FRANKLAND GRACE C.

BACTERIA IN DAILY LIFE

Grace Frankland
Bacteria in Daily Life

http://www.litres.ru/pages/biblio_book/?art=24859043
Bacteria in Daily Life:

Содержание

Grace C. Frankland
Bacteria in Daily Life

PREFACE

The title of this little volume sufficiently explains its contents; it only remains to add that much of the text has already appeared from time to time in the form of popular articles in various magazines. It has, however, been carefully revised and considerably added to in parts where later researches have thrown further light upon the subjects dealt with.

G. C. FRANKLAND

Northfield, Worcestershire,
November, 1902

BACTERIOLOGY IN THE VICTORIAN ERA

A little more than sixty years ago the scientific world received with almost incredulous astonishment the announcement that "beer yeast consists of small spherules which have the property of multiplying, and are therefore a living and not a dead chemical substance, that they further *appear* to belong to the vegetable kingdom, and to be in some manner intimately connected with the process of fermentation."

When Cagniard Latour communicated the above observations on yeast to the Paris Academy of Sciences on June 12, 1837, the whole scientific world was taken by storm, so great was the novelty, boldness, and originality of the conception that these insignificant particles, hitherto reckoned as of little or no account, should be endowed with functions of such responsibility and importance as suggested by Latour.

At the time when Latour sowed the first seeds of this great gospel of fermentation, started curiously almost simultaneously across the Rhine by Schwann and Kützing, its greatest subsequent apostle and champion was but a schoolboy, exhibiting nothing more than a schoolboy's truant love of play and distaste for lessons. Louis Pasteur was only a lad of fifteen, buried in a little town in the provinces of France, whose peace of mind was certainly not disturbed, or likely to be, by rumours of any scientific discussion, however momentous, carried on in the great, far-distant metropolis. Yet, some thirty and odd years later, there was not a country in the whole world where Pasteur's name was not known and associated with those classical investigations on fermentation, in the pursuit of which he spent so many years of his life, and which have proved of such incalculable benefit to the world of commerce as well as science.

Thanks to Pasteur, we are no longer in doubt as to the nature of yeast cells; so familiar, in fact, have we become with them, that at the dawn of the twentieth century we are able to select at will those particular varieties for which we have a predilection, and employ those which will produce for us the special flavour we desire in our wines or in our beers.

Large and splendidly-equipped laboratories exist for the express purpose of studying all kinds and descriptions of yeasts, for finding out their characteristic functions, and cultivating them with all the tenderness and care that a modern gardener bestows upon the rarest orchids.

All this is now an old story, but some sixty years ago the great battle had yet to be fought which was to establish once and for all the dependence of fermentation upon life, and vanquish for ever those subtle arguments which so long refused to life any participation in the work of fermentation and other closely allied phenomena.

When, however, Pasteur finally cleared away the débris of misconception which had so long concealed from view the vital character of the changes associated with these processes, the bacterial ball, if we may so call it, was set rolling with a will, and information concerning these minute particles of living matter was rapidly gathered up from all directions.

The recognition so long refused to bacteria was now ungrudgingly given, for it was realised at last that, in the words of M. Duclaux, "Whenever and wherever there is decomposition of organic matter, whether it be the case of a weed or an oak, of a worm or a whale, the work is exclusively performed by infinitely small organisms. They are the important, almost the only, agents of universal hygiene; they clear away more quickly than the dogs of Constantinople or the wild beasts of the desert the remains of all that has had life; they protect the living against the dead. They do more; if there are still living beings, if, since the hundreds of centuries the world has been inhabited, life continues, it is to them we owe it."

Fortunately, the provisions made by Nature for the preservation of the bacterial race are of so lavish a description that no fear need be entertained that this useful and indispensable world of life will be wiped out. The fabulous capacity for multiplication possessed by them (a new generation arising in considerably less than an hour), the powers of endurance which some of them exhibit in presence of the most trying vicissitudes of heat and cold (they have been known to survive exposure lasting for seven days to a temperature of about -200 °C.), the inability of starvation or desiccation to undermine their constitution, combine to render the question of the extinction of bacteria as remote as it is undesirable.

Tempted by the prospects of exploring in this newly-revealed world of life, investigators rushed into the field, and the bacterial fever has been hardly less pronounced in these last years than that rush for a material golden harvest which has characterised so many enterprises in southern latitudes.

The scientific results of this microbe fever have happily, however, been of a more solid and substantial character than can be said to have followed the more tangible but sordid ventures in South African mines. Vague hypotheses have given place to facts, and bacteria have been brought more and more within the horizon of human knowledge, thanks to the genius and untiring zeal of investigators all over the world.

By mechanical improvements in microscopes, and subtle methods for colouring bacteria, enabling us to study their form with precision, by ingenious devices for supplying them with suitable food materials, or, in other words, by the creation of bacterial nurseries, providing the means for watching their growth and observing their distinctive habits and character, this important branch of the vegetable kingdom has been raised from obscurity to one of the principal places in our catalogue of sciences, and Bacteriology has won for itself an individual footing in the scientific curriculum of our great educational institutions, and is represented in literature by such famous serials devoted to the publication of bacterial and allied researches as the *Annales de l'Institut Pasteur*, the *Centralblatt für Bakteriologie*, the *Zeitschrift für Hygiene*, the *Annali d'Igiene Sperimentale*, and other well-known journals which constitute an essential but ever-increasing burden upon the library shelves as well as pocket of the investigator.

Museums of bacteria have been established where not only specimens of particular varieties of a permanent character for comparison and reference can be obtained, but living cultivations of hundreds of different micro-organisms are maintained; and only those who have had the charge of bacteria can realise the enormous amount of skilled labour involved in the catering for such a multitude, in which individual likes and dislikes in regard to diet and treatment must, if success is to be secured, be as carefully considered as is necessary in the case of the most delicate and highly pampered patient.

Bacteria, by means of these depôts, can, in fact, be bought or exchanged by collectors with as much facility as postage stamps, with the all-important difference that this collecting of bacteria is not a mere mania or speculation, but serves a most useful purpose.

To the busy investigator who cannot afford either the time or space in which to maintain a large bacterial family, it is of immense convenience to be able to obtain at a moment's notice a trustworthy culture, say, of typhoid or tuberculosis, or specimens of obscurer origin from air or water for purposes of investigation. These bacterial cultures are all guaranteed pure, free from contamination or admixture with other and alien micro-organisms, and are strictly what they are represented to be. Although such a declaration is attached to many commodities at the present day with ludicrous incongruity, in the case of micro-organisms such a breach of faith is unknown, and the antecedents of a microbe may be said to be regarded as of as much moment and to be as jealously preserved as is the pedigree of the most ambitious candidate for honours at a cattle or dog show!

