by normal agglutination; whereas in the anti-Rh_1 sera, which had not been heated but stored at — 20° C., all the standard anti-*Rh* antibody was in the incomplete form while all the anti-Rh_1 antibody was in the complete form. The behaviour of anti-*Rh* sera, heated to 65–70° C., is now being investigated.

Very recently a sixth anti-Rh_1 serum has been found, locally. The incomplete antibody was present in good strength immediately after taking the blood.

R. R. RACE.

Medical Research Council,
Emergency Blood Transfusion Service.

May 17.

[1] Wiener, *Proc. Soc. Exp. Biol. and Med.*, **54**, 316 (1943).
[2] Race, Taylor, Cappell and McFarlane, NATURE, **153**, 52 (1944).
[3] Magraeth, Findlay and Martin, NATURE, **151**, 252 (1943).
[4] Shibley, *J. Exp. Med.*, **50**, 825 (1929).

Rh Antibodies in Human Sera: a New Variety

Human sera containing several varieties of *Rh* antibodies have been described[1]. These may be distinguished one from another by their reactions with *Rh*-positive cells, particularly with the rare types *Rh′* and *Rh″*. The reactions are shown below.

Serum	Cells			
	Rh_1	Rh_2	*Rh′*	*Rh″*
Anti-*Rh*	+	+	—	—
Anti-*Rh′*	+	+	+	—
Anti-*Rh″*	+	+	—	+
Anti-Rh_1	+	—	+	—
Anti-Rh_2	—	+	—	+
Serum-*Hi*	+	+	+	+

The sera anti-*Rh′* and anti-*Rh″*, confirming previous work, have been shown to contain two agglutinins: anti-*Rh* and anti-Rh_1 in the former case, and anti-*Rh* and anti-Rh_2 in the latter. Each individual anti-*Rh′* or anti-*Rh″* serum varies in its content of component agglutinins. In many cases the relative strengths of these agglutinins may be judged by titration of the original serum with the cell types shown in the table.

A maternal serum (*Hi* in table) was studied which reacted with nearly all *Rh*-positive cells. This mother had given birth to three children but none had survived. The mother was *Rh*-negative and the father subtype Rh_2.

Absorption of this serum with certain *Rh*-positive cells has shown that it contains three agglutinins, anti-*Rh*, and two others resembling in their activity anti-Rh_1 and anti-Rh_2. The paternal genotype is unknown but it may be Rh_0Rh_2, and the immunizing effect of fœtal erythrocytes of genotype Rh_0rh may be responsible for the appearance in this maternal blood of the agglutinins which react with *Rh′* cells. This is supported by the fact that anti-*Rh′* agglutinins have been found in the serum of a mother, Group *Rh″*, whose child, genotype Rh_0Rh'', was affected with hæmolytic disease.

The serum *Hi* reacts very strongly with cells of genotype *Rh′Rh″*. This genotype has been seen four times, twice in siblings.

F. STRATTON.

Regional Transfusion Service,
Manchester.

[1] Wiener, A. S., *Proc. Soc. Exp. Biol. Med.*, **54**, 316 (1943).

Sulphur-containing Amino-Acids and Jaundice

IN connexion with part of the recent note of Beattie and Marshall[1], which may give the impression that methionine has a strikingly beneficial effect upon patients suffering from so-called "post-arsphenamine" jaundice, we feel that the time has arrived to report very briefly some of our own results in a trial on similar lines started by us more than a year ago. Promise of its success was indicated by the literature; and it was felt that every therapeutic possibility should be explored in view of the high incidence of this serious complication.

More than 450 cases have now been studied, and the progress of individual cases has been judged both clinically and by determination of the rate of fall of the serum bilirubin level. Of these cases, more than three hundred had to be excluded from the present analysis because the jaundice was too slight or too long established for satisfactory demonstration of a therapeutic effect. The ultimate assessment has been confined therefore to the hundred and fifty most severe cases coming under observation early in the disease. Some of these were treated with cysteine (as the ester hydrochloride), 2 gm. daily, some with methionine, 2·5 gm. or 5 gm. daily, and some with casein, 60 gm. daily. Throughout the trial an appropriate proportion of cases was set aside as controls. All patients were kept in bed, and received the same diet. There were 57 controls, 41 cases treated with cysteine, 33 with methionine, and 19 with casein. A brief summary of the results is set out in the accompanying table.

	Total no. cases	Mean no. of days for serum bilirubin to fall below 4 mgm. %, with no subsequent exacerbation, counted from the onset of jaundice
Control	57	25·8
Casein	19	32·9
Cysteine	41	21·3
Methionine	33	19·7

PERCENTAGE OF CASES IN WHICH THE SERUM BILIRUBIN FELL TO BELOW 4 MGM. %, WITH NO SUBSEQUENT EXACERBATION, IN THE PERIODS STATED, COUNTED FROM THE ONSET OF JAUNDICE.

	Less than 14 days	14–20 days	21–27 days	More than 27 days	% down in under 3 weeks
Control	10	23·5	29·5	37	33·5
Casein	10·5	26	10·5	52	36·5
Cysteine	12	51	12	24	63
Methionine	22·5	48·5	22·5	6·5	71

The results given in the table have been examined statistically; they show that both cysteine and methionine had a significant but not remarkable effect on the course of the jaundice. These findings confirmed the clinical impression that the benefit, although definite, was not sensational under the conditions of these tests. The casein had no action. In view of the known methionine content of the latter, it is surprising that no effect was obtained, and it is hoped that further work will provide an explanation of the apparent discrepancy. A full report of this work is now being prepared for publication.

(This work was made possible by Major-General L. T. Poole and Brigadier T. E. Osmond, and by the willing co-operation of a large team of workers, among whom we may mention Major Lane for estimations of serum bilirubin, Dr. Stocken and Messrs. Whittaker and Spray (Department of Biochemistry, Oxford) for preparation of natural cysteine (from hair), the Ministry of Supply for the supply of synthetic methionine, and the Statistical Committee of the Medical Research Council.)

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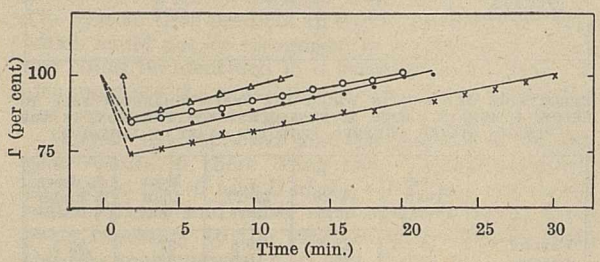
[1] NATURE, **153**, 525 (1944).

Adenosine-triphosphate Initiating Contraction and Changing Bi-refringence in Isolated Cross Striated Muscle Fibres

SINCE previous investigations[1] have demonstrated close relationship between myosin and adenosine-triphosphate, it seemed of interest to investigate the action of adenosine-triphosphate and related phosphorus compounds on living isolated muscle fibres.

So far we have used adenosine-triphosphate (isolated from rabbit muscle and purified several times through the mercury and barium salts), inorganic triphosphate, pyrophosphate and orthophosphate. All substances were used in iso-osmotic solutions of *p*H 7·3, part of the sodium chloride in the Ringer solution being replaced by an equivalent amount of the sodium salts of the substances in question.

Micro-application with micropipette and micro-manipulator[2] of adenosine-triphosphate in amounts of $2–3 \times 10^{-1}$ μgm. on non-curarized and curarized muscle fibres initiates repeated, twitch-like contractions. These are accompanied by action potentials. Repeated application (with washing out in between) has the same effect.



DECREASE AND RESTITUTION IN PHASE DIFFERENCE (Γ) (ORDINATE) AFTER ELECTRIC TETANIC STIMULATION, —Δ—Δ—.

—o—o—, after application of $2·85 \times 10^{-6}$ mol./ml. aden. triphos.
—·—·—·, " " " $4·25 \times 10^{-6}$ " " "
—×—×—, " " " $5·7 \times 10^{-6}$. " " "

Bi-refringence, examined by means of the Babinet compensator[3], falls 20–30 per cent after application of adenosine-triphosphate ($1·2–7·3 \times 10^{-6}$ mol./ml.) and recovers spontaneously in the course of 15–20 min. The degree of decrease and the duration of recovery depend on the concentration applied, and the time course corresponds closely to that observed after tetanic electric stimulation (see graph).

Cozymase (60 per cent preparation) in concentrations of 0·05–0·5 mgm./ml. is without effect either on the mechanical response or bi-refringence.

Preliminary experiments with inorganic *triphosphate* ($6·1 \times 10^{-6}$ mol./ml.) likewise show release of contraction of a more contracture-like type, the decrease in bi-refringence being only a quarter to a third of that occurring after application of adenosine-triphosphate.

Pyrophosphate in concentrations of $6·7–9·8 \times 10^{-6}$ mol./ml. initiates contraction, and bi-refringence exhibits an irreversible fall of *c.* 40 per cent. Lower concentrations without releasing mechanical responses are accompanied by a decrease in bi-refringence the partial recovery of which takes more than 40 min.

Orthophosphate in concentrations of $2·5 \times 10^{-5}$ mol./ml. likewise initiates contracture-like contractions, but no changes in bi-refringence occur.

The experiments indicate that: (1) In spite of the fact that different investigators[4] find that muscle membranes are impermeable to adenosine-triphosphate, it may react directly or indirectly with contractile and doubly-refracting elements. (2) Adenosine-triphosphate normally could be an agent of contraction, while adenosine-triphosphate present in muscle cannot be in immediate contact with the contractile elements due either to differences in local distribution or to the presence of a non-reactive compound. Addition of adenosine-triphosphate thus would correspond to the establishment of contact between adenosine-triphosphate and contractile elements otherwise initiated by the nervous impulse. (3) In contrast to findings with pure myosin, phosphorus compounds other than adenosine-triphosphate may release contraction and cause changes in bi-refringence.

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[1] Needham, J., Kleinzeller, A., Miall, M., Dainty, M., Needham, D. M., and Lawrence, A. S. C., NATURE, **150**, 46 (1942). *Stud. Inst. Med. Chem. Univers. Szeged*, edited by Szent Györgyi, A., **1** and **2** (1942, 1943).

[2] Buchthal, F., and Lindhard, J., *J. Physiol.*, **90**, *P* 2 (1937).

[3] Buchthal, F., and Knappeis, G. G., *Skand. Arch. Physiol.*, **78**, 97 (1938).

