speaks in a low, measured monotone which is as deep as the nethermost depths of human misery, suffering, and wrong; and, so standing and speaking, he seems as one fit to command from Heaven itself the boon of vengeance for which he supplicates. It has been objected to by some of Mr. Willard's critics that his tone is both too low and too monotonous in this scene; but it is to be considered, we think, by its effect upon the ears, the hearts, of those upon which it falls. I doubt if those who have heard the curse of *Lear* as Booth pronounced it, or of *Richelieu* as Forrest delivered it, were ever more moved by it, though it was sounded in a more heroic key, than were those who heard Mr. Willard's more subdued prayer. No one, I believe, was ever quite certain that *Lear's* or *Richelieu's* curse would have fulfilment, but no one doubted that *Cyrus Blenkarn's* would. The strange figure of "that poor bankrupt there" was clothed with his great wrong in majesty and power so great as to seem to compel the vengeance for which he asked. The man appeared for the moment to the overwrought imagination of the spectator to be himself the awful minister of retributive justice; he seemed to fill the stage, to pervade every part of it. He appeared more than a man, an overpowering image of one on whom sin and sorrow and suffering had laid their hands to dignify, strengthen, and ennoble. He seemed as great as fate itself, and those who heard his supplication knew that it would be answered, that *Cyrus Blenkarn's* enemies would be made even as he prayed they should be, as wax in his hands. It was not the author's words, but the actor's art, that assured to the audience the consummation of his prayer far in advance of its realization.

The great purpose — the moral — of the play is not destroyed, not impaired even, by the man's petition and hope for vengeance upon those who had wrought him such sore hurt. This baser desire of a noble mind was but an episode, a temporary yielding to temptation which vanished when the opportunity to realize it came to *Cyrus Blenkarn*. They who had wrought him ill were subdued, even as he had prayed they should be, to his will; but with all his wrongs and sorrows thick upon him he sat down in the place of wealth and power from which he had displaced them and simply asked, the time having come when he could say, Vengeance is *mine*, and *I* will repay, "What would *Mary* do?" He knew what the child that he had so loved, and had for so long mourned as wronged and dead, would do. He knew that, out of her infinite goodness, she would forgive her enemies even as she would be forgiven. So, in tribute to and influenced by his abiding love for her and her power over him still, he also forgave them. He did more. He gave them of his plenty. Then the original great purpose and moral of the play stood unbroken by any lesser, baser one.

At the end of the third act, in the firing-house, when *Cyrus Blenkarn* threw down the wall of the oven and with mad haste and trembling hands, his noble face blanched to the color of the clay, seized the crate of crumbling clay, the actor's look, his low, sharp cry of despair, struck despair to every heart in the theater, and when, a moment later, from among the shattered forms of beauty he plucked the perfect vase, holding with it, in his eager, hungry hands, the recovered secret of the ancient Tatlow pottery, dead and buried a hundred years, and dead and buried forever except for him, his exaltation, his mighty triumph,— for which he had paid down the price of hope a thousand times defeated, of thought, of labor, of the sacrifice of all the golden years of youth and manhood, and of all the things which others do hold more precious than life itself,— was only more pitiful than his previous desperation. The actor did not rave nor shout because he had discovered the secret of the lost art, the discovery of which would make him rich, famous; that would put his enemies as wax into his hands for him to stamp and mar and crush as his long-delayed and ever-increasing vengeance willed him to do. The moment of his triumph was one of those supreme ones in which the overwrought heart finds no relief in words. As the curtain fell upon this marvelously impressive scene *Cyrus Blenkarn* held close to his heart the precious vase which was vital with an art that his genius of patience and labor had restored to the world. A great joy illumined his face, but he said nothing. There were five recalls of the actor on the evening I first saw this scene presented. But the author as well as the actor contributed to its successful ending. The former had provided the body, and the actor had breathed into it the vitalizing breath of his genius, and it so became one of the most sentiently human scenes of the modern drama.

