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THE
ETIOLOGY AND PREVENTION OF INFECTIOUS DISEASES.*

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It is in the field of infectious diseases where preventive medicine doubtless has and will continue to exert its greatest usefulness, and there is ample room when we contemplate the frightful mortality from these diseases. During the census year of 1880, consumption caused 91,270 deaths in the United States; scarlet fever, 16,388; diphtheria, 38,143; croup and allied diseases, 17,966; measles, 8,072; whooping cough, 11,064; enteric fever, 22,854; malaria, 20,231; and erysipelas, 4,275.

Not many years ago, it was assumed that the infectious diseases were caused by a miasm, or a contagium. A miasm in the minds of those physicians constituted some hypothetical matter formed outside of the system, which contaminated the air and gained admission in respiration, and then produced pathological conditions. Moscati tried over a hundred years ago to demonstrate the character of malaria to the senses by condensing the moisture of the air over rice fields and marshy districts; and though certain organisms were found, all efforts proved useless to connect them with the disease as a causative factor, and thus the real nature of a miasm remained unexplained.

Another class of physicians assumed that many of the infectious diseases were caused by a contagium, by which they understood a specific morbid material generated within

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the body of persons affected with a certain disease, and capable of producing the same disease in others. This contagium was presumed to be communicable by immediate or mediate contact, but they failed to isolate the various specific agents or to demonstrate them to our senses.

About fifty years ago, Donne first demonstrated the presence of vibriones in syphilitic pus. In 1840, Henle ventured the opinion that the morbid matter of all infectious corpses was of a living organized character; and in order to determine whether the cadaver poison was produced by micro-organisms, he strongly urged to search for such organisms in the bodies of those affected with infectious diseases, and, if possible, to isolate them and establish their respective characters. This awakened a most earnest desire to determine whether or not organisms could be found in the bodies or excretions of infectious patients which might be the carriers or agents of the respective virus.

Very soon after this announcement, Davaine discovered the *cause of anthrax*; he found in the blood of animals suffering from splenic fever, invariably certain rod-shaped organisms, which, in 1855, were confirmed by Pollender and Brawell. These observers also demonstrated the fact that the blood of such animals inoculated into other animals produced the disease in question, and the blood of animals thus inoculated likewise contained the peculiar rod-shaped organisms. Pasteur, in 1877, finally proved that inoculation of blood, which had been freed from these organisms, failed to produce anthrax. This led to the natural conclusion that there was a causative relation between these rod-shaped organisms and the disease in question.

In the beginning of the seventies, Waldeyer, Recklinghausen, Weigert, and others, discovered a number of micro-parasites in the internal organs and wound secretions of various surgical infectious diseases; and in 1876 Koch published his researches on the etiology of splenic fever and anthrax, and presented the life history of the bacillus anthracis, which is one of the many varieties of bacteria.

The simple methods employed by this author in the

detection and cultivation of disease germs resulted in the discovery of many other pathogenic bacteria, viz: the tubercle bacillus of Koch; the bacillus of glanders, by Schülz and Loeffler; the lepra bacillus, by Hansen and Neisser; the gonococci, as the cause of gonorrhœa and gonorrhœal ophthalmia, by Neisser; the coma-bacillus of cholera, by Koch; the micrococcus erysipelatis as the cause of traumatic erysipelas, by Fehbeison; the tetanus bacillus, by Nicolaier; the staphylococcus pyogenes-aureus, albus, and citreus, the cause of suppuration, by Ogston and Passet; the lancet-shaped pneumonia bacillus as the cause of pneumonia; the bacillus of typhoid, by Eberth, etc. The evidence as to the cause of puerperal fever is still conflicting, but points to the fact that it is due to the micrococcus erysipelatis; nor is it settled whether Loeffler's bacillus or Prudden's streptococcus is the cause of diphtheria.

We may be disposed to smile with something less than contempt when we read of the importance attached to the microbic origin of certain diseases; but Koch has laid down *certain conditions*, upon the proof of which alone it can be asserted that *a particular microbe is the cause of a certain disease*. They are:

(1) The micro-organisms must be found in the blood, lymph, or diseased tissues of man or animals suffering from, or dead with the disease.

(2) The micro-organisms must be isolated from the blood or tissues, and cultivated in suitable media outside the animal body, and these pure cultivations must be carried on through successive generations of the organism.

