Original Articles.

THE PREVENTION OF THE SPREAD OF TYPHOID FEVER.¹

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THE views, therefore, of so eminent and original an observer as Dr. Budd would seem to demand our first and most respectful consideration.

He held that typhoid fever is in its essence a contagious or self-propagating fever; that it is a member of the great natural family of contagious fevers, of which small-pox, scarlet fever, and measles are to us the most familiar examples; that, like other members of the family, it has for its exciting cause its own specific poison, and never any other; that this specific poison breeds and multiplies itself to an unlimited extent in the living body of the infected man; and that this reproduction of it in the infected body, together with all the disturbance to which its rapid and tumultuous growth gives rise, constitutes the fever. He held that this enormous reproduction of the poison in the system is in typhoid fever precisely the same in kind as that of which we have in the pustular eruption of small-pox an outward ocular demonstration; that the disease of the intestine, which is the distinctive anatomical mark of typhoid fever, and its only constant and characteristic lesion, is the specific eruption of the fever; and that this intestinal eruption bears precisely the same pathological relation to the disease that the pustular eruption upon the skin does to small-pox.

As might be anticipated from such views, he held that the contagious matter by which the fever is propagated is cast off, chiefly, in the discharges, from the diseased intestine, and that it makes a large constituent part of every intestinal evacuation. Further, that, as a necessary result, privies, sewers, and cess-pools, which, under existing sanitary arrangements, are the common receptacles of these discharges are also the principal instruments in the transmission of the contagion, but that they never originate it, and that it is never in them, except as they have received it from a diseased person.

Taking cognizance, however, of the fact that physicians, nurses, and other attendants upon the sick are often remarkably exempt from infection, and that, consequently, the contagious matter as it appears in the dejections upon their issue from the body is not probably in a condition favorable to the manifestation of immediate activity, he held that it requires to undergo some changes, outside the body, to fit it for transmission. It was his idea that when first cast off it is, so to speak, in *bulk*; that it appears in the discharges in the form of "clots or pellets of yellow matter," which are "to the contagious germs that float impalpable in air or water much as the block of granite is to the dust into which it may be ground;" and that before it can exert to its full extent the contagious power inherent in it, the infective germ or particle must be liberated from its entanglements and the organic husks in which it is imbedded, by drying, fermentation, or some other mode of disintegration and subdivision. But while it was his belief that such processes external to the living body were necessary to the liberation of the

"fever seed," and so to its ultimate dispersal, he did not think that the contagious agent acquired by the means any new powers, or gained any increase in quantity.

With regard to the spreading of the disease, he maintained that the poison, having been thus propagated and cast forth and prepared for final dispersion, may be conveyed to healthy persons in the vicinity of the sick, and even to those at a distance, by the same media of transmission that serve to convey the poison of other contagious diseases, with, however, one important additional medium, that of drinking-water, which the poison of this infects because the discharges infect the ground. And he believed that the course and progress of the disease in individual cases, and in its mode of spreading, increased and confirmed the evidences of its analogy with the contagious eruptive fevers; that, like all the members of that class, it has its incubative stage, and its stages of invasion, continuance, and decline; that, like them, it usually attacks the same individual but once; that it spreads as they spread from single cases; and that its spreading requires, as with them, the lapse of a fixed and uniform time after the occurrence of the first case,—a time during which the poison may not only prepare itself for transmission, but be transmitted to and incubate in the person of a new sufferer.

Thus, according to Dr. Budd, typhoid fever is an eruptive fever, differing only from other eruptive fevers in the seat of the eruption, and in the manner of giving off and dispersing its contagious poison.

As a necessary result he held that it is kept in existence by a continuous succession of cases, and that wherever a case occurs it is the lineal descendant of one that somewhere preceded it. He recognized, of course, the great difficulty, at times, of tracing this lineage, and the fact that it is often impossible. But he held that if due care is exercised in obtaining the historical facts the difficulty will not be greater in this than in many another sporadic case of universally acknowledged contagious disease. It was his unhesitating belief that the line of descent, discovered or undiscovered, always exists. But he held that, while it may not be always easy to learn the origin of the first single case in an outbreak, no such difficulty can ever exist with regard to any of the cases that may follow. These, whatever their number or the order of their occurrence, will be the immediate or remote descendants of that. To the contamination of the air, or of the ground, by the poison derived from the intestinal discharges of the first all that follow may trace an undoubted origin.