Amongst some of the curiosities to be found on the shelves of microbe-museums may be mentioned bacteria which give out light, and thus, like glowworms, reveal themselves in the dark. These light-bacteria were originally discovered in sea-water and on the bodies of sea-fish, and cultures of them have been successfully photographed, the only source of light being that provided by the bacilli themselves. The amount of light emitted by a single bacillus might indeed defy detection by the most sensitive plate procurable, but when gathered together in multitudes, the magnitude of which even eight figures fail to express, these phosphorescent bacteria enable the dial of a watch to be easily read in the dark, whilst photographs of the face of a watch taken in such bacterial light have been so successful that the time at which the photograph was taken could be distinctly seen.

Of bacteria it may indeed truly be said, as has Maeterlinck of the labours of bees – "though it be here the infinitely little that without apparent hope adds itself to the infinitely little, though our eye with its limited vision look and see nothing, their work, halting neither by day nor by night, will advance with incredible quickness!"

Mention may perhaps appropriately be made here of the highly interesting fact discovered by Professor Percy Frankland, that ordinary bacteria which do not phosphoresce are capable of affecting a photographic film in absolute darkness, and can by this means produce a picture of themselves. If, however, a transparent piece of glass is placed between the bacteria and the film no photograph results, showing that glass interferes with their activity in this respect. The author points out that as this action upon the photographic film does not take place through glass, it is in all probability due to the evolution by the bacteria of certain volatile chemical substances which either directly or indirectly enter into reaction with the sensitive film. Similar phenomena have been discovered in regard to many metals as well as organic substances, but this is the first observation which has been recorded of the action of living structures on sensitive films in the dark.

We have already referred to the important services which Pasteur has rendered by distinguishing between different varieties of yeast, and separating them out according to their functions and properties – pioneer work which has been followed up by and borne such splendid fruit in the hands of the renowned Danish investigator, Emil Christian Hansen of Copenhagen. This work of isolating out individual varieties of micro-organisms has been not only pursued with the energy familiar to all in the case of bacteria associated with disease, but has been pursued in various other, though perhaps less well known, directions.

A great deal of activity has lately been exhibited in so-called dairy bacteriology, and a long list has already been compiled of milk, cheese, and butter microbes; and agricultural authorities, even in this country, are slowly awakening to the fact that, in order to compete on modern lines with foreign dairy produce, dairy schools must be established, where bacteriology is taught, and where instruction is given in the principles of scientific butter and cheese making.

But bacteria of the brewery and of the dairy are not the only useful germs which are to be found on the shelves of microbe museums. Wine and tobacco manufacturers on application may respectively obtain the bacterial means of transforming the crudest must into the costliest claret, and the coarsest tobacco into the most fragrant Havana. Already considerable progress has been made in the isolation of particular varieties of wine-yeast, whilst highly encouraging results have been obtained by Suchsland and others in the separation of various valuable tobacco-fermenting organisms. Agricultural authorities, again, owe a debt of gratitude to those distinguished investigators whose labours have discovered the art of imprisoning the micro-organisms which play such an important part in the fertilisation of the soil. Bacterial fertilisers are amongst the latest achievements which bacteriology has accomplished in this wonderful half-century, and the purchase of special varieties of bacteria to suit the requirements of particular kinds of leguminous plants is now fast becoming a mere everyday commercial transaction. But efforts for the amelioration of the conditions under which plant life is carried on have not been confined to providing plants with suitable bacterial friends; vigorous and successful efforts have been made to remove from their *entourage* those bacterial enemies and undesirable parasites which have for so long played so important a part in the crop-returns of many an agriculturist.

For the identification and separation of the plant-parasites of various kinds we have largely to acknowledge our indebtedness to American investigators, and the encouragement and support which Dr. Erwin Smith, amongst others, has received from the Government of the United States in the prosecution of these researches indicates how great is the public importance attached to them. There are in America alone fifty experiment stations where plant diseases are studied, whilst at a number of the colleges and universities more or less attention is given to the subject. Some idea of the loss occasioned to agriculturists by these plant pests may be formed by a recent announcement that the Department of Agriculture in Queensland was prepared to offer a reward of £5,000 for the discovery of a means to eradicate the prickly-pear disease. Plant pathology has not yet had a distinct chair allotted to it in any of the great universities, but the subject is of such vast industrial importance, that doubtless before long some seat of learning will do itself the honour to establish one, and so set the example.

A striking instance of the advantages of taking stock, so to speak, of the attributes of bacteria will occur to everyone in the revelation which has followed of their powers to solve one of the most knotty problems of the day – the efficient manipulation of those vast subterranean rivers of sewage which honeycomb every city of the world.

The purification which sewage underwent by passing it through the pores of the soil, or, in other words, by filtration, was recognised about the year 1870, soon after the Rivers Pollution Commissioners had begun to make their classical investigations on the land treatment of sewage; but although the rapid transformation of ammonia into nitrates which followed the passage of the sewage through a few feet of soil was noted, yet the mechanism of this nitrification process remained a mystery until 1877, when two French chemists – MM. Schloesing and Muentz – made the then astounding discovery that this change was dependent upon the vital energies of micro-organisms.

The part played by bacteria in the purification of sewage thus became an established fact, and the later experiments have been devoted to studying the necessary conditions under which the maximum amount of work is obtainable from these novel bacterial labourers.

Two different classes of bacteria are required to carry on the purification of sewage: those which flourish in the *absence* of air and are known as anaërobic bacteria, and those to which the *presence* of air is essential for the exercise of their functions, the latter being therefore called aërobic bacteria.

The work of the anaërobic labourers consists in breaking down the complex organic compounds present in sewage, whilst the completion of the process of purification is left to the aërobic varieties. In the ordinary course of nature both these processes are going on side by side, but it has been found advisable to separate these two different classes of bacteria as far as possible, and allot distinct premises to the anaërobic and aërobic varieties respectively engaged in the purification of sewage, for by so doing experience has shown that the work is not only more expeditiously, but also more efficiently, carried out.