To the end of the play of "The Middleman" there was no descent from the high plane on which author and actor began it. But it was the greater power of the actor that brought the curtain down upon the last act so effectively. When the daughter that he had so long thought dishonored and dead stood before him, as one risen from the grave, alive, and the happy wife of the man she loved and who loved and honored her, and who had always done so, *Cyrus Blenkarn* stood awed to silence, fearfully bewildered and to reason lost as do those who see spirits walk. And then to see his face change from fear to doubt, from doubt to assurance that it was his living child he saw, and not the ghost of her, and to hear his exultant cry of joy as he flung his arms about and held her close to his old, scarred breast, was to see and hear something worth remembering forever.

We cannot always have actors on the stage of genius or talent like that of Mr. Willard's, but we can, if audiences so will it, have always plays which, like "The Middleman," elevate, not debase, the stage. "The Clémenceau Case" survives only by the sufferance of audiences, and the lovers of the drama have but to turn their backs upon that play and all of its kind to banish them from before the floats. The theater is one of the greatest of teachers. Why should it not be one of the best?

L. Clarke Davis.

The Discoveries of Pasteur, Koch, and Others.

A BRIEF REVIEW TO DATE.

THE subject of microbes and bacteriology has been often discussed before lay audiences. However abstruse the researches which have opened up the modern field of knowledge in this direction, however subtle the technique by which these researches are controlled and prosecuted, the fundamental facts of the subject are easily explained, because they are easily assimilated to those of everyday observation.

Microbes are plants of microscopic minuteness, consisting each of a single cell so small that many thousands must be placed end to end to traverse the diameter of a pin's head. These plants produce spores, exactly analogous to the seeds of visible plants, like those disseminated in the air, or clinging to solid substances, capable of maintaining their vitality for an indefinite time, and ready to grow and reproduce their kind whenever they can find a suitable soil upon which to implant themselves.

It is in the nature of this suitable soil, in the mode and consequences of the growth and reproduction of microbes, that this class of cryptogamic plants distinguish themselves in the most important way from the ordinary denizens of the woods and fields. Like other plants, microbes require oxygen for their development. But instead of appropriating oxygen from the air, they withdraw it from the molecules of organic matter in which they may find themselves embedded. The organic molecule therefore tumbles to pieces, as a wall falls down when bricks are taken out of the middle of it. In other words, the organic matter is decomposed by the intramolecular respiration of the microbes, and new substances are formed from the rearrangement of such molecules as remain.

It is in this way, as Pasteur proved in 1857, that the yeast plant causes the fermentation of beer and bread and wine. Plunged below the surface of the dough or liquid, thus withdrawn from immediate contact with the air, the yeast withdraws oxygen from the sugar of the barley or grape juice, or from the starch of the flour. Part of the oxygen is absorbed into the substance of the yeast plant, which, thus nourished, buds with inconceivable rapidity. The remaining atoms of oxygen unite with the carbon and hydrogen atoms in different proportions to form alcohol, carbonic acid, and glycerin. Thus the process of fermentation, which, in its entirety, had been known from the dawn of history, and in modern times had been explained by chemical theories, was now for the first time made clear, and shown to be an incident in the life history of a microscopic plant, and dependent upon its nutrition — upon its "intramolecular respiration."

That yeast consisted of microscopic cells was proved in 1680 by Leuwenhoek, the improver of the microscope. That these cells were plants, which breathed and grew by budding, was shown by Cagniard de la Tour in 1836; and in 1837 Schwann discovered numerous organic germs in the air, and associated with processes of fermentation and putrefaction. But it was the brilliant researches of Pasteur that first thoroughly explained the mechanism of the relations between fermentation and the vital processes of micro-organisms. From their date the yeast plant, which first enters history — and most dramatically — as the leaven which the Israelites did *not* have when they escaped out of Egypt, has become immortalized as the type of a class of living beings whose importance seems proportioned to their incredible minuteness and their potency to their invisibility.

The association of these micro-organisms with disease was established almost simultaneously with that of their relations to fermentation, and low and humble was the door which opened to research the magnificent field of inquiry now being everywhere prosecuted with such restless activity. It was on the body of the silkworm that the first pathogenic organisms were found — by Bassi — in the disease known as the muscardine. Afterward the potato blight and other vegetable diseases were similarly shown to depend on the invasion of microscopic fungi, entering into a struggle for existence with their hosts. Analogous fungi were found in several skin diseases affecting human beings, and finally, in 1853, Davaine discovered little rod-shaped bodies swarming in the blood of patients suffering from splenic fever. Inoculations of animals with a drop of such blood sufficed to produce the disease in them, and a drop of their blood in turn originated the disease, and so on, until by successive generations the original infecting drop might be considered reduced to the trillionth dilution and beyond. The virulence even increased with each new inoculation. The apparent paradox was only explained by the fact that the rod-shaped organisms — the bacilli, as they were thenceforth called — reproduced themselves like plants sown from seed, so that it was a matter of indifference how large a quantity should be originally used as a source of infection.