Observing now that these bowel discharges, with all the contagious properties they possess, are as they issue from the body completely within human control,—subject, indeed, to human disposal,—it occurred to him that if the poison they contain could be destroyed before being cast out upon the ground, or into privies, or cess-pools, or sewers, the spreading of the disease through their agency might be prevented. Upon the idea so suggested he proceeded to act. Knowing the power of strong chemical agents to destroy the contagious poison of other contagious disease, when subjected to them in circumscribed and limited form, he determined to subject the typhoid excreta to the influence of precisely such agents. He caused the dejections to be received into vessels containing solutions of strong caustic and disinfectant substances, and after they had been so received directed that still more of the same solutions

¹ Concluded from page 104.

should be poured upon them. 'Remembering also, from the subtle and impalpable nature of the poison, that everything which might have been soiled would be liable to become a medium of its transmission, he caused equally disinfectant precautions to be exercised with regard to the bed and body linen of the patient, and with regard to the person of the patient himself. He did not forget the minutest details or the remotest possibilities; not even the possibly soiled hands of the attendant or nurse. He put such measures to the test of severest trial, and demonstrated that what had seemed theoretically possible was actually practicable. He satisfied himself that the discharges might be disinfected, and that disinfecting them prevented the spreading of the disease. He applied the methods in hospital practice and in a large private practice, and with uniform success. He applied them in convents and schools and other large establishments where the disease was in progress and rapidly spreading, and through their agency arrested the epidemic.

Upon such views and by such methods Dr. Budd attained the object of his "burning desire," and thenceforth to show why prevention by disinfection is possible, by what means it may certainly be accomplished, and to urge the adoption of the disinfectant plan upon the profession and the public, became almost the absorbing purpose of his life. He prepared for popular use a set of rules for preventing the spread of the disease, with a clear statement for the popular ear of the assured knowledge which makes prevention possible. These rules are so simple, so plain, and withal so practicable that almost any one may comprehend them, and almost any one may easily apply them. They are too long for reproduction here, and I can only refer you to them now. I wish they might be distributed in every household in New England, and I cannot believe that the lesson they are intended to teach would be taught in vain. I simply quote the paragraph with which they close, and with it take my leave of the distinguished author and his attractive views: "These are golden rules. Where they are neglected the fever may become a deadly scourge; where they are strictly carried out it seldom spreads beyond the person first attacked."

It will occur, I presume, to every one familiar with the history of opinions upon typhoid fever that there is little of positive originality in these views of Dr. Budd, except so far as they relate to the measures of prevention proposed. In forming his theory of the nature of the disease, and of its pathology and mode of spreading by contagiousness of the discharges, it is probable that he only took up and enlarged upon ideas which had been advanced before his time. Bretonneau, in France, had published his well-known observations ten years before Dr. Budd saw the epidemic at North Tawton, and had pointed out what appeared to him to be the true significance of the abdominal lesion. It was with him that the opinion originated that this lesion is a true furuncular eruption, and that typhoid fever is an exanthematous fever. The opinion has since been maintained by many observers of great eminence, and by none with more ability than by Trousseau.

No one here who recalls the memorable address delivered before this society forty-five years ago will fail to observe how strikingly the elaborate views we have been considering sustain and extend the parallel of marked affinities drawn there by Dr. Bigelow between typhoid fever and the class of eruptive fevers. And no one conversant with the well-known opinions of Dr.

Nathan Smith upon the contagiousness of the disease will fail to notice how they corroborate and explain the original observations of that remarkable man. Nor will it escape remark that the opinions of Dr. Smith, which were given to the profession almost sixty years ago, were founded upon an experience of precisely the same general nature as that which first attracted to the subject the attention of Dr. Budd.

The doctrines I have presented for your consideration, with all their practical conclusions and applications, have been adopted without qualification or reserve by living scientific men of the highest eminence. Among such it is enough to mention the names of Sir Thomas Watson and Dr. Aitken, both of whom have lent to them, in their elaborate works upon *The Theory and Practice of Medicine*, their powerful sanction. But they have received the most influential support and perhaps the most decided impulse at the hands of the distinguished author of the article upon typhoid fever in Ziemssen's *Cyclopædia of Practical Medicine*. It is true that Liebermeister is not in full accord with Dr. Budd in regard to the natural history of the typhoid poison. He maintains with the latter that it multiplies in the body and is contained in the alvine evacuations. But it is his idea that it requires for the full development of its infective powers to undergo a stage of growth and multiplication outside the body, in connection with decomposing animal and vegetable matter, such as, eminently, it finds in privies and cess-pools and sewers. According to his theory, "the poison travels from the diseased individual to localities favorable for its growth and multiplication, and from these localities again into the human body."