(3) A pure cultivation thus obtained must, when introduced into the body of a healthy animal, produce the disease in question.

(4) In the inoculated animal the same micro-organism must again be found.

It has been shown, beyond a doubt, that some of the bacteria are the etiological factors of communicable diseases, and this is a strong argument in favor of those in which the proofs are not yet conclusive. For obvious reasons the

inoculation of pure cultures cannot always be applied to man; but in diseases which are interchangeable between animals and men, the complete sequence of proof has been established, and the successful inoculation of certain pathogenic germs into healthy animals certainly warrants the assumption that similar results will take place in the human system.

What are bacteria? Prudden tells us that they are so small that for a long time scientists were uncertain whether they belonged to the animal or vegetable kingdom; but it is now definitely settled that they are plants, and closely related to the algæ. Under the microscope, we see that the bacteria or shizomycetes are made up of vegetable cells containing slightly granular matter and surrounded by a somewhat denser envelope; they are so pale and translucent that they can only be distinctly recognized by staining them.

The bacteria may be spheroidal, ovoidal, rod-shaped, or spiral-shaped, and have been named according to their form.

All *spheroidal bacteria* are called *micrococci* or simply "cocci." If they cling together and form chains they are called *streptococci*; if they are grouped together in a rather irregular manner, like a bunch of grapes, they are called *staphylococci*.

Of the *rod-shaped bacteria*, the most common genus is called *bacillus*. If they are rather slender and delicate, they are called *leptothrix*. If they have the form midway between the round and rod-shaped bacteria, they are spoken of as *cocci-bacilli* or *cocci-bacteria*; the spiral or cork-screwed bacilli are called *spirillæ*, and the curved bacilli are spoken of as *coma-bacilli*.

Warmth, moisture, oxygen, and a certain amount of organic matter are essential for the growth of bacteria. When these conditions are present, the process of reproduction is so rapid that a single germ, by growth and subdivision, may give rise to over sixteen millions of similar organisms within twenty-four hours; they multiply either by transverse fission or by spore-formation.

Pathogenic bacteria may be present in all the media with which we come in contact, *i. e.*, in the air, water, soil, food, the wastes of human life, in the excretions and secretions, in the blood, in the internal organs, and on the surface of the skin. Yet we must not assume that they are omnipresent, for many of them select, after all, only certain localities or media. This is quite true of the *plasmodium malaria*, and likewise true of the *bacillus of syphilis*. The latter appears to select exclusively the human body as a suitable soil for its growth.

So far, only the staphylococci of pus and the somewhat dubious bacillus of malaria have been demonstrated in *the open air*.

In *the air of rooms*, the bacillus of pneumonia, of anthrax and tuberculosis, and the micrococci of pus and erysipelas have been isolated.

In the *water supply*, the bacillus of cholera and of typhoid have been demonstrated.

In the *soil*, the bacillus of anthrax, of typhoid, of tetanus, and malignant œdema have been found.

In *articles of food*, the bacilli of anthrax and tuberculosis, and the staphylococci of suppuration have been found in the milk and meat of diseased animals.

In *clothing*, the staphylococci of pus, the bacillus of anthrax and malignant œdema have been demonstrated, and there is reason to assume that the germs of all diseases conveyed in the air, can also be carried in clothing.

It has also been shown that the walls, floors, and ceilings of our habitations may harbor disease germs. The pneumonia bacillus has been found in the ceiling spaces, the bacillus of tetanus in mortar, and the tubercle bacillus on the walls, floors, bedsteads, and in fly spots.

The surface of our body harbors many bacteria, both harmless and pathogenic. They are especially numerous in the armpit, between the toes, and the dirt of finger-nails. Multman demonstrated no less than seventy-two varieties of bacteria in nail dirt. Of the pathogenic forms, the micrococci of pus and the tubercle bacillus have been demonstrated in nail dirt.

The *pyogenic cocci* have also been found in the pustules of impetigo and sycosis, and the bacillus of syphilis in the secretions of syphilitic ulcers and condyloma. It is quite likely that the bacilli of cholera and typhoid will be found on the skin of persons soiled with dejecta, and that the scales of the epidermis contain the carriers of the acute exanthemata and of erysipelas.

