An Address ON THE PRESENT POSITION OF MEDICAL BACTERIOLOGY.

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INTRODUCTION.

THE chair of bacteriology is still young in the history of the University of Edinburgh, and, lacking the historical traditions of older foundations, owes its present prestige not only to its origin and associations, but also in large measure to its first occupant, the late Professor James Ritchie; and on this occasion I may be permitted to pay a humble tribute to the distinguished memory of my predecessor by recalling the eminent place he had earned for himself as one of our leaders in pathology and bacteriology through his scientific achievements, his teaching and writings, and his constructive work in the interests of these sciences. He was aptly described as one of the moving forces in pathological work in this country, and his death deprived British medicine of one of its best influences.

The justification for the subject I have selected for this customary inaugural lecture is, I think, an ample one. At all times there is need for critical revision in every domain of learning, for sorting out and arranging accumulated data so that each achievement may be apportioned its due place in the general structure. Only in this way can we ensure a sound basis for further progress. In recent years knowledge has advanced with truly remarkable rapidity, and in all the sciences such often bewildering masses of detailed information have been accumulating that the present times demand the most accurate and proportioned survey of scientific knowledge—if only for its direct application to human needs. This is particularly true for bacteriology, which, no one will deny, has conferred on mankind some of the great advantages enjoyed in these modern times.

This science has long passed out of that phase in its history when it presented to the world those dramatic discoveries that established the germ theory of infective disease and defined the causal agents of many human and animal scourges; but even to-day the scope for discovery of unknown morbid germs is by no means exhausted. Of recent years a vast amount of non-spectacular work has been accomplished by laborious and patient research, all directed to increasing the knowledge of our microbe enemies, their method of attack, and our means of defence against them. The information obtained has elucidated many a problem, but new data have often served only to exhibit the complexity of the subject; and in this, as in other sciences, there are many tangles that still require unravelling.

It is, of course, impossible to review the whole subject as it is studied at the present time without introducing a mass of technical detail that would be out of place in an address of this nature, but I shall attempt to indicate in the simplest fashion certain aspects which seem specially significant to me as a teacher of bacteriology. While I shall confine my remarks mainly to bacteriology in its medical applications, it is impossible to sound the depths of the subject by limiting oneself to any one division; and at the present time our conception of bacteriology must be based on its position first and foremost as a biological science with intimate relations to human and veterinary pathology and hygiene, and also with important economic applications in agriculture and in various industries. To instance a comparatively recent industrial application arising out of war needs, we have the production of acetone on a commercial scale—as a solvent of nitrocellulose—by the bacterial fermentation of starch. The part played by saprophytic bacteria in resolving dead organic matter in the soil into simple chemical substances available for

plant nutrition is one of the great natural processes at the very foundation of life on this planet, and even apart from agricultural considerations must be studied as a biological phenomenon of primary importance. Microbic disease itself is simply a biological process which constitutes one phase in the general struggle for existence that goes on in nature and represents the predatory aggression of minute forms of life towards larger organisms.

PURELY BIOLOGICAL CONSIDERATIONS.

Our first approach, therefore, to the study of even medical bacteriology must be along the avenue of general biology.

The scope of bacteriology in these days, when lines of demarcation between previously well defined spheres of knowledge are becoming less marked, requires the first consideration. The name of the science is suggestive, but the conventional name of a subject—often a product of usage and convenience—may fail to express its scope. Bacteriology, of course, takes its name from the bacteria, which were the first pathogenic or disease-producing microbes to be systematically studied. The early biological studies of these organisms led to their classification as the most primitive forms of plant life, and they have been generally designated “schizomycetes.” This has no doubt satisfied the systematic biologists, but the relationships of the bacteria and many other unicellular organisms are by no means a matter of certainty, and competent systematists (Zopf and others) have regarded the bacteria not as low primordial organisms but developed by reduction of higher forms.

For many years now, following the lead of Pasteur, the great pioneer of the science, bacteriology has included in its scope all micro-organisms that can be studied by the same general methods and technique. In its widest range it might be more appropriately designated “microbiology,” and this name could well be substituted for the older traditional one. The elements then of bacteriology would embrace the biological study of all micro-organisms—popularly known as microbes or germs—and from this fundamental basis the various divisions and applications ramify in diverse directions. In medicine we are concerned primarily with certain pathogenic and commensal microbe species which represent not only the bacteria but also the true fungi, the protozoa, and a group—probably a heterogeneous one—of still undefined organisms, the so-called filtrable viruses, which are so minute or so plastic that they can pass through a porcelain filter. The medical applications have extended to detailed studies of infection, microbial toxins, immunity, the germicidal chemicals, and the bacteriology of water and foods.