This fact is of cardinal importance in the theory of infectious diseases, and in the practice of disinfection and prevention. Upon it depends the whole system of antiseptic treatment which, since the Scotchman Lister first deduced it from the researches of Pasteur, has wrought a revolution in surgery unparalleled in the history of the world. It is not enough to diminish the number of germs in the air or the media brought in contact with living tissues liable to infection. The germs must be absolutely excluded, for the fewest number, if falling upon a propitious soil, are liable to propagate rapidly, and to determine all the consequences which could follow the most massive invasion.

The epoch-making discovery of Davaine was followed by similar discoveries in relation to many diseases long known to be infectious, but whose agent of infection had been hitherto shrouded in mystery. Singularly enough, however, it is for several of the most familiar diseases that the precise infecting microbe yet remains to be discovered.

The micro-organisms associated with infecting diseases differ from the yeast plant by their mode of reproduction, and hence belong to a different botanical class. The yeast plant buds, and hence is called the Spross pilze, or budding fungus. The bacteria consisting of either round cells (*Micrococci*), or rods (*Bacilli*), multiply by scission, each cell dividing into two new individuals. They are hence called the splitting fungi, or Spalt pilze (*Schizomycetes*). Like ordinary visible fungi, these microscopic organisms are destitute of the chlorophyl which enables green plants to fix the oxygen of the air, and therefore they withdraw the oxygen needed for their nutrition from the molecules composing the vegetable or animal tissues upon which they may have become implanted. In so doing they resemble the yeast plant, and an analogy is immediately established between the process of fermentation set up by the yeast in organic fluids and the processes of disease often initiated by bacteria in organized tissues.

The process is not always a disease. Many bacteria develop chiefly or exclusively upon dead tissues, animal or vegetable, like the fungi on decaying trunks of trees, and, like them, could obtain no foothold on a living organism. The decomposition and reduction to elementary gases of the organic substances daily consigned to the earth depends upon this action of countless swarms of bacteria — action in this case most beneficent, indeed, indispensable. Indeed, if the soil be too poor in bacteria, as sometimes is the case with the sand of the sea-shore, organic matter is insufficiently decomposed, and the intermediate products of putrefaction remain to pollute the water of the vicinity.

Again, the intestines of all animals swarm with bacteria. These are present in the pancreatic juice, and they aid the digestive ferments in breaking up the ingested food and providing for its assimilation.

Thus some among these now dreaded bacteria are useful, many others are harmless. Flugge enumerates 132 species of bacteria (*Schizomycetes*), of which 44 are round cells (*Micrococci*); the remaining 88 are little rods (*Bacilli*); 16 species of the first group, and 36 of the second group, originate specific diseases in either man or the lower animals; leaving 80 species which are entirely harmless. The last either never gain access to the animal organism, or, being admitted, quickly die without reproducing themselves, or may even multiply within the tissues of the body yet occasion no disaster.

It is when disaster occurs that the analogy with the fermentation set up in saccharine fluids by the yeast plant becomes most striking. The process of fermentation — *i. e.*, the growth of the yeast plant — is attended by the formation of alcohol, carbonic acid, and a little glycerin. The process of growth of the parasitic bacteria is attended by the formation of numerous organic substances (33 have been described), among which one class possesses well-defined poisonous properties, and resembles in many respects such poisonous vegetable alkaloids as conicin, atropin, woorara, or even morphine. These latter substances have been called ptomaïnes. Their discovery is one of the most recent and remarkable in bacteriology, for it tends to establish for the first time a plausible theory of the mode of action of pathogenic bacteria. This action could not be satisfactorily explained by the mere presence of bacteria in the body of a patient ill with a given disease; because it often happened that the bacteria seemed to remain localized in one given tissue, yet, nevertheless, the entire organism was poisoned. This is especially the case with diphtheria. The fact seemed inexplicable so long as the microbes were supposed to affect only those tissues with which they came immediately in contact. It is now explained by the supposition that the injurious action is more indirect. The decomposition of living tissue caused by the growth of the bacteria in it is relatively trifling in amount and importance. It is the poison which is formed incidentally during the bacterial growth which is to be dreaded. This first kills the tissue immediately below that in which the bacteria are growing; then, being absorbed, tends to overwhelm the heart and nervous centers. Fresh supplies of poison are constantly being generated at the foci of infection; and this constitutes the characteristic peculiarity of bacterial diseases, and distinguishes the effects of their organic poison from that of the venom of rattlesnakes, which acts once for all at a given dose, and without possibility of reproduction.