In the *mouth and saliva*, there have been found four different bacteria, capable of producing septicæmia in animals; also the streptococci of diphtheria and the bacillus of tuberculosis and pneumonia, not to mention the *oidium albicans*, which belongs to the fungi, as the cause of thrush.

In the *mucus* of the respiratory passages, the bacilli of pneumonia and tuberculosis have been isolated; also Fränkel's and Weichselbaum's pneumoniococci. In *vaginal mucus*, the *oidium albicans*, the staphylococci of pus, and the streptococci of diphtheria have been found.

In the *intestinal contents*, the bacillus of cholera and typhoid, and it is assumed that the carriers of dysentery and tuberculosis are also present.

The *blood and internal organs* of healthy individuals are free from micro-organisms. In disease, the bacillus of typhoid has been found in the blood and spleen; the bacilli of anthrax and tuberculosis have been demonstrated in the blood and various internal organs; the same is true of the streptococci of diphtheria.

Normal *urine* has been found to be quite free from germs, but bacteria have been demonstrated in certain diseases of the bladder and embolism of the kidneys.

The *cutaneous perspiration* is believed to be free from microbes; if found, they are probably derived from the skin. The *exhalations* of healthy and diseased persons, even the breath of consumptives, have been found to be free from bacteria. But more remains to be done in this direction, as there are many infectious diseases which are doubtless in their first stage communicated by the exhalations of the patients.

In this connection, it is well to remember that, in addi-

tion to disease germs, there are many so-called *harmless bacteria*. The latter [are so abundant and common that, apart from existing in the air, water, soil, and food, they are also found in the mouth and digestive tract of man, in the nose, in the respiratory passages, in the internal meatus. The fæces of the healthiest subjects contain numerous ferments and bacteria, and even the meconium of the new-born has been found to contain bacteria.

One of these bacteria, the *bacillus coli communis*, was considered heretofore a harmless inhabitant of the colon, but the recent studies of Rodet and Roux render it probable that the bacillus of Eberth is nothing more than a modification of the *bacillus coli communis*, and that the latter acquires its virulent features outside of the body. And this opens a question of much practical interest, Whether bacteria may be benign in one locality and malignant in another, or whether the property of infection is an adventitious one, depending upon the soil in which the organism grows, or inherent in its substance? Of this, more will be said hereafter.

Having indicated, briefly, where the disease germs have been found, it will be readily inferred that the air, water, soil, and articles of food are the principal media for their dissemination. Apart from these, clothing, bedding, and personal effects are common means of spreading infectious diseases. Man himself is often the cause of spreading disease germs. This is true of many mild cases of typhoid fever, and other diseases of a mild type, not to mention the spread of scarlet fever, measles, small-pox, etc., by convalescents and infectious corpses.

Perfectly well people may carry the germs in their clothing, or about their person, and infect some distant locality. One of the severest scarlet fever epidemics I ever encountered was due to a man who came after me on horseback, some sixty-five miles, to see some scarlet fever cases. He slept that night with one of his little nephews, and in less than ten days that boy developed scarlet fever, which subsequently invaded almost every family.

Insects, especially flies, are doubtless frequently the cause of spreading disease germs; they are usually present where the existence of germs may be suspected, and feed on the material likely to contain them. As a matter of fact, Celli, of Rome, in 1888, demonstrated that the bacilli of tuberculosis, of anthrax, and typhoid, as well as the micrococci of pus, retain their virulence and power of propagation after passing through the intestinal tract of flies. Spillmann and others have demonstrated that flies, which were caught whilst feeding upon the sputum of consumptives, contained invariably vital specific bacilli, and Hoffmann not only confirmed these observations, but also found them in the fly spots on the walls of rooms of phthisical patients.

As already indicated, bacteria require for their growth a suitable soil; they need moisture, carbon, nitrogen, and mineral matter, and quite a number also oxygen. The majority cannot exist in highly acid nutrient media, but prosper best in neutral and faintly alkaline media. It has also been demonstrated that they vary considerably with regard to their pabulum; some flourish in certain media, where another species finds it hard to live.

The majority of pathogenic germs develop best at a temperature between 28° and 68° F. The vitality of some is destroyed at the freezing point, whilst others remain active even in ice for long periods. A temperature of 250° is quite likely to destroy all varieties of bacteria and their spores.