At the present time in bacteriology we are confronted with the problem of biological classification. Of the various microbial groups some have been assigned to the plant kingdom, some to the animal kingdom; but among the unicellular organisms it is difficult to draw a sharp line of demarcation between the two great kingdoms of life, and we may well follow Haeckel, who first classified together and designated as “protista” all those primitive organisms which lie, as it were, at the point of fusion between the two kingdoms. If we consider, for example, the order of spiral flexuous micro-organisms, the so-called spirochaetes, which are responsible for certain important diseases of man and animals, we find that at one time they have been placed in the plant kingdom, at another time in the animal kingdom—that is, among the bacteria and protozoa respectively. According to contemporary systematists, they are now to be regarded as an order of the schizomycetes or bacteria (Dobell and others), in spite of recent tendencies to classify them as animal forms. There is much to be said, however, for recognizing them as intermediate between the true bacteria and protozoa. As regards the filtrable viruses we must confess that there is quite insufficient knowledge of their biology to justify systematic classification.

Bacteriology, as I have defined it, and the science of parasitology as a branch of zoology, meet and may overlap, therefore, in the study of certain types of minute organisms; but this is no disadvantage to either subject, and protozoology as a special study merits the most serious

consideration in view of its obvious importance in relation to various tropical diseases in man and certain widespread diseases of animals.

Apart from the systematic position of the different main divisions of micro-organisms, the classification of the bacteria into families, genera, and species is one of the most confusing of our immediate problems. As in other departments of biology, the determination of species is a fundamental difficulty. While the botanist and zoologist relies on morphology as his ultimate criterion, in bacteriology physiological functions, biochemical reactions, and disease-producing properties may serve to differentiate and identify important species. In addition, the specific reaction of the serum of an immunized animal to the homologous bacterium—a criterion not employed thus in other branches of biology—constitutes one of our most delicate tests of identity. On the other hand, this finesse in identification has often complicated our classification to such an extent that we hardly dare speak of "species" in bacteriology—if such a fixed entity really exists—and in certain bacterial genera biochemical and serological criteria yield the most amazing multiplicity of types. A broad system of classification is urgently required, however, and the most serious attempt in this direction is that of the Society of American bacteriologists, which has recently proposed a new classification of the bacteria. While this system is undoubtedly sound and seems to possess a convenient elasticity, it involves a revolution in nomenclature—a disadvantage to older students of the subject.

Among the bacteria it has been found possible to follow closely the process of spontaneous variation, and in this way the evolution and origin of new types can be studied. The great diversity and multiplicity of types among certain bacterial groups can thus be explained to some extent on the basis of rapid mutation.

From the purely biological standpoint the question of a bacterial life-cycle deserves some comment. It has been generally accepted that bacteria, as contrasted with the protozoa, exhibit no real life-cycle, and that their morphology is of the simplest and most uniform type. On the other hand, it has to be remembered that our knowledge of the structure of such exceedingly minute organisms must necessarily be somewhat limited. There is already a considerable amount of literature dealing with the supposed life-cycle of bacteria, and this conception has been daringly used to elucidate certain unexplained epidemiological peculiarities (for example, waves of epidemic prevalence, etc.). A further development of this idea is to presuppose changes in toxicity and virulence associated with different phases in life-history. Moreover, the question of an exceedingly minute or filtrable phase in certain recognized pathogenic micro-organisms has also been raised, and might be considered in relation to the whole problem of the filtrable viruses. Though the interpretation of many of the data in this subject justifies frank scepticism, they at least point to an interesting field for further investigation.

Within the last few years a remarkable biological phenomenon among the bacteria has been observed and studied, the so-called Twort-d'Herelle phenomenon—that is, the lysis of bacteria by some active principle transmissible from generation to generation of a bacterial culture. D'Herelle has elaborated the somewhat startling idea that the lytic effect is due to an ultramicroscopic parasite of bacteria, or "bacteriophage," which actually reproduces itself within the bacterial cell. It would thus fulfil the old postulate versified by Swift that even a small parasite has its own lesser parasites. The biochemical explanation that the active principle is an autolytic enzyme of bacteria, and that its apparent transmissibility and reproduction are not necessarily due to a separate living organism, is perhaps the more acceptable theory.

There is no lack of scope, therefore, for the purely biological investigation of the bacteria, and at the present time it might appear that the study of the fundamental biology of these micro-organisms has perhaps been sacrificed in the past to the more attractive investigation of their direct relation to disease and the everyday affairs of mankind.

ETIOLOGICAL CONSIDERATIONS.

Bacteriology, though primarily a purely biological science, owes most of its actual development to the modern study of pathology, for its importance in medicine must always depend on the essential fact that it deals with the genesis of a large number of diseases. The majority of deaths among our own species are attributable to microbial infection, and certain prevalent diseases of still unknown etiology may yet be shown to be due to micro-organisms or their toxins.