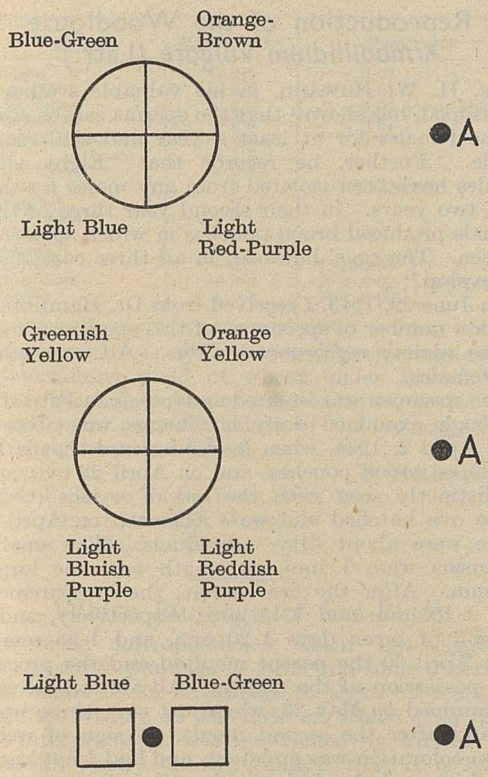
[4] Boyle, P. J., and Conway, E. E. J., *J. Physiol.*, **100**, 1 (1941).

Colour of Small Objects

IF a circle, 2 cm. in diameter, is divided into quadrants and coloured as in Fig. 1, placed on either a black or white ground, and then viewed with one eye from a distance of about 3 m., it will be found that there is considerable difficulty in distinguishing the green from the light blue on one hand and the orange-brown from the light red-purple on the other, so long as the brightnesses of the fields are made as equal as possible. There will be no difficulty in distinguishing the green from the orange, provided that the observer is not red-green colour-blind in the sense that he habitually confuses such colours, and the circle will appear to be divided into two halves, right and left. Red-green colour-blind observers see the circle as uniform, or they may be able to separate the quadrants on subtle brightness differences.

Similar effects will be observed if the quadrants are coloured as in Fig. 2. The result in this case is even more striking since, if the circle is viewed at close range, it divides naturally into a yellow and green upper half and into a purple lower half. At a distance it divides vertically into a greenish-grey left half and a brownish-grey right half. It will be found that each particular green has its corresponding blue or mauve with which it is confused, and each yellow, orange or brown has its own particular reddish-purple.

In both cases, if the eye is focused not on the centre of the circle directly but on the point *A*, about 4 cm. from the centre of the circle, then all the quadrants stand out in their true colours. The point *A* may lie upon any radius of the circle. Similar effects are also obtained if the colours are arranged as in Fig. 3, so that they are probably not due to simultaneous contrast or to the overlapping of the images formed on the retina.



It may be inferred from these observations that under these conditions the centre of the fovea is not so good at distinguishing colours as the immediately surrounding area of the retina. The size of the circle is such that it corresponds closely to the so-called rod-free area. Both circle and external fixation point fall within the macula, so that the effect is probably not due to the macular pigment, which would perhaps be expected to act in a rather similar manner by cutting out the blue light. The confusions which occur at the foveal centre are almost exactly those made by the blue-blind person or tritanope[1], so that this area appears to be in some degree dichromatic and lacking in the blue sensation. This is not strictly true, since small objects seen at the centre of the eye may appear blue, but in this area the blue has no unique quality and, as has been shown, is readily confused with certain greens. The retina immediately surrounding the 'rod-free' area is normal and trichromatic.

Recently, the idea was put forward[2] that many of the data concerning colour vision could be explained in terms of two receptors, one the cone and the other the rod; that is, an element depending upon visual purple for its light sensitivity. It was pointed out at the time that this would lead to exactly the type of confusion which the above observations show to occur in the centre of the fovea. This area of the retina therefore perhaps consists of two elements, so far not distinguished histologically, but essentially corresponding to the cone and the rod, with the reservation that in this situation the latter does not accumulate visual purple or become dark-adapted as it does elsewhere in the retina.

Now Granit[3] has found that in the all-rod eye of the guinea pig the shape of the photopic visibility curve differs from that of the corresponding scotopic curve in such a way as to indicate that the retinal element in question acquires a relatively increased sensitivity to blue when light-adapted. If this change in relative sensitivity were dependent upon the 'bleaching' of the large quantities of visual purple in the dark-adapting rods, then this might provide a basis for a possible explanation of human colour vision on the following lines. The centre of the fovea may consist not only of cones but also of rods, the latter depending upon visual purple but not accumulating it. This area would therefore be dichromatic with the properties outlined previously. The rest of the retina would then depend on cones, on rods like those in the fovea, and on 'normal' dark-adapting rods which under photopic conditions would have a higher sensitivity to blue than the other rods and so act as a third receptor. In the red, yellow and green parts of the spectrum, both types of rods would have much the same sensitivity, and it is significant that from about 540 mμ to the red end of the spectrum all spectral colours can be matched by mixtures involving red and green only.

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May 11.

[1] Pitt, F. H. G., *Proc. Roy. Soc.*, B, **132**, 101 (1944).
[2] Willmer, E. N., NATURE, **151**, 213 and 632 (1943).
[3] Granit, R., *Acta Physiol. Scand.*, **3**, 318 (1942).

Visibility of Blue and Yellow

IF a pattern consisting of blue and yellow areas be viewed at a sufficient distance by an observer, then, in certain circumstances, the blue is seen as black and the yellow is seen as white, so that the pattern appears to be a black and white one. Factors of importance in determining whether the pattern is seen as blue and yellow or as black and white have been found to be (1) the size of the pattern, (2) the intensity of illumination, (3) the size of the pupil, (4) the exact colours of the yellow and the blue pigments used in the design, (5) the adaptation of the retina, (6) spectral content of illuminant. It is suspected that factors of importance would also be (7) absorption of the eye media, and (8) absorption by the macula lutea.

Some quantitative measurements have been made in respect of factors 1, 2 and 3 (size, intensity and pupil diameter).

TABLE 1. EFFECT OF SIZE OF PATTERN.

	3,000 ft. c. 1 mm. pupil	
Visual angle (min. of arc)	Blue appeared to be:	Yellow appeared to be
3	Black	White
4	Black	White
5	Bluish Black	White
6	Blackish Blue	Cream
7	Blue	Pale Yellow
8	Strong Blue	Yellow

TABLE 2. EFFECT OF DIAMETER OF PUPIL.

	3,000 ft. c. 6 min. of arc	
Pupil Diameter	Blue appeared to be:	Yellow appeared to be:
1 mm.	Blackish Blue	White
3 mm.	Blue	Yellow

TABLE 3. EFFECT OF ILLUMINATION.

	1 mm. pupil 6 min. of arc.	
Illumination in ft. c.	Blue appeared to be:	Yellow appeared to be:
3,000	Blue	Yellow
1	Black	White

Of the three variables which have been tested so far, the change in the size of the pattern has most effect, and the change in the illumination has least effect on the colours seen.

The explanation of the disappearances of the colours appears to be as follows:

Both the blue and yellow pigments are greatly diluted with white light. Owing to the chromatic aberration of the eye, blue and yellow rays cannot be focused simultaneously. Therefore, if yellow images be sharp the blue images form wide diffusion circles; and vice versa. If the yellow images be sharp they fall on areas of retina which are already being illuminated by blue rays, and since these are complementary in colour to the yellow rays, the yellow is greatly diluted with white light, and this dilution increases as the pattern becomes smaller. If the blue images be sharp, it is these which suffer dilution with white light. If the eye be focused at an intermediate position, both blue and yellow images are slightly out of focus and each dilutes the other with white light. This dilution increases as the pattern becomes smaller.

The normal adjustment of the eye is that which produces sharply focused yellow images, and it is, therefore, these which become diluted with white light. In consequence, as the distance between the observer and a given pattern of blue and yellow increases, it is the yellow which first becomes confused with white. The blue images remain undiluted, but they suffer greatly in intensity, as Table 4 shows. It will be seen that down to the visual angle of 12 min. of arc, the fall in intensity of the blue is relatively slight, but that as the visual angle decreases to 3 min. of arc, there is a sudden fall in intensity. It is usually somewhere within this range that the blue is replaced by black.

TABLE 4. EFFECT OF VISUAL ANGLE ON LOSS OF INTENSITY OF GREEN, BLUE AND VIOLET RAYS.

Visual angle (min. of arc)	Percentage loss of intensity for: 5000 A.	4500 A.	4000 A.
24	3	5	9
12	6	10	18
6	12	20	36
3	24	40	62
1·5	48	63	78

The reason for considering the case for rays of 5000 A. is that blue pigments reflect or transmit these almost as much as they do the blue rays and the violet rays.

An increase in the aperture from 1 mm. to 3 mm. adds to the colours of the pigments the colours which are produced by the chromatic aberration of the eye. Consequently both blue and yellow become more visible; as shown in Table 2.

A decrease in illumination from 3,000 to 1 ft. c. decreases the visibility of the colours, because the amount of colour which is above the threshold of the foveal cones at a high intensity of illumination falls below that threshold at a low intensity, as shown in Table 3.

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Reproduction of the Woodlouse *Armadillidium vulgare* (Latr.)

DR. H. W. HOWARD, in his valuable studies on this isopod, has shown[1] that the sperms can be stored in the females for at least a year and still remain viable. Further, he records that "Eight virgin females have been isolated from any males for more than two years. In their second year three of these animals produced brood pouches in which eggs could be seen. The eggs, however, in all three cases failed to develop."

On June 29, 1943, I received from Dr. Hamilton E. Quick a number of specimens of this species referable to the variety *rufobrunneus* Cllge. All were adults and females.

One specimen was isolated and kept in a Petri dish. Although examined daily no change was observed until April 2, 1944, when it was noticed that it had developed brood pouches, and on April 22 ova could be distinctly seen with the aid of a lens (× 20). These ova hatched and were liberated on April 27. There were about fifty individuals. The smallest specimens were 1 mm. in length and the largest 1·5 mm. After the first moult, the measurements were 1·10 mm. and 1·15 mm., respectively, and at the end of seven days 1·20 mm. and 1·35 mm.

On April 30 the parent moulted and the progeny took possession of the exuviæ. All are still alive.

Examined on May 23, when just over three weeks old and after the second moult, no sign of red or brown coloration was apparent, and had I not known their history I should have identified them as young specimens of the variety *plumbeus* Lereboullet.

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May 25.

[1] *J. Genet.*, 85 (1940); 143 (1944). NATURE, **152**, 331 (1943).

Reaction of Wheat Varieties Grown in Britain to Erysiphe

IN May 1944 a moderately heavy attack of mildew (*Erysiphe graminis*) developed in my wheat yield trial near Maldon, Essex. This trial consisted mainly of experimental breeding material, but since it also contained twenty rod-row plots of each of fifteen important commercial varieties of wheat, an opportunity arose of evaluating these varieties according to their susceptibility or resistance to mildew. Individual rows were classified on a scale of marks according to intensity of infection and the data subjected to an analysis of variance. These data are summarized in the accompanying table, a negative value indicating an attack of less than average severity and a positive value of more than average. Levels of significance are indicated where $P < 0{\cdot}05$.

Certain other commercial varieties were present in the trial in six replications only. Of these, the variety Picardie showed highly significant resistance (score $-6{\cdot}5$, $P < 0{\cdot}001$), but no other departure from the average was significant. There was, however, some indication ($P < 0{\cdot}10$) that the varieties Setter, Steel, Benoist 40, Red Drottning and Square-head II were resistant, while Robusta, Redman and Vilmorin 29 were susceptible. No variety showed complete immunity to the disease.