In the *cultivation of bacteria*, some interesting observations have been made. It would appear that wherever varying forms of bacteria are growing together a struggle for existence begins. The hardy and rapidly growing bacteria struggle with their weaker neighbors, and the weaker, as usual, go to the wall.

Thus it has been observed, that the bacteria of fermentation and putrefaction furnish a material which poisons neighboring pathogenic bacteria. But such an antagonism does *not always* exist, for many varieties appear to grow together, whilst others prepare the way for a succeeding race,

and often one species adapts itself to the conditions which brought about the extinction of its predecessors.—(Prudden.)

Bacteriological studies have also shown us that, as the bacteria grow, they set free various chemical compounds—the result of their own life processes—chief of which are the ptomaines; they also liberate some of the amido-compounds of the aromatic series, and ammonia, taurin, fatty acids, hydrogen sulphate, carbon dioxide, carburetted hydrogen, and other stinking gases, not yet determined.

The subject of *ptomaines* is to us of special importance, because it is believed that these alkaloids, closely resembling the vegetable alkaloids in chemical and pathological properties, produce the real mischief in the human system.

Quite a number of ptomaines have been discovered, and we know to-day that the cadaver poisons, such as *cholin*, *neuridin*, *neurin*, *cadaverin*, *putrescin*, etc., are the products of bacteria. Ptomaines have also been demonstrated in decomposing milk, cheese, meat, and fish.

But most important of all, they have also been discovered in the culture fluids of certain pathogenic microbes. Thus *cadaverin*, first demonstrated in the human cadaver, has been found in connection with putrescin in pure cultures of the cholera bacilli. And it is believed that the symptoms of cholera are produced by these poisons; for when introduced into animals, violent inflammation and necrosis of the intestinal mucous membranes results.

Typhotoxin has been obtained from pure cultures of the typhoid bacillus; this alkaloid, when injected into animals, produces inability to control the voluntary muscles, and excites increased flow of the salivary and intestinal secretions.

Another ptomaine, called *tetanin*, has been demonstrated from the cultures of the tetanus bacilli. This alkaloid, when injected into animals, produces clonic and tonic spasms—in fact, the symptoms of tetanus. The recent researches by Koch as to the discovery and effects of *tuberculin* are too well known to require special notice.

The admirable methods of Brieger, employed in the detection of ptomaines, will doubtless succeed in demonstrating that such products are formed in all pure cultures of pathogenic bacteria, and this would, of course, materially enhance our knowledge as to the deleterious effects of these compounds on the system.

Indeed, it would seem that the time is not far distant, when we can say, that certain bacteria invade the system. These develop, under favorable conditions, in sufficient number to produce, by their own life-processes, certain ptomaines, which, in turn, cause a train of toxic symptoms not unlike those of the vegetable alkaloids. When we consider the peculiar idiosyncrasies of individuals to some of the vegetable alkaloids—morphine and quinine, for instance—we need not wonder at the variable effects of ptomaine intoxication in infectious diseases.

There is much reason for believing that the urticaria and gastro-intestinal symptoms produced in some persons after eating shell fish, etc., are due to the production of ptomaines in susceptible subjects. It is also held that ptomaines may be formed in perfectly healthy individuals in the intestines, under the action of the bacteria of putrefaction, and the indol, phenol skatol, and kreosol, found in the urine, are really products of these processes.

There is evidence to show, that one ptomaine may act as a counter-poison to others; we know, at least, that some of these products destroy the very organisms which generated them. So, for example, lactic acid, which is the product of the bacillus acid lactici, destroys that same bacillus in a one per cent. solution; and this, perhaps, explains the efficacy of lactic acid in the treatment of cholera infantum. Grawitz has shown that cadaverin in certain concentrations arrests the growth of the pyogenic micrococci. We also know that some species of bacteria die in the same culture fluid, while others live, which possibly furnished the material to poison their neighbors, and the presence of phenol, skatol, and kreosol, which are products of putrefactive micro-organisms, retard the growth of these same germs.

Many persons still believe in the spontaneous generation of bacteria, and naturally hold that, if disease germs cannot originate *de novo*, all efforts in prevention must prove useless, because the divine law of death has decreed otherwise. Whilst the experiments of Pasteur, Tyndall, and others, have shown that every living thing—be it man, beast, plant, or cell—must come from some pre-existing living thing, clinical experience points to the occurrence of many infectious diseases, which cannot always be traced to a pre-existing cause; and the question naturally arises, Where did the germs come from?