As to the fact that the disease never occurs spontaneously, but is due always to a disease germ originating in some previous case, and as to the absolute certainty of the relation between the first case of any outbreak and the cases that follow, these authors are in perfect accord. The danger that will result from allowing single cases to establish centres of infection, and so to give rise to epidemics, is constantly dwelt upon by Liebermeister. It is especially against the formation of these foci of infection through the agency of the intestinal discharges that he urges preventive measures. That their formation may be prevented, and that therefore spreading may be prevented, he gives the most constant and encouraging assurance.

The measures upon which he relies differ in nothing essential from those advised by Dr. Budd. They are applied to the same material and with the same purpose, and are recommended with precisely the same degree of confidence. Alluding to their efficiency, he declares that "if the physician," in their application, "is supported by tolerably intelligent attendants, he may give the fullest guaranty that no extension of the disease will ensue from a single case."

Numerous authors and observers, whose high character gives great weight to any opinions they may offer, and who have adopted fully, or in the main, the views of Liebermeister in regard to the origin and cause of spreading in epidemics of the disease, have borne almost equally plain and decided testimony to the value of disinfectant methods. Professor Loomis, of the University of New York, in his recently published *Lectures upon Fevers*, says in regard to this matter, after giving direction for the disinfection of the discharges, "This procedure will certainly destroy the infective power of the typhoid poison contained in the

intestinal discharges, and in the majority of instances you will prevent the spread of the fever."

A committee of distinguished Fellows of this society, appointed six years ago by the city of Boston to examine into and report upon the causes of the high rate of mortality in that city, speaking of the measures of prevention against this disease, say, "Our first line of defense against the spread of typhoid fever from a diseased individual consists in the proper treatment of the dejections, which are held to contain the seeds of the disease."

In a lecture upon the origin and propagation of typhoid fever, delivered within a few weeks before the Royal College of Physicians, of London, by Dr. William Cayley, of the London Fever Hospital, the speaker, after a discussion of the important question as to how soon after their issue from the body the stools acquire contagious properties, draws the following practical conclusion: "That we have in all cases a few hours, during which it lies in our power to render the poison innocuous and to prevent the spread of the disease by direct infection."

Mr. Simon, the eminent English sanitarian, speaking of the importance and possible value of disinfectant measures in the prevention of infectious diseases, and this among the rest, says, "It is greatly to be hoped that with time and with progress of general education the systematic doing of such acts as these will in each sick house be considered an imperative duty of good citizenship, and may at last be so fully understood in that light as to be made as far as practicable an obligation at law."

But it is unnecessary to pursue either the theory or the testimony farther. I have spoken to you of the spreading of the disease *as it occurs among us*. I have pointed out the fact that in our experience spreading begins with a single case, and that other cases do not usually follow for two or three weeks, — a fact sufficient of itself to establish *a priori* probability that the first stands to the last in the relation of cause to effect. I have called attention to a theory which explains this relation, and shows that the last cases *are* caused by a poison derived from the first, and that the intestinal discharges of the first *are* the medium of communication. I have shown how there has grown out of this theory a possible and practicable plan for preventing the disease from spreading, and have suggested the general features of that plan. I have given you the assurance of its most prominent advocate that it has been put to the test of severest practical trial for years, and always found successful, and I have introduced abundant corroborative testimony from other sources of high authority. In doing this, I have accomplished the main object I had in view at the beginning by showing that there is not only reasonableness, but great weight of testimony, in favor of the possibility and practicability of preventing, or at least of diminishing, the spreading of the disease as it occurs among us.

I need hardly dwell upon the obvious, practical conclusion that if this theory is true every case of the disease, wherever it may occur, whether mild or severe, ambulatory or confined to the bed, may be, if left to itself, the first case of a serious outbreak. Nor do I need to remind you that if this plan of prevention is to be carried out and is to be effectual it must be entirely under the advice and direction of the attending physician, and form an important part of the general and

prescribed treatment of each individual case, and that an essential prerequisite of its success is "that whatever be done should be done in that thorough and conscientious way which alone befits acts which may issue in health or disease, in life or death, to indefinite numbers of men."

