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SOME MECHANISMS UNDERLYING ORAL INFECTIONS AND THEIR CONSEQUENT LOCALIZED AND GENERAL LESIONS*

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I COULD NOT SPEAK this evening without expressing my very great appreciation of the splendid and unanimous support that has come from the profession in this state, not only to me personally, but to this work with which I have been associated for the National Dental Association, and I bespeak for the National Dental Association a very much larger future and usefulness than would have been possible for it had it not been for the spirit of Iowa, and I take this opportunity to express my great appreciation for the invitation to come the third time to your state. It speaks louder than any words that you could use in assuring me of your sympathy and co-operation with the work.

We will speak this evening of the work of the Research Institute first, and then of some special studies that we have been making, and in regard to the work of the Research Institute I want to say briefly that the researches are being conducted in eight different cities: in Minneapolis under the direction of Dr. Hartzell, assisted by Drs. Henrici, Grey and McCarthy; in Colorado Springs under the direction of Dr. McKay; at Chicago under the direction of Dr. Noyes; in Ann Arbor under the direction of each Dr. Ward and Dr. Bunting; in Boston under the direction of Dr. Percy Howe; in New York City under the direction of Dr. Gies; in Cincinnati under the direction of Dr. Callahan, and in Cleveland under the direction of Dr. Fahrenwald and myself, Dr. Fahrenwald being a trained metallurgical expert. In connection with this work I wish to state that several very important discoveries from a metallurgical standpoint have been developed and those processes are being protected for the dental profession by patents, which patents are being assigned for the free use of humanity.

I shall not have time to study with you at any length the splendid work which these men are doing. When we mention the work of Dr. Hartzell we are speaking the latest word on oral infection as related to systemic disease, for no man—I shall not except any—has done or is doing as important work in working out the details of mouth infections as they relate to systemic disease as the magnificent work of Dr. Hartzell and his splendid corps of workers, and I have very great pleasure in doing what little I can to raise money to support such work as they are doing. When I tell you though that a man like Dr. Henrici is devoting all of his time to research work and must have support, you will understand why a man of his competency, doing

*Stenographic report of a lecture delivered before the Iowa State Dental Society, 1916.

nothing to earn money, must have a salary competent and commensurate with his ability and that salary must be forthcoming from month to month, and we must know more than a month ahead, and more than a few months ahead, whether we can pay such salaries. Therefore, the research department of the National Dental Association, which is the Research Institute, is working out a plan whereby we shall have ample support for all the research work, and we shall probably have an opportunity to speak of that at another time. But the plan, in brief, is to have an endowment of one million dollars, the interest on which would be practically fifty thousand dollars a year at five per cent., and that interest will maintain and enlarge our present researches and carry them on in a way that would be commensurate with the problems that are at hand. And, more than that, it is hoped and expected that the dental profession of the country will take practically one-third of that million dollar endowment in this simple way, viz.: by paying one dollar additional dues each year, which dollar will pay the interest on twenty dollars of principal. If, then, the 18,000 members in the National Dental Association each pay one dollar annually, we will have the interest on twenty times $18,000, or $360,000.00, which would, you see, be more than a third of the million. And I have an idea that every state in the Union will take that matter up unanimously and put it into effect within twelve months. Practically every state that has taken it up has done so unanimously, and at their first opportunity after the plan was suggested. There are important difficulties with the present plan of a few men each paying a large subscription for a period of years. It is not fair in the first place that a few men should pay for the privileges and benefits that come to the large majority. Accordingly all are put on an equal basis by each man paying one dollar a year to support the research work. That plan is to supersede the individual pledge plan and we will then have every person feeling that he has an equal part with everybody else.

The metallurgical department is furnishing substitutes for platinum in sufficiently large quantities to amount to a saving of many thousands of dollars to the dental profession. I should think it would amount to nearly twenty thousand dollars that has been saved to the dentists of the United States already by the tungsten that they have purchased through the research department at cost. It is used for orthodontic appliances and reinforcement over which to cast bridges, and for crowns, posts, etc. The sum saved would go a long way toward paying for all the researches that have been made. You are all familiar with the effort to make this an everybody's movement, a National Dental Association work, and when I tell you that the medical profession and the laity are, if possible, just as much interested in this movement as the members of the dental profession, you will realize the great responsibility that is upon the dental profession, for they are asking us many questions that cannot, as yet, be answered.

We are to discuss this evening some of the mechanisms of infection. This problem is infinitely too large, too difficult, for me to discuss compre-

hensively. I shall bring out only a few of the mechanisms and as we do so I want you to think of the relation of the organisms to the human element, the human body, a great deal as you think of other mechanistic problems; and to get your thought in that respect I am going to ask you to think with me for a moment of the little caterpillars that trouble the orchards. This little organism, as you have observed, goes to the end of the twig; it never goes down to the ground; the ground is cold and damp and clammy, and it would die there; there is nothing green there for it to eat and it never goes down, it always goes up to the end of the branch—God's wonderful instinct we call it. Yes, but now we can see the foot-prints of God; we can understand how God makes that little insect go to the end of the twig, for God has put into the eye of that little animal a motor control just similar to the patent recently purchased by the government which controls the little boat that goes out with a load of dynamite, a torpedo, controlled by a wireless apparatus; and just so God has put into the eye of that insect a mechanism that, when the light strikes it, it cannot travel against or away from the light, so, since the light is above it must go to the end of the twig. And the involved physical chemistry is now pretty well understood, for when that little organism goes to the end of the twig and finds there the green succulent leaf, it takes in a new chemical from that leaf which acts on its body and on its eye in such a way that after it has once filled its little stomach with food from the green leaf, the chemistry of the eye is changed and it is freed from that mechanistic control; it is no longer light-controlled, heliotropic, and can now turn around and go down. If you take those little insects and put them in a little box right beside some green leaves and put a bright light just on the other side, and even though there is an abundance of food all around and behind them, they cannot turn around to take that food, and will starve. Why? Because of the mechanistic, physico-chemical control. In other words, we just see for a moment God's method.