Now the anaërobic bacteria are supplied along with the sewage, and the retention of their services offers practically no difficulty as long as an ample allowance of space and time is given them in which to carry on their labours. The aërobic bacteria, however, besides demanding space and time, insist upon their workshops being well ventilated, and if the supply of fresh air is in any way curtailed they stop work entirely. Hence the ventilation of the aërobic workshops becomes a matter of primary importance if the valuable services of these labourers are to be retained. To ensure a sufficient supply of air being provided, it has been found advisable to have two or more aërobic workshops or bacteria contact beds, and the sewage is passed from one on to a second, and so on, until the purification is complete. Under proper management the sewage should leave the works as an inodorous, almost pellucid liquid, incapable of putrefaction, which may be turned into rivers or other waterways without fear of rousing the wrath of local riparian authorities.

But whilst the commercial side of bacteriology, so to speak, has made such great strides, the purely scientific applications which have been made of the facts it has furnished have by no means lagged behind. Chemists, from Pasteur downwards, have made use repeatedly of special bacteria to perform delicate operations in the laboratory which other methods have either failed to accomplish or have performed in a clumsy and less expeditious manner.

There can be no doubt that, as our knowledge grows from day to day, we shall find more and more how much depends upon the work of individual bacteria, and how much importance attaches to the selection of just those varieties which are of value, and the banishment of those which are detrimental; and thus the many applications which bacteria already admit of render their easy access a matter of increasing consequence, enhancing the value of bacterial institutions such as already exist on the Continent.

But whilst the easy access of bacteria for experimental and scientific purposes is of great importance to the investigator, their indiscriminate distribution would equally be a source of uneasiness and danger to the community at large. Already sensational fiction has made considerable capital out of the pathogenic microbe, and with the winged aid of penny publications it does not take long for suggestions of such kinds to spread in society and assume practical shape, and whilst the administration of bacterial poisons offers comparatively but little difficulty, their identification would be a far greater problem for experts than that presented by particular chemical poisons. To cope with this danger to the public, specimens of disease-germs from these bacterial depôts may not be supplied to applicants unless the latter can prove to the satisfaction of the director that they are connected with responsible public institutions.

In recent times, indeed, one of the most remarkable practical uses to which bacteria have been put is that of poisoning-agents on a large scale, or in other words vermin exterminators; if this new rôle for bacteria becomes extended, as no doubt it will, the law for the sale of noxious drugs and preparations will also doubtless be amended to cover the distribution of bacterial-poisons.

It was in the year 1889 that Professor Loeffler, while experimenting with mice in his laboratory at Greifswald, discovered a micro-organism which was extremely fatal to all kinds of mice. The happy idea occurred to the Professor that this lethal little microbe, which he christened *Bacillus typhi murium*, might be turned to excellent account in combating plagues of field mice in grain-fields, where the devastation committed by these voracious rodents had become in parts of Greece and Russia a serious source of loss to agriculturists. Experiments were accordingly made on a small scale to test the efficiency of this bacterial poisoner in destroying field mice, and so successful were the results that Loeffler confidently announced the possibility of keeping down these pests by distributing food material infected with these bacteria over fields which were invaded by them. The Greek Government took up the question, and Loeffler's method was applied with brilliant results; the disease was disseminated with extraordinary rapidity and severity, and the mice were readily destroyed.

It is highly satisfactory to find that the character of this mouse-bacillus has stood the test of time, for after a period of more than ten years most encouraging reports concerning its efficiency still continue to be received. In one of the latest of these, drawn up by the Director of the Experimental Agricultural Institute in Vienna, we read that in no less than seventy per cent. of the cases in which it was employed it was completely successful in its work of extermination, and it is interesting to note that in a considerable number of these instances it was the domestic mouse against which its energies were directed. The rat has, however, until recently escaped the hand of the bacterial executioner, but his knell has also now been sounded in the announcement that a rat-bacillus has been discovered.

Considering the undesirable notoriety which these rodents have of late obtained in connection with their undoubted culpability in the dissemination of plague, this discovery, if correct, should be warmly welcomed. That there is plenty of work awaiting such a micro-organism may be gathered from the fact that during the outbreak of plague in Sydney the crusade against rats which followed led to the slaughter in one year of over 100,000.

The discoverer of this useful member of the microbial community is Tssatschenko, of the University of St. Petersburg, and in his memoir he states that, whilst highly virulent as regards rats, it is quite harmless to domestic animals of various kinds. Thus cats, dogs, fowls, and pigeons when fed with food infected with the bacillus suffered no ill effects whatever, whilst its administration in large quantities to farm stock, such as horses, oxen, pigs, sheep, geese, and ducks, was also without result; hence its distribution, according to its discoverer, offers no danger to other animals.

This idea of employing bacteria as executioners was not original, for Pasteur had already in 1888 suggested to the Intercolonial Rabbit Commission in Australia that chicken-cholera microbes should be employed for destroying the rabbits, which then, as now, are such a source of difficulty and pecuniary loss to the country. No active measures appear to have been taken, however, to carry out this suggestion, one of the principal objections raised being the undesirability of introducing a disease which was at that time believed to be a stranger to the colony. Recently the idea has been revived by Mr. Pound, the Government bacteriologist at Brisbane, in consequence of his discovery that chicken-cholera, far from not existing in Australia, has infested poultry yards more or less extensively for several years past, although it has only lately been accurately diagnosed as such. This chicken-cholera microbe is particularly well suited for the work in question, inasmuch as, whilst extremely fatal to rabbits, it produces, like Loeffler's bacillus, no ill effect whatever on farm-stock of various kinds, and is perfectly harmless to man, so that its handling by the uninitiated is not attended with any personal danger.

This brings us to what may be designated the human side of bacteriology, *i. e.* its relation to disease and its prevention. In these important departments of life the services already rendered by this infant prodigy of science can as yet be only approximately appreciated. Anthrax, tuberculosis, cholera, typhoid, plague, influenza, tetanus, erysipelas, are only a few of the diseases the active agents of which bacteriology has revealed to us. Bacteriology has, however, not been content to merely identify particular micro-organisms with particular diseases, it has striven to devise means by which such diseases may be mastered, and one of the most glorious achievements of the past sixty years is the progress which has been made in the domain of preventive medicine.