I have referred to the great discoveries of the latter part of the nineteenth century which brought to light the causal agents of many prevalent diseases—the discovery of the typhoid bacillus, the cholera vibrio, the diphtheria bacillus, the tubercle bacillus, and many other pathogenic micro-organisms in rapid succession. The etiology of various diseases was thus explained in what seemed at first to be a relatively simple manner; but the identification of the causal agent has not always elucidated every problem in the particular condition.

Disease is a complex process dependent on several factors, and in even a well defined infection the invading micro-organism, though the specific and essential cause, is not the only factor that determines the process. It is futile to study a parasite apart from its interaction with the host and without regard to the passivity or antagonism of the latter, and also the external influences that affect both.

While the achievements of bacteriology in elucidating disease have been of almost unequalled value in medicine, serious obstacles still confront us in the fuller application of our science. Granted that all infective diseases are of microbial origin, there are still many obvious infections whose causal agent remains undetermined; but we have to remember that it is not so many years ago in this present century since the *Spironema pallidum*, the organism of syphilis, was observed for the first time, and it is only within the last few years that the leptospiras of infectious jaundice and yellow fever, and other previously unknown pathogenic micro-organisms, have been described. Bacteriology was alluded to in 1918 by one of the leaders of our profession (Sir Clifford Allbutt) in pointing to possible new conquests in other branches of medical science, as a "territory—largely won," but I can assure you we have only passed the frontiers, and there is still great scope for conquest in this department of science. Consider, for example, the bacteriological problem in leprosy: the leprosy bacillus was first described about fifty years ago by Hansen, and to anyone approaching the study of leprosy for the first time the problem might seem one of the easiest to solve; but in spite of repeated studies of this organism little is yet known of its biology and experimental pathogenesis. Without this knowledge definite information cannot be obtained as to the transmission of the disease and immunity to the infection—important practical questions in countries where leprosy is prevalent. In fact, the bacteriological difficulty in this infection is almost unparalleled; no other obvious bacterium occurring in such enormous numbers in the lesions of the disease has proved so resistant to artificial cultivation. The majority of attempts to obtain cultures for experimental study have been unsuccessful, and where success has been claimed the results are still open to doubt. When a fundamental problem still remains unsolved with regard to a micro-organism so easily demonstrable as the leprosy bacillus, it is not difficult to appreciate the obstacles still to be overcome in demonstrating less obvious microbial agents and in proving their pathogenicity beyond a shadow of doubt.

The pioneer work in bacteriology brought into rapid subjection certain groups of micro-organisms which now yield many of their biological secrets to our ordinary technique, and diseases due to such organisms have been investigated bacteriologically with most valuable results as regards diagnosis, prevention, and even cure. There still remain a large number of prevalent infections in which a microparasite has proved less easy of demonstration—where the customary technique has been quite ineffective. The *Spironema pallidum* long remained refractory to microscopic observation until special methods had been

elaborated for the purpose, but at the present time this organism yields easily to a specialized technique; and so it may be with certain other pathogens.

For a good many years now active studies have been steadily proceeding, which first raised the question of an "ultramicroscopic" type of organism minute enough to pass through the pores of a porcelain filter, and therefore designated "filtrable virus." Proof that these viruses represent living organisms was established by experiment, and many prevalent human and animal diseases were shown to be due to such agents—for example, rabies, epidemic poliomyelitis, rinderpest, etc. More recently, attempts to cultivate them artificially have in certain instances proved successful, with the result that some information is now directly obtainable regarding their biology. It seems unlikely, however, that all the viruses of this nature represent a homogeneous biological class.

It is interesting to recall how, a number of years ago, the virus of yellow fever present in the blood of infected persons was found to be filtrable and it was classified as ultramicroscopic. In 1919, however, Noguchi described as the causal organism of the same disease a leptospira whose etiological relationship to yellow fever is now generally accepted. The filterability of the virus was also confirmed by Noguchi, and the possibility of a granular phase of the leptospira such as that described in the case of other spiro-nemata was suggested. All these facts are of the greatest significance in relation to the whole question of the biology of the filtrable viruses, but hasty generalizations and speculations are to be avoided.

The influenza problem also exemplifies the intricate difficulty of determining the exact causal agent of an obvious infective disease. Since the pandemic of 1918 bacteriologists have been divided in opinion as to whether the classical *B. influenzae* of Pfeiffer or a filter-passing virus is the primary causal agent in the disease. Without treading already well worn ground in this controversy, attention may be drawn to the successful isolation of an exceedingly minute bacilloid filter-passing organism from this disease by independent workers in different countries—the *Bacterium pneumosintes* of Olitsky and Gates. Having had the opportunity of studying the biological characters of this organism (isolated by Sir Spencer Lister), I have little doubt of its close relation to the true bacteria; its size is not constant and in a certain environment it may attain the dimensions of one of the recognized bacteria. These facts are also highly significant in any biological speculations regarding the filter-passing organisms. The "Rickettsia bodies" of typhus fever and the "globoid bodies" of epidemic poliomyelitis provide further examples of exceedingly minute structures of doubtful biological nature that have to be reckoned with in the new bacteriology.