Tomorrow evening when we are studying developmental deformities and the entire process, and will see the elements coming together to make the component and ultimate life, you will see they are controlled by chemical reactions which take place so quickly that you cannot see them, and you will also see organisms that move under the mechanistic control, for example, the paramecia with the electric current. They are so perfectly under the control of the electrical current that they go in only one direction, and when you reverse the current they can go only the opposite way. What is it? A mechanistic control. And these little organisms that we are studying this evening do very many of these same things. If you take endameba, it has just as definite mechanistic problems. The very process of its throwing out its pseudopodia is one largely of the relation of surface tension at that point and the rhythmic motion, as you will see in the motion pictures, by which it throws them out in concentric waves is almost entirely a mechanistic problem.

Now as we undertake to get into an attitude of mind to see these things mechanistically, let us also think of how much alike the organisms that are in our mouths are like ourselves. You can hardly tell the organisms that you will see tonight on the screen from some of the first-stage cells of embryonic life; they will be identically like many embryonic life forms that we will see tomorrow night; they are one-celled organisms; there was a time when you and I were each a one-celled organism; then we changed to two cells, then to four, then to eight, etc. These we study tonight are practically all one cell, just as we were once, and they behave just as we did—they eat just as we must do. Every living cell, whether a bacterium or a cell of my body from the lung, the liver, kidney, or my hand, behaves just like every other cell. It must do three things, viz.: it must eat, it must assimilate and it must eliminate. Now let us get this definitely in mind, that every living cell, whether a plain human tissue cell, whether a bacterial cell or any animal or plant tissue cell, does these same three things. There are, however, certain resting stages in all these different forms of life. A grain of corn is a resting stage. A human ovum is a resting stage. The spores of bacteria are resting stages. They are all identical. A resting stage only differs from the active in that it contains potential life instead of active life. The potential life that is stored up is expressed in the grain of corn as so much enzyme, so much food, and a fertilized germ cell. This germ of life has been fertilized, for in the corn we have the male and the female elements, nourished and fed by the digestive enzyme acting on the starch just as you have been nourished by your stomach digesting that good dinner you had tonight. Each and every living thing has a digestive fluid so that when we study these bacteria tonight we will find that they are living by means of their digestive fluid just as you and I do. The chief difference between one kind of cell life and another, whether human or animal tissue, is the difference in the protein that makes up the cell. And similar cells have similar proteins, but the vital part of all cell life is that protein.

I want you to keep another important fact in mind. Life's activity is metabolism and has to do with vital processes. You cannot have continual life without activity. It is impossible for the resting stage, such as these germ cells that we are speaking of are capable of assuming, to continue for a very great length of time, and these spores that we shall study exist as such in the mouth for not a very great length of time. But these different forms of cell life which have different protein within themselves will live on a common protein from which they make their particular protein.

Now, when you take a splendid piece of roast beef like I had tonight, and you make it over into your various cell proteins, what takes place? Your body furnishes first an enzyme or digestive fluid to split up the protein you take into your body and makes it over into a protein suitable for your individual cells—a different protein for every different tissue of the body.

The difference between the dinners that you and I ate tonight would depend upon our taste, and our taste is determined largely by the digestive enzyme that we have, or digestive ferment with which we do the digesting. Now, let us suppose that you take into your body a quantity of beef-steak. How does it get to the cell of your hand? First, those large molecules that make up the protein of the beef-steak are split up into smaller elements and are passed through the walls of the alimentary canal, and get into the circulation and pass into the blood stream and from the blood stream are delivered to the different tissues of the body. Now, the different tissues of the body in turn have different digestive fluids and they will take the particular split protein that comes to them, will make it over to suit their own cell life, and they will make it fit exactly the type of protein that is needed for their cell structure. Now supposing some of the protein would go through the stomach wall directly into the circulation; what would happen? It is so foreign and coarse, so to speak, that it cannot be digested.

Take another illustration: Suppose you had a soft boiled or a raw egg and you take it into your stomach. It is digested and thereby split up and then the protein in a split form is put into your circulation. Now supposing you put some of that egg into your circulation without breaking it up in your stomach. What would happen? Why, it would be as indigestible there as so much foreign substance—just like chips floating on a stream of water; it would not be acted on at all at first. If you were to take even one-millionth part of an ounce of an egg and put it into your blood stream tonight and then next week put in a greater quantity, it would kill you. Now why? Note when you put it in first it would not hurt you a bit; but when you put it in the second time it will probably kill you. What happens? When that first protein goes into your blood stream, immediately nature realizes the presence of a foreign protein and undertakes to build up a chemistry that will destroy it. There is no chemistry normally in your blood stream to destroy the egg albumen, but presently one will be built up and in probably twelve to fourteen days there will be so perfect a chemistry built up that if you put any more of that protein, or most any protein whatever, into your blood stream on two different occasions, when it goes in the second time your blood stream is ready with a chemistry that will split it up so readily that it will probably kill you. Now, how does it kill you? Some of you cannot eat eggs; some of you cannot drink milk; some of you cannot eat bananas. When I was a student in college and bananas were cheap, I overate on bananas, that being a cheap food, and I was trying to live very cheaply. What did I do? Probably every person in this room has done it with some particular kind of food. You have eaten enough of that one food so that some of it goes through the alimentary wall and it has thereby gotten into the blood stream in sufficient quantity that ever after that, because a chemistry was built up to tear that protein apart, whenever you would eat too much of that protein it would go through your stomach wall and the least little bit getting into the blood stream circulation would be

sufficient to bring on certain definite symptoms. That is the process when a person is not able to eat a certain kind of food, and it is identically the same process which takes place when you get an immunal disease.

Let us suppose that you have had typhoid fever, and now you do not get it again. Why? When you first got typhoid fever, an organism got into the blood stream; you were not sick at all; the organisms themselves did not kill you, the organisms themselves did not hurt you—they did not even make you ill. What they did was to produce a certain definite specific protein by taking your blood proteins and building a toxic protein out of them, which in turn floated through your system just like the egg albumen. You said you never felt better, until suddenly your blood had perfected a chemistry whereby it could take that foreign protein and split it up. Now here is the tragedy: One-half or one part of every protein is a rank poison, just as common table salt is made up of two poisons, sodium and chlorine; you could not take either one into your system and yet they both do not hurt you. Every protein is made up of a poisonous part. That action, then, of the blood in splitting up the protein that gets into your blood, which we know as an enzyme action, is the very thing that makes you sick and you were not sick until the blood liberated the toxic poison from the protein. History shows that the stronger the man is the more likely he is to die with pneumonia or typhoid. Why? Because the more of that protein that he can tear apart in a given length of time the more poison he thereby liberates in his system and it is the presence of that overwhelming amount of liberated poison that kills the man. That is why the great epidemics in the past have not taken the poorest of the population but have taken the best of the population. The fact that they can rapidly tear down the bacterial specific protein is the very thing that is their undoing. The man who has so weak a constitution that he cannot tear the protein apart rapidly gets over the disease.