Variety	Mildew score	Significance
Juliana	−2·9	$P < 0·01$
Iron III	−2·7	$P < 0·01$
Wilhelmina	−2·6	$P < 0·01$ resistant
Desprez 80	−2·5	$P < 0·02$
Weibull's Standard	−2·0	$P < 0·05$
Als	−1·3	
Garton's 60	−0·3	
Victor	0	Average
Steadfast	0	
Red Standard	+0·1	
Wilma	+0·2	
Yeoman I	+1·5	
Holdfast	+2·3	$P < 0·05$
Little Joss	+3·3	$P < 0·01$ susceptible
Warden	+9·3	$P < 0·001$

While mildew is not a factor of major importance in determining yield of wheat under British conditions, these data are of interest since, so far as I am aware, no numerical data of similar scope have previously been published.

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White Plumage of Sea-Birds

IN recent correspondence, Craik[1] has suggested that the white plumage of gulls and some other sea-birds might be an advantage to them by rendering them less visible to the fish on which they prey. This interpretation was questioned by Pirenne and Crombie[2], partly on the grounds that it is by no means certain that fish can see birds in the air, whatever their colour. This uncertainty, however, does not arise in the case of birds of prey which hunt over land, for these are undoubtedly seen by their prey. The reactions of other birds to a passing hawk have often been described. It would seem, therefore, that if a white under-surface were of adaptive value to birds which hunt against a background of sky, this form of cryptic coloration would be found among predaceous land-birds. Yet none of the eagles, hawks or owls have the pure white plumage of gulls. Some are certainly very pale on the under-surface, but there does not seem to be a greater tendency among these birds to have light-coloured under-parts than there is among other land-birds.

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[1] Craik, K. J. W., NATURE, **153**, 288 (1944).
[2] Pirenne, M. H., and Crombie, A. C., NATURE, **153**, 526 (1944).

The Hole Theory of Liquids

RECENTLY, Fürth[1], in a series of papers, has developed the hole theory of the liquid state. A liquid is regarded as a continuum permeated by a large number of holes, the number of holes being comparable to the number of particles in the liquid. The motion of the holes in the material continuum is similar to that of particles in a gas, and the hole theory on this account has a formal similarity with the kinetic theory of gases. A hole has four degrees of freedom, three of translation and one corresponding to a change in its radius. The average period for radial oscillation of holes is found to be

$$\Gamma_0 = 0·17 \frac{\rho^{1/2}(kT)^{3/4}}{\sigma^{5/4}},$$

which is of a far smaller order of magnitude than the meanlife Γ of the hole. σ represents the surface tension of the liquid, ρ its density, T the temperature and k is Boltzmann's constant. The meanlife as discussed by Fürth is the time for which a hole lasts before it is destroyed by evaporation of molecules into it. In determining the meanlife, Fürth has neglected the effect of curvature on the rate of evaporation. When this is taken into account, the hole theory affords a simple though, because of its inherent defects, not quantitatively accurate description of the variation of viscosity of liquids with pressure. For example, for pressures smaller than p_2, the internal pressure of the liquid, we have

$$\log_e q = \frac{0·54M}{\rho RT} p,$$

where q is the ratio of the viscosity under pressure p(kgm./cm.^{2}) to that under atmospheric pressure, M the gram molecular weight, and R the gas constant. For most liquids p_i is of the order of 10^3 kgm./cm.^{2}.

It is interesting to observe that (on certain assumptions) the thermal conductivity of a liquid can be connected with the period of the radial oscillations of a hole. We find that the theory requires

$$C \equiv 2\chi/\rho^{1/2} S (\sigma kT)^{1/4}$$

to be a constant and equal to *unity* for all unassociated liquids. In the above expression, χ is the thermal conductivity and s the specific heat per unit mass. The accompanying table gives the observed values for C—the average value for non-metallic liquids is about twice the theoretical value. In the case of metallic liquids, the observed value for C is of the order of 10^2; this is as it should be, for in metallic liquids the conductivity is due to electrons and the hole theory is inapplicable.

Substance	Temperature (T°K.)	Thermal conductivity, χ (watts/cm. deg.)	Specific heat, S (joule/gm.)	Surface tension, σ (dyne/gm.)	C
Mercury	273	8360	0·14	466	158
H_2O	293	587	4·18	74·2	2·1
C_6H_6	293	170	1·7	28·9	2·1
CCl_4	273	110	0·84	28·0	2·0
C_2H_5O	273	180	2·0	44·0	1·6
CH_3OH	293	209	2·5	22·6	1·9
CS_2	293	161	0·96	33·8	2·7
$CHCl_3$	285	138	0·95	28·5	2·3
$C_5H_{10}O$	293	138	2·29	17·0	1·5
C_3H_6O	293	179	2·21	23·7	1·8

The full account of this work will appear in the *Proceedings of the National Institute of Sciences, India*.

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[1] Fürth, R., *Proc. Camb. Phil. Soc.*, **37**, 252 (1941).

Deformation of Rubber-like Materials

IN a recent paper on the highly elastic deformation of polymers, Aleksandrov and Lazurkin[1] give the following expressions, first for the total deformation $D(t)$ of rubber at time t after application of a constant stress:

$$D(t) = D_0 + D\infty\ (1-e^{-t/\tau}), \quad . \quad . \quad . \quad . \quad (1)$$

and second, for the amplitude D of deformation under a harmonic stress:

$$D = D_0 + \frac{D\infty}{1 + i\omega\tau}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where D_0 is the 'ordinary elastic' component, very small compared to $D\infty$; $D\infty$ the 'highly elastic' component, obtained for $t \to \infty$ in (1) or $\omega \to 0$ in (2); ω is $2\pi \times$ the frequency of the applied stress; τ a 'relaxation time'.

It may be noticed that expressions (1) and (2) would be given by the mechanical model shown in Fig. 1, where K_0 is the stiffness of a spring corresponding to the 'ordinary (crystal) elasticity'; $K\infty$ one corresponding to the 'high elasticity'; R the 'damping coefficient' of a dashpot in parallel with the spring, giving rise to a viscous force proportional to the velocity. When a constant force F is applied to the system, the solution of the equation of motion gives the displacement:

$$D(t) = \frac{F}{K_0} + \frac{F}{K\infty}(1 - e^{-tK\infty/R}); \quad . \quad . \quad (3)$$

while for a harmonically varying force $Fe^{i\omega t}$ the steady state solution is a harmonic displacement of frequency $\omega/2\pi$ and amplitude D:

$$D = \frac{F}{K_0} + \frac{F}{K\infty + i\omega R} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

(3) and (4) reduce respectively to (1) and (2) on writing $D_0 = F/K_0$; $D\infty = F/K\infty$; $\tau = R/K\infty$.

If one considers a rubber unit stressed, for example, in shear, it is easy to see on introducing an elastic modulus G and a 'normal viscosity coefficient' ν (cf. Kimball[2]) that the 'relaxation time' τ has the expression

$$\tau = R/K\infty = \nu/G \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

It is of interest to compare the results of Aleksandrov and Lazurkin with those of other workers using the free or forced vibrations of tuned systems, as shown in the mechanical model of Fig. 2. The 'ordinary' elasticity was neglected by these authors ($1/K_0 = 0$); a justifiable approximation for the type of polymers and range of temperatures in their work.

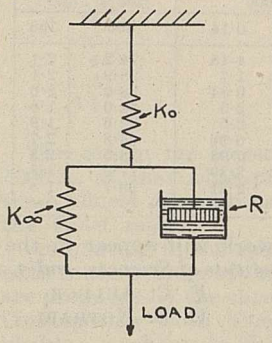

Fig. 1.

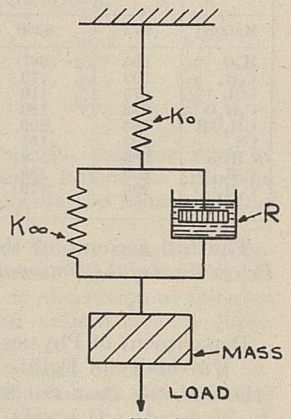

Fig. 2.

An advantage of the tuned system method is that it permits the separate determination of elastic and viscous forces. The elastic modulus is determined from the frequency of the free vibration[3], or from the frequency of resonance of the forced vibration[4,5]. The viscosity coefficient is determined from the rate of decay of the free vibration[3], or from the amplitude at resonance of the forced[4,5]. The 'relaxation time' is then determined from Equation 5: $\tau = \nu/G$. Now all the authors quoted[3,4,5] have found that G varies little, if at all, with frequency, while ν is roughly inversely proportional to frequency. This fits in better with the phenomena of elastic hysteresis connected with ordinary elastic solids (cf. ref. 2) than with the notion of a 'relaxation time' constant at a given temperature. In order to connect these results with the 'freezing up' of rubber with increased frequency observed by Aleksandrov and Lazurkin, one would expect the curve of τ versus frequency to start at low frequencies roughly in the shape of a rectangular hyperbola, but tend asymptotically with increasing frequency to a constant positive value. The determination of G and ν over a wide range of frequencies and temperatures would not only be of theoretical interest, but also of great practical value in the engineering application of rubber. One further point that is best brought out by the forced vibration method is the departure from linearity of elastic and viscous effects in rubber: it is found that the measured values of G and ν vary with the amplitude of strain.

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Metalastik, Ltd.,
Leicester.
April 27.

[1] Aleksandrov, A. P., and Lazurkin, Y. S., *J. Tech. Phys. U.S.S.R.*, **9**, 1249 (1938).
[2] Kimball, A. L., *Trans. Amer. Soc. Mechan. Eng.*, **51** (1), 227 (1929).
[3] Harris, C. O., *J. Appl. Mech.*, **9**, 129 (1942).
[4] Naunton, W. J. S., and Waring, J. R. S., *Proc. Rubber Tech. Conf.* London, May 23–25, 1938, 805.
[5] Gehman, S. D., Woodford, D. E., and Stambaugh, P. B., *Ind. and Eng. Chem.*, 1032 (Aug. 1941).

Solubility of Basic Open Hearth Slags

A CONSIDERABLE amount of work has been done, over a number of years, regarding the phosphate solubility of basic open hearth slags. The *Proceedings of the Faraday Society* of 1920 contains "A Symposium on Basic Slags" giving much data regarding the subject of phosphate solubility.

Our investigations, commenced in 1920, employed pieces of basic finishing slag, in lump form (Fig. 1) instead of the powdered samples used in the original work. These sample pieces of slag have been subjected to extraction in 5 per cent hydrogen chloride solution, the acid solvent being changed at 24-hour intervals and analyses made on the contents of these soluble portions, these results representing the daily extraction.

This method of extracting revealed an interesting fact, namely, that when the acid extraction was complete, a practically pure silicious resdeue (Fig. 2) remained in the beaker. The residue was of similar shape and size to that of the original slag lump, but was in appearance of a porous skeleton nature.

The rate of solution of the different constituents is also informative, as shown in Fig. 3. The extraordinary feature is the residual matrix of practically pure uncombined silica (Fig. 2). The chart gives the relative solubility rates of typical slag lumps extracted by a 5 per cent hydrogen chloride solution.