The classical investigations of Pasteur on the attenuation of bacterial viruses such as those of chicken-cholera and anthrax, and his elaboration of a method of vaccination with these weakened viruses whereby the power of the disease over its victim is removed or modified, are too well known to require repetition here. The success which followed Pasteur's researches in this direction led him to undertake that great and difficult task, the prevention of rabies in the human subject – a task well-nigh superhuman in its demands, and one which only he could accomplish in whose life the pregnant words of a modern writer found expression – "il ne suffit pas de posséder une vérité, il faut que la vérité nous possède." The victory over this disease, which crowned a long life replete with brilliant achievements, has been universally recognised, and numerous institutes have arisen in all quarters of the globe for extending the benefits of this discovery for the relief of suffering humanity. These Pasteur or bacteriological institutes also furnish highly important centres where original research work of various kinds is carried on, and the stimulus which has thus been given to experimental science in the remotest parts of the world cannot be overestimated.

Methods for the prevention of disease have, however, not been confined to the elaboration and employment of modified or weakened bacterial viruses; the subject has been still more recently approached from another and quite different side. This new departure we also originally owe to France, although its practical development has been worked out in Germany.

It was in 1888 that two Frenchmen, Richet and Héricourt, communicated a memoir to the *Comptes rendus* of the Academy of Sciences, describing the curious results they had obtained with rabbits purposely infected with a disease microbe, the *Staphylococcus pyosepticus*. Some of the rabbits died after being inoculated with this micro-organism and some remained alive, and they proceed to point out how it was that such different results were obtained. Before the inoculations were made some of the animals received injections of blood taken from a dog, which a few months previously had been infected with this same microbe, but had recovered. The rabbits which received the dog's blood all survived the inoculations, whilst those which did not, succumbed in every case to the action of the *Staphylococcus pyosepticus*. So struck were the authors by these remarkable results that they repeated them, and their further investigations fully confirmed those originally obtained, proving that they were not "un fait exceptionnel."

Here we have the first steps in the direction of serum-therapy, that new treatment of disease which during the last few years has been so prominently before the public in the cure of diphtheria, tetanus, and other maladies, and for the development of which we owe so much to the labours of Behring, Roux, Kitasato, and other investigators.

The astounding fact that the blood of animals which have been trained to artificially withstand a particular disease becomes endowed with the power of protecting other animals from that disease is only in the earliest stages of its application. The results, however, which have already been accomplished are of so encouraging a character that the hope is justified that serum-therapy is destined to revolutionise the treatment of disease. One of the latest uses which has been made of this method of combating disease is the employment of serum for the cure of bubonic plague. During the recent outbreak of plague in India, Yersin, formerly a student and assistant at the Paris Pasteur Institute, was despatched to India to superintend the administration of this new remedy, and the serum he employed was that derived from horses which had been subjected to, and had recovered from, inoculations with the plague bacillus. The treatment of snake bites by means of curative serum will be dealt with in more detail later on; it only remains to cite it here as another instance of the success which is attending the new methods of protection against disease.

Another and highly ingenious application of serum has been brought forward by Pfeiffer, Gruber, Widal, and others. This is the so-called sero-diagnosis of disease, and has been employed already with success in the identification of typhoid fever as such. The method sounds simple in the extreme, and consists in taking a few drops of blood from a patient supposed to be suffering from typhoid fever and mixing them with a recent cultivation in broth of genuine typhoid bacilli. If the blood is derived from a typhoid-infected person, then the bacilli should exhibit a curious and characteristic appearance when examined under the microscope. Instead of moving about as individuals in various parts of the microscopic field, they should be seen gathering or clumping together in numerous small heaps, their movements the while becoming paralysed.

The State Board of Health of Massachusetts has recently taken up the official sero-diagnosis of typhoid fever, and issues in response to applications a simple outfit with instructions how to collect specimens of blood and a form which they request shall be returned filled in with all the details concerning the case under observation. Only a few drops of blood are required for the examination, and these before being despatched to the State Laboratory are collected on slips of paper and allowed to dry. If the addition of this suspected blood in the proportion of one to twenty to a young and vigorous culture of typhoid bacilli succeeds in paralysing their movements, producing the characteristic clumping together or agglutination of the bacilli, then the reaction is considered positive and the case one of typhoid fever.

That, however, some risk attends the placing of too implicit a reliance on this method of diagnosis alone is evident from the fact that a *negative* reaction, or in other words, absence of all agglutinising phenomena, is sometimes associated with blood throughout what is beyond all question a well-defined case of typhoid fever, whilst in the first week of this disease the test is frequently negative in character. Rouget, who has made a very careful inquiry into the value to be attached to the sero-diagnosis of typhoid fever, states that he has found in a large number of examinations of blood derived from undoubted typhoid patients the agglutination phenomena fail altogether; it is, therefore, not surprising that the sero-diagnosis of this disease is still the subject of much discussion and investigation.

An interesting example of how particular serums may be employed for the detection of particular poisons has been furnished by Dr. Calmette. In some districts of India the natives have an ugly custom of wreaking their vengeance on their enemies by poisoning their cattle, and to effect this both expeditiously and secretly they employ subtle poisons which they know can only be detected with great difficulty. Serpent venom is a favourite substance, whilst abrine, a highly toxic vegetable poison, is another. The method adopted for the application of this abrine is highly original, and consists in taking small bits of wood shaped like miniature clubs, so diminutive in size that they can be concealed in the hand. In the head of the club small holes are bored, and tiny pointed rodlets of a hard greyish substance are fitted into them. Armed with these crude instruments, the natives scratch the cattle in several places, and, although but little external sign of injury is to be seen, the rod-points penetrate the skin and are broken off, and the poison is left to work its lethal way through the animals' system. Mr. Hankin forwarded some of these broken-off rod-points to Dr. Calmette for the identification of their composition, and he diagnosed the material employed as abrine in the following original manner. He first introduced some of this rod material into animals, and found that their symptoms were suggestive of abrine poisoning. To confirm his suspicions, however, he took some more of this rod material, and, before inoculating it into animals, he mixed it with serum derived from animals which had been artificially rendered immune to abrine poison. Instead of the animals into which this mixture of serum and "rod material" had been introduced dying like the previous ones, they remained alive. Had the "rod material" consisted of some poison other than abrine, the abrine serum would not, according to Dr. Calmette, have negatived its action, and it has thus been indicated how protective serums may be successfully employed for the detection of poisons.