Now then, coming back, let us suppose that you have an infection, say a typhoid infection; you have taken the germs into your stomach, they have gotten into your circulation and all through the body and generate or create a new specific protein which of itself is not a poison to you, but finally your body builds up a chemistry for that or any other foreign protein that gets into the blood, and when it does and splits it up in sufficiently rapid quantity then immediately you feel sick and develop a fever. The fever that accompanies it can be produced precisely the same without any bacteria whatever by simply taking the proteins themselves and injecting them into the body.

Now, what has that got to do with mouth infection? Why, it is the basic principle of the whole process. It is why you and I are alive tonight. Almost every one of us would have enough bacterial infection in his mouth to kill him if it were not for the fact that each body has built up a chemistry that destroys the protein as fast as it comes into our blood. But finally some people get so sensitized to it that a very small quantity is sufficient to seriously injure them. I know of a case where a man

was suffering from protein poison from eating apples and they suspected that was the cause; so they took some of the apple and rubbed it on his skin, first extracting the protein, and from Tuesday until Thursday they thought he would not live. He was so extremely sensitive to that small amount of apple protein that they found that one seven-millionth of a gram of the protein of that apple was sufficient to bring on a profound reaction in him. That seems strange to you, but yet you drive through the fields and come in contact with the pollen from the plants and it does not take one seven-millionth part of a gram of the pollen to make you ill. Some people cannot ride behind a horse, and others cannot smell certain flowers. There are a good many things that irritate different people's bodies. Some people cannot be in the presence of rag weed in pollen season without causing hay fever. It is the same process. They are sensitized to an infinitely small amount of the pollen.

Just so, then, our mouth infection problem is related directly to our sensitization and a great many people are so sensitized that they are just on edge all the time; they are in the balance and the balance swings one way and then the other and if you get to studying this protein poisoning problem you will see that they sway as a pendulum does. For a period they are perhaps having an intense headache, a great deal of lassitude, and perhaps the next week they will say: "I never felt better in my life." What has happened? Why, just by the presence of that protein, Nature has been stimulated to build up its chemistry a little more actively, and immediately that it has done so they are able to destroy and neutralize that poison, and for two or three weeks or maybe longer they are a great deal better, until finally they sag back to the same position, and so you see them oscillate.

You may have the process in your own life. That is the reaction and the whole process of using a vaccine. If we are going to be successful with it we will put in the right amount to stimulate nature to build up the proper chemistry.

We will now take the slides and study some of the different infective processes, and as we go along, if we have time, we will try to discuss some of them from a mechanistic standpoint, and for the final pictures we will have a motion picture of the organisms of the mouth and of the blood stream, showing the normal blood stream with the blood cells seen driving through very plainly, and then bacteria will be introduced into the blood stream and you will see the process of agglutination and embolic clot formation. It is an interesting thing that when you take a rabbit and inject the anthrax germs there is something about the rabbit's blood that destroys entirely that organism, but they grow readily in a guinea pig's blood. There are, then, in our blood, certain elements that are provided or developed by nature for destroying organisms and, if we have time to go into the mechanistics of resistance of the different tissues of the body, we will emphasize them, and the process of resistance or immunity to disease is entirely measured

by the activity of this reaction. Why is it that the organisms in my mouth do not enter my system? It depends on three things, chiefly, as pertaining to the organism. That organism must have virulence we say. What is virulence? It is the ability to produce disease, but that is not related always to my susceptibility; it must have another thing, it must have the ability to break down the resistance of my body and it must have numbers. And there will be another side to the battle, the elements of which will vary, namely, the protecting skin of my body, the resisting agents in the blood and the traveling army of leucocytes and phagocyting cells.

So think of every cell, whether a bacterial cell of a human tissue cell, as having these three elements: It must be in the presence of food; it must digest that food and it must eliminate it. Now supposing that a bacterial cell was affixed to a living cell in my mouth; both are at the same game, both have largely the same weapons of attack and defense. Just as the bacterium is trying to throw out a poison to paralyze the tissue cell and is trying to digest the tissue cell, just so the tissue cell is throwing out a fluid to digest the bacterial cell and each one is at the same time building up a chemical that will paralyze the other as well as digest it or neutralize its injurious effects. Now, the body has these wandering cells or white blood cells—we will see them wandering through the blood stream—whose function it is to come to the bacteria and collect them. That is almost entirely a mechanistic process and they have the property of furnishing a chemical that will dissolve, digest and paralyze certain of the bacteria. What is the reason that you, for example, will not be particularly subject to a certain infection that will be perhaps very natural to a certain group of people living in some other district? Let us take, for example, the white plague. You realize that certain peoples are more susceptible than others. Some have a chemistry that is already built up which will attack the first organism or protein that gets in from that organism, and destroy it immediately, while others would not have that chemistry. In other words, as we will see tomorrow night, we actually inherit a preparation, a sort of chemistry, that will prepare us for it. You take the measles; it is almost always fatal to the Eskimo. It is not so with us; we have somewhat of an immunity. Syphilis does not hurt the Chinese much; it is quite destructive to the ordinary Caucasian and it is absolutely fatal to the Eskimo. Why? Because these different peoples have built up, or failed to build up, a resistance to that particular infection. An ordinary sheep will die of anthrax, while certain wild sheep living in the hills never get anthrax; you could not inoculate them with it. Why? They have built up an immunity to it. What is an immunity? You cannot have immunity to typhoid without having had typhoid fever or your ancestors having had typhoid fever. The very reason that I have a chemistry to fight any particular contagious and infectious disease is the proof that I have had that protein in my blood and have acquired the chemistry to destroy it and that is the reason we do not die of mouth infection. We have a mouth infection continually with us and it has

built up within us a resistance to it, and because we have a high resistance to it we escape its effect and take care of the poison. When it gets into the system it does not seriously attack us. But here is the tragedy of the whole mouth infection process: The organism that will attack us and produce a definite reaction and make our chemistry fight it, is not always the one that you are in most dread of. It is also those that do not irritate your body, and that includes strains from nearly all the streptococcus group. I repeat—the tragedy in the whole dental field of operation is that we are dealing with organisms with so low a virulence and irritating ability that when they get into the tissues at the apex of the tooth, they will lie there for years, even whatever time the patient may live, and produce no soreness or irritation observable on the outside, or to the patient. I say it is a tragedy for if it were worse it would be better. If they would make a bad sore at the apex of the root, nature would build up a resistance and fight, but because they have a low virulence and because they can live there without producing any local sore, they can produce a toxin which passes out into the blood or pass out themselves and select tissues.