The ease with which the foregoing statement can be made and read conceals the enormous difficulty of the researches by which these facts have been demonstrated. Three problems presented themselves — how to recognize the different species of bacteria, identify them, and distinguish them from one another; how to prove their causal relation to specific diseases; how to contrive means to antagonize their injurious action. The method which has led or is leading towards the solution of these problems is profoundly simple in its conception and wonderfully fertile in its results. The bacteria are cultivated in suitable media, as ordinary plants are cultivated in suitable soils. The colonies or masses of microbes thus obtained are visible to the naked eye, and much more readily differentiated than are the microscopic cells from which they originate. The culture of any suspected microbe, therefore, is now always used as a means of identification. By following the complete history of the plant from its invisible origin to the death of the visible masses which have been generated under the eye of the observer, it becomes possible to discover what circumstances favor, what antagonize, the growth.

This culture method is due to Pasteur. He sowed micro-organisms in alkaline fluids, whose exact composition he delicately varied until the most favorable conditions were obtained. A minute drop from such a fluid, though representing the trillionth dilution of the original substance, would swarm with bacteria reproduced from the original stock, and inoculated under the skin of animals would produce the same symptoms as had resulted from the original infection.

It was therefore by the results of experimental inoculation that the fluid cultures enabled the observer to identify any species of bacteria. An immense stride was made, however, by the substitution of solid substances upon which to cultivate bacteria. This was Koch's first great achievement. He sowed the bacteria first on boiled potatoes, then on gelatin solidified in cakes or in test tubes. So far has this kind of horticulture now advanced that the exact taste of different species of bacteria may be suited by mixing different substances with the nutritive gelatin, among which some form of beef tea seems to be best adapted to these carnivorous herbaceæ.

The first micro-organisms discovered were rendered visible in fluids merely by being exposed to very high powers of the microscope (1500 diameters). But as the research continued, and bacteria were sought not only in fluids but in tissues, another device was necessary in order to make them distinguishable. It became necessary to color the specimen, and to find, moreover, some method by which the bacteria could be stained a different color from that of the tissue in which it was embedded. The second great achievement of Koch, after the invention of the gelatin cultures, was the discovery of a stain which did actually succeed in drawing out of its hitherto unfathomable obscurity the tubercle bacillus.

This great discovery was made in 1882, and immediately set observers all over the world to work upon experiments of criticism or control.

The German discovery of a specific agent of infection in tubercular disease had been prepared for by researches made in France in 1866, in which Villemin demonstrated that tuberculosis was an infectious disease, identical in general character with the acute contagious diseases, but differing from them principally in the slowness of its march. It was also known that a constitutional predisposition on the part of the living organism was far more necessary to enable the tubercle bacillus to obtain a foothold in it than seemed to be the case for the agents of such diseases as scarlatina, diphtheria, etc.; also, that direct infection from patient to patient was immensely less liable to occur. These facts of clinical observation all find their rational interpretation in the history of the tubercle bacillus, as it has now been unfolded — a secret history more momentous than that found in the memoirs of a thousand Talleyrands, for in such histories literally lie the issues of life and death.

It has been demonstrated by the numerous observers who have followed the guidance of Koch that the tubercle bacillus is present in all the little tumors known as tubercles, which may invade any organ of the body, and are the basis of the lung lesions in consumption. The bacilli are also present in the expectoration of consumptive patients, and the exact nature of a doubtful cough may thus often be diagnosed. The bacilli may be cultivated in masses on gelatin plates, and fragments from these again planted and cultivated, and so on in an indefinite number of successive generations; and inoculations made from minutest fragments of the latest, inoculated into animals, will determine characteristic tubercular disease.