The whole subject of the filtrable viruses is a field of study in which a vast amount of careful investigation is required and it holds many pitfalls for the unwary observer; but here we must look for some of the conquests of the future.

The present position, then, in the etiology of infective disease is that a large number of infections are due to, as it were, tangible micro-organisms, but in a considerable proportion of prevalent diseases admittedly infective, the causal microbe is either quite unknown, or doubtful, or still undefined in the biological sense. I need only quote, to exemplify this, such human diseases as small-pox, measles, scarlet fever, and rheumatic fever, though we have a large volume of highly suggestive observations bearing on their causation.

While in medical bacteriology a single specific organism is the usual objective, we cannot disregard the fact that the sum-total result in an infective disease is not always the product of one parasitic species; micro-organisms may and do attack the tissues in team fashion. In certain of those processes due to saprophytic bacteria that go on in nature, it is generally agreed that the changes cannot be interpreted as a function of one species acting alone but of two or more flourishing together in symbiosis. This must not be overlooked when investigating the causation of microbic disease. Studies of dysentery have shown that a specific dysentery bacillus may only be the starter of the process and

that special concomitant bacteria may aid and abet the other (Mackie). The same is true for other conditions. An interesting example of a concomitant organism is seen in actinomycosis, long recognized as due to one of the higher bacteria, the actinomyces; in most of the cases that have been fully investigated the actinomyces is found to be associated with another organism of apparently different order which can be grown quite independently (*B. actinomycetum comitans*). The full significance of such concomitant infections is somewhat obscure and requires further elucidation.

The selective affinity that different bacteria possess for particular animal tissues is also an important etiological factor, and it has been shown that within the same species there may be separate types differing in their tissue selections. This is of the greatest significance in the pathology of certain infections: for example, dermatrope and neurotrope types respectively of the syphilis virus have been recognized, the latter being the responsible agent in syphilitic disease of the central nervous system. On the other hand, as shown by animal experiment, the virus of herpes may also produce encephalitis—thus two diverse types of lesions in different tissues may be due to the same agent (Levaditi, Kling).

Apart from exogenous infection due to micro-organisms that have usually no place in the body of the healthy animal, those commensal microbes which normally inhabit the surface of the body and certain body cavities represent a constant menace to the tissues. Exogenous pathogens, however, may gain access to the body and for a time assume a commensal rôle without tissue invasion and pathological effects.

These facts all indicate the extreme complexity of the etiological problem.

IMMUNOLOGICAL CONSIDERATIONS.

The study of immunity (immunology) is inseparably bound up with bacteriology and pathology, though at the present time it has practically attained the position of an independent science. Well defined principles have been established which have stood us in good stead from the practical standpoint, but the general tendency of recent research has been to demonstrate the complexity of the underlying biological processes, and now we are being confronted with new principles and new theories often subversive of the older ideas. The original work on immunity, however, elicited facts and phenomena which are still incontrovertible, and the artificial production of immunity for prophylaxis and treatment will ever be one of the greatest achievements in the history of medicine. The early scientific work on artificial immunity almost seemed to herald a glorious future in which infective disease could be easily overcome; the antitoxin treatment of diphtheria revolutionized the therapeutics of this disease; Pasteur's hydrophobia vaccine minimized the terrors of rabid dog bites; typhoid vaccination has reduced the great prevalence of typhoid among armies in the field; tetanus antitoxin used as a prophylactic has obviated many a death from this fatal disease; small-pox vaccination has contributed to the removal of that epidemic scourge of past times, and it is to be hoped that the lessons of the past will not yet be entirely forgotten. But many natural obstacles have barred the universal application of this means of prophylaxis and treatment. Unfortunately immunological therapy has not always been employed in a rational or scientific manner, and certain measures of this type, not fully justified by the general value of the results obtained, have been exploited to such an extent that the whole system has often been in danger of discredit.

Attention has been drawn quite recently to a possible obstacle in artificial immunization against certain types of bacteria—for example, the tubercle bacillus: that these organisms possess fatty envelopes which prevent their proteins from coming into contact with the tissue cells and so stimulating an immunity response when injected in vaccine form (Dreyer). If the removal of this obstacle is ultimately proved beyond doubt to allow of effective immunization against such bacteria, medicine will owe a great debt to this immunological achievement.