Foremost, however, among the beneficent reforms which have followed in the wake of bacteriology must be placed the antiseptic treatment of wounds, or Listerism, as it is now universally designated in recognition of its renowned champion, the former President of the Royal Society. "Lister comprend," in the words of Dr. Roux, "que les complications des plaies sont dues aux germes microbiens venus du dehors et il imagine les pansements antiseptiques. Avec l'antiseptie commencent les temps nouveaux de la chirurgie." It only remains to add that, with the modesty characteristic of a great man, its brilliant author delights in repeating how any good which he may have been permitted to do he owes entirely to the inspiration which he received from the labours of Louis Pasteur.

But if the Victorian era has been productive of so many important applications of bacteriology to commerce and medicine, this period has been also fraught with results of the highest moment in the progress of hygiene.

The terms of intimacy, so to speak, which we have been now able to establish with bacteria has enabled us to discover details of their life and habits which before were shrouded in mystery. Their distribution in air has led to renewed endeavours on the part of sanitary authorities to procure efficient ventilation in our hospitals and public institutions; dust has acquired a fresh horror since it has been shown how disease germs may be disseminated by its means; whilst the important part which flies and lice may play in the spread of epidemics has opened up a new field for research, and made us conscious of a fresh source of danger in our daily life.

The general public, however, is hardly yet fully alive to the capacity for mischief possessed and exercised by the common house-fly. True, it is universally execrated and regarded as a tiresome attendant upon the summer months, but it is not usually considered in any more serious light. That however, the comparative indulgence with which this homely insect pest has been treated is decidedly misplaced and fraught with danger to health, the researches of numerous scientists have now conclusively proved.

As long ago as the year 1888 Professor Celli showed that the germs of consumption, anthrax, and typhoid fever could pass through the digestive organs of flies and reappear in the excreta of the latter not only alive but in full possession of their disease-producing powers. Dr. Sawtschenko made similar experiments with cholera germs. Healthy flies were placed under glass shades and fed with broth in which these micro-organisms were growing, and the latter were not only subsequently recovered from the digestive organs of the flies but also from their excreta in a living and virulent condition.

This is, however, not the only means whereby these insects can distribute deadly and other microbes, for it has been shown that in crawling over substances containing bacteria these may become attached to the feet of flies, and are in this manner transferred to other materials upon which they may alight, just as Pasteur showed many years earlier silkworms can communicate the fatal plague of pébrine by crawling over each other's bodies, carrying in their disease-laden feet the infection from one worm to another. During the recent outbreak of bubonic plague in the East the part played by flies in disseminating the virus has been repeatedly emphasised. Yersin was the first who called attention to the presence in large numbers of virulent plague bacilli within the bodies of flies which he collected in the vicinity of plague-stricken persons, and it was found that flies which had fed on plague-infected material and were then isolated lived for several days afterwards, during which time virulent plague bacilli were present in their bodies in immense numbers; thus were these insects converted into winged messengers of evil of the most repulsive type.

I am not aware whether any experiments on the vitality and transmissibility of diphtheria and consumption germs by means of flies have been made; but in view of the overwhelming evidence of the culpability of these insects in spreading plague, it is not unreasonable to presume a responsibility on their behalf in regard to other diseases; indeed, in the report issued by the Army Medical Commissioners of the Spanish-American War, it is emphatically stated that flies played an important part in the dissemination of typhoid fever.

There is no question as to the capability of certain micro-organisms to reside for considerable periods of time within the bodies of flies, and during this sojourn to abate no jot of their virulence. Indeed, it has been shown that the bodies of these insects may constitute incubators of a most successful type, for some varieties of bacteria grow luxuriantly and multiply abundantly within them.

In the hot days of summer, when flies abound, it would be well to banish these insects, as far as lies in our power, not only from our sick-rooms in particular, but from our general surroundings. The catholic taste of flies for garbage of all kinds is too well known to require entering into, but the consequences which may follow from their visits to dustbins and centres of disease, and then alighting upon our food or persons, has received too little attention in the past.

In regard to the subject of insects as disease disseminators, it may be mentioned that Mr. Hankin, when studying plague conditions in India, expressed his belief that ants in Bombay also assisted in spreading the scourge, for he found that when he inoculated mice with the excreta of ants, such insects having previously fed on plague-stricken rats, the mice succumbed to plague in a few hours. Fleas have also been conclusively proved to be carriers of plague germs.

There is no doubt that the revelations of hygienic science have aroused the vigilance and zeal of public authorities in various new directions to try and cope with the spread of zymotic disease.

In no direction, perhaps, is the fruit of this energy so apparent as in the increasing supervision which it has incited over two of the greatest menaces to public health which hang over society —*i. e.* our water and dairy supplies. Now that it has been proven beyond doubt that the germs of consumption, typhoid fever, and cholera can be and are distributed through the consumption of contaminated milk or water, not to mention other diseases such as diphtheria and scarlet fever, an ever-increasing demand is being made that these all-important articles of diet shall be protected from pollution, and that public authorities shall be made responsible for their distribution in a pure and wholesome condition.

It is, however, undoubtedly in the matter of water that the greatest service has been rendered by bacteriology to sanitary science, and for the important advance in this department we are indebted to the beautifully simple and ingenious methods devised by Robert Koch.

Not yet twenty years have passed since the new bacterial examination of water was introduced and systematically employed, and the use which has been made of the opportunities thus opened up of investigating water problems on an entirely new basis is shown by the voluminous dimensions which the literature on this one branch of bacteriology alone has reached. Considerably upwards of two hundred different water bacteria have been isolated, studied, and their distinctive characters chronicled. The behaviour of typhoid, cholera, and other disease-producing microbes in waters of various kinds has been made the subject of exhaustive experiments; the purification power of time-honoured processes in operation at waterworks and elsewhere has been for the first time accurately estimated. Water engineers have through these bacteriological researches been provided with a code of conduct drawn up by the light of erudite scientific inquiries, which has now rendered possible the removal of the process of water purification from the rule of empiricism guided by tradition, and to raise it to the level of an intelligent and scientific undertaking.

The above short sketch may serve to convey some idea of the rise and phenomenal development of bacteriology during the past sixty years. To record, even in outline, the individual triumphs of the various branches of this science would require volumes, whilst the astounding mass of work already accumulated by its devotees is but the earnest, the guarantee of yet greater achievements in the future.

The progress which has been made in this brief period of time must not necessarily be expected to continue at this rapid rate; it may be that generations to come have yet the hardest and the longest tasks to accomplish; for in science, as in other walks of life, it is, as a rule, the easiest problems, which are first disposed of, and the farther we advance the more complicated, the more intricate become the questions to be attacked, the difficulties to be overcome.