Thus the demonstration is complete that tubercle is caused by the bacillus finding soil favorable to its growth in the tissues of certain peculiarly predisposed persons. The delicacy of the nutritive conditions required for this dangerous invisible organism may be inferred from the fact that the tissues of so many persons will not nourish it, but rather prove deadly to its development.

The ancient problem of Samson seems to have been repeated for the tubercle bacillus. From it alone could be wrenched the discovery of the means by which its strength could be antagonized. It had long been known that certain cheesy masses which had been familiar in the lungs of consumptive patients consisted of lung tissue completely destroyed, and reduced to a structureless pulp. It was now inferred, by comparison with the necrotic tissue found around foci of bacteria in acute diseases, that this tissue was destroyed by the direct agency of the bacillus growing in it. Aided by the new discoveries in regard to the production of ptomaïnes during the growth of bacteria, it was inferred that the destruction of tissue was due, not to the micro-organism itself, but to the poison formed innocently during its growth, as the alcohol is formed incidentally during the growth of the yeast plant. Now when the tissue died, the bacillus embedded in it soon died also, as the coral insect dies in the mausoleum it has built for itself. The problem given could therefore be stated in this form: To find something which will either directly kill the bacillus, or so destroy the tissue in which it is embedded as to arrest its development.

Until the present moment scientific expectation has chiefly been directed along the first line of thought. It has long been known that the products formed during the growth or respiration of bacteria always suffice, when accumulated in sufficient quantity, to annihilate their existence — precisely as a certain accumulation of carbonic acid gas in the air suffices to kill the animals exhaling it.

Just before the announcement of the most recent and famous discovery of Koch, Dr. Trudeau, of Saranac Lake, carried out a remarkable series of experiments to test the effect of inoculations with fluids in which tubercle bacilli had been growing, and which therefore might be presumed to be saturated with the products of their growth. These experiments were guided by the great doctrine of vaccination, which was the starting point of Pasteur's researches on hydrophobia. The attempt was made, not to cure tubercular disease in animals already affected, but by the inoculation of an attenuated tubercular virus to render them impervious to subsequent inoculations with tubercle. This is the mysterious method by which immunity against small-pox is secured by vaccination, and by which Pasteur seems to have secured immunity against the development of hydrophobia by inoculation with attenuated specimens of rabic poison. Dr. Trudeau's experiments had all negative results, but they are nevertheless extremely interesting.

It is by slightly varying both the method and its intention that Koch's extraordinary results have been obtained. He has made a glycerin extract of a cultivated mass of tubercle bacilli,—precisely how has not yet been told,— and presumes to have thus obtained in a concentrated form the poisonous substance whose incessant production enables the living bacillus to destroy the tissue around itself. Injection of this substance into the body of a patient, although at a distance from the seat of the disease, thus intensifies and accelerates the destructive, the necrosing, process going on spontaneously under the influence of the disease. The poison is carried to the tissues whose vitality is already undermined, and destroys them so rapidly that they immediately begin to slough away from the surrounding parts and to be absorbed. It is the absorption of this dead tissue into the circulation that is apparently the cause of the fever which is so constantly produced as a result of the lymph injections. By the uprooting of the soil on which they were growing like a destructive mold the bacilli are also uprooted and thrown into the circulation. It is perfectly natural, therefore, that, as has been reported, bacilli should be found in the blood of patients undergoing the treatment. It is not impossible that in some cases they may thus be carried to tissues and organs hitherto uninfected, and re-implant themselves. The immense probability is, however, that the bacilli die in the torrent of oxygenated blood. The researches of Nutall and other German observers, which have been repeated by Dr. Prudden in New York, have shown that the blood of living animals possesses extraordinary germicidal properties, at all events for many forms of bacilli. Tuberculosis is not a form of blood poisoning; the bacilli creep underground as it were, through the lymphatics, the sewers of the animal economy. Hence, as Dr. Quimby has pointed out in an interesting paper, the specific treatment of tuberculosis by the Koch lymph requires to be reinforced by all hitherto known methods for invigorating the patient, and, especially in pulmonary disease, for stimulating the lymphatic circulation of the lungs.

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