One of the great principles of antibacterial immunity has

been that the immune state is due to specific serum antibodies which have an adverse influence on the particular organism or neutralize its toxin, and passive immunization by the injection of the serum of an immune animal, which has undoubtedly proved of the greatest value in certain conditions, is based on this. The study of these antibodies is one of the most fascinating in the whole field of scientific medicine and its range now extends far beyond strictly bacteriological limits. In short, antibody development constitutes an important demonstrable reaction of the tissues to the introduction of any alien protein, and the specificity of antibodies for the particular type of alien substance (antigen) is one of the most remarkable of biological phenomena. It is more than doubtful, however, if these reactions constitute the complete immunity mechanism of the body. The tendency may have been to attribute immunity to phenomena observable by known laboratory methods, but present knowledge is now revealing the existence of still unknown factors. Immunity may exist in the absence of "immunity reactions," and it is open to question whether certain antibody effects signify an immune state. It has been shown that particular tissues may be locally immunized to certain bacteria without any general reaction (Besredka). Moreover, we now know that the resistance of the tissues may be influenced in a non-specific fashion by the parenteral injection of alien protein, and it is difficult sometimes to disentangle in our interpretation of results the specific from the non-specific effects when an alien protein substance is injected into the body for immunization purposes—for example, an immune serum or a vaccine consisting of killed bacteria. The possibility that one infection may influence the resistance of the tissues to another is already supported by experimental and clinical experience. We find also that an endocrine secretion, adrenaline, may play a part in the immunity mechanism and render innocuous certain bacterial toxins—for example, that of the diphtheria bacillus (Marie). Finally, it must be borne in mind that while the interaction of antigen and antibody may under one set of conditions lead to immunity, under another set the very opposite effect—anaphylaxis, or hypersensitiveness—is produced.

Thus the scope of immunology has been gradually widening, and the solution of many of our problems must ultimately depend to a large extent on a fuller knowledge of the underlying chemical changes in the tissues on which immunity depends and of the chemistry of the reacting elements and the chemical and physical nature of the reactions. In laboratory immunological work we observe and utilize reactions in which we still know comparatively little about the fundamental chemical and physical phenomena. The reacting substances are apparently colloids—the "dynamical state of matter" (Graham)—and the reactions may only be elucidated by further reference to colloid chemistry.

I have referred to the high degree of specificity of serum antibodies; in virtue of this certain antibody reactions play an important part in the diagnosis of infections. The classical example is the Widal reaction, which depends on the *in vitro* clumping or agglutination of the typhoid bacillus by certain antibodies (agglutinins) in the serum of an infected person. Similar tests have been employed in other bacterial infections, but at the present time their limitations must be emphasized as well as their value. Antibody development in infection is inconstant both in degree and time, and such variations must be reckoned with in this method of clinical diagnosis. Moreover, the serum of a normal person is not always without agglutinating properties, especially for certain bacteria, and the quantitative limits of normal effects will determine what is a significant diagnostic result. This has been particularly true in the serum diagnosis of Malta fever.

One of the most unexpected developments of recent years in this field is the so-called Weil-Felix reaction, which depends on the agglutination of a certain type of *B. proteus* by the serum in typhus fever. In this disease antibodies are developed that are specific for an antigen which, as far as we know, has no etiological relationship to the particular disease. These so-called "heterogenetic" antibodies present further interesting complexities to the student of

immunity. The Wassermann serum reaction, which was discovered in almost a fortuitous manner, is probably to be regarded also among these obscure heterogenetic phenomena. Even the apparent anomalies in immunity have, therefore, rendered service in practical medicine.

Antibodies are specific for the biological species, and antibody reactions have therefore become criteria of species; but this specificity may be more restricted and has often revealed profound differences in the immunological characters of different strains of the same species. This knowledge has had an important bearing on artificial immunization. Among the pneumococci, for example, a number of different immunological types can be recognized. Immunization against one would not confer immunity to another, and for prophylactic vaccination against epidemic pneumonia all types must be represented in the vaccine used. This system has yielded most valuable results in combating pneumonia among the native labourers in the gold mines of South Africa (Lister); at one time this epidemic disease seriously threatened the gold mining industry in that country.

The recognition of different immunological types among certain pathogenic bacteria has influenced immunological measures both for prophylaxis and treatment and has overcome to some extent one of the obstacles in the way of applied immunity.

THE MECHANISM OF MICROBIC ATTACK ON THE TISSUES.

For many years we have spoken of bacterial toxins, we have prepared toxic substances artificially from bacteria, we have utilized them for immunization, studied their experimental effects, classified them and so on, but this work has generally aimed at demonstrating some specific poison in artificial culture of bacteria. In some cases it has been apparently successful and substances have appeared in culture which, apart from the bacteria themselves, can reproduce the particular disease in animals. In other cases no specific poison can be prepared. These so-called toxins, however, have never been isolated as pure substances. By reference to the biochemistry of the saprophytic bacteria the most elaborate chemical changes produced by these organisms in nature are interpreted in terms of enzyme action. In explaining the mechanism of disease production by microparasites, according to Pasteur's original conception, the ultimate interpretation of the tissue changes, which are fundamentally chemical, must be on similar lines; but in addition to the microbic ferments acting on the tissues, there is the reciprocal effect of the tissue enzymes to be reckoned with. Even the specific toxins show a close though not exact analogy with the ferments.