The late Queen's reign has bestowed a splendid legacy of bacteriological discoveries upon those who, in the future as in the present, must inevitably follow in the footsteps of those great and brilliant leaders of bacteriological science belonging to this auspicious era, Louis Pasteur and Robert Koch.

WHAT WE BREATHE

Few people realise that, with the advent of autumn, the great majority of the swarms of bacteria which have been circulating in the air during the hot summer months take their leave of us and disappear.

Practically, however, we are all conscious of this fact, for we know what greater difficulties attend the keeping of food sweet and wholesome in the summer than are met with in the winter; bacteria, not unlike some other armies of occupation, securing a footing rather by their numbers at this season of the year, than by virtue of the superior strategy or, in other words, special attributes of their units. Bacterial operations are, however, distinctly favoured by the accident of temperature, the warmth of the summer encouraging their vitality and multiplication.

When Pasteur first announced his conviction that the familiar phenomena of putrefaction and decay were due to minute living particles present in our surroundings, his sceptical critics sought to ridicule his conclusions by declaring that, were this the case, the air must of necessity be so heavily laden with living forms that we should be surrounded by a thick fog – "dense comme du fer." We do not now, forty years later, require to recite the exquisitely simple experiments which, whilst sufficiently establishing his theories, served to effectually suppress those of his opponents.

Since Pasteur's pioneering work was carried out, a vast number of investigations have been made in all parts of the world by scientists of almost every nationality on the subject of the distribution of bacteria in air, and not only on their distribution, but on their functions or the place they occupy in the economy of nature. With our increased knowledge concerning their distribution has come our ability to differentiate between individuals, and to adequately assess the value and importance of their work from various points of view.

In the bacterial treatment of sewage we have not only one of the latest, but perhaps also one of the most successful examples of that system of division of labour, or specialisation of energy, which forms such a characteristic feature of work of all kinds at the present time. Other familiar instances of the applications of individual and special bacterial labourers to the solution of industrial problems are to be found in the conduct of commercial undertakings of such national magnitude and importance as brewing and agriculture. But it is not with these beneficent or great industrial classes of bacteria that we are now more immediately concerned, but rather with the malevolent varieties, or the so-called "submerged tenth," for which no labour colony has at present been created to direct their energies into useful and profitable channels.

We know that as regards mere numbers the bacteria in air may vary from 0 to millions in a couple of gallons, these extremes being dependent upon the surrounding conditions or relative purity of the atmosphere.

Out at sea, beyond the reach of land breezes, it is no uncommon thing to find none whatever; on mountains and even hills of humble elevation the paucity of bacteria is very marked if there are no abnormal or untoward circumstances contributing to their distribution. In illustration of this the recent investigations of the air on the summit of Mont Blanc by M. Jean Binot are of especial interest, inasmuch as the altitude at which they were carried out is the highest at which the search after bacteria has so far been pursued. This intrepid investigator spent no less than five days in the observatory, which is situated on the top of the mountain. As was to be anticipated, frequently no bacteria at all were found, and it was only when such comparatively large volumes of air as one thousand litres (about 200 gallons) were explored that microbes in numbers varying from four to eleven were discovered. The air of the country is far freer from microbial life than that of cities; whilst open spaces, such as those afforded by the London parks, are paradises of purity compared with the streets with their attendant bacterial slums.

That it is no exaggeration to describe streets from the bacterial point of view as slums is to be gathered from the fact that much less than a thimbleful of that dust which is associated with the blustering days of March and the scorching pavements of summer may contain from nine hundred to one hundred and sixty millions of bacteria. But investigators have not been content to merely quantitatively examine street dust; in addition to estimating the numerical strength of these bacterial dustbattalions, the individual characteristics of their units have been exhaustively studied, and the capacity for work, beneficent or otherwise, possessed by them has been carefully recorded. The qualitative discrimination of the bacteria present in dust has resulted in the discovery of, amongst other disease germs, the consumption bacillus, the lock-jaw or tetanus bacillus, bacteria associated with diphtheria, typhoid fever, pulmonary affections, and various septic processes. Such is the appetising menu which dust furnishes for our delectation.

There can be no doubt, therefore, that dust forms a very important distributing agent for micro-organisms, dust particles, aided by the wind, being to bacteria what the modern motor-car, with its benzine or electric current, is to the ambitious itinerant of the present day. Attached to dust, bacteria get transmitted with the greatest facility from place to place, and hence the significance of their presence in dust.

Mention has been made of the fact that the germs of typhoid fever have been discovered in dust, and the belief in the possibility of this disease being spread by dust is gaining ground.

An interesting case in point is afforded by an outbreak of typhoid fever which occurred in Athens a few years ago, and in which the starting-point or nucleus was discovered to be a group of labourers who were engaged upon excavating the soil in a street through which a sewer had once been taken. The epidemic subsequently spread to those districts of the city swept by the prevailing wind, which passed over the place where the soil had been turned up and exposed. M. Bambas, who brought his observations before the International Congress of Hygiene at Buda-Pesth, was convinced from the inquiries he made that this outbreak of typhoid was due to the disturbance of the soil and the dissemination by means of the wind of typhoid-dust-particles to certain parts of the city.

That this hypothesis is by no means without experimental justification is shown by the properties possessed by the typhoid bacillus in regard to its vitality in soil which have been discovered. Thus numerous investigators have studied the important question of the behaviour of this micro-organism in soil, and have found that it can exist over periods extending from three to twelve or more months in the ground. This property of the typhoid bacillus may possibly explain the appearance over and over again of typhoid fever in particular localities, suggesting that the bacteria had become indigenous in the soil.

Dr. Mewius, of Heligoland, describes an epidemic of typhoid fever in the island, concerning which he made a most searching and elaborate inquiry. It appears that a case of typhoid occurred and was concealed from the medical authorities, so that no steps for disinfection could be taken in the first instance; and, following the primitive custom which prevails on the island, the dejecta was thrown over and upon the cliffs, this being the usual method of disposing of sewage. Ample opportunity was thus given for its desiccation and subsequent distribution as dust. That this typhoidal matter did subsequently become pulverised and spread the infection Dr. Mewius has no doubt, the germs having been conveyed to the open rain-water cisterns which constitute the water-supply of the majority of the inhabitants. His theory is again supported by the coincidence between the prevailing direction of the wind and the quarter where the outbreak occurred.