Reproducible results can be obtained on various basic open hearth finishing slags, irrespective of their origin.

The above experiments led us to use a similar extraction method on transparent, glassy, amber-coloured slags extruded into the cavity at the head of large forging ingots of acid open hearth steel. The typical analysis of these slags is as follows:

Fig. 1.

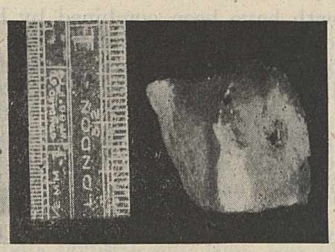

Fig. 2.

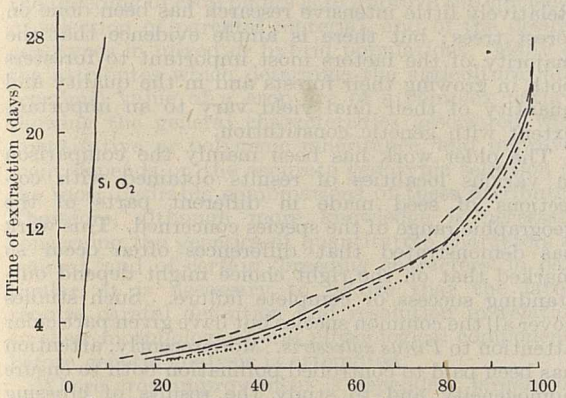

Fig. 3. SOLUBILITY OF LUMP BASIC SLAG IN 5 PER CENT HYDROGEN CHLORIDE SOLUTION.

Fe, ——— ; CaO, – – – – ; MnO, ... ; P_2O_5, — — —.

silica, 45·51 ; ferrous oxide, 0·90 ; alumina, 23·10 ; manganese oxide, 28·52 per cent.

When extracted by warm, concentrated hydrochloric acid, these slags yield white, glossy residues of pure silica.

Further interesting phenomena were observed during an investigation dealing with hæmatite iron ores. Ordinary lump ore samples when extracted in concentrated hydrochloric acid, as above, leave a rigid porous skeleton of pure silica ; this residue has a crystalline appearance. Samples of kidney and pencil ores from the same mine, when thus extracted, leave the silica in a laminated, transparent, gelatinous form.

The information, here available, may shed some light on this very obtuse problem and be of value to future investigators.

B. W. METHLEY.
H. J. TURNER.

Steel, Peech and Tozer,
The Ickles,
Sheffield, 1.
May 4.

Non-Solar Planetary Systems

IN his communication in NATURE[1] on non-solar planetary systems, Sir James Jeans writes, "Mr. Sen refers with approval to Banerji's modification of this [tidal] theory. This makes the original sun a Cepheid which had its oscillatory instability increased by the gravitational attraction of a passing star. But a passing star cannot increase the instability of a Cepheid appreciably unless it comes very near. . . . Judging from their luminosity, all Cepheids are much more massive than the sun or 61 Cygni or 70 Ophiuchi."

In my paper[2] on "The Instability of Radial Oscillations of a Variable Star and the Origin of the Solar System", I have given a theory which, I believe, satisfactorily accounts for the amount of angular momentum and energy possessed by the planets. The sun is supposed to have been originally a *part* of a Cepheid variable much heavier than the sun, which oscillated radially with small amplitude. It has been shown mathematically that the oscillations are stable only if the amplitude is so small that its square may be neglected. Instability will ensue if the amplitude is increased so that its square can no longer be neglected. The nearby passage of a star of about the mass of a Cepheid increased the amplitude of the oscillations, rendering them unstable. Matter was consequently thrown out, which condensed into the sun and the planets. If the parent Cepheid had a mass about nine times that of the sun, the sun and its planets would take away about two fifths of the Cepheid's energy. It has also been shown that the encounter need not be "very close", nor need the intruding star have an inordinately large velocity to give the requisite angular momentum to the sun and the planets and enough energy to the solar system to escape from the parent Cepheid. It appears that due to the difficulties of transit at present, Sir James Jeans has not perhaps seen my paper.

Jeans has also suggested[3] that the sun was originally big enough to include the orbit of Uranus and yet not too diffuse to hang together dynamically. There are several difficulties in such a theory which cannot be explained satisfactorily. The angular velocity imparted to the surface of the primitive sun extending up to the orbit of Uranus will presumably be of the same order as the angular orbital speed of Uranus. If the sun contracted from its enormous original size to its present dimensions, its angular velocity should increase considerably. Even granting that 98 per cent of the original angular momentum has been taken away by the planets, a little calculation will show that the sun should be rotating with at least 400 times its present angular velocity and should on that account become *distinctly* spheroidal in shape.

Moreover, with such rapid rotation, possibly the critical value for $\omega^2/2\pi\gamma\rho$ will be reached, and there will be equatorial break-up, resulting in the formation of rings of particles surrounding a central lenticular mass. Again, if the planets had taken away 98 per cent of the total angular momentum as calculated on the above theory, they should be revolving much more rapidly at present.

Another point in this theory may also be mentioned. Jeans supposes that the planets are most likely to have been formed before the sun's radius fell much below 4,000 times its present radius. It is difficult to understand what processes might have helped to bring the innermost planets to their present distances of the order of 100 times the sun's radius.

Sen has referred in his communication in NATURE[4] to the well-known Jeans-Jeffreys theory, from which it follows that planetary systems should be of "the nature of freak formations"[5]. It seems that he did not refer to Jeans's recent communication in NATURE[1], as the suggestions there are "very tentative".

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[1] NATURE, **152**, 721 (1943).
[2] Banerji, A. C., *Proc. Nat. Inst. Sci. Ind.*, **8**, 173 (1942).
[3] NATURE, **149**, 695 (1942).
[4] NATURE, **152**, 600 (1943).
[5] Jeans, J. H., "Astronomy and Cosmogony", 401 (1928).

APPLICATION OF GENETICS TO PLANT AND ANIMAL BREEDING

THE Genetical Society held a symposium on the "Application of Genetics to Plant and Animal Breeding" in London on April 13. The president, Dr. C. D. Darlington, in opening the meeting, said that genetics owes a debt to plant and animal breeding both for its foundation and its development. If the purpose of agriculture in the future is to be the highest production, genetics will have the opportunity of repaying this debt. The object of the symposium was to discuss whether genetics has the capacity to do so.

Mr. M. B. Crane, dealing with fruit and forest tree breeding, said that the production of new varieties, and the maintenance and efficient use of old ones, are problems within the scope of our present genetic knowledge. The first essentials for improvement are a knowledge of modern techniques and of the variation, relationship and distribution of the plants and trees within the different groups. Without this knowledge the breeder would often be working in the dark and be likely to follow some of the old traditions, such as breeding from the best for the best, often to find that this does not work.

The cost of fighting the diseases and pests of fruit, as of other crops, can be largely saved by the establishment of resistant and immune forms, so far attempted only on a small scale. Many crops are susceptible to injury by the sulphur, copper and other drugs used to combat diseases. It is known that immunity to this injury is often heritable. Advantage is likely to be obtained by the replacement of continuous vegetative propagation by sexual propagation. The devastation wrought by virus disease on the growth and yield of raspberries and strawberries, and the common freedom of seedlings from serious infection for a profitable time might be turned to account. The uniformity of healthy clonal reproduction would not be surpassed, but, in the clone, virus gives rise to great variability and decline in yield, quality and growth.

In apples and pears about a third of the varieties are triploids. This means that they have been favoured by selection. In the past we have had to depend on their spasmodic occurrence. In pears triploid families can now be raised at will, and the breeding and induction of tetraploids is likely to give new forms of outstanding value. To get the best from new polyploid fruits, new polyploid root-stocks might have to be made to fit them. In addition to old varieties, new wild stocks of useful species should be collected and established for the breeders' use, to introduce frost and disease resistance and high nutritive value and to maintain hybrid vigour and variability.

In our farm and garden crops selection and breeding have given us many improved forms which have long ago displaced most of the original wild forms from cultivation. In Great Britain, practically no such improvement has been made or even attempted with forest trees. It seems to be assumed that with forest trees technique would be difficult, and selection and breeding work inevitably prolonged. In the United States and in Sweden, however, both selection and breeding of forest trees have been carried out with decisive results in a short time. Selection for growth and quality has been effective, and important characters such as frost resistance and rapidity of growth have been combined by hybridization. The efficiency of new afforestation programmes will depend on the use made of genetics.

Prof. H. G. Champion indicated the great scope for the practical application of the genetical knowledge which can be gained about our important forest trees. He said it is exceptionally wide in Great Britain owing to the general reliance on plantations for regenerating or creating forests, and to the widespread use of exotic species. The consequences of mistakes made in selection of the stock used in any locality will carry on for at least a tree generation. Relatively little intensive research has been done on forest trees; but there is ample evidence that the majority of the factors most important to foresters both in growing their forests and in the quality and quantity of their final yield vary to an important extent with genetic constitution.

The older work has been mainly the comparison in various localities of results obtained with collections of seed made in different parts of the geographic range of the species concerned. This work has demonstrated that differences often occur so marked that on the right choice might depend outstanding success or complete failure. Such studies cover all the common species but have given particular attention to *Pinus sylvestris*. More recently, attention has been paid to controlled pollination both to ensure homogeneity and to study the results of crossing both within a species and between species. Examples of commercially important hybrids and polyploids are available, notably with Larix and Populus.

Genetical research on forest trees and the practical application of results present special difficulties as compared with similar work on other plants. These have probably been over-emphasized, but are the main cause of the relative neglect under which the subject has suffered at the hands of botanists and practical foresters. These difficulties were briefly reviewed. For research, they derive from the large size of the tree unit, the late maturation and inaccessibility of the flowering branches, and the fact that growth in crops is essential for proper assessment. In application of results, these same hindrances are involved and, furthermore, most forest trees cannot easily be multiplied vegetatively. Considerable progress has already been made in surmounting these obstacles and it is thought that many of the problems should be capable of solution; organized attack with official support is strongly to be recommended.

Prof. T. J. Jenkin explained the conflict that existed before genetic methods were applied to grass breeding. The grassland farmer wanted a permanent sward, and the seedsman selected for abundant seed; but the two are incompatible. More recent work has been directed mainly towards improvements in yield, particularly in the form of hay, and it was not at first realized that practical grass-breeding involves at least two distinct problems, of which the simpler and less important is this increased hay yield. The second, and the more important under Welsh conditions, is the production of persistent and productive strains that will stand continuous grazing over a period of years. The grasses, even apart from their heterozygosity, are not good subjects for formal genetical studies (except where defective seedlings are concerned) because they present very few characters that can be easily observed in the mature plant. The important characteristics such as growth habit, tillering capacity, persistence of the individual plant,

time of flowering, growth and productivity and so on are presumably extremely complex, and a satisfactory method of studying them is greatly needed. At the same time, the grass breeder should not completely neglect formal genetics, and particularly should a general genetical survey of plant material be made if only in order that a more definite estimate of the total heterozygosity of the various species might be made.