In this study new lines of thought and experiment have been indicated by Vaughan, who conceives the whole chemistry of infective disease in terms of protein decomposition by ferment action and the liberation of a protein poison or poisonous atom group of the protein molecule which is active in virtue of its intense chemism. The toxic principles in infective disease are not necessarily direct products of the parasite in the same way as poisonous chemicals are directly elaborated by plants.

New ideas regarding the mechanism of infection must be reflected in our conceptions of immunity, and at the present time there is the most urgent need for marshalling all the valid data with a view to their co-ordination. Otherwise our knowledge is in danger of becoming simply a chaos.

REGARDING CHEMICAL AND PHYSICAL INFLUENCES ON MICRO-ORGANISMS.

The adverse chemical and physical influences that can be artificially brought to bear on micro-organisms have proved an attractive study, and the results have provided important practical applications not only in general disinfection but also in the therapeutic elimination of organisms from the tissues. Certain therapeutic substances of the present day are the direct product of this study (salvarsan in the treatment of syphilis) and there is great scope for chemotherapeutic investigation. The primary aim in this work is to identify chemical compounds with the maximum germicidal power for particular micro-organisms and the minimum toxicity for the tissues—a combination not easy of fulfilment.

The bactericidal action of light is one of the most remarkable of natural phenomena. It has been generally agreed that it is due to the ultra-violet region of the spectrum, but recent investigations have shown that certain parts of the visible spectrum, particularly the red region, are powerfully inhibitory and even lethal to various bacteria (Van der Lingen and Mackie; unpublished observations).

THE INFLUENCE OF THE WAR ON BACTERIOLOGICAL SCIENCE.

The war both emphasized problems and necessitated their expeditious solution. War conditions also, with the inevitable prevalence of infection among armies in the field, provided large collected masses of material for the study of individual diseases. The concentration of troops in various tropical and subtropical parts of the world with the occurrence of infective diseases characteristic of these regions greatly widened the range of study, and British bacteriologists were enabled to investigate etiological, diagnostic, and immunological subjects that normal conditions in Great Britain would never have provided. The result has been a significant gain to pathology and bacteriology, and out of the welter of war has come a further justification of scientific medicine.

The value of antityphoid vaccination was one of the earliest results to be noted, though in the Near Eastern campaign a by no means negligible loss was due to the initial overlooking of paratyphoid fever as a prevalent infection in the East. This omission was rectified by the use of the combined typhoid-paratyphoid vaccine, and after 1916 the incidence of the enteric fevers became practically minimal.

The great war also proved beyond doubt the prophylactic value of tetanus antitoxin, and this immunological application alone contributed something to alleviating the horrors of war.

Dysentery, both amoebic and bacillary, was studied in a truly exhaustive fashion; in fact few individual infective diseases have ever been so extensively investigated. New types of causal organisms were observed, methods of laboratory diagnosis were perfected, and certain systems of treatment were carefully evaluated. On a smaller scale choleraic disease attracted a certain amount of attention among army bacteriologists in the East, and the occurrence of paracholera was established—that is, choleraic illnesses due to vibrios specifically different from the classical cholera organism and of different epidemiological significance (Mackie).

The war also brought to light a previously unknown disease, designated by the historic and significant name of "trench fever." The infective nature of this condition was clearly proved, and later work which showed it to be louse-borne indicated means of prevention. The question of the microbic agent, however, provides a further instance of the difficulty of demonstrating and defining the infecting organism in certain diseases. The presence of the organism in the blood was proved indirectly by experiment, but it cannot be said that microscopic examination ever clearly revealed a definite parasite, and the virus was not of the filtrable type. It was shown that the excreta of lice which had fed on the blood of persons suffering from the disease were infective and contained certain minute bodies with recognizable characters but smaller than the ordinary bacteria—the so-called "Rickettsia bodies"—and though there is strong evidence that these represent the causative microbe, the final proof is still awaiting and their biological nature remains uncertain.

Many other important data of outstanding practical importance were obtained during the war period. These have contributed much to our present knowledge of bacteriology and are now reflected in laboratory and clinical methods. They are well exemplified by the work done on epidemic cerebro-spinal meningitis, infectious jaundice, malaria, the venereal diseases, gas gangrene, etc. The period of the great war will always be a memorable one in the history of medicine, and bacteriology may justifiably claim a signal share in the medical and surgical triumphs of that epoch.

THE STUDY OF BACTERIOLOGY IN THE UNIVERSITIES AND MEDICAL SCHOOLS.

The observations I have made, scanty though they be, all go to show the need for a continued and even more vigorous

attack on disease by microbiological methods. In equipping the necessary personnel for this offensive and in the ordinary medical training, the question of bacteriological teaching in the medical schools merits some consideration.

