relating to health and prosperity for different countries, showing the lowest death-rate and the lowest infantile mortality for the years 1926–35 to be those of New Zealand, the country which I have always regarded as having the best climate of all countries in the world. Over most of New Zealand the mean temperature of the hottest month lies between 62° and 70° F., and that of the coldest month between 45° and 52° F. We might compare these figures with the corresponding figures for the British Isles, where the July mean temperature lies between 58° and 62° F., while the mean temperatures of the coldest month of the year lie between 39° and 44° F. In the British Isles, temperature readings above 90° F. are infrequent, and values exceeding 95° F. are decidedly rare, being generally confined to the inland regions of the southern half of England. In the British Isles the highest temperature recorded during a month may exceed the mean for that month by about 20° F. in winter, and by about 30° F. in summer, while the lowest temperature recorded may fall below the mean of the month by about 30° F. in winter, and by about 20° F. in summer.

Development of the Weather-proof House in England

The weather-proof house required glass for the windows, bricks for parts at least of the structure, and the fireplace and chimney as we know it. The history of the development of these three features in England is by no means clear. Houses were glazed in the Roman Empire, but the making of glass disappeared from Britain with the Romans. The Venerable Bede described how, in 675, Benedict, when building a church at the mouth of the Wear, had to go to France to find and bring back glass workers to glaze the windows of his church. Bede further states that these glaziers not only glazed the church windows, but also taught the English how to make glass. The knowledge they imparted was not lasting, for in 758 we find the Abbot of Jarrow appealing to the Bishop of Mainz to send him a craftsman in glass. The earliest evidence we find of glass-making in England refers to 1230, in which year a deed granted certain lands at Chiddingfold in Surrey to one Lawrence, "vitrarius". Chiddingfold was apparently the earliest centre of glass-making, but English glass was poor in quality until the sixteenth century. Even then glass windows were so rare and valuable that they were often bequeathed, like jewels, apart from the house. The decision by the Court of Common Pleas in 1599, that glass windows should not be removed from a house, reveals the prevailing state of things with regard to windows.

Aubrey, an antiquarian writer of the seventeenth century, said that glass windows were rare except in churches and gentlemen's houses until the time of Henry VIII, and added that to his own remembrance, copyholders and poor people in Herefordshire, Monmouthshire and Shropshire had none before the Civil War. Aubrey also wrote that before the Reformation, ordinary men's houses "had no chimneys, but flues like louvre holes. Some of 'em were in being when I was a boy".

So far as definite records are available, bricks were first made in England (at Hull) in 1303, and only became reasonably good and cheap a century later. One of the earliest examples of brickbuilding in England, with English bricks, is the north and east part of Queens' College, Cambridge, built in 1448.

There are still to be seen in England a few houses with fireplaces and chimneys as we know them dating back to the middle of the twelfth century, as for example the Norman House at Christchurch, Hants (the ruins of which are in the gardens of the King's Head Hotel), built between 1125 and 1150, and a house at Boothby Pagnell, Lincoln, built about 1150. But chimneys as we know them only became common about the time of Henry VIII.

We can thus say that by the time of Henry VIII the weather-proof house had become possible in England, but was still too expensive except for the wealthy, and that it was late in the sixteenth century before it became widespread throughout the country. The development on the Continent was roughly parallel with that in England. Once weather-proof houses had become general, England had a great advantage in its cheap supply of coal for indoor heating, and it may not be a fortuitous coincidence that the glories of Elizabethan England came soon after the advent of the weather-proof house.

MICROBIOLOGY

ITS BASIC CONCEPT AND ITS FUTURE

By DR. A. C. THAYSEN

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IT will probably be conceded that the terms 'microbiology' and 'biochemistry' can be roughly translated into English as the knowledge of invisible life and as the chemistry of the living cell respectively. As such, these definitions aptly circumscribe the fields of study embraced by the two branches of science. Yet, all too often, the term microbiology is referred to as synonymous with that of biochemistry, as if these two branches of science dealt with identically the same problems, required the same training, and would use the same approach to the solution of their problems. This, however, is not necessarily the case and has no foundation in the basic concept of microbiology.