Dr. G. D. H. Bell pointed out that the most obvious contribution which genetics can make to the breeding of crop plants is to improve the efficiency of selection of parental material, and of the desired genotypes in mixed or hybrid populations. Many of the attributes which determine the agricultural and economic value of a crop are of a complex nature, showing the general characteristics associated with quantitative or polygenic inheritance, and improvement depends on the accurate genotypic selection of the most desirable combinations of these attributes. Therefore, although more knowledge is necessary concerning the genetics of quantitative characters in general, and of certain 'breeding characters' in particular, it is necessary to realize that the latter require careful definition and resolution in relation to their morphological and physiological components before genetic analysis is attempted.

Where crop improvement is dependent largely on hybridization, its efficiency is dependent, first, on the correct choice of the parental material, and it is essential to have knowledge concerning the breeding value of the material available, and the possibilities of combining characters which might show physiological incompatibility. This is a matter of considerable importance in any scheme of hybridization which involves a progressive synthesis of components affecting the expression of a complex character.

Accurate genetical investigation is dependent on the reasonably easy recognition of genotypes and genotypic variation. The difficulty in plant breeding which involves field selection is the assessment of the individual, or of a small progeny, when several characters are concerned and each is affected to varying degrees by the environment. Attempts have been made to develop selection indices for improving the efficiency of field selection; but there are considerable difficulties in the application of such methods to any reasonable amount of breeding material. However, it is in relation to the above considerations that any further contributions on the part of genetics to plant improvement must be considered.

Dr. K. Mather remarked that the progress of genetics has not yet led to the marked advances in plant and animal breeding which has been so confidently expected in the past. He pointed out that it will be necessary to determine which branches of genetical study are directly concerned with the problems of breeding, and deliberately to foster investigations of these kinds. They must aim primarily at increasing the precision with which the tools of the breeder—selection, adjustment of the mating system, and adjustment of population size—can be used to manipulate the heritable variation which constitutes his raw material.

The first necessity is a knowledge of the type of inheritance involved in breeding for any particular character, and this is not yet available in all cases. Where inheritance is simple, depending on major genes, genetics can already supply the information necessary for estimating the progress which might be expected, for determining how to plan the breeding programme, and for calculating its magnitude. The great majority of characters involved in breeding programmes, however, show polygenic variation, depending on many genes having small, similar and supplementary effects. Such genes determine a type of inheritance different from and more complex than that depending on major genes. Furthermore, they cannot be individually identified owing to the masking effects of one another and of non-heritable variation. Genetics has in the past offered little help in handling polygenic variation; but recent investigations are changing this situation. Methods are now available for separating and estimating, from F_2 and F_3 data, the non-heritable, fixable genetic, and unfixable genetic, parts of the variation in crosses, and so of gaining an idea of the progress which can be expected from them. The action of selection on such systems of variation is also being elucidated, as is the response of variation to changes in mating system. These advances have been made possible by the application of statistical methods developed during the past fifteen years, and further progress in this field will depend on the close co-operation of geneticists, breeders and statisticians.

Dr. Mather concluded by discussing the possibilities of building up new systems of variation through species crossing and polyploidy, and of inducing new and desirable variation by experimental means.

Turning to cattle breeding, Dr. H. P. Donald pointed out that the evolution of breeds is controlled by the isolation and size of populations, random fluctuations in gene frequency, and selection. Isolating factors at work both within and between breeds include pedigree registration, closed herds, attestation, geography and breeding objective. Within breeds, however, the rate at which breeding stock, especially bulls, are exchanged between one partially isolated group and another must reduce the effects of the isolation and prevent the growth of locally adapted types. The small size of many herds retards selection. In one breed, about 70 per cent of the herds are estimated to have fewer than twenty-five calved cows or heifers. The number of bulls in use is correspondingly small, and the result is that the herd is subject to random fluctuations in gene frequency, that the stockbreeder is obliged to purchase bulls, and finds difficulty in discriminating against unsuccessful sires. The constant process of dispersal of established herds and their replacement by new ones results in a herd-age distribution somewhat resembling the age distribution of animals themselves. There are many herds which have had opportunity to practise selection for only three or fewer generations. About 60 per cent of the herds in a sample of 475 herds in one breed of dairy cattle have been breeding pedigree animals for seventeen years or less. This immaturity of so many herds must also markedly reduce the amount of effective selection being practised within breeds.

Dr. A. Walton said the main function of the animal in farming economy is the conversion of available raw materials, unsuitable or less suitable for direct human consumption, into products which can be directly consumed. It follows from this that as techniques of production improve, not only does the standard of the product rise but so also does the standard of nurture of the animals supplying the product. Livestock is improved as a direct result of better nurture. Improvement might be independent

of any change of genotype, although the expression of the genes might be considerably altered. In the past, improvements due to both nurture and genetic selection have proceeded simultaneously and it is impossible to evaluate either separately. Livestock improvement is not the simple sum of improved nurture plus genetic improvement but is more nearly expressed as the resultant of the two factors acting together. If genetic selection is applied to a heterogeneous population maintained at a constant level of nurture some improvement might result from the isolation and combination of major genes. There will be an approach to homozygosity and genetic stability, and the level of nurture will set a limit to any further improvement. If the standard of nurture of a heterozygous population is raised, there will be increased differentiation of genotypes, and selection (whether conscious or natural) will proceed more rapidly than on a lower plane but eventually the same condition of stability will be reached. By feeding animals individually and successively raising the plane of nurture, and by selecting those genotypes which respond, the breeder directs the evolution of superior strains. In the past, nutritional research and genetics have been carried out in isolation. Livestock improvement requires the combined attention of both nutritionist and geneticist.

Dr. J. M. Rendel argued that, owing to the division which exists between commercial and stud breeding in animal husbandry, attempts to improve stock are handicapped in two ways.

(1) The size of the effective breeding population is reduced to approximately 1,250 males and 30,000 females per breed in sheep, 180 males and 5,000 females in cattle, and 70 males and 1,000 females in pigs, these being the populations required to provide sires for the commercial breeders; the universal introduction of artificial insemination will reduce the size of stud populations, if the present organization is kept, to ridiculously small numbers. In such small populations the variability upon which selection depends is reduced and recombination of genes in any particular way is made more difficult; the comparatively small size of flocks and herds of sheep and cattle may account for the restricted lines along which each breed has been improved as compared to the Rhode Island Red, which, with a pre-war population of twenty million, combines good table qualities with a very large egg production.

(2) There is reason to believe that if selection is carried out to produce a given character in two different environments, two different sets of genes will be selected, neither of which would produce the desired result if the environments were interchanged; thus, where stud breeders are selecting in an environment different from the one the commercial farmer will provide, they are selecting animals in a direction not best suited to the commercial breeder. The distinction, therefore, between commercial and stud breeding should go, and populations made up of whole breeds, working under uniform environmental conditions, be treated as one unit for breeding purposes.

Prof. R. A. Fisher said that the production of *élite* breeding stock is a different matter from its dissemination or its utilization. In the period of modern genetics, the traditional procedure of selective breeding has been shown to be capable of great acceleration by the use of objective tests of performance, developed chiefly abroad. Progeny tests were here included, for they are only performance tests applied to relatives, usually daughters, of the animals selected. Unfortunately, they can only be applied to the minority, the great majority having to be eliminated on other grounds.

It should be remembered in this regard that mothers are as closely related as daughters. The only difference is that there are fewer mothers. The advantage of using daughters for performance tests depends, therefore, on their correct statistical treatment.

Recording societies do valuable work in testing performance in practical conditions of animal husbandry, but the conditions are highly variable. There is need for selective livestock improvement centres equipped to carry out tests with some experimental refinement. These could issue certificates of performance, and should be associated with selective breeding projects (Prof. Fisher personally favouring dual-purpose projects), with the central organization of recording activities, and with artificial insemination units. Artificial insemination alone, however, can do little towards livestock improvement, unless based on the use of objectively tested stock. Price is no criterion.

The genetic personnel available is so limited for any serious programme of livestock improvement that specialization will be essential. The problem of improving the objective tests so far used in respect of precision, for the two objects of (*a*) assessing the commercial value of a farm animal, and of (*b*) assessing its breeding value, is too technical and intricate to be added to the responsibilities of the livestock improvement centres. There is need of a single laboratory charged solely with the study of these tests, with the view of increasing their precision in these two respects. In addition to the published literature, it should in time be able to draw valuable data from the experience of carefully planned selective improvement projects carried out with the best available types of livestock.

For the sake of brevity, Prof. Fisher omitted reference to the very extensive, important and successful work carried out in hybrid corn programmes in the United States; as this was referred to in discussion, he added that he regards the experience gained in this field in the last twenty years as of the utmost consequence, especially to animal breeders.

In the discussion, Dr. A. E. Brandt explained that twenty years ago maize yields in the United States were no higher than those produced by the Indians before the discovery of America. Breeding improvement had no more than made up for soil deterioration; but lately a great change has taken place. From 10 million acres of maize in Iowa in 1933 the yield was 37 bushels per acre; in 1942 it was 62 bushels per acre, both without fertilizers. Two thirds of the increase was due to the use of hybrid seed produced for local conditions.

Touching this question, Dr. S. Ellerton said that breeders would sometimes maintain that a particular crop or animal has been so highly bred that further genetical improvement would be so slight and so difficult as not to be worth while. This was said of maize before the introduction of hybrid combinations of inbred lines. It has been said of cattle in the U.S.S.R. and of cereals in Great Britain. In his opinion, such apparent 'genetical limits' are merely imposed by the shortcomings of current breeding methods and would prove to be false, as was clearly so in maize. In the case of wheat he had some evidence. In 1943 he tested forty-two F_1's involving

the best British wheat varieties against their parents and established an average increase in the hybrids of 10 per cent in number of ears per plant and 4·6 per cent in weight of grain per ear, a total increase of 15 per cent in yield of grain. Some individual crosses would naturally show more heterosis than others, so that this strongly suggested that wheat could be bred for British conditions with yield increases of 20 per cent at least.

Dr. J. S. Huxley and others stressed the need for physiological and genetical examination of practical breeders' data, which are now available.

Prof. J. B. S. Haldane pointed out the importance of natural selection in domestic plants and animals and of undesirable selection for high seed number, or for longevity; the fallacy of assuming that in-breeding necessarily leads to homozygosis; and the danger of standardized clonal reproduction leading to epidemics.

Mr. W. J. C. Lawrence said that ultimate progress in plant breeding would often depend on the selection for efficiency of specific nutrient intake, for rich soils as well as for poor unbalanced ones. In this regard Dr. G. D. H. Bell discussed the need for combined manurial and variety trials for selection under local and good conditions.