In 1886, I was called to treat three young "cow-boys," who had been alike exposed to the process of catching cold. One developed facial erysipelas; the second, an abscess of the thigh, following a slight saddle-bruise; the third, a case of typho-malarial fever. Here we have three young men, of average good physique, exposed to a chilling of the general surface, and consequent suppression of the cutaneous function, causing a retention of the effete matter in the blood, which, in turn, supplied a suitable pabulum for the development of septic germs. Still, it seems to me quite a mystery, why, in one case, the micrococci of erysipelas; in another, the staphylococci of pus; and in still another, the etiological factors of typhoid fever and malaria, should have been developed.

In tracing the family history, I found that the mother of my erysipelas patient had died from that disease in one of her confinements. Such cases are especially calculated, in the absence of a pre-existing case, to suggest the *possibility of an auto-genetic origin of disease germs*.

In our present state of knowledge, we can only explain such cases by assuming that disease germs may gain admission into the system at all times, but can only multiply in sufficient numbers to produce mischief when the blood, from any of the numerous causes, is charged with an excess of waste matter. If disease germs are not omnipresent (and I do not believe they are), we must assume that auto-infection can take place. It is quite possible that the ordinary so-

called harmless bacteria acquire virulence by suitable food and environments; and the retention of leucomaines and extractives in the blood, whose elimination has been interfered with, may furnish the requisite food for such transformations within the body; and that soil pollution and unsanitary surroundings may do so outside of the body. A disease thus developed could, of course, be spread in the usual manner.

In my *Report to the State Board of Health of California* in 1886, I attributed certain cases of typho-malarial fever and erysipelas to autochthonous septicæmia, and presented a strong argument in favor of the *de novo origin of diphtheria*. At all events, I adduced evidence to show that the same polluted soil and unfavorable sanitary surroundings were capable of developing different disease germs.

We know that there are mild and malignant epidemics of scarlet fever, measles, etc., indicating at least a difference of degree in virulence. We also know that the virus of certain infectious diseases may be attenuated; and there is no special reason why certain harmless bacteria should not assume pathogenic action by changed environments within or without the body.

But whatever the origin of disease germs may be, I believe they would never produce deleterious effects if the human system were at all times fitted to resist them.

We certainly know that invasion of the microbes alone is not sufficient to produce the disease, because this can take place often enough. If, therefore, disease results, there must have been a state of the body which rendered it peculiarly liable to be affected injuriously by the respective morbid agent, and this we call predisposition.

Now, *what constitutes this predisposition?* Is it a weakness of the organism, a diminished power of resistance, or a peculiarity of the tissues—more especially of the tissue cells—which places them at a disadvantage in their struggle against the invasion and effects of these germs? Is it the addition or subtraction of a certain something in the blood, which furnishes the proper food for their growth? These

are difficult questions to answer, but we will sum up the existing views on this subject.

In the first place, it is suggested that this predisposition in many persons amounts to only *simple lesions of the skin and mucous membrane*, which would favor the invasion of the germs. Thus it is held that the peculiar susceptibility of persons, suffering from whooping-cough and measles, to tuberculosis, is due to the catarrhal condition and alteration of the epithelial layer of the respiratory tract, which favors the invasion of the tubercle bacilli; for similar reasons the delicate mucous membranes of anæmic and scrofulous subjects are believed to favor the invasion of these germs. This is highly probable, when we consider that only the delicate mouths of children are susceptible to the effects of the *oidium albicans*. Loeffler has also shown that the vagina of young guinea pigs favors the inoculation of his diphtheria bacilli more than that of older animals.

Functional derangements of the stomach appear to play an important rôle in predisposition. Thus we know that normal gastric juice destroys the bacilli of cholera; but if the fluid is only faintly acid, neutral, or alkaline, this protection ceases, and the germs will reach the intestines and proliferate. This is doubtless true of many other germs.