Toxines have a selectivity for tissue. Did you ever have the mumps? If you take the organism for mumps and grow it outside of the body and inject it into animals, it will select the parotid glands and make them swell. If you inject that organism into a pregnant dog and then kill her, you will find the organisms not only in her parotid glands, but also those of the unborn pups. That organism has a selectivity for that particular tissue and its specific toxin has also. And when you have bacteria growing at the apex of a root and they produce a toxin, it may pass out and keep on irritating a special tissue. That irritation prepares that tissue for the invasion of that same organism and it may be a joint, it may be in the muscular tissue, it may be nerve tissue or it may be in the heart valve tissue, but with that toxin going through the system, its selectivity often precedes the infective process. So it is of very great importance and wonderfully significant that when a case of arthritis comes to us the lesion that we will look for and the one we will be most afraid of will not be the active inflammatory process or the abscess with the fistula, because that is not the type of organism such as seems most frequently to produce arthritis. The organism that will produce a quantity of pus sufficient to produce a fistula is not the type that produces arthritis; and you will see many of these cases like I saw last week of a man who was carried into the Research Institute—we have a number of them carried there because they cannot walk—with ten abscesses at the apices of roots and only three with fistulas, and I will show you the case of a woman, who is now walking and who has not for years, where there were five infected areas and only one with a fistula. What is the tragedy? The tragedy is that the strain of organisms that we are most concerned about is the one that produces no appreciable sore; the tooth is never even lame. There may be but a very slight area of absorption about it.

The first case I will show you is an illustration of this selectivity. This man, about fifty years of age, has been out of employment for four years, has been incapacitated so that he has been in hospitals a great deal of the time for two years and the symptoms have been those of a liver and stomach disturbance. A careful study of his body by different men revealed no local source of infection. One or two physical examinations were made and we found an area of absorption about two of the lower incisors. He gives a history of having had a boil on his chin about twenty years previously. The significant thing is that one of these teeth had been treated and the other had not. We took a strain of germs from this dead pulp canal and inoculated white rats with them, with the results shown in the next slide, a selectivity in these animals for the liver. Remember, this man had been taken to the hospital for gall stones; they decided not to operate at that time. The next slide shows two things that are important, not only the characteristic infected area forming a miliary abscess but also a blocked blood vessel. Note the mechanism of this—that there has apparently been a stoppage of the blood vessel and the infection arose around it. The organisms within this occluded blood vessel had the ability because of their digestive fluids to digest the tissues of the liver; they possibly could not digest any other tissue of that man's body, and they form multiple miliary abscesses all through the liver. With no other treatment than the treating of these teeth, which was done by treating and filling the roots, and root amputation, that man gained so rapidly that in six weeks he was back managing his business, working from seven o'clock in the morning until eleven o'clock at night. He lived in another city and his physician called me on the long distance telephone to tell me that he had no doubt but we had found the cause of his trouble. Why this selectivity? The organisms growing in that environment all that time probably covering twenty years, had developed a particular type of toxin which selected the liver tissue as did also the invading organisms, and continually produced the irritation and destruction in this tissue. We may have other tissue selected as we indeed often do.

(To be continued)

Isn't it high time that the root-canal problem be given a short vacation for better assimilation, and that a little attention be given to the subject of artificial dentures made by the dentist, rather than for him by the office boy or the commercial laboratory? Let's stop making plates at so much per and give our patients the highest type of service known to the profession for a dignified professional fee.—*N. S. Hoff, Dental Register.*

W 73 Part II

SOME MECHANISMS UNDERLYING ORAL INFECTIONS AND THEIR CONSEQUENT LOCALIZED AND GENERAL LESIONS*

BY WESTON A. PRICE, D.D.S., M.S., CLEVELAND, OHIO
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(*Continued from page 378 May Summary*)

Here is a case that is being treated in the Research Institute. This woman was just like a cast when we started; she could not move her hands, she could not move her knees, they were perfectly rigid; she is now walking on crutches. She had been nine years getting worse and worse and had the prospect not only that she was going to be petrified, as she called it, but her husband had said she must do one of two things: she must die or she must get better. She had four beautiful children, one after the other, and they had been given away. The dream of her life was lost; she was helpless, she was hopeless, she was to have her husband leave her or she was to get better or die. She had been in different hospitals without avail, but now with no other treatment, the fingers have all straightened out, she can move the joints which were perfectly rigid, almost perfectly straight, and at the time we started she could not flex them an inch. The next slide shows the dental condition. There was a crown on the lower bicuspid; which tooth had a fistula. There was no area of absorption around the lateral, which had a crown but no fistula, and this lateral with an abscess, a molar root and a bicuspid root, all five with areas of infection and only one with a fistula. This is particularly interesting because this woman, with no other treatment than that in relation to the dental infection and the stimulation of the chemistry of her own body, was put on her feet and last week she sent word to me that she was again running her sewing machine. Now, for a woman who could not even bend a joint or rotate her body, and who was destined to have her husband leave and have the tragedy of having her home broken up and has now the prospect of having her children back, that one case is compensation enough to me for the little bit of sacrifice I may have made in trying to build up this work.

Here is a case I have watched develop that I think I had something to do with myself. This woman has developed an arthritis, as you see by her fingers, and I will show you the root filling that I put in some eighteen years ago. I thought I was doing quite good work at the time, and some two or three years ago I took that root filling out and made that operation over again. She had gotten to the point where she could only get around with the greatest of difficulty on crutches and she was dependent entirely on being carried to the street car or the automobile. With no other treat-

*Stenographic report of a lecture delivered before the Iowa State Dental Society, 1916.

ment she is now walking all about her home, makes her beds and walks up stairs, and she says that nothing else that she knows of has had anything definite to do with it except the treatment of that tooth which I myself probably caused. Now I may be a lot worse than the average dentist, but I am afraid the average dentist has been guilty of sending a whole lot of people to the rack with rheumatism. I am not only afraid of that, but I am sure of it. I am sure that modern dentistry has been creating the ideal conditions for this type of organism to grow and the tragedy is that the amount of infection that will develop around an infected area like that is ample for the producing of a very definite and continued arthritis. We thought it took a number of teeth or a large area of infection. We now are more afraid of an area of this kind than we are of the type where we have a larger quantity of infection. We must differentiate between these of rapid growth and the slow, insidious infections.