I am aware that for many years a very different theory of the cause of typhoid fever and of the endemics which mark its course has prevailed in Massachusetts. I suppose it still prevails. It is that the disease originates in a poison which is generated outside the human body, in dead organic matter, in filth, in decomposition of animal and vegetable substances, in putrescence. This theory, which originated with Dr. Murchison, and from whom it received the name of "pythogenic," — born of putrescence, — has been, as you are well aware, very ably presented and supported here by the late Dr. Derby, in a paper on this subject, which has justly attracted the attention of sanitarians in all parts of the world. The conclusions arrived at by Dr. Derby, in forming which he had the assistance by correspondence of a great number of the leading physicians of the State, have long been the apparently accepted doctrines of the medical profession among us. Under this theory it has usually been considered a satisfactory explanation of one of the terrible outbreaks we have considered to find that the air of the house had been vitiated by decomposing vegetable matter in the cellar, or by emanations from surrounding filth; or that the drinking-water had been made foul by the filtration into it of the products of decomposition from neighboring privies or sink-drains. To these influences, or to some combinations of them, have been ascribed almost every example of spreading I have found alluded to in our "health of town" reports; and in none of them until those of the present year have I found allusion to the intestinal discharges of the typhoid patient as the source of the poison by which privies and cess-pools and sewers become the communicators of the disease.

I have avoided entering into any argument in support of the theory to which I have called your attention to-day, and I do not propose to enter into one to show that the theory of origin in putrescence is incorrect. It is only to the difference between the two in their practical bearing upon prevention that I would wish to direct attention. The doctrines of Dr. Budd and of Liebermeister, that the typhoid poison has a vital, living origin in the human body, propose a simple, plain, practical test, by which they may be tried and their truth or falsity proved. Upon the result, when the method is faithfully carried out, they are content to stand or fall. The test is not difficult to apply. If applied and unsuccessful, no harm has been done. If applied and successful, a great good has been accomplished. Had they been put to the test in the three cases to which I have called your particular attention by way of illustration, and had they been as successful as their advocates promise, the result would have saved in those instances alone a protracted and dangerous illness to at least twenty-three persons and not less than nine valuable lives.

It seems hardly possible that we can overestimate the importance of the point we have been considering in its relations to the general subject. From the earliest times of which we have any authentic medical knowledge, typhoid fever has been among us a perpetual and unrelenting scourge. Some of our most

dreaded and destructive forms of pestilence come and go, — ravage for a time, and then depart. Diphtheria, one of the oldest of human diseases, had been absent from New England for almost two whole generations before its unlooked-for reappearance in 1857, and had become well-nigh forgotten in our medical literature. Small-pox almost wholly disappeared from our community during the thirty or forty years which immediately followed the introduction of vaccination; then gradually regained a footing, and has continued to prevail ever since to a greater or less degree. Cholera, now and then, at long and irregular intervals of time, suddenly and abruptly visits us, lingers for a time, and then as suddenly and abruptly takes its departure. Cerebro-spinal meningitis, at times one of the most malignant of epidemics, gives also long and happy periods of exemption. But typhoid fever stays. It never leaves us. It never grants our people a respite even for a day. Somewhere among us it is always present, doing its specific work, which is to multiply and replenish and scatter abroad the morbid agencies by which, from generation to generation, it perpetuates its baleful existence among men.

In forty years, from 1840 to 1880, a period which falls within the professional recollection of many of the gentlemen whom I see before me, there have perished by typhoid fever alone, in Massachusetts, forty thousand persons, — *about* forty thousand persons. It is a common opinion, founded upon observation and statistics, that for every one who dies by this disease at least eight or nine suffer by it and recover. If we adopt the method of computation, it will appear that the number of those who, during the same period, have been made sick by it and have not died can hardly be less than three hundred and fifty thousand. These are startling figures. But if either of the statements were made less general and in terms more precise and particular, as by the aid of what are considered reliable statistics would be practicable, the immense aggregates would be increased rather than diminished. The annual average of this sickness and death is as if, every year, for the space of forty years, all the inhabitants of some one of our populous and important towns, like Northampton, for example, or Malden, had been attacked by typhoid fever, and one in ten had died.