During these times of reconstruction most careful attention has been given to the subject of medical education, and existing systems have been revised in the greatest detail. The trend of development in medicine towards scientific application demands that the student should obtain as complete a scientific education as possible; but the possible scope of science teaching in medicine is an exceedingly wide subject, and in any case it is obvious that no undergraduate education could compass a full training in all the medical sciences. Whatever education the undergraduate receives can only be an introduction to a wider experience and a fuller knowledge.

Among the medical sciences bacteriology offers an attractive and educative field of study as a biological and applied science, though it is only one branch among many of medical training and research. In the past the training in this subject given to the undergraduate in this country has been for the most part a product of pathological teaching, and at the present time the correlation of pathology and bacteriology in the curriculum is still ideal and essential in the interests of both subjects; but bacteriology now provides so many methods of direct application in clinical diagnosis and treatment and in preventive medicine that an adequate though elementary course must now hold an essential place in any curriculum. The Education Committee of the General Medical Council in a recent attempt to systematize medical teaching recognized this, and in its draft curriculum placed this course as a preliminary to the regular clinical training of the student as a clinical clerk and surgical dresser. In short, some fundamental knowledge of microbiology is an absolute essential now to the practitioner of medicine, for he is constantly called on to approach the bacteriological problem in the causation, diagnosis, and treatment of disease. He need not carry out the investigation to a conclusion—that will usually be delegated to laboratory specialists—but on the practitioner will always fall the responsibility for initiating these procedures, and he must be in a position to appreciate the significance of results reported to him. The undergraduate course, therefore, may not convey any elaborate training, but it must impart a sound knowledge of fundamental facts and principles and a reasonable understanding of methods and procedures, with, in addition, a practical knowledge of those methods which are within the scope of the general medical worker. With only a microscope and a few simple implements and materials a vast amount of valuable diagnostic work can be done, and this is particularly true for certain parts of the world—and I can speak from personal observation—where various microbic diseases are very prevalent and where the practitioner is thrown back on his own resources without the immediate aid of laboratories.

Our aim, therefore, in bacteriological teaching, as far as the undergraduate is concerned, is to convey the theoretical and practical knowledge that will assist him to a better understanding of disease and may be necessary for the purposes of ordinary medical practice. Special or advanced knowledge of the subject and its technique can only be acquired by more intensive practical courses such as those prescribed for certain post-graduate qualifications in public health, tropical medicine, psychiatry, and for the training of special workers in this branch of experimental medicine.

Apart from human and veterinary medicine and agriculture, little provision has hitherto been made in the universities for a training in bacteriology as a purely biological science. Its increased importance at the present time makes its inclusion among the various subjects for a science degree eminently desirable, and it is gratifying to find that this has already been recognized in our University. The recent institution in an English university of a post-graduate course and diploma in bacteriology marks a further development in bacteriological teaching, and the course of training prescribed aims at providing a thorough general knowledge of the subject and also a special acquaintance with certain of its practical applications.

CONCLUSION: A PLEA FOR BACTERIOLOGICAL STUDY
AND RESEARCH.

In putting before you certain aspects of the present position of this branch of science, my aim has been to indicate that bacteriological knowledge, though already advanced to a prominent place in the forefront of human progress, still presents so many crucial problems that its further advancement must be continuously maintained. Effective teaching is vital to the progress of a science, and the student must be taught in the research atmosphere if he is to gain any real inspiration from his studies. In these respects the universities, as apart from the purely research institutes, present the ideal conditions for the advancement of science, and therefore, in inaugurating my work in this historic seat of learning which has contributed an important share to the world's stock of knowledge, I would venture to make an earnest plea for the fullest possible encouragement of bacteriological teaching and research, both in the immediate interests of medicine and in the greater and wider interests of human welfare.

SANITARY ADVANTAGES OF SOCIAL
AMENITIES.AN ADDRESS DELIVERED BEFORE THE METROPOLITAN
COUNTIES BRANCH,

BY

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THE County Borough of West Ham, which I have the honour to serve, is situate on the River Thames, but I doubt whether most of the members of the Branch, if given a drawing of its sinuous curves between Richmond Lock and Tilbury Fort, could place the borough in its correct position on the river bank, or could accurately describe its chief characteristics. Unkind folk have alleged that West Ham is readily recognized—witness the patronizer of the Belle steamers, plying in the summer between Fresh Wharf and Margate, who said he knew when he passed Silvertown by the row of chimneys belching forth black smoke; and there is a fairly authentic legend of an elegant young lady who, when the train came to a standstill in a thick fog and her mother said, "I wonder where we are," replied, "Oh, we are at Stratford; I can smell Pa's factory."

It will be my endeavour to enlist interest in the past history of the district—which, thanks to the patient labours of Katherine Fry, who with her eminent sister Elizabeth Fry lived there for many years, has been studied and placed on record—and to consider what bearing, if any, the changes that have occurred may or may not have had on the present-day problems of the inhabitants.