Dr. F. Yates directed attention to the importance of testing new varieties of agricultural crops under a wide range of environmental conditions. Varieties might vary considerably in their reactions to different weather conditions, different soil types and different nutrient supplies in the shape of fertilizers. Thus, for example, one of the biggest factors limiting the yield of cereals in Great Britain is their inability to stand up to high levels of nitrogenous manuring without lodging. Modern developments in the technique of experimental design, in particular the development of factorial experiments, which enable several factors to be tested simultaneously (for example, varieties and different fertilizer components), provided the necessary machinery by which such tests can be efficiently made. It is equally important to carry out the tests at a number of different centres and over a number of years, so as to obtain adequate variation in weather and soil conditions. Any experimental programme of this type necessarily involves a large number of co-ordinated experiments. The organization required for the efficient execution of such experiments has not yet been fully developed, but there is now good prospect of radical improvement in this respect. It is of the utmost importance that the plant-breeding interests should be adequately represented, and should lend their full support to the development of such a co-ordinated programme.

Dr. Darlington, summing up, said that the papers showed an important contrast in treatment between two levels of breeding practice. On one hand there is the situation where common sense alone will sufficiently indicate the breeding programme in its initial stages. This is particularly true in undeveloped conditions and those where negative selection has been practised. Examples have been described in grasses and forest trees where commercial practice favours quantity of seed rather than quality of fodder or timber, and in cattle-breeding when the breed society, founded to improve cattle, has become organized to prevent improvement, a condition which will obviously be broken down by the spread of artificial insemination. No more economical or fruitful programme of genetical research in cattle-breeding could be suggested than the long-neglected survey of actual breeding practice and performance in Great Britain to-day, the outlines of which were indicated by several speakers. At the other extreme is the situation of the highly developed breeds of poultry and varieties of cereals where maintenance and, still more, improvement demand a skilful combination of elaborate techniques. The statistician is necessary for design and for interpretation, the cytologist for exploration and creation, the geneticist for planning and direction. The discussion was chiefly useful in showing what the different levels of organization are and where each is required.

TUBERCULOSIS AND PULMONARY DISEASE

A RECENT issue of the *British Medical Bulletin* (2, No. 2; 1944) is devoted to pulmonary disease. It also contains two new features: one consists of notes from medical publications which are not classified as journals and the other lists the titles and authors of papers in medical journals published in Great Britain and Northern Ireland.

Dr. P. M. D'Arcy Hart, in a special article on the medical and social aspects of pulmonary disease, deals with tuberculosis and industrial diseases of the lungs. The Committee on Tuberculosis in War-time, set up by the Medical Research Council, reported that the social background of tuberculosis is of primary importance and emphasizes the part played by war-time conditions in the rise of mortality due to tuberculosis which has occurred between 1939 and 1941. Blackout, over-crowding, the movement of populations, destruction of homes by bombing, and the entry into industry of people who are not accustomed to its conditions and fatigue are all factors contributing to this rise. Nutritional deficiency is probably less important in this War than it was during 1914–18, because of our efficient national food policy. But working conditions should be carefully watched, especially those of young adults, who are especially susceptible to tuberculosis. The Committee recommends (1) routine mass radiography and advocates the miniature method pioneered by Abreu in Brazil, priority being given to young adults such as factory employees, medical students, nurses, merchant seamen; (2) special money grants to sufferers for at least a year to enable them to leave work, maintain their own standard of living and that of their families and to undergo treatment; (3) rehabilitation of convalescents and, if possible, their gradual return to work.

The Ministry of Health has already instituted the main recommendations of this report. War-time restrictions, Dr. Hart says, have limited the manufacture and issue of miniature radiography sets, but about half a dozen local authorities have received and are using them, and field trials are being carried out with them by a team appointed by the Medical Research Council. It is hard to understand why the manufacture of these sets should not be a first priority. The Ministry of Health's scheme of financial help is in general operation already. The general policy is one of continued watchfulness and avoidance of complacency which everyone will commend.

The Medical Research Council Committee on

Industrial Pulmonary Disease has studied the problem of silicosis in South Wales miners and also the environment of these workers. Dr. D'Arcy Hart summarizes the resultant additions to our knowledge of this problem and the Committee's recommendations. Readers interested in other work being done to increase the safety of the mines will find useful the Ministry of Fuel and Power's annual report for 1942 of the Safety in Mines Research Board (London : H.M. Stationery Office, 1943. 1*s.* net), which deals with work on coal-dust and fire-damp explosions, mining explosives, falls of ground, electrical researches and kindred problems.

In the same issue of the *British Medical Bulletin* Mr. R. C. Brock writes a valuable article on the present position of thoracic surgery. The advances in this field in recent years have been remarkable, and the surgical treatment of tuberculosis has an important place among them. Mr. Brock names X-rays and anæsthesia as the twin pillars of thoracic surgery, which requires of the surgeon such a wide knowledge of the anatomy and physiology of the chest as well as his essential pathological and medical experience. The anæsthetist has the especially difficult job of maintaining respiration and the circulation of the blood during operations on the very organs which maintain these essential functions. Mr. Brock thinks that, during the next ten years, we shall see advances in the surgery of the heart and œsophagus as great as those which have occurred in thoracic surgery during the past ten years. A good idea of the quality of the anatomical research on which thoracic medicine and surgery are based is given by the succeeding illustrated article on the anatomy of the bronchi by Dr. A. F. Foster-Carter. Excellent bibliographies add to the value of all these articles. They are supplemented by reviews of selected articles on pulmonary anatomy, surgery and disease, and on further papers on tuberculosis in children and on the statistical and social aspects of this outstanding scourge of our civilization.

The results of further important work on various aspects of tuberculosis have been published in *The Lancet* and the *British Medical Journal* during recent months and we know, from reports on the health of the occupied countries, how important a factor tuberculosis will be in the immense task of reconstruction after the War. A correspondent of *The Lancet* (Feb. 12, 1944, p. 225), taking his information from French underground medical papers, states that tuberculosis has increased in that country by at least 20–30 per cent. French medical men, moved to horror by the ever-increasing number of French workers deported to Germany who return with tuberculosis, are unable to save their lives because the necessary diets and drugs are not available. They are trying to sabotage the deportations by ordering long rest-cures, laboratory investigations, consultations with absent specialists and similar means. The discussion on nutrition in enemy-occupied Europe at the meeting of the Royal Society of Medicine on November 23, 1943 (*The Lancet*, Dec. 4, 1943, p. 703, and *Proc. Roy. Soc. Med.*, **5**, 37, Jan. 1944, p. 113) reveals a similar grave situation in Greece, Jugo-Slavia and Belgium. In the U.S.S.R. the problem is being tackled partly by village settlements similar to the English settlements at Papworth and Preston Hall, but the Russians appear to be concentrating on large-scale rehabilitation in and around the normal sites of industry (*Brit. Med. J.*, Nov. 20, 1943, p. 652).

G. LAPAGE.

SCIENCE CLASS LECTURE CINÉ-FILMS

A PARAGRAPH in the News and Views column of NATURE of November 27, 1943, p. 623, referred to a ciné-film showing the Brownian movement Dr. Quintin Moore, Mr. Thos. Smith Wylie ; and Mr. Frank G. Conway, of the Royal Technical College, Glasgow, have given the following particulars regarding the method and apparatus.

Microscopical Unit. Through the courtesy of the Royal Technical College, Glasgow, we had the use of a 'Siedentopf' Cardioid Ultra-microscope (manufactured by Carl Zeiss) together with associated apparatus.

The source of light was a 15-amp. carbon arc with a horizontally positioned positive carbon. A converging lens projected the light as a parallel beam. The light passed through a cooling chamber containing slightly acidulated 20 per cent ferrous ammonium sulphate solution, then directly to the 'Cardioid Condenser', which was fitted into the sleeve of the Abbe illuminator of the microscope. The top of the condenser was connected to the object slide by a layer of distilled water.

A 1 mm. thick quartz slide and quartz cover formed a chamber which was mounted in a metal holder and held firmly against the stage of the microscope. This quartz chamber resembles that of a hæmocytometer slide without engraved ruling ; but the depth is considerably less, only 2–4 μ deep. A colloidal solution of Carey Lea's silver, suitably diluted, was placed on the centre of the object slide and excess solution overflowed into the surrounding channel. The dimensions of the colloidal silver particles were of the order of 50 mμ.

By careful adjustment and focusing, the oblique light from the condenser was made to illuminate completely the thin stratum of colloidal solution in the chamber. None of this oblique light can enter the microscope directly, due to the high numerical aperture of the objective. The light which does enter is scattered from the surfaces of the colloidal particles and it passes into the following microscopical combination : an apochromatic glycerine immersion objective adapted for use with the thick quartz cover and of magnification 58, focal length 3 mm., and numerical aperture 0·85. The objective, carried by a centring nosepiece, was used in conjunction with a compensated focusing eyepiece, and the combination gave a magnification of 1,160 diameters.

Photographic Unit. This consisted of a Bell-Howell 16 mm. camera fitted with a f 1·5 lens of 1 inch focal length.

The camera was mounted on a heavy base and carefully set up so that the lens combinations of the microscope and camera were in accurate co-axial alignment. The camera lens set to infinity and at full aperture was placed in a ground glass focusing mount, which in turn was clamped to the eyepiece of the microscope. Through this combination the microscope was focused. The lens was then replaced in the camera, maintaining the same relative positions of lens and eyepiece.

Kodak Super XX reversal panchromatic film was used with a camera frame speed of 4 per sec., giving an exposure of approximately $\frac{1}{8}$ sec. per frame. No filters were used.

Excellent darkground effects were obtained with the above equipment provided the requisite care was

taken in the alignment of the microscope and the cleaning of the quartz chamber.

Copies of this instructional film (screening time about 4 min.) can now be hired from the Scottish Central Film Library, 2 Newton Place, Glasgow, C.2.

CONTROL OF ST. JOHN'S WORT IN AUSTRALIA*

By DR. A. D. IMMS, F.R.S.

FIVE species of St. John's wort (Hypericum) occur in Australia—mainly in Victoria and New South Wales. These species are *H. perforatum* L., *H. androsæmum* L., *H. calycium* L., *H. gramineum* Forst. and *H. japonicum* Thunb. The first-named is by far the most widespread and the chief pest. Between 250,000 and 400,000 acres of land in Victoria and very large areas in New South Wales are infested with *H. perforatum*, and it also occurs in South Australia, Tasmania and Western Australia. The species was introduced in 1870 in Victoria, and since it occurs chiefly in hill and plateau country it is one of the most injurious of Australian weeds. Growing thickly, it eliminates all low-growing vegetation including pasture grasses, and some of the areas covered by the weed have had to be abandoned. It is, furthermore, poisonous to stock.

Several methods of controlling *H. perforatum* have been adopted in Australia and some success has been achieved by the application of common salt at the rate of ten, or more, tons to the acre. This treatment, however, is too expensive for general use although it is employed in Victoria to keep the roadsides free from the weed. The possibility of its repression by insects was first taken into account in 1917, and certain species of Hypericum-feeding insects were introduced in succeeding years from England. These were certain beetles of the family Chrysomelidæ—the species *Chrysolina varians* Schell., *C. brunsvicensis* Grow. and *C. hyperici* Forst., all of which are leaf-feeders. The Geometrid moths *Anaitis efformata* Guen. and *A. plagiata* L., the larvæ of which feed on the foliage of Hypericum, were also introduced from England. None of these appeared to become established and the primary cause of the failure of most of them appeared to be climatic.