But, after all, bald figures and statistical statements can convey but an imperfect idea, except by suggestion, of what our people have really suffered in their persons and their homes, directly and indirectly, by the disease. Just as, after a long and destructive war, it is possible to count up the immediate casualties of the field, — so many slain, and so many wounded, — but impossible to state in words or figures the indirect, remote, far-reaching consequences of the deadly strife upon individuals and the community, so here, reviewing the contest of years between our people and a most destructive disease, we can count up the dead and compute the number of those who have sickened and have not died, but we cannot give in arithmetical statement or in words the disastrous result of the unequal conflict upon their fortunes and their happiness.

We cannot adequately estimate even the pecuniary loss which it has brought upon individuals, nor yet that which it has occasioned the state, by the death and disabling of such vast numbers of its efficient and productive members; much less can we enumerate the families it has broken up and scattered, the cherished hopes it has crushed forever, the dependent and

the helpless from whom it has snatched the reliance and support, or yet the many, many homes where its dark shadow has fallen, never to be lifted up.

Fellows, the animating purpose of what I have now imperfectly presented has been to suggest and to urge the adoption of some tried and approved methods by which the physicians and the people of the State, in their individual capacity, may effectually aid and supplement the efforts of boards of health and sanitary authorities generally, in the prevention or in the mitigation of one of the severest features of the disease. And here I close, invoking for the subject once more not merely a present consideration, but a future and fuller discussion.

APPENDIX.

RULES FOR PREVENTING THE SPREAD OF TYPHOID FEVER, DRAWN UP FOR POPULAR USE.

The means by which typhoid fever may be prevented from spreading are very simple, very sure, and their cost next to nothing.

They are founded on the discovery that the poison by which this fever spreads is almost entirely contained in the discharges from the bowels.

These discharges infect: (1) The air of the sick-room. (2.) The bed and body linen of the patient. (3.) The privy and the cess-pool, or the drains proceeding from them.

From the privy or drain the poison often soaks into the well and infects the drinking-water. This last, when it happens, is of all forms of fever poisoning the most deadly.

In these various ways the infection proceeding from the bowel discharges often spreads the fever far and wide.

The one great thing to aim at, therefore, is to disinfect these discharges on their very escape from the body, and before they are carried from the sick-room.

This may be perfectly done by the use of disinfectants; one of the best is made of green copperas. This substance, which is used by all shoe-makers, is very cheap, and may be had everywhere. A pound and a half of green copperas to a gallon of water is the proper strength. A teacupful of this liquid put into the night-pan every time before it is used by the patient renders the bowel discharge perfectly harmless.¹ One part of Calvert's liquid carbolic acid in fifty parts of water is equally efficacious.

To disinfect the bed and body linen and bedding generally, chloride of lime, or MacDougall's or Calvert's powder, is more convenient. These powders should be sprinkled by means of a common dredger on soiled spots on the linen, and about the room to purify the air.

All articles of bed and body linen should be plunged, immediately on their removal from the bed, into a bucket of water containing a tablespoonful of chloride of lime or MacDougall's or Calvert's powder, *and should be boiled before being washed.* A yard of thin, wide gutta percha placed beneath the blanket, under the breech of the patient, by effectually preventing the discharges from soaking into the bed is a great additional safeguard.

The privy, or closet, and all drains communicating with it should be flushed twice daily with the green

¹ As the discharge is sometimes much more copious than at others, the quantity of disinfectant added must of course be copious in the same proportion. A teacupful is mentioned in the rules, but the principle is to be lavish of the chemical.

copperas liquid, or with carbolic acid diluted with water.

In towns and villages where the fever is already prevalent, the last rule should be put in force for all houses, whether there be fever in them or not, and for all public drains.

In the event of death the body should be placed as soon as possible in a coffin sprinkled with disinfectants. Early burial is on all accounts desirable.

As the hands of those attending on the sick often become unavoidably soiled by the discharges from the bowel, they should be frequently washed.

The sick-room should be kept well ventilated day and night.

The greatest possible care should be taken with regard to the drinking-water. Where there is the slightest risk of its having become tainted with fever poison, water should be got from a pure source, or should at least be boiled before being drunk. Immediately after the illness is over, whether ending in death or in recovery, the dresses worn by the nurses should be washed or destroyed, and the bed and room occupied by the sick should be thoroughly disinfected.