The River Lea, which separates the counties of Herts and Middlesex from Essex, and the River Roding some four and a half miles to the east, which enters the Thames near the ancient town of Barking, enclose, with the River Thames and the southern border of Epping Forest land, a quadrilateral area now occupied by the county boroughs of West Ham and East Ham, but formerly covered by the great Essex forest with some arable pasture and extensive marshes bordering the royal river. It is not surprising that Roman remains have been discovered, as the vicinal way passed through or a little to the north of the area, and Boadicea, Queen of the Icenii, who laid London in ashes A.D. 61, probably brought her forces through the same route.

One of the earliest references to the district occurs in connexion with the burial of St. Erkenwald, Bishop of London, who died at Barking Abbey in 685 while on a visit to his sister St. Ethelburga, the first Abbess. Visitors to Epping Forest even now in the height of summer can occasionally find themselves in a morass unexpectedly, and extensive floods from the swollen rivers before mentioned are still a burden to the district, and it would appear that an exceptional storm interrupted the passage of the Bishop's corpse on its journey from Barking to St. Paul's. A later writer,

gifted with greater love of the miraculous than of scientific investigation, records how

"All the people kneeled down and prayed devoutly and as they were in prayer they sawe the water divided lyke as it did to Moyses in the Red Sea and to the children of Israel goynge through into the deserte. In lyke wyse God gave a drye path to the people of London for to convey this holy body through the water to the Cytee and anon they took up the body with great honour and reverence and by one assent they hurried through the path, the water standyng up on every syde and so they came to Stratforde and set down the bere in a fair mede full of floures."

Every schoolboy knows how King Alfred in 895 stranded the ships of the Danes at Ware by cutting channels so as to divert the course of the River Lea, but few who cross them know that there are four streams passing through Stratford from a bend in the Lea which are traditionally the enlargement of Alfred's original undertaking. On this point it would be waste of time to argue with a Stratford man.

By the Domesday Book we learn that the quadrilateral area mentioned was labelled Hamme, and was, prior to 1066, in the ownership of two Saxon freemen, Alesxan and Leured, but soon after that fated year passed into the possession of two Norman Barons, Ralph Peverell and Robert Gernon. Little is known of the after-history of these worthies, but during the next two centuries the chief family connected with the district was that of Montfichet, which possessed extensive lands in Essex, including several manors in Hamme. Originally from the neighbourhood of Cerisy in Normandy, a Sire de Montfichet accompanied and aided William the Conqueror at the battle of Hastings. According to Stow he appears to have built "Montifiquet's Castle" a little to the west of Baynard's castle at Blackfriars, and to have been among the hunters in the New Forest when William Rufus was shot. Either he or his son came into possession by marriage, for in 1134 William de Montfichet II was a capital lord of Hamme, where he established the Abbey of Stratford Langthorne, endowing it with his demesne and two mills near Stratford Causeway. The most redoubtable member of this family was the last of his line, Richard de Montfichet II, who was a minor when his father died in 1202, but is named by Stow along with Robert Fitzwalter and Robert FitzRoger as "three most forcible and valiable Knights of England." He was one of the twenty-five Barons chosen to enforce the observance by King John of Magna Charta, was Sheriff and Forester of Essex, Governor of Hertford Castle, and assisted Henry III against Louis VII of France, and on more than one occasion against the turbulent Welsh. He died childless in 1267 and was buried in St. Paul's Cathedral, his extensive possessions ultimately being divided among the descendants of his three sisters, and what remained was subsequently acquired by smaller landowners, because by this time the greater part of West Ham had become the property of the monks of the Abbey of Stratford Langthorne.

In the meantime Queen Maude, wife of Henry I and daughter of Malcolm Canmore, King of Scotland (an additional title inserted for the benefit of Scottish members of the Branch), had suffered while crossing the Lea at Old Ford a similar disaster to that which befell the cortège of St. Erkenwald, and to avoid a repetition she constructed what is reputed to be the first bridge built with a stone arch in England at Bow, a second bridge over the Channelsea stream, and a causeway between the two. These bridges and causeway not only proved a great benefit to Hamme but also to London, which derived much of its food supplies, garden produce, potatoes, and especially flour from the several mills at Stratford, but they became a source of much contention and litigation from the time of Henry II to Queen Victoria. Queen Maude placed the maintenance and repair of the bridges and causeway in the hands of the Abbess of Barking, endowing them with certain lands and a mill. The Abbess transferred her trust, at his request, to the Abbot of Stratford Abbey on its foundation. Subsequent Abbots constantly neglected their responsibilities until forced by the courts to comply, and after the dissolution of the Abbey on March 18th, 1538, subsequent owners of what had been Abbey lands endeavoured to avoid their liability for the necessary repairs or for paying the Abbey land rate. The upkeep was finally taken over by the local board in 1876 (for a consideration), so that visitors who now motor to