If one searches for this basic concept, one must eventually be led back to the living cell itself as it exists in its natural habitats. For only by a study of the changes which the cell performs under such conditions does it appear possible to obtain a correct insight into its functions ; and only by an evaluation of these functions under controlled growth conditions can a measure be obtained of the future possibilities of the science of microbiology. This is undoubtedly the lesson to be learned from the polemic between Pasteur and Liebig in their writings on the function of yeast in fermentations, and it is the axiom insisted upon by Koch, when he demanded that, before a disease can be ascribed to the action of an organism, it is essential to grow the suspected type under artificial conditions free from all others and to produce with the cultured specimen the identical symptoms in healthy animals which had been observed to occur in diseased forms under natural conditions.

A primary function of microbiology then appears to be the study of micro-organisms in their natural habitats and to endeavour to isolate them from these for cultivation under artificial conditions with the view of reproducing natural changes or any other changes of which they may be found capable.

The knowledge which has accumulated since Leeuwenhoek first observed micro-organisms in droplets of water has shown, not only that the invisible population of the earth is as abundant as is its macroscopic counterpart, but also that it is met with in places and under conditions which would be utterly inadequate to sustain the life of higher organized plants or animals. This presupposes a flexibility in the make-up of the free-living microscopic cell which far exceeds that of any higher organized living being and gives an insight into the diversity of the problems with which microbiology may be called upon to deal. On the other hand, a study of the natural habitats of micro-organisms should make it possible to circumscribe the limitations of this branch of science.

For example, the microscope reveals that, where water is present, even in the form of a humid atmosphere, free-living microscopic cells can be met with almost anywhere. On the surface of inert objects; in the arctic ice; in the sea; in the soil; in the hot springs of volcanic localities; in subterranean oil wells; on the surface of living plants and animals; in the intestinal tracts of animals and throughout the interior and exterior of dead and dying animal and vegetable tissues, actively growing microscopic cells are present. In such varying habitats, then, must they find conditions which make it possible for them to survive and to propagate their kind.

On the other hand, where water is absent it may safely be predicted that no microscopic life can persist, and it may positively be asserted, for example, that the so-called 'curse' of the tomb of Tutankhamen could not possibly be ascribed to microbiological life, as was done in some quarters when this tomb was opened and found devoid of moisture.

There are, of course, other limitations, such as temperature and reaction, but the range here is often extraordinarily wide, much wider than would be feasible among higher cell organizations.

A particularly interesting form of limitation of types rather than of numbers is met with in the soil and among the microflora and microfauna of the intestinal tract of most animals, where a few types have established themselves irrespectively of the feeding habits of the animal. Though a much wider range of types must originally enter the intestine they appear unable to survive in competition with the established forms.

The mechanism by which such specialization is brought about can only be ascertained by a study of the habits of the living cell itself. It is conceivable that the rate of growth of the established types may be faster than that of the accidentally entering cells, either because the conditions prevailing favour the former, or that the normal types during their growth produce substances which are harmful to all but the established types. Whatever the explanation, the example given illustrates the influence which the natural habitat may exercise on the organisms living in it and indicates the importance which must be attached to its study.

An extensive exploration of some of these habitats began during the second half of the nineteenth century. Because of the utilitarian aspect of this study it resulted not only in added knowledge and in a widening of the field of microbiology, but unfortunately also in a subdivision of the science into at least four different and more or less water-tight compartments: medical, or pathological bacteriology; dairy bacteriology; soil bacteriology; and the mycology of the fermentation industries. Though this specialization may have been unavoidable at the time, it did much to obscure the potentialities of microbiology. It is undoubtedly responsible for the neglect of many fields of exploration, such as the microflora of oil wells and oil storage tanks, of the rotting of textiles and of the corrosion of metallic structures in soils and water. How important an extension of the exploration of natural habitats of micro-organisms can be, can be seen from the modern developments in sewage purification and in the retting of textile fibres.