Here would be an illustration of selectivity. This woman has lost her voice almost completely, for five years, and has had it failing a great deal of the time for twenty years. She has a chronic infection around the laterals and centrals. Here are two different cases of selectivity. The significant thing about this is that the organism in this case was selecting the throat, in this instance producing a chronic irritation, and later the voice was affected. This woman recently talked to me over the long distance telephone from a city a hundred miles away to show me that she could now talk perfectly over long distance even, which she could not do for five years. It is wonderfully significant to me that we have a large number where the voices have been affected in this way and it is particularly significant because so many cases of voice disturbance are due to streptococcal infection. Here is a school teacher who had lost her position for two years because she could not talk. Here was a pulp which could not be extracted but the pulp died and we had develop in this case a very definite infective process without any local irritation, but it selected out the throat and without any other treatment than that, this woman's voice came back and she has been teaching for three years. Now some of these organisms will lodge in the tissues or in the bone and linger there for months at a time, for years even. Then later when opened up they give us a pure culture and this organism shown here is one that accompanies pneumonia infection. We asked her if she had ever had pneumonia and she said, "Yes, seven years ago I had pneumonia." Now it is wonderfully significant that that organism grows with two different types of infection. You have all had this experience. You have drilled into a tooth that was not sore and immediately it flamed up just like touching a match to gun powder. This mouth was perfectly normal at the time, but by ten o'clock that night was so infected and her mouth and face so swollen that she had a temperature of 103; she came to the office the next day with complete lassitude and prostration, just the picture you have all seen. What had happened? I had opened up her tooth and let the air in and this organism has two different types of expression.

When it grows without air it produces no pus and no pressure and grows very slowly. It grows very rapidly in the presence of oxygen and we have produced here a most profound growth, a rapid growth, with the formation of this very poisonous toxin which it produced and completely and excessively prostrates the patient, just the thing we have all seen often when we have let air into a tooth.

When and where will we use vaccines? Here is the jaw of a young woman twenty years of age, who had a necrosis so extensive that you could inject fluid around or into the socket where the first molar was removed and it would come out around the second or third molar either lingually or buccally. It did not respond to any local treatment but when we took a culture and treated it, it cleared up just like magic and this girl, who had been prostrated in bed, got up in a few days and is perfectly well. What had happened? She was suddenly overwhelmed by that particular strain of organism and her body could not whip up its resistance enough to destroy the organism or its toxins. Immediately we put on the lash and the whip and made nature, by the use of the added vaccine, whip up the chemistry of the body. Nature was able to build up the needed anti-body and destroy this toxin. The result was that we completely eliminated this infection with nothing else but the vaccine. Now where will you use vaccine? I will say you may do so quite successfully in people under 20 or 30 or 40 years of age, but less successfully with older people; the ability of the older people to respond is so much less.

Now here is a particularly significant case. You notice that in the area of absorption around this distal root of this molar the root itself is absorbed. This gentleman has been suffering from bladder infection which has given him so much trouble that for the last five years he could not go into public life at all by reason of lack of control of the urine. We found in the urine the same strain of infection apparently that we found in this distal abscess. With no other treatment than the removal of this dental abscess, the extraction of this tooth and curetting, his bladder trouble was so greatly corrected that for the first time in years he left the city and went to New York to visit his son. We had removed apparently from his body the source of continuous infection. Now this particular patient had in succession a whole series of infections. The first complaint she had was she noticed in getting on a street car a stiffness of the joints; a little later she had a heart lesion; a little later she had liver and stomach disturbance; a little later she had a large carbuncle and then multiple furunculosis all over her body and sties on her eyes, and from the infection taken from the mouth and from these different lesions we apparently got the same strain of organisms. We will show you in the motion pictures some taken from the boils and some from the teeth, showing the same organisms, and yet this woman would not have those miserable teeth extracted nor would her physician encourage her. I put that slide on partly because I want to emphasize the fact that in so many instances we do not get the proper co-

operation on the part of the medical profession to have dental symptoms cleared up. On the other hand, we get sometimes such active co-operation that they want everything extracted in the mouth and that is, of course, as far in error as is this condition.

Now we like to differentiate between those reactions of the body that are due to mechanical pressure and those from infective processes. These express themselves more likely as mental disturbances or very often as mental disturbances. Here is the case of a girl 22 years of age, who has been for two years in a sanitarium or asylum because of mental disturbance, really an insanity. She was brought to Cleveland from another city for examination, and we found two impacted third molars above and the distal root of a lower first molar. With no other treatment than the removal of those impactions and the root I show you, she was sent back to the asylum and in two weeks she was dismissed as cured. That was in June of last year. She went to Boston to study music and is studying now in grand opera, and recently in a contest with sixty others, won first prize. That girl is apparently perfectly sane. The next shows a rather striking case, a girl who is 30 years of age who has had this lesion for 12 years, and she has part of the time been in an institution because she was mentally disturbed. The removal of this third molar, which you see was impacted and developed backwards, with no other treatment than the removal, has enabled that girl to take an important position in an institution where they are studying feeble minded people and she herself was at one time in a similar institution for part of the time the past ten years. She is apparently perfectly restored and the significant thing is that these cases both date back to the time of the development of the third molar, from 18 to 20 years of age. It is important to keep that in mind. But the reaction that we would get from infections are not like these quite purely physical reactions to which I am referring.

Now I will show you three or four pictures from Dr. Hartzell's splendid work, than which there has never been anything so significant in the whole study of these processes. This gentleman can now put his hands behind his neck and over his head. Six weeks before this he was in bed practically helpless and suffering intensely. The infection was found about these roots and with no other treatment than the extraction of these teeth and the making and use of a vaccine that man in six weeks went back to his position, as a street car conductor.