Attention was then directed to Hypericum insects in southern France, where field observations showed that a high degree of control is achieved in particular places by the Buprestid beetle *Agrilus hyperici* Creutz. and the Chrysomelid beetle *Chrysolina gemellata* Rossi. Supplies of both these species were shipped to Australia in 1939 and 1940. The species *Chrysolina hyperici* disappeared for some years after its liberation, but has since been found in large numbers and is now firmly established in many areas.

None of the other species of insects introduced from England has apparently become established. While *C. hyperici* now occurs in many localities, as yet it only occupies a mere fraction of the total Hypericum area of Australia. *C. gemellata* became very readily established and spread and the *Agrilus hyperici* gives great promise and is increasing rapidly in several of the areas where its original liberation took place in 1939 and 1940. At present, however, the area actually covered by these last two species is even smaller than that covered by *C. hyperici*. There is every prospect that the three species named will eventually occur in all the St. John's wort areas. Their present limited distribution is naturally to be expected because they have only been introduced during a brief period. The retrogression of the weed where *C. hyperici* is numerous and the continuous increase in the numbers of this insect, together with the ease with which the other species (*C. gemellata* and *A. hyperici*) have become established, give ground for confidence that a useful degree of control of the weed will, in time, be achieved.

* The Entomological Control of St. John's Wort (*Hypericum perforatum* L.) by Frank Wilson. Bull. No. 169 Council for Scientific and Industrial Research (Melbourne, 1943).

STRUCTURE, FUNCTION AND SYNTHESIS OF POLYSACCHARIDES*

A NEW chemical synthesis of cellobiose by a simple and direct method has been accomplished by Stacey and Gilbert. The structure of the repeating unit in cellulose is therefore well established, and the microbiological synthesis of the polysaccharide was achieved by Hibbert. Starch, another functional material of the plant, is recognizable as two structural types of polysaccharide: amylose giving the deep blue coloration with iodine and representing about 25 per cent of natural starch, and amylopectin, the remaining 75 per cent, giving a reddish-blue colour. Amylose, synthesized both by plant and muscle phosphorylase, is represented as a continuous chain of maltose units and this is completely hydrolysed to maltose by β-amylase. Amylopectin is also composed of maltose units in shorter chains which are united as a laminated or branched-chain structure, and this is hydrolysed in stages to maltose and various dextrins. The factor responsible for the synthesis of amylopectin has not yet been isolated, but attempts have been made in this direction. Products related to amylopectin have been obtained by Dr. Peat, but their identity is not yet established.

Many of the specific and somatic bacterial polysaccharides contain amino-glucose and uronic acids as constituent units. The constitutional relationship of these polysaccharides is only partly revealed, although some synthetic analogues which are bioses are seen also to have antigenic properties. Structurally related to these are the polysaccharides produced by non-pathogenic organisms such as Rhizobia; and the plant gums which also contain uronic acid groups.

Heparin, the blood anti-coagulant factor of liver, contains glucosamine and glucuronic acid units together with acetyl and sulphate residues. The chondroitin of cartilage is similar in the composition of its individual units except that galactosamine (or talosamine) replaces glucosamine.

The synthesis of the levans by enzymes has been frequently reported; their constitution is now established, as is also that of the dextrans from *Penicillium luteum* and *Leuconostoc dextranicum*. These are 1 : 6-glucopyranose polymers.

B. welchii, the gas gangrene organism, is convertible into a Gram-negative form by sodium cholate extraction. The Gram-positive character can be restored by combination with the magnesium salt of ribonucleic acid. The constitution of both this acid and desoxy-ribonucleic acid is partly revealed by the recognition of ribo- and desoxyribofuranose units, the mode of combination of which, whether single or linked units, is not yet known.

* Substance of the Bakerian Lecture delivered before the Royal Society by Prof. W. N. Haworth, F.R.S., on June 15.

FORTHCOMING EVENTS

Saturday, June 24

ASSOCIATION FOR SCIENTIFIC PHOTOGRAPHY (joint meeting with the SCIENTIFIC FILMS ASSOCIATION) (at the Large Theatre, Ministry of Information, Malet Street, London, W.C.1), at 3 p.m.—Discussion on "The Construction and Presentation of Scientific Films". (Mr. Arthur Elton: "The Scope and Distribution of Scientific Films"; Mr. Geoffrey Bell: "Shooting Scientific Films"; Dr. J. Yule Bogue: "The Production of Scientific Films for Medical and Biological Purposes".)

Tuesday, June 27

SOCIETY OF CHEMICAL INDUSTRY (NUTRITION PANEL) (at the Chemical Society, Burlington House, Piccadilly, London, W.1.), at 2.30 p.m.—"The Taste and Quality of Food in relation to Nutrition". (Prof. H. Hartridge, F.R.S.: "The Physiology of Taste and Smell and its Nutritional Significance"; Dr. G. W. Scott Blair: "The Assessment of Food Quality by Handling"; Dr. D. R. Davis: "The Subjective Effect of Food in relation to its Nutritional Value"; Mr. R. R. Plowman: "The Art of Tea-Tasting").

QUEKETT MICROSCOPICAL CLUB (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Exhibition of specimens and discussion.

Saturday, July 1

INSTITUTE OF PHYSICS (LONDON AND HOME COUNTIES' BRANCH) (in the Physics Department, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 2 p.m.—Conference on "Applied Spectroscopy". (Prof. H. Dingle: Introductory Address; Mr. F. Twyman, F.R.S.: "Spectroscopic Instruments"; Mr. D. M. Smith: "Spectrographic Analysis"; Dr. W. A. Roach: "The Determination of Mineral Deficiencies and Excesses in Plants by Spectrographic Analysis"; Dr. R. W. B. Pearse: "Applications of Molecular Spectra").

APPOINTMENTS VACANT

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

ASSISTANT PHYSICIST in the Physics Department—The Secretary, Royal Cancer Hospital (Free), Fulham Road, London, S.W.3 (July 1).

CHEMICAL ENGINEER for Aluminium Powder and Paste Works (location, Middlesex)—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. C.2149XA) (July 1).

TWO MECHANICAL ENGINEERS with good technical and practical experience in Heavy Engineering (Reference No. C.2155XA), and a MECHANICAL ENGINEER with good technical and practical experience in Heavy Engineering plus ability to act as Assistant to Responsible Executive (Reference No. C.1994XA)—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting the appropriate No.) (July 5).

ASSISTANT MECHANICAL ENGINEERS for the Tanganyika Government Railways—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. C.2170A) (July 5).

CHIEF ENGINEER, Port of Basrah—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. E.756A) (July 5).

ASSISTANT TECHNICAL OFFICER by the Agricultural Lime Department of the Ministry of Agriculture and Fisheries—The Ministry of Labour and National Service, Room 432, Alexandra House, Kingsway, London, W.C.2 (quoting Reference No. O.N.F.1808A) (July 8).

LECTURER OR SENIOR LECTURER IN GEOGRAPHY, and an ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, The University, Manchester 13 (July 10).

LECTURER (temporary) IN MINING, a LECTURER (temporary) IN MINERAL DRESSING, and a LECTURER (temporary) IN ENGINEERING—The Professor of Mining, Royal School of Mines, Prince Consort Road, London, S.W.7 (July 15).

DIRECTOR OF THE OTAGO SCHOOL OF MINES (University of Otago)—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (July 21).

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

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

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

ESTIMATING AND COSTING SURVEYOR OR ENGINEER by small but well-established firm of Civil Engineering Contractors, E. London area—The Ministry of Labour and National Service, Appointments Department, Sardinia Street, London, W.C.2 (quoting Reference No. Q.R.106).

MECHANICAL ENGINEER by Liverpool firm manufacturing textile fibre by chemical processes—The Ministry of Labour and National Service, Appointments Office, Cotton Exchange Buildings, Liverpool 3 (quoting Reference No. A.O.128).

SECRETARY TO THE ROYAL INSTITUTE OF CHEMISTRY—Prof. A. Findlay, President, Royal Institute of Chemistry, 30 Russell Square, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Abstracts of Dissertations approved for the Ph.D., M.Sc., and M.Litt. Degrees in the University of Cambridge during the Academical Year 1942–1943. Pp. 40. (Cambridge: At the University Press.) [185

Reports of the Council and Auditors of the Zoological Society of London for the Year 1943. Pp. 18. (London: Zoological Society of London.) [185

Ministry of Health. Reports on Public Health and Medical Subjects. No. 92: Report on the Incidence of Rickets in War-time. By the British Paediatric Association. Pp. 36. (London: H.M. Stationery Office.) 9*d*. net. [225

Aims and Objects of the Eugenics Society. Pp. 12. (London: Eugenics Society.) [235

Leverhulme Trust. The West Africa Commission, 1938–1939. Technical Reports, 1: Crop Production and Soil Fertility Problems, by H. C. Sampson and Dr. E. M. Crowther; 2: Live-Stock Problems, by Lieut.-Colonel A. G. Doherty. Pp. 84+14 plates. (London: Leverhulme Trust.) [245

Rural Housing: Third Report of the Rural Housing Sub-Committee of the Central Housing Advisory Committee. Pp. 68. (London: H.M. Stationery Office.) 1*s*. net. [255

Research Reports of the British Non-Ferrous Metals Research Association. Association Series, No. R.R.A. 635: Metallography of some Aluminium Alloys. By M. D. Smith. Pp. 12+8 plates. (London: British Non-Ferrous Metals Research Association.) 2*s*. [265

Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Season 1942–1943; Programmes of Experiments, Season 1943–1944. Pp. ii+181. (London: Empire Cotton Growing Corporation.) 3*s*. [16

Cambridge Joint Advisory Committee for Biology. Syllabuses in Botany, Zoology, Biology. (Published for University of Cambridge Local Examinations Syndicate, Oxford and Cambridge Schools Examination Board.) Pp. 24. (Cambridge: At the University Press.) 6*d*. [66

Geological Survey of Great Britain: Scotland. Wartime Pamphlet No. 40: Scottish Slates. By Dr. J. E. Richey and Dr. J. G. C. Anderson. Pp. 42. (London: Geological Survey and Museum.) 2*s*. [86

Joint University Council for Social Studies and Public Administration. A Review of Work during the Years 1918–1944. Pp. 14. (London: Wm. H. Taylor and Sons.) 6*d*. [86

Other Countries

Imperial College of Tropical Agriculture: Low Temperature Research Station. Memoir No. 20: Studies in Tropical Fruits; 11: Carbohydrate Metabolism of the Banana Fruit during Ripening under Tropical Conditions, by H. R. Barnell; 13: Carbohydrate Metabolism of the Banana Fruit during Storage at 53° F. and Ripening at 68° F., by H. R. Barnell; 14: Carbohydrate Metabolism of the Banana Fruit during Storage at 53° F., by H. R. Barnell. Pp. 94. (Trinidad: Imperial College of Tropical Agriculture.) [85