That diphtheria germs can remain for a long time in a living and, what is more, virulent condition in dust has been clearly demonstrated by Germano, amongst other investigators, this organism being specially endowed with the capacity for resisting the, to other microbes, lethal effect of getting dried up.

Bacteria, however, survive this desiccation process much better when they are herded together in large numbers than when they have to face such untoward conditions as isolated individuals. This has been well illustrated in the case of diphtheria bacilli, and the difference in their powers of endurance under these respective conditions is very striking. Thus when a few only were exposed to a very dry atmosphere on silken threads they disappeared after eight days; but when somewhat larger numbers were taken they contrived to exist for eighteen days, whilst when great multitudes of them were herded together even one hundred and forty days' starvation in these desert-like surroundings could not entirely stamp out their vitality.

This dangerous property possessed by the germs of diphtheria should, if possible, increase the vigilance with which the outbreaks of this disease are watched and dealt with. Abel cites an instance in which a wooden toy in the sickroom of a child suffering from diphtheria was found six months later to have *virulent* diphtheria bacilli upon it.

This reminds me of a case in which tetanus or lock-jaw ensued from the use of some old cobwebs in stopping the bleeding of a cut. The wound was a perfectly clean one, and nothing need have resulted from this obedience to a superstitious prejudice had not the cobwebs unfortunately arrested some tetanus germs, and these getting access to the wound set up the typical symptoms of lock-jaw. That this implication of the cobweb was no idle accusation was subsequently proved by portions of the same web, on being inoculated into animals, inducing in the latter well-defined symptoms of tetanus.

That cobwebs readily catch dust is familiar to everyone who has the mortification of seeing them adorn ceilings and corners; that they also arrest bacteria follows as a natural consequence of the presence of dust, and hence these delicate filaments may become veritable bacterial storehouses, more especially as it is usually in the dark and remote corners that they best succeed in eluding the vigilance of the domestic eye, and are thus also out of reach of the lethal action of sunbeams; and hence their unwelcome lodgers may manage to maintain a very comfortable existence over long periods of time.

That the bacillus of consumption should have been very frequently found in dust by different investigators is hardly surprising when it is realised that the sputum of phthisical persons may contain the tubercle germ in large numbers, and that until recently no efforts have been made in this country to suppress that highly objectionable and most reprehensible practice of indiscriminate expectoration. Considering that the certified deaths from phthisis in 1901, in England and Wales only, reached the enormous total of 42,408, and bearing in mind the hardy character of the *bacillus tuberculosis* when present in sputum, it having been found alive in the latter even when kept in a dry condition after ten months, it is not too much to demand that vigorous measures should be taken by the legislature to cope with what is now regarded as one of the most fruitful means of spreading consumption. We know that in some of the states of America public opinion has permitted the enactment of laws penalising this practice. Local rules to the same effect exist in our Australian colonies. On the Continent the trend of public opinion is evident by the prohibition found in the railway carriages and the notices to that effect conspicuously posted in public places. In this country public opinion moves so slowly that we are not yet ripe for any such strong step, and so far one of the few attempts at official activity in this respect is to be found in a circular issued by the Local Government Board of Ireland to the various local authorities stating that "tuberculous sputum is the main agent for the conveyance of the virus of tuberculosis from man to man, and that indiscriminate spitting should therefore be suppressed." The public exhibition of notices calling attention to the danger accruing from expectoration in public resorts is, as already pointed out, one means of educating the people, and it has been stated that such a notice is posted in every beerhouse in Manchester. The question has also been raised of the inspection of beerhouses and the suggestion made that licences should be withdrawn in the case of those holders who did not wash the floors of their public rooms and keep them in a sanitary state. At the present time, in this country, it is perhaps more to the private conscience of the individual and the pressure of public opinion than to penal enactments that we must look for effective reform in this direction, for the objection of the English to official sanitary control is deeply rooted. It is to be hoped, however, that with the spread and popularisation of the knowledge acquired through the arduous labours of so many scientific authorities, it may come to be regarded as a matter for both public and private morality that every step should be taken which lies in the power of each member of society to minimise the opportunities for the spread of a disease which by its very familiarity we have until the last few years accepted as incurable and the ravages of which as inevitable.[1]

---

[1] Since the above was written, the first international conference of the Central Committee for the Prevention of Consumption has been held in Berlin. The official report of the English National Association for the Prevention of Tuberculosis was presented to the Congress, and the encouraging announcement was made that the Corporations of Glasgow, Manchester, and Liverpool had made expectoration in tramcars a punishable offence; and that the Glamorganshire County Council had passed a bye-law providing as penalty for expectoration in public buildings a fine of £5, which enactment had been sanctioned by the Secretary for the Home Department.

Now that we are considering the status of street dust in bacterial circles, it will not perhaps be out of place to inquire into the character of another waste product of streets, *i. e.* the discarded ends of cigars and cigarettes. That what is carelessly tossed away on the one hand may be as carefully collected on the other is well known, as is also the fact that such material may subsequently be raised once more to the dignity of a marketable commodity. Under these circumstances, it is of hygienic interest and importance to ascertain whether disease germs, should they have obtained access to this tobacco refuse, are in a virulent or quiescent condition.

Some experiments to decide this question in connection with the tubercle bacillus have been recently carried out in Padua by Dr. Peserico, who, whilst extending our knowledge on the subject of bacteria and tobacco, has also confirmed the earlier results obtained by Kerez.

Portions of cigar-stumps smoked by phthisical persons in whose saliva the tubercle bacillus was known to be abundantly present were inoculated into guinea-pigs, with the result that fifty per cent. of the animals thus treated succumbed to tuberculosis. Thus neither the fumes nor juice of the tobacco had destroyed the consumption bacillus. In these experiments the cigar ends were used directly they were discarded, in another series of investigations they were collected and kept in a dry place for from fifteen to twenty days before being tested; but even storage for this length of time did not prevent the animals inoculated with them from contracting tuberculosis. In another series of experiments Dr. Peserico kept the infected cigar-ends in damp surroundings, and it was satisfactory to find that under these conditions the tubercle bacillus at the end of ten days was entirely deprived of its virulence. Encouraged by these results, inoculations were made with cigar-ends which had been left in the open and exposed to normal atmospheric conditions, which included falls of rain and snow, and in this case also no symptoms of tuberculosis followed their introduction into the guinea-pigs. These experiments show that the tubercle bacillus is prejudicially affected by contact with tobacco when the latter is kept in a moist condition, but that in a dry condition the properties in tobacco inimical to its vitality are not liberated and the bacillus can retain its virulent properties for a period of over twenty days.