The next is one of his important cases. This woman had been in the hospital a great deal of the time for three years and, as you see, her knees and ankles are badly swollen and she was bed ridden, suffering a great deal. Month after month they were writing in the hospital record in Minneapolis, "Present treatment doing patient no good." The next slide shows the dental condition, an area of absorption and infection. In all these cases the viridans streptococcus was isolated, and a vaccine made. This woman was so greatly improved in a few weeks that she could straighten the joints and she was able to walk out of the hospital and go back to her family.

The next shows a case suffering with an iritis due to dental infection which entirely cleared up with no other treatment than the removal of the dental infection. All are illustrations of the selectivity of the organism for certain tissues of the body.

Here is a young man in my own care who had the painful recognition that his mother, who had been bed ridden, had much the same difficulty that he was having himself and, fearing that he was going to have arthritis, personally presented himself to have all of his teeth extracted. We made an examination and found five teeth in his mouth only partly filled, and we got the history that these had been filled with mummifying paste. We found that we could get a strain of viridans from nearly all of them by the method we use of aspiration. Now the method of aspirating is an important one; and we can get an infection from practically any condition that we ever tried where it showed an absorption and infection and we are coming to think that all absorbed areas are infected areas. This is a tubing with a rubber barrel to which is attached a piece of copper tubing with a glass tip; the tip may be attached with sealing wax or sticky wax, the entire barrel being filled with sterilized water. As we aspirate we lower the vacuum in the tooth, which produces a pressure and we will get an oozing right into the tooth and you can make almost any tooth bleed with the instrument. The instrument has proved that we cannot sterilize an infected root with any means that we have ever tried. We have never once produced a condition from which we could not aspirate an infection at some time later. Whether it was a reinfection or whether we had failed to remove all of it I do not know. Recently someone told me after using the instrument, that I did not have the patient take a bath; said this was strong enough suction to draw germs from the whole body. That is not true, but it will draw germs from some distance. Now, when we cannot get the germs immediately, we pinch that copper tubing off, which is sealed perfectly into the tooth with cement, with a pair of dull pliers or nippers, and that leaves us a small vacuum in the tooth and the next day we will practically always find the tooth filled with fluid, and whether we use ionization or any other form of root medication we have never once produced an area sufficiently sterile so that we could not either immediately or later get germs from it by this method of aspiration. Now, it does not mean, please remember, that ionization is not a good thing. It may prove that ionization is a good thing. It only illustrates that infective processes do not have to be entirely removed at the apices of roots, but if we largely remove the infective process, nature takes care of the balance, and I think that is the best we generally do. And I will say further that when we open into a streptococcal infected root, I firmly believe we will have streptococci around that area and in the bone for months afterwards unless we curette. We will pass this and not take time to discuss it at greater length; we have already taken too much time.

Another of the mechanistics of infection which will immediately appeal

to you is the pumping motion that takes place when we bite on teeth with infection at the apices. The very process of putting pressure on the teeth drives the blood out, and when we withdraw that pressure we let the blood come back into the tissue. We are making a pumping motion and we will readily have a suction, a pumping motion sufficient to make organisms that are already in the tissue pass into deeper tissue.

This little mass of debris which is so rapidly going out of sight by the clouding of this film, will contain probably ten million to five hundred billion bacteria; that is about the amount you can put on the head of a pin, and you will readily understand that when we put a force on that tooth of one ton in twenty-four hours, you get some idea of the effect of that pumping motion. Now, if you were to make an estimate of the number of germs in the mouth you would find you could hardly get a sheet of paper large enough to hold the figures. So that you would then have the opportunity not only of the pumping motion, but with this infective process you would have the opening up of the gingival notch, allowing organisms to go directly into the tissue, and there is in my mind a great probability that some of the organisms that we will study with the motion pictures go directly into the peridental tissues which are opened up because of their motility when the sound tissues are opened up. You can see the force that will go through the debris. They have a very definite power; they have an ability to push things out of their way.

This is a splendid slide, given me by Dr. Buckley, and shows beautifully the circulation that comes through the tissues. Dr. Hartzell has recently brought out very forcibly, and I think perhaps one of the most important contributions made for a long time, that infection passes into the gingival margin, into the gingival membrane and down into the peridental tissue to the apex and infects the tissue about the apex probably more often than the germs come through the blood stream to produce an apical infection. He has shown a slide in which you can see the germs in the tissues and the very fact that the poly-morphonucelar is a leukocyte that is called out in reaction to streptococcal infection, and the fact that it is present suggests that it is a streptococcal infection, but we will find that the motile organisms enter into it also.

Now the lesion we are most concerned about is not the fistula coming under the lip or hard palate, but one without any fistula whatever, a so-called blind abscess. How are you gentlemen to recognize it without a radiogram? I do not know how any dentist can intelligently or safely diagnose without either the use of an X-ray machine in his own hands or one available where he can send his patients for radiograms. I cannot conceive of the dentistry of today doing this class of work without access to one.

Coming again to the mechanisms, there are two principal processes of infection; one will be the embolic where the organisms pass through the blood stream and are occluded in the blood vessels, blocked in the blood

vessels, and produce an actual stasis and clot, which clot itself breal and infects the tissues; the other being the selectivity for the tissue toxin produced which prepares the tissue for the organisms. Th would be the process that we speak of and show in the motion picture bacteria would pass easily through the large blood vessels but the b an animal or the human blood would have the power of agglutina forming into clots. The organisms will pass through the large blood and even through the small vessels if they can go through singly, but t that they are agglutinated into clumps blocks the passage and you v that very thing in the motion pictures and finally the complete stopp the circulation.