Papers of the Michigan Academy of Science, Arts and Letters. Vol. 28 (1942). Pp. xiii+701. (Ann Arbor, Mich.: University of Michigan Press; London: Oxford University Press.) 28*s*. net. [95

U.S. Department of Agriculture. Miscellaneous Publication No. 525: A Victory Gardener's Handbook on Insects and Diseases. By W. H. White and S. P. Doolittle. Pp. ii+30. (Washington, D.C.: Government Printing Office.) [95

Commonwealth of Australia: Council for Scientific and Industrial Research. Bulletin No. 170: Pea Mosaic on *Lupinus varius* L. and other Species in Western Australia. By D. O. Norris. Pp. 27+2 plates. (Melbourne: Government Printer.) [115

Astronomical Papers prepared for the use of the America Ephemeris and Nautical Almanac. (Published by the Nautical Almanac Office, U.S. Naval Observatory, by direction of the Secretary of the Navy and under the authority of Congress.) Vol. 11, Part 1: The Motion of Mercury, 1765–1937. Pp. 221. (Washington, D.C.: Government Printing Office.) 65 cents. [185

Education and Research. Three Editorials reprinted from *Natural History Magazine*, November 1943–January 1944. By A. E. Parr. Pp. 14. (New York: American Museum of Natural History.) [225

National Geological Survey of China. Palaeontologia Sinica, New Series D. No. 10 (Whole Series No. 127): The Skull of Sinanthropus pekinensis; a Comparative Study on a Primitive Hominid Skull. By Franz Weidenreich. Pp. xxi+485 (93 plates). (New York: G. E. Stechert and Co.) [245

U.S. Office of Education: Federal Security Agency. Annual Reports of the United States Office of Education for the Fiscal Years 1941–42, 1942–43. Pp. viii+88. (Washington, D.C.: Government Printing Office.) 15 cents. [255

Proceedings of the American Philosophical Society. Vol. 87, No. 4, January 29, 1944: Symposium on the Organization, Direction and Support of Research; Papers read before the American Philosophical Society, Autumn Meeting, November 19–20, 1943. Pp. iii+291–364. (Philadelphia: American Philosophical Society.) [255

U.S. Office of Education: Federal Security Agency. Bulletin 1943, No. 1: Education in Cuba. By Severin K. Turosienski. Pp. vi+90. (Washington, D.C.: Government Printing Office.) 20 cents. [255

U.S. National Museum. Bulletin 184: The Metallography of Meteoric Iron. By Stuart H. Perry. Pp. vii+206+78 plates. (Washington, D.C.: Government Printing Office.) 60 cents. [265

Proceedings of the United States National Museum. Vol. 94, No. 3172: The Catfishes of Venezuela, with Descriptions of Thirty-eight New Forms. By Leonard P. Schultz. Pp. 173–338+14 plates. (Washington, D.C.: Government Printing Office.) [265

Smithsonian Institution: Bureau of American Ethnology. Bulletin 133: Anthropological Papers, Nos. 19–26. Pp. ix+615+34 plates. 1 dollar. Bulletin 136: Anthropological Papers, Nos. 27–32. Pp. viii+375+32 plates. 75 cents. (Washington, D.C.: Government Printing Office.) [16

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

MURDOCH TRUST

For the BENEFIT of INDIGENT BACHELORS and WIDOWERS of good character, over 55 years of age, who have done " something " in the way of promoting or helping some branch of Science. Donations or Pensions may be granted to persons who comply with these conditions.

For particulars apply to MESSRS. SHEPHERD & WEDDERBURN, W.S., 16 Charlotte Square, Edinburgh, 2.

ESSEX EDUCATION COMMITTEE

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

Principal: N. M. H. Lightfoot, M.A., F.R.S.E.

Applications are invited for the following permanent post for September next:

SCIENCE DEPARTMENT

A full-time Lecturer in Chemistry. Candidates should possess good honours degree in Chemistry and have had some experience in teaching Chemistry to B.Sc. Honours standard. Research or industrial experience also desirable. Knowledge of metallurgy would be regarded as an additional qualification. Salary: Burnham (Provincial) Scale.

Further particulars and forms of application obtainable from the Clerk to the Governors at the College, on receipt of a stamped addressed envelope. Applications, together with copies of two recent testimonials, must be sent to the Clerk to the Governors not later than July 3, 1944.

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

THE ROYAL CANCER HOSPITAL (FREE)

Fulham Road, London, S.W.3.

Applications are invited for the post of Assistant Physicist in the Physics Department of the above Hospital. Applicants should preferably have had some experience of radiological physics, and, if appointed, will be expected to take part in the routine, research, and teaching work of the Department. Commencing salary £400 per annum (superannuable).

Applications, which must be received not later than July 1, 1944, should be addressed to the Secretary of the Royal Cancer Hospital (Free), from whom further details may be obtained.

UNIVERSITY COLLEGE OF WALES, ABERYSTWYTH

Applications are invited for the newly established Research Professorship in Animal Health. The appointment will be for a period not exceeding 10 years in the first instance at a salary of £1,200, with superannuation contribution. While the subject is defined broadly as being a study of the causes and conditions of animal health and includes animal breeding, animal nutrition, and the prevention and control of animal diseases, it is expected that the Research Professor, when appointed, will work in close conjunction with the Welsh Plant Breeding Station established at the College. Further information may be obtained from the Principal.

THE WEST OF SCOTLAND AGRICULTURAL COLLEGE

The Governors invite applications for the post of VETERINARY SURGEON, mainly with a view to research on bovine mastitis.

Salary, £450 per annum plus appropriate war bonus.

Applications, stating age, training (degrees or diplomas held), and experience, should be lodged with the undersigned not later than June 30, 1944.

A. J. WILSON,
6 Blythswood Square, Secretary.
Glasgow.

UNIVERSITY OF BIRMINGHAM

ANGLO-AMERICAN STUDENTSHIPS

Studentships of the value of £225 for the first year and £250 for the second year, if renewed, are offered to graduates in Science. Holders will be expected to devote full time to Research in the Department of Oil Engineering and Refining.

Applications, which should give details of age, academic qualifications, and career, should be submitted to the Registrar not later than July 15. Names of two referees should also be given.

THE ROYAL INSTITUTE OF CHEMISTRY

In view of the approaching retirement of the Registrar and Secretary (Mr. R. B. Pilcher, O.B.E.), the Council of the Royal Institute of Chemistry will shortly appoint a Secretary, who should be a Chemist of standing, with administrative ability. Salary not less than £1,500 p.a. Any Chemist wishing to be considered for this appointment is invited to send his name, in confidence, to Professor A. Findlay, Pres. R.I.C., 30 Russell Square, London, W.C.1.

UNIVERSITY OF OTAGO, DUNEDIN, NEW ZEALAND

DIRECTOR OF SCHOOL OF MINES

Applications are invited for the position of Director of the Otago School of Mines. Candidates must be qualified to teach either mining or metallurgy. Salary £1,000 per annum (New Zealand currency).

For further particulars apply, not later than July 21, to the High Commissioner for New Zealand, 415 Strand, London, W.C.2.

THE UNIVERSITY OF SHEFFIELD

The Council of the University invite applications for the post of LECTURER IN EXPERIMENTAL PHYSIOLOGY.

Basic salary £600 per annum, plus substantial wartime allowances.

The successful candidate will be expected to enter upon his duties on October 2, 1944.

Applications should reach the undersigned (from whom further particulars may be obtained) by July 28.

W. M. GIBBONS,
Registrar.

ROYAL HOLLOWAY COLLEGE

(University of London)

Appointment of ASSISTANT LECTURER and DEMONSTRATOR IN ZOOLOGY

The Governors invite applications for the above post, which is resident and open to women only. Applications are required not later than July 15, 1944.—Full particulars may be obtained from the Principal, Royal Holloway College, Englefield Green, Surrey.

UNIVERSITY COLLEGE OF HULL

Applications are invited for a Temporary Lecturer in Geography. Salary up to £400, according to qualifications and experience. Particulars of the appointment may be obtained from the Registrar, to whom applications must be sent not later than June 23.

Midlands firm, engaged under Essential Works Order on medicinal and fine chemical production, requires Process Chemists. Commencing Salary £300-£330. Good experience and excellent prospects for young chemists with industrial bias. Must be prepared to work one week in three at night as control chemist during first contract period.—Apply, Box 205, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

International Chemical Co. Ltd. have a vacancy for a process chemist, up to B.Sc. standard, with some pharmaceutical and plant experience if possible.—Write, Personnel Officer, Braydon Road, London, N.16.

A large firm of Paper Manufacturers requires (a) one Research Chemical Engineer or Physicist for plant investigations; (b) one Research Physicist or Chemist, preferably with some experience in research in printing; (c) one Organic Chemist, preferably with knowledge of adhesives and/or plastics; (d) one Junior Chemist or Physicist for training in mill control work, etc., previous industrial experience not essential. Commencing salary for junior not less than £275 per annum. Applicants under (a), (b), and (c) should be of more senior standing (up to the age of 35) and salary will be in accordance with qualifications and experience of the candidate. Applicants at present in Government service or in Essential Industries may be interviewed with a view to engagement, to be deferred until release is obtained. Will candidates please state whether they are applying under (a), (b), (c), or (d). All applications and particulars will be treated in strictest confidence.—Box 206, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Progressive well known firm of cattle food manufacturers have plant and selling organization to develop other lines in this field or human foods. Sole concession or buy outright. Information invited in first instance of sufficient detail to warrant further negotiation.—Box 202, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Editorial Assistant (woman) required by metallurgical institute. Training in metallurgy, physics, or chemistry and a knowledge of German are essential. Salary by arrangement; superannuation scheme.—Box 201, T. G. Scott & Son, 9, Arundel Street, London, W.C.2.

B.Sc. in chemistry or metallurgy (capable of abstracting in two or three languages) required for London industrial science library.—Write full details, Box 204, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

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

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

Micro Chemical Balance, Oertling No. 63 PB or 62 preferred, required for urgent research work or would hire for definite period.—Apply, Box 203, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

For Sale: *J. Soc. Chem. Ind.*, 1905– 1923 and Reviews 1918-1922, all in black cloth. *Annual Reports*: 1904-1932; 1934-1937; 1940-1942. Meyer, Jacobson's *Lehrbuch. der Organischen Chemie*, 2nd Edn., complete. May be sold together or separately.—Write offers to Box 290, Smiths', 100 Fleet Street, E.C.4.

The proprietor of British patent No. 380,220 is prepared to license British manufacturers to work thereunder. It relates to analytical distillation apparatus.—Address: Boult Wade & Tennant, 112 Hatton Garden, E.C.1.

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

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this publication should not be taken as an indication that they are necessarily available for export.

Printed in Great Britain by FISHER, KNIGHT & Co., LTD., The Gainsborough Press, St. Albans, and published by MACMILLAN & Co., LIMITED, at St. Martin's Street, London, W.C.2, and THE MACMILLAN Co., 60 Fifth Avenue, New York 11, N.Y., U.S.A.—Saturday, June 24, 1944.