In view of the importance of this discovery on the destruction of the toxic character of the tubercle bacillus by contact with moist tobacco, further experiments were made in which emulsions of tobacco were infected with tuberculous sputum. It was found that the bacilli steadily declined in virulence as the length of time they were kept in the emulsion was prolonged. Thus whereas after a few hours they were still armed with all their virulent properties, after three days, out of the four animals inoculated with the emulsion three succumbed to tuberculosis, after five days two out of four succumbed, whilst after eight days only one animal out of the four was infected, and after a period of ten days' immersion in the tobacco emulsion the tubercle bacillus failed to kill a single animal.

Cigar- and cigarette-ends were collected from the streets and cafés of Padua by Peserico, but in spite of consumption being stated to be very prevalent in this city, in no single case could the presence of the tubercle bacillus be discovered, although, as in the other investigations, the surest method for its detection, *i. e.* animal inoculations, was employed.

Brief reference may be made also to the experiments conducted to ascertain if cigars and cigarettes, as sold, contain the tubercle bacillus. The more interest attaches to this investigation because it is well known that the operators employed in tobacco factories are, as a rule, an unhealthy class, diseases of the respiratory organs, and especially tuberculosis, being very prevalent amongst them. A German official report on this subject states that the average duration of life of such factory hands only reaches thirty-eight years. Doubtless the lightness of the occupation encourages many to seek employment in these factories whose state of health would debar them from obtaining work under more trying circumstances. Some of the conditions under which cigars and cigarettes are made, such as the workers using their saliva to facilitate the rolling of them and fixing of the leaves, and the testing of the "drawing" properties of a cigar by placing it in the mouth, with the facilities offered for the dissemination of dried tuberculous sputum as dust, contribute to make it highly probable that tobacco as it leaves the factory may contain the germs of consumption.

Before leaving the subject of tobacco and disease germs it may be of interest to inquire what justification in fact there is for the practice adopted by anxious mothers, when travelling in times of epidemics of zymotic disease, of thrusting themselves and their children into the sanctum of the other sex – the smoking compartment of a railway carriage. I have frequently seen this done, despite the voluble protests of its legitimate occupants. Tassinari has made some very interesting experiments on the effect of tobacco smoke on the vitality of various descriptions of disease germs. He constructed an apparatus in which he suspended pieces of linen soaked in broth infected with the particular micro-organism to be tested. Tobacco smoke was then admitted, and the microbes were retained in this stifling atmosphere for half an hour. In these surroundings cholera and typhoid germs were destroyed, and other bacteria, such as the anthrax bacillus and the pneumonia bacillus, were so prejudicially affected, that when subsequently transferred to their normal surroundings it was only with extreme difficulty that they could be revived. When, however, the tobacco smoke was made to pass through water before reaching the bacteria, its pernicious influence was entirely removed, and the latter suffered no detriment. Hence the practice, so often seen in the East, of passing tobacco smoke through rose or other perfumed water before inhaling it, whilst doubtless rendering it less noxious to the smoker, deprives the exhaled tobacco fumes of all their bactericidal or disinfecting properties.

To return, however, after this somewhat lengthy digression, to the question of dust and its bacterial properties, we have learnt enough to enable us to realise that the movement for the migration of the working-classes from crowded streets to rural districts, in which Mr. George Cadbury has played so practical and important a part in the creation of his model village, with its gardens and open spaces, some five miles from the city of Birmingham, is, if only bacterially considered, a very real barrier against the dissemination of disease, for the denser the population, the greater will be the crowd of bacteria, and the greater the chance of pathogenic varieties being present amongst them. Again, we know that sunshine is one of the most potent germicides with which nature has provided us;[2] and it requires no effort of the imagination to realise how, in the gloomy back courts and crowded tenements of our great smoke-laden cities, bacteria succeed in obtaining a firm hold on their surroundings, and, in the shape of spores, attaining an undesirable and hoary old age, in which they are in some cases almost indestructible. Fräulein Dr. E. Concornotti has shown that this is no figment of fancy only, for she has recently made a special and very elaborate study of the distribution of pathogenic or disease bacteria in air, searching for them in the most varied surroundings, such as prisons, schools, casual wards, etc., with the result that, out of forty-six experiments in which the character of the bacteria found was tested by inoculation into animals, thirty-two yielded

---

[2] See "Sunshine and Life."

organisms which were pathogenic. Dr. Concornotti concludes her valuable memoir by stating that her investigations proved conclusively that the dirtier or more slumlike the surroundings, the greater was the frequency with which she found bacteria associated with disease in the air.

Messrs. Valenti and Terrari-Lelli have quite recently been able fully to endorse these statements in the results they have obtained in their systematic study of the bacterial contents of the air in the city of Modena. In their report they state that the narrower and more crowded the streets, the greater was the number of bacteria present in the air, and the more frequently did they meet with varieties associated with septic disease.

Numerous detailed investigations have also been made of the bacterial contents of the dust in hospitals. That cases of infection arising within hospital precincts are of no uncommon occurrence may be gathered from the observations made by Lutand and Hogg, who report no fewer than 2,294 such cases having arisen in the space of six years in certain Paris hospitals, whilst Solowjew records 1,880 cases as occurring in the space of four and a half months in the St. Petersburg city hospital. Solowjew made a special study of the bacterial contents of dust collected in hospitals, and states that 41·8 per cent. of the samples examined contained disease germs. The degree of infection possessed by dust in such surroundings must, of course, depend upon the degree of cleanliness which characterises the management of any particular institution; and such investigations as the above can only help to emphasise the immense importance of common cleanliness and the reasonableness of taking every precaution possible in the disinfection of utensils, etc.

Some years ago Messrs. Carnelley, Haldane, and Anderson carried out an elaborate series of investigations on the air of dwelling-houses in some of the poorest parts of Dundee. The samples were taken during the night, between 12.30 a.m. and 4.30 a.m., and in their report the authors state that the one-roomed tenements were mostly those of the very poor; "sometimes as many as six or even eight persons occupied the one bed," whilst in other cases there was no bed at all. As regards the number of bacteria present in the air in these one-roomed houses, an average of several examinations amounted to sixty per quart; in two-roomed houses it was reduced to forty-six, and in houses of four rooms and upwards only nine micro-organisms in the same volume of air were discovered.

Конец ознакомительного фрагмента.