Turning to the free-living cell itself and to the bearing which its study must exercise on the progress of microbiology, it appears appropriate to illustrate this by a few examples. The first which comes to one's mind is the revolution which was caused in the brewing industry by the introduction of pure cultures in the brewing of lager beer. There are many others which carry equal weight, such as the prophylactic treatment of infectious diseases with pure cultures of certain pathogenic organisms, the preparation of 'starters' for cream used in butter-making, the inoculation of deficient soils with cultures of specific strains of nitrogen-fixing bacteria and, to take a more recent example, the use of micro-organisms in the assay of vitamins.

If it be conceded, then, that a knowledge of both the living cell and of its habitat is essential for the successful expansion of microbiology, it is relevant to ask how such knowledge should be circumscribed. Obviously it should be as comprehensive as possible and should embrace all relevant information on the morphology, the biology, including cytology and physiology, and the chemistry of the cells, the latter both as regards their composition and their functions. An exclusive study of one or two of these aspects would fail to give a balanced picture of an organism and would in many cases lead to an erroneous estimate of its potentialities. For example, in the case of the preparation of gluconic acid by certain fungi the conversion of the sugar used is governed by the biochemical properties of the organism. But it is influenced also by its morphology, for it has been shown that the action of the fungus used on the sugar which it converts to gluconic acid can be greatly increased by a change in the morphology from matted hyphæ to smaller cell aggregates which can be more uniformly aerated than the mats of hyphæ.

Again, in the production of baker's yeast, an industry which is based on the ability of certain yeasts to build up their cell substance from carbohydrates and inorganic nitrogen, the rate of growth of the cells is markedly influenced by the number of cells present in their habitat at any given time. Here a study of the growth-rate of the individual cell will indicate the conditions required to secure full advantage of the biochemical process of the organism.

Finally, a case may be cited in which the exploration of the biochemical activities of an organism supplied the clue to the connexion between its growth and the spoilage of fish living in the proximity of its natural habitat. It had been observed that trout and salmon entering certain rivers became useless as a food because their flesh became contaminated with a pungent earthy taint. The origin of this taint remained obscure until an examination of the river beds revealed extensive areas covered with the growth of a micro-organism which produced a volatile organic nitrogenous substance. This substance, when dissolved in high dilution in water in which fish were living, imparted to their flesh the same earthy taint with which the spoiled fish had been tainted.

Reverting to the significance of biology in microbiological research, it is relevant to point out that without its aid it would be impossible to describe an organism and to compare or identify it with known types for eventual classification and conservation. Neglect in this respect has been responsible in the past for much confusion, and many types already studied have been lost in the course of time with little hope of recovery, because their original description was wholely inadequate for them to be re-identified. Within the last two decades a serious effort has been made to remedy this state of affairs by the acceptance of a standard code of identification and by opening in various countries specialized collections of type cultures in which recognized types of micro-organisms are maintained and into which new types can be incorporated as they become known, each provided with a comprehensive description, covering its general biological characters, its relationship to other types, as well as any special pathogenic, chemical or other properties which it may possess.

Turning to the place of chemistry in microbiology, it is probably correct to claim that its functions should be twofold. It should explore the relevant changes in a habitat which result from the metabolism of micro-organisms, and it should investigate the chemical composition of the organism itself so that information may be obtained on its food requirements. Further, the intermediary products which result from its activity should be explored so that the steps can be ascertained by which the final metabolic products are arrived at.

In the course of time chemistry, as applied to micro-organisms, has branched off into a third direction which cannot be regarded as strictly relevant to its main function. This side-line originated in the observation that the metabolic processes of micro-organisms are fundamentally similar to those of higher organized forms of life. The free-living microscopic cell, therefore, with its much contracted life-cycle, is often chosen for the study of metabolic changes, which might not be as conveniently explored on tissues removed from higher animals or plants.

Within its more legitimate sphere, the chemistry of micro-organisms covers a wide field of unexplored ground, in spite of the not inconsiderable amount of information which has been acquired already. Such knowledge makes it possible, for example, to predict with some measure of assurance the nature of some of the chemical compounds which can be produced by micro-organisms and the stages through which the substances utilized by the free-living microscopic cell are broken down into final metabolic products. This is particularly so in the case of the carbohydrate metabolism of micro-organisms. Much less is known about the changes through which nitrogen passes under their influence, and still less of those in which sulphur, phosphorus, silicon and other elements may be involved.