These are golden rules. Where they are neglected the fever may become a deadly scourge; where they are strictly carried out it seldom spreads beyond the person first attacked.

W. B.

NOTE. Dr. Budd's own practice was to place in the sick-room, or close at hand, a large can filled with the mixed solution of carbolic acid and sulphate of iron; to keep the night-pan always charged with it, and after each use of the pan to pour upon the discharge a quantity of the solution sufficient to insure the disinfection of what had been voided.

Calvert's liquid carbolic acid, which is referred to, is of about the same strength as the acidum carbolicum impurum of the United States Pharmacopœia, and the latter may be substituted for it.

"MacDougall's powder contains about thirty-three per cent. of carbolate of lime, fifty-nine per cent. of sulphite of magnesia, the rest being water.

"Calvert's powder contains from twenty to thirty per cent. of carbolic acid mixed with the powdered refuse from alum works."¹

These "powders" are favorite disinfectant compounds in Great Britain, and can be obtained without difficulty, but Dr. Budd appears to consider the chloride of lime for dredging purposes equally efficacious.

T. H. G.

BACTERIA, AND THEIR RELATIONS TO DISEASE.²

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It is proposed in this paper to give a brief sketch of the classification and mode of development of bacteria, together with a consideration of the points in favor of regarding them as the originators of the diseases with which they are found associated, in order to see what principles should serve as guides in the interpretation of results or the criticism of the work of others.

¹ The Antiseptic System, A. E. Sansom, London, 1871, page 204.

² Read before the Massachusetts Medical Society at its annual meeting, June 8, 1880, and recommended for publication by the society.

First, considering their natural position and mode of development.

These organisms are doubtless vegetables, and as such have been placed in the lowest division of the cryptogams (the order containing the mosses, fungi, and the like), under the name of bacteria or schizomycetes. Their general characteristics are described by Cohn as follows: Cells without chlorophyll, of round, oblong, or cylindrical form, at times twisted or bent, which increase entirely by division and vegetate either singly or in colonies. The cell contents consists of protoplasm, surrounded by a cell membrane, closely allied to cellulose, and insoluble in caustic alkalies. Their presence in large numbers gives a cloudy or milky appearance to the fluid in which they vegetate; but if present in small numbers, or if the index of refraction is the same as that of the fluid in which they are suspended, their presence is only to be determined by aid of the microscope.

The bacteria are divided into four tribes, and these again into one or more genera, as follows:—

Tribe I. Spherobacteria (Round Bacteria). Genus 1. Micrococcus.

Tribe II. Microbacteria (Rod-Like Bacteria). Genus 2. Bacterium.

Tribe III. Desmobacteria (Thread-Like Bacteria). Genus 3. Bacillus. Genus 4. Vibrio.

Tribe IV. Spirobacteria (Screw-Like Bacteria). Genus 5. Spirillum. Genus 6. Spirochæte.

The development of the spherobacteria (micrococcus) is as follows: The cells divide, and are usually found joined together by twos, the point of junction being markedly contracted. By further division there can be formed short chains of three, four, eight, or more members, which are either stiff, straight, or bent, and in consequence of their contractions have an appearance like a rosary. This has received the name of the torula form. Besides this, there occur two other forms: one where the cells have become twisted or disarranged, and form small irregular masses of bands, and but a step removed; the second, or so-called zooglœa form, where the cells are produced in all directions, and bound together by a very tender, gelatinous, or mucous-like mass, giving to the whole, under the microscope, an appearance very like that of shark skin. These bacteria have no movement.

Further than this they present no distinction of size or form, and their division into species is based upon the action which they are supposed to exercise; and they have been distributed among three groups, namely, chromogenous (producing pigment), zymogenous (causing fermentation), and pathogenous (causing disease).

The pigment-producing micrococci are all harmless. The oldest and best known, the micrococcus prodigiosus (Ehrn.), will serve as an example, for it is that which produces red spots on boiled potatoes or bread, and has given rise to the superstitious name of "the bleeding host." There are several others named after the colors which they produce: a yellow, which is insoluble in water; and orange, green, and blue, which are soluble in water.

Of the ferment-working micrococci, the one causing the alkaline fermentation of the urine, called micrococcus ureæ, is the best recognized, and the indirect effect it has upon the economy will be considered later. Micrococci are always found in putrefying substances associated with the rod-like forms (bacterium proper), but as yet their peculiar action has not been determined.