For a time at least it was believed that the leucocytes assumed the rôle of defenders of the body against bacterial invaders—that, according to Metschnikoff, they are phagocytes in this, that they either swallow and digest the bacteria, or surround them so closely as to cut off their oxygen and food supply, and thus kill them. According to this theory, which was based on the fact that many dead bacilli were found inside the bodies of leucocytes, an animal whose white blood-cells can successfully battle with and eat up a given species of bacteria, enjoys immunity from its deleterious effects; if, on the other hand, they are not strong enough to resist them, the battle is lost and the way is open for the spread of the infecting germs.

Now, whilst it cannot be denied that bacteria have actually been found in the bodies of leucocytes, it does not follow

that they were taken up alive and destroyed by these cells; and until this is shown, no proof exists that their action towards the bacteria differs in any way from that towards other dead matter which they absorb or transport. This has been well presented by that indefatigable bacteriologist, Dr. Prudden, of New York.

Indeed, recent experiments appear to indicate that after all, "it is the blood serum which possesses in different degrees in different animals and in varying potency with the different bacterial species, a most marked germicidal power;" and this same observer has proved that a similar germicidal power resides in fresh, human, non-inflammatory transudations. In his opinion, "this power is not directly associated with the formed elements of the blood or transudates, but is in some way dependent upon their albuminoid constituents, and that this singular and apparently most significant capacity of the body fluids is intimately associated with that complex condition which we call life."

Whatever the exact rôle of the blood may be, the influence of a healthy condition of this fluid cannot be questioned. If healthy blood offers a natural defence, impure blood would constitute a prominent predisposing factor; and the average layman may after all not be very wrong when he talks to us about his "blood being out of order."

We know from clinical experience, that bad food, impure air and water, and the absorption of putrid gases formed in the intestinal tract, general mal-nutrition, physical and mental exhaustion, fever, anxiety, etc., predispose to a number of infectious diseases; and it is not unreasonable to assume that these factors, apart from producing an alteration of the blood, also tend to lower the vital powers of the system, and necessarily diminish the power of resistance to bacterial invasion and their products. Wyssokowitsch's experiments have shown that the same bacilli, which under normal conditions of the blood were rapidly destroyed under the influence of a ptomaine poison, at once began to manifest their pathogenic effects.

In the light of clinical experience, the existence of an

individual predisposition to infectious diseases cannot be questioned. We also know, that this may be congenital and acquired; and in our present state of knowledge, we may assume that a vulnerability of the tissues and tissue cells exists, which renders the system peculiarly susceptible to the invasion of certain germs, and the particular form of poison evolved during their life processes.

It is no more difficult to account for inherited vulnerable anatomical elements to certain germs and their toxic products, than to explain the hereditary transmission of physical and mental peculiarities, and the many idiosyncrasies to drugs, etc.

Now, whilst we find a natural predisposition to certain diseases, we also observe a natural *immunity from certain diseases*. This has been ascribed by some to the fact that the avenues for the invasion of the microbes are so well protected that they cannot enter the system, or that the blood and character of the tissues render it a poor soil for the proliferation of the disease germs; but these are unsatisfactory explanations in many instances. We know there are mild and malignant cases of scarlet fever, walking cases of typhoid, and cases of a profound type. We also know that some systems are peculiarly susceptible to the physiological effects of certain drugs, and others are not. For all such reasons, I am tempted to accept Arlong's explanation, that immunity is due to the inaptitude of certain organisms to feel the effects of ptomaines evolved by the microbes. According to his explanation, germs of infectious diseases may exist within the body, and the disorder they give rise to may be absent; for infectious disease *does not exist merely* because some noxious micro-organisms have taken their abode in the system. They exist because functional or structural troubles are brought about through the agency of ptomaines. Of course, this explanation does not apply to *all* infectious diseases, for in some instances, one attack affords no exemption from a subsequent attack; indeed, the susceptibility is rather increased than diminished. This is true of malaria, gonorrhœa, croupous pneumonia, and erysipelas.

The question of practical interest as to *how the disease is brought about by the bacteria*, is next in order. Some of the germs evidently remain, for a time at least, at the point of invasion and vicinity; here they grow, and as they grow, evolve the so-called ptomaines, which being irritants, often cause an inflammation, and this as in erysipelas, malignant œdema, cholera, and some forms of pneumonia, may go on without suppuration. Other bacterial forms cause the white blood cells to gather about the parts, and as they accumulate more and more, the leucocytes die, and we have inflammation with suppuration, as in abscess, furuncles, impetigo, and sycosis; other forms of bacteria cause inflammation with necrosis, as in diphtheria, hospital gangrene, etc.