The stomach ulcer is one of the most important problems we ar sidering today because so many patients develop cancer of the sto as a sequel to stomach ulcer. And I think Dr. Mayo's recent work has us an emphasis that we cannot overlook and it is probably one o most important of recent contributions. This would give us a ty ulcer, and it does not occur because the patient swallows pus which at the stomach wall, but the organism passing through the system with tivity for this tissue occludes the blood vessels, breaks down the tissues has a digestive fluid capable of digesting those particular tissues, an have the peptic ulcer breaking out in the stomach on the stomach This is one of Dr. Mayo's slides. He showed it at the opening of the Rese Institute, and I would have given almost anything if you could have h that address; it was one of the most masterly addresses, but it put a responsibility on the dental profession. He showed this slide and t is a typical ulcer produced as he believed by a dental infection. And in next slide is a cancer superimposed on a peptic ulcer, the result of the stom ulcer, and he made the inference for us that he believed a large numbe the cancers of the stomach were caused indirectly by dental infections. W is the significance? The dental infection producing the stomach ul the stomach ulcer in turn producing the cancer. It has been found, illustr ing the selectivity of the organisms for certain tissue, that when we tak certain strain of streptococcus from a particular tissue of the body and ject it into animals, that organism selects the same tissue in that anim that it had been taken from to get the culture. For example, if we take from an appendicitis case when we inoculate animals we find that in sixt eight per cent. of the animals it produced an appendix infection. While we take the infection from miscellaneous sources, only five per cent. pr duced that selectivity. Do you get the significance of that? If he wishe to take streptococcal infection from your mouth and from your appendi and from any tissue of your body that might be infected and make a mis cellaneous mixture and inoculate it into an animal, only five per cent. of tha would select the appendix, while if it were taken from the appendix infec tion alone, in sixty-eight per cent. of the animals the organism would selec the appendix. When he took ulcer of the stomach here, in sixty per cent. it

would select the stomach, and if he took it from miscellaneous sources, only twenty per cent. would select the stomach. Again, if he took the gall bladder infection, thirty cases selected the gall bladder and only eleven did so from miscellaneous infection.

What does it mean? It means, if it means anything, that if I should get that particular strain of streptococci into my mouth and into my system, and it would find lodgment, it might select out my joint or my heart valve. In other words, it means (I do not say it does mean, but it may mean) that if somebody plants a drinking cup with a strain of streptococcal infection which in his body is selecting his liver to produce the gall stones, and I drank of that cup it may be the source of my own development in the same way. In other words, we cannot yet tell how far-reaching this selectivity may be and how important it may be in the transmitting from one person to another. It may be that we really are subject to contagion almost to these organisms. Now certain chemicals select certain tissues. I think I showed you this slide two or three years ago when I was here. But now the significant thing is here, that this arsenic is a splendid illustration of selectivity just as mercury is a splendid illustration of the selectivity of certain toxins for certain tissues of the body. And we find that these great areas of absorption produced around the apices of roots, when we put formalin into the root, are the ideal conditions for infection from the gingival margin or the blood stream. I fear very much that I myself have planted literally hundreds of systemic infections by using too strong medication in these root canals. I hope I have not. I am very much afraid I have. I am very much afraid you have. I think one of the greatest mistakes the dental profession is making today is in over-treatment. Our surgeon would not think of using bichlorid of mercury if he was operating for appendicitis. Why? It is too strong; it will produce adhesions, and yet we continue to put strong medicines into the teeth. Yesterday or the day before a patient told me, "My dentist said that that tooth might give me trouble, but it would not be his fault if it did because he had used the strongest medicine that was known to his profession." He had done the very thing that would be most likely to produce an area of scar tissue around that root, which would be subject to infection because nature cannot tear it down and destroy it. Now, when we study the organisms in a mass of debris we will be surprised to find from ten million to five hundred million of micro-organisms, but what I want to emphasize is that a microscopic study will show forty-seven million in this case, but when he made the plate culture there were one million, or, according to the different media, he found ranging from one million to two million instead of forty-seven million. What is the significance? It is that not more than twenty-five per cent., if more than five per cent., of the organisms of the mouth will grow in any artificial media that we know of today, certainly not fifty per cent., and there is an immense field for research.

Dr. Benedict, whose work we know on this problem, has spent a large part of his time this year studying culture media and preparations that will

make it possible to grow certain organisms and by the addition or subtraction of a small amount of a certain chemical, an organism will or will not grow, showing its wonderful selectivity. For example, there are organisms so sensitive that they will not grow in a culture media that is contained in a platinum dish, but will grow in a glass dish because they have to have a certain amount of silica and there is enough silica from the glass going into the fluids to make that bacteria grow. That gives an idea of the infinitely small amount of some chemical that will be sufficient for that purpose.

We have a tendency today to extract everything that has a dead pulp in it. If the pulp needs to come out some say, "Take the tooth out." Now I put this slide on taken from Dr. Black's wonderful pathology, the work, I think, of Dr. Arthur Black.

Here we have a large area of absorption shown, and after he has filled the root I want you to note the area of absorption getting smaller and smaller until it is almost obliterated. Dr. Rhein has done some work along that line and he has emphasized the necessity of filling to and beyond the apex of the root. I think there is abundant evidence today to demonstrate that when we have not a streptococcal infection we can expect to cure a large proportion of these dental abscesses. When we have a streptococcal infection, however, that is producing a systemic lesion, I myself have not the confidence to leave many of those teeth in the mouth. If the patient is doubled up with arthritis like the woman I showed you, who is now running her sewing machine and walking, I think extraction is indicated. That woman had her bad teeth treated for six or eight weeks and every week we made aspiration and week after week we were able to get the cultures by aspiration, and when we extracted the last tooth she got better much more rapidly than she had prior to that time; I believe we would have made a fatal mistake if we had left the one tooth in the mouth. I am not competent to tell you how to treat them, but I myself would not leave a tooth in the mouth with streptococcal infection that was producing lesions if I did not make an artificial fistula and curette, either that or extraction. If I have time later to discuss that problem I may do so.

As to the amœba problem. I think I need not say a great deal about that. Our studies on the amœba of the mouth are proving that it is not an important feature in pyorrhea, but that it is there because the bacteria are there. It is in many mouths in September, but not there in January, but again there in March, April and May, and you will also find that if you start to use the emetin in January when the organism is present that it will be there in large quantities in February, March and April after you have used it. In other words, it does not seem to be definitely related to the stages of the infective process of pyorrhea but is dependent on our northern climate and temperature. There are a number of arguments for and against it. I think one of the most important new things I can tell you is that we are now able to grow that organism artificially. The various

organisms that you will see now in the motion pictures will be shown here. You have the streptococci that I have been talking about, a chain of beads long or short chains; the staphylococci or the short bodies. One of the things that will surprise you, if you have not seen it, will be the tremendous speed with which some of these organisms will move. The motion pictures now will give us the motility and behavior of these organisms. (Motion pictures shown from this point to close of lecture.)