As for the carbohydrates, it may be said that, whether they be polysaccharides or monoses, hexoses or pentoses their breakdown by micro-organisms gives rise to the same ultimate products: carbon dioxide and water. Some organisms fail to utilize carbohydrates to this extent and more complex end-products will result, notably organic acids, alcohols, ketones and esters. But even in such cases, and in spite of the seemingly endless possibilities, the number and the nature of the end-products will be restricted to comparatively few groups. This is due to the standardized type of enzyme reaction employed by micro-organisms in metabolizing carbohydrates, even where the organisms belong to the most varied biological groupings.

It is for this reason that the application of micro-organisms in the preparation of organic compounds from carbohydrates must remain a limited field of application, a field which in the course of time, and for economic reasons, may become even further restricted than it is to-day. Where fermentation processes have already been introduced, for example, in alcohol manufacture and in the production of citric, lactic and acetic acids, they have in most cases maintained their economic predominance. That they will do so in future is already problematic, at any rate in the case of lactic and acetic acids, other than vinegar. For these acids can now be produced more cheaply by chemical methods than by fermentation. That vinegar is still made commercially with the aid of micro-organisms illustrates the advantage possessed by fermentative processes in such industries as brewing and wine production, which are based on the conversion of carbohydrates into products in which subtle and often undefinable metabolic substances constitute an essential part of the final product.

It has already been mentioned that the biochemical aspect of the nitrogen metabolism of micro-organisms is far less explored than that of carbon. Nevertheless, micro-organisms have been, and are being, used on the largest scale in processes which are based on the nitrogen metabolisms of such organisms. The fixation of atmospheric nitrogen in the soil by addition of pure cultures of certain bacteria is a case in point; removal of undesirable tissues from hides in leather manufacture; sewage disposal; casein digestion in cheese-making; and protein synthesis from inorganic nitrogen compounds are others.

A very special interest is attached to the chemical exploration of bacteriostatic and bacteriolytic substances produced by micro-organisms, substances into the composition of which nitrogen enters. A purely biological approach to this subject, though an essential preliminary, would not suffice for full advantage to be gained from the existence of these substances. Their production by micro-organisms at any given time may often be totally inadequate for large requirements, and they will, moreover, often be difficult to isolate from the substrates in which they have been produced biologically. The final goal here would appear to be their chemical identification and synthesis by the organic chemist.

Recent work on the sulphur metabolism of micro-organisms has brought to light several interesting observations which indicate that this field also may be of interest not only to the biologist but also to the chemist, the farmer and the engineer. For it has by now been established that certain micro-organisms, through their sulphur metabolism, play a significant part in the corrosion of metallic structures which are exposed in soils or water. Others influence soil fertility through their sulphur metabolism.

The fields of the phosphorus and silicon metabolism of micro-organisms remain almost unexplored. If experience gained in other fields may be taken as a guide, an exploration here could most profitably be approached by a study of those micro-organisms which occur in places where phosphorus or silicon undergo 'spontaneous' changes.

This brings the discussion back from a contemplation of the functions of chemistry in microgeology to the question of the significance of the free-living cell in its natural habitat, a question which has already been referred to as fundamental. It seems appropriate at this juncture to substantiate this contention by a further example.

Where micro-organisms develop in their natural habitats they do so at the expense of substances which can serve their energy requirements. Such substances may range from highly complex organic compounds to simple elements. The result of the action of micro-organisms on them will inevitably be a change in their chemical composition, a change which, if undesirable from a human point of view, will be characterized as destructive.

The destructive activities of micro-organisms are too manifold to enumerate, ranging as they do from the taking of human life to the elimination of dead vegetation; from the spoilage of milk and all other foods to the mildewing of fabrics; from the contamination of gas stored in gasometers to the destruction of natural rubber, or the breakdown of liquid fuels, or the corrosion of metallic structures. A study of all such destructive activities and a clarification of their significance must always constitute a major function of microbiological research, worthy of a degree of attention at least equal to that devoted to the adoption of micro-organisms as catalysts in the production of organic substances.