Another class of germs proliferate at the point of invasion, and subsequently invade the deeper tissues. This is probably true in tuberculosis. The bacilli of tetanus appear to proliferate at the point of invasion, and spread along the nerve trunks, and finally enter the blood. The germs of syphilis and of leprosy are at first localized, and finally invade other parts. The virus of hydrophobia appears to develop first at the point of invasion, extends along the nerve trunks, and subsequently invades the central nervous system and blood.

In some diseases, the pathogenic germs are transported through the lymphatic spaces and vessels; in others, the invaders enter the blood, multiply there, and either remain or are deposited in different organs, or in all parts of the body; this may be said of the germs of anthrax, of typhoid, of acute miliary tuberculosis, and the various acute exanthemata.

An exact *classification* would be entirely premature. The most we can say at present is, that the effects of pathogenic germs may be local and constitutional, the result of the absorption of their toxic products. Take, for example, a case of malignant scarlatina, where a child in the midst of perfect health is suddenly seized with vomiting, perhaps violent diarrhœa, with a remarkably frequent and small pulse,

and such sudden collapse that the pulse disappears within eight to twelve hours, the face and the extremities become cold, and death occurs in coma within twenty-four or thirty-six hours, without any eruption having appeared. Such symptoms point to paralysis of the cardiac centre; and if these and all the various shades of brain symptoms in infectious diseases are not the result of ptomaine intoxication, it will be difficult to account for them in any other manner.

If it be true that infectious diseases are produced by the invasion of bacteria, their subsequent development and the poisonous compounds evolved during their growth, the next question to be disposed of is, *How and under what circumstances do these processes terminate?*

We have seen that under certain circumstances the accumulation of disease germs and their products may be so great in the capillaries as to destroy the vitality of the part by cutting off the blood supply. Now this may be a purely local condition; but let us figure to ourselves all the blood of the body charged with an organic poison, the capillaries obstructed with the invaders; and should this perchance take place in the same vital organ, we can at once appreciate how either or both of these conditions may produce death. If death does not take place under such circumstances, it is because at this critical moment something occurs which renders further proliferation of the germs and ptomaine production impossible, and recovery ensues, provided pathological lesions do not prolong the disease.

It was at one time assumed that the bacterial invaders were eliminated by the kidneys and other emunctories of the body; but Wyssokowitsch's experiments indicate, that in animals, at least, they are not thrown off by the kidneys, unless these organs are themselves the seat of disease. Nor can we ascribe the destruction of the disease germs to the leucocytes; for it seems to me, if they were not vigorous enough to cope with them at the onset, it is not likely that their phagocytic power increased during the illness.

There remain but a few explanations. One is that recovery ensues because of the exhaustion of certain substances

essential to their growth ; in brief, they die for want of suitable food. The second explanation, which is extremely plausible, is, that the very poison evolved by the bacteria has accumulated to such an extent as to prevent their own growth, and they die self poisoned. There is nothing strained in this theory, as culture experiments indicate this possibility. Since some bacteria do not flourish with a high temperature, it has been suggested* that a continuous fever heat may aid in their destruction ; but this seems to me the least acceptable explanation.

I have consumed much of your valuable time in the presentation of our knowledge on the germ theory of infectious diseases. Many points are still obscure and require explanation.

Whether internal medication will ever succeed in rendering pathogenic germs innocuous remains to be seen. Whilst we possess remedies of decided value for local use, it is doubtful whether we can employ these agents in sufficient concentrations to be of service in internal medication. Nevertheless, it is possible, that we may be able to diminish their virulence ; and we can at least place the system in a better condition to resist them, and perhaps, after awhile, some appropriate antidotes will be found for the various bacterial forms and their toxic products.

In the meantime, the bacteriologist deals with living organisms. In place of hypothetical agents, like miasms and contagia, he has isolated these germs, demonstrated their morphology and biology, and to what extent they are instrumental in the production of disease, and how and by what means these organisms may be destroyed outside of the body. All of these studies indicate that much may be done by efficient and thorough disinfection in the prevention of infectious diseases ; and it is in this field bacteriology will achieve its greatest triumphs, and humanity derive its greatest blessings.