When the germs are taken from around the teeth in a case of this kind we find a very typical organism growing there; when we take it from a deep cavity we get a practically pure culture. We remove the surface debris and take simply the pure culture from deep in the pockets and add it to a slide and put it in the field of the microscope, and in taking the pictures we let the light strike the mirror and pass up through the slide and be reflected from a prism into the motion picture machine. Here is a very motile organism inducing the caries in that particular tooth. If we study a mixed infection from that same patient's mouth we have this condition; notice the extreme rapidity. Now this, I think, was taken from a boil or a carbuncle; this was exceedingly serious and it had been diagnosed as produced by a staphylococcus infection. The organism taken from a long series of boils is shown in the next part of the film; note the organism and note its motility. The next part of the film will show you the same organism from an infected root canal. This man had not been without boils for nine months. After the treatment of this tooth he had no boils and has none at the present time, and apparently he was getting his infection from this dental infection. This is a more diluted culture but it shows the same organism. This last was taken directly from the root canal; the other was taken directly from the boil.

Here now we study the protozoa of the mouth, the amœba particularly, and you will note the slow migration. This is the amœba bacillus and you will notice the rhythmic motion. Now those who have suggested that it was a carrier of infection into the tissues have said that it did so by carrying the bacteria as such on its back, so to speak, across the tissues. This organism will take hours to travel a hundredth part of an inch. It simply goes round and round in this motion. The next variety does have a projected motion in one direction and this is the type that has been said to be the cause of pyorrhea, though I think not. It would be like imagining a fox squirrel taking a turtle as a means of locomotion; these bacteria swim in circles. This one has never been suggested to be the cause of pyorrhea, and yet you will notice how it does migrate directly across the field. Recently I said to a group of nurses that if they would feel around their teeth they might feel some of these, and one of them told me how she felt with her tongue and she did feel two or three. The organism is about one two-thousandths of an inch in length. Here you will see that variety again and here is one on this side of the field, and you will notice how strikingly it moves. This is a mass

of ingested food that contains a great many bacteria. These organisms that you see swimming here are so motile that they will swim almost as rapidly in proportion to their size as a dog would run in proportion to its size. You see in this field the trichomania, as called by some; it is not, as the trichomania has only one flagellata at one end of the body as you will see here. Here is the enlarged protozoan that I spoke of. It is not properly described in some of the literature. We will call it organism "Y" until we find a name for it. This would be the typical appearance of the mouth with the ordinary amount of bacteria except you would not often find these; and here it is again. Now watch that as it swims up the field; that is the trichomania that you will find in some of the literature and is thought by some of us to be connected with the important forms of infection. There you see them go through the field like a submarine. The dark field will show a hundred organisms to ten that you would see without the dark field.

We will study the circulation in the lung of a frog, which is done by cutting a hole in an anesthetized frog's back—remember it was anesthetized—and another in the chest and letting the light in through the back and out of the front, and we get this picture. The heart is pushing the lung with every beat, so that you get the rhythmic motion, but as you get used to it you will see the red blood cells; those are the red blood cells drifting through the tissue and these large ones are the leucocytes of the white blood cells. Here is the blood stream showing the gushing stream in the artery; we see the gushing of the heart. There you have that highly magnified, the red blood cells are as large as saucers. Here is a fork in the stream, and note the gushing at the fork. There is the capillary circulation. Now this will show you the veins gathering up the blood; see the blood going back into the veins; here is an artery; here is a vein gathering up the blood; see how the blood comes to a standstill between each beat. Note percolation through the capillary system and see the difference when we put a few organisms, only two drops of a culture taken from the mouth, into it, into that same system. Here you have the fork and just at this time we injected two drops of a culture of mouth organisms and we immediately got the formation of the embolical clot in certain of the arteries and they focused on the clot here. Here you have the very slow circulation; it gets more and more slow. If you will watch this large blood vessel you will see that it has a mass of slowly moving bacteria and red cells. There is an obstruction somewhere; there it breaks loose; there is the formation of the embolical clot and ænemia surrounding it; see it breaks loose. Here the vessel is almost entirely stopped up and here we have the complete ænemia; there is no more circulation in the capillary; here is the blood vessel highly magnified and you see the bacteria right in the mass of the blood vessel and a complete ænemia all around. Now if that organism would have the power of digesting the tissues surrounding it an abscess would form. If on the other hand, the tissues would

produce a digestive fluid that would destroy the bacteria, they would be destroyed and an abscess averted. We are constantly fighting a warfare against the organisms. Some day the battle will be over and they will ultimately win. For the present you and I are alive. Why? Because we have enough resistance, we have enough fighting ability to overcome the infection of the organisms. Some day there will be too many of them, or our resistance will go down so that we cannot carry on the fight. Will it be when we are sixty years of age? Will it be when we are seventy? Will it be when we are eighty? That will depend largely on how well we keep up our resistance and how perfectly we keep our bodies from being overwhelmed with organisms. And we as dentists have in our power and in our care probably years of the life of many of our patients; I think we might say perhaps at least one year; perhaps we might say ten years of the lifetime of every patient who comes into our care, because if we produce in that patient a condition that will let infection develop and allow the body to be overwhelmed that patient must necessarily succumb earlier in life than would be the case if we could keep the patient from that infection. My prayer is that we, as dentists, may be able to add to the lifetime of our patients and not subtract from it. I feel, in fact I am perfectly confident, that I myself have shortened the lifetime of some of my patients by creating in their mouths conditions that encouraged infection and produced actual infection that invaded the body and brought on some form of these systemic lesions. And, on the other hand, if we as dentists can keep our patients from getting these infections and thereby prevent those catastrophies coming to them, I know of no greater service to humanity. I tremble when I think of the possibilities. When I realize that in one of the London hospitals they have recently made a study of the children in that asylum or that home for orphans, where they can tell precisely their histories, because they have had entire care of them, and where they studied the source of the heart infection, and they found that fifty-two out of every one hundred of the children developing a heart infection had as the primary lesion a dental abscess, I tremble, and I think of the possibilities of my neglecting the children that are in my care and thereby producing heart infection or other infection. Just as heart infection may be produced in the children's mouths so easily, just so easily may this whole train of infection which we have considered to be diseases, but which we now know to be simply symptoms of disease, be averted. There is today no such a thing as gall stones as a disease; gall stones are symptoms of a disease, or systemic infection. Peptic ulcer is not a disease; it is a symptom of disease, the disease of systemic infection. Appendicitis is not a disease; it is a symptom of disease, the disease is systemic infection.

Did you ever plant a systemic infection? I did. I am afraid we are all doing it. I hope we may do less of it in the future.