What bearing, it may finally be asked, has all this on the planning of future microbiological research? It implies that the biological aspect should be safeguarded in greater measure than has been done in the past, and that a more general approach to the subject should be encouraged, not, be it understood, at the expense of specialized investigations, but in addition to and in amplification of them.

There will be needed in future a more comprehensive survey of the natural habitats of the microscopic world than has hitherto been undertaken. There is need to-day for a much more thorough exploration of the destructive activities of micro-organisms than has so far been conducted. There is need for a better understanding of the symbiotic and antagonistic activities of micro-organisms, and of the adaptive properties of the microscopic world in its natural habitats. There is need for more work connected with the classification and preservation of type cultures, and for a fresh approach to an understanding of the biological and biochemical principles underlying established microbiological processes. Improvements in such processes could not fail to result from such work. Finally, there is need for the training of workers in general microbiological principles.

Planning of microbiological research on the above lines is unlikely to be effectively undertaken in laboratories designed for specialized purposes such as pathology, dairying, soil investigations or biochemistry.

A homestead for general microbiological research is needed suitable for carrying out also the training of workers on more general lines than has been customary in the past. By whom such an establishment should be conducted, by universities or under Government auspices, may be a matter for discussion. Of its usefulness there can be but one opinion.

OILFIELDS IN GREAT BRITAIN*

By Dr. G. M. LEES
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IN *Nature* of March 31, 1934, an article on "Petroleum in Great Britain" gave the following conclusion on the prospects:

"Oil pools of commercial magnitude (*pace* natural gas, shale oil and allied indications and potentialities) cannot reasonably be anticipated in any known area in Great Britain. Many years of official geological survey—a centenary in 1935 in point of fact—together with much independent work, leave few spots unknown, if not in detail, at least in sufficient outline to preclude even faint hope".

On December 6, 1944, G. M. Lees and A. H. Taitt read a paper to the Geological Society of London on "The Geological Results of the Search for Oilfields in Great Britain" and the president of the Society, Prof. W. G. Fearnsides, on opening the discussion, said that "Never before had so much exact and new information about the underground geology of Britain been presented to the Society. . . . The D'Arcy Exploration Company's [the exploration subsidiary of the Anglo-Iranian Oil Co.] delivery of some 300,000 tons of native oil had been a notable contribution to the war effort, but the by-product of knowledge gained of Carboniferous rocks, under and about the edges of the coalfields, was not less vital in the interests of the nation".

The pessimistic, though confident, opinion of 1934 was presumably written without a full appreciation of the capacity of the modern technique of geophysics and of rapid exploration drilling to probe the structural and stratigraphical secrets below the unconformable cover of Permian and Mesozoic strata. This blanket completely obscures the older rocks throughout extensive areas in the Eastern Midlands, East Anglia and south-central England, and such borings as had penetrated below the unconformity were too few and too scattered to allow any satisfying deductions to be drawn from their results. These areas were, therefore, virtually *terra incognita* at depths below a few thousand feet, or less, from surface.

The exploration programme of the D'Arcy Exploration Company has extended over a number of separate and unrelated geological prospects—the Mesozoic in southern England, the Carboniferous in the western and eastern Midlands, the Permian in North Yorkshire and the Calciferous Sandstone Series in Scotland. During the course of the past ten years, intensive geological and geophysical work and the drilling of fifty-two deep and forty-three shallow exploration borings by the Company have yielded an immense amount of new information. They have proved five oilfields and two areas of natural gas, and these fields are now producing from 243 wells. The total production up to the end of 1944 was 337,000 tons. The crude oil is of good quality, with good light and lubricating oil fractions. The specific gravity ranges from 0·83 to 0·89.

The oilfields are situated about eight miles north-west of Newark at Eakring, Duke's Wood, Caunton and Kelham Hills, and there is one isolated small field at Formby, between Liverpool and Southport. The Nottinghamshire oilfields produce from depths of 1,900–2,500 ft. from sandstones in the Millstone Grit Series and, to a lesser extent, from sandstones

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