the mineral matter of which the completed enamel consists. As the globular bodies pass from the ameloblasts they are seen to be connected by plasmic strings, which strings can often be plainly seen in the body of the ameloblasts. The globular bodies are also often connected laterally by strings or projecting processes. Around the skeleton thus formed, which constitutes the real structure of enamel, the albumen-like substance flows, supplying the cement-substance and probably the mineral matter for the calcification of the whole. All of this structure can be plainly seen in mature enamel, but in

FIG. 83.

Section cut transversely to show arrangement of enamel-rods in groups. This section also shows how longitudinal sections may be so ground that when the section is considerably less in thickness than the diameter of a single enamel-rod, there shall be no underlying rods to disturb a perfect view of the structure. The true structure of enamel-rods can only be clearly seen when the sections are ground in accordance with the above suggestions. a, Cement-substance between groups of enamel-rods; b, Ends of enamel-rods or rods seen in transverse section; c, Dentine.

normal enamel it is everywhere completely calcified and containing no trace of organic matter. No physiological change, therefore, is possible in completely formed enamel.

Enamel is a solid mineral substance, and the finest lenses reveal not the slightest difference between enamel ground moist from a living tooth and that which has laid in the earth for a hundred centuries.

THE X RAY AND ITS APPLICATION IN DENTISTRY.

BY WILLIAM JAMES MORTON, M.D., NEW YORK, N. Y.

(Address at a special meeting of the New York Odontological Society, April 24, 1896.)

MR. PRESIDENT, FELLOW-MEMBERS OF THE ODONTOLOGICAL SOCIETY, AND THEIR GUESTS: I regret that, as appears from the letters just read, Mr. Tesla and Mr. Edison, those great lights of the X ray, will not be with us to-night; but if you knew how much work the X ray has entailed upon those who have attempted to follow it
into its darkened recesses, you would not wonder that anybody would be willing to stay at home, either to rest or to do some new work. The work is never ended. It is a pursuit that is most fascinating, and yet never seems to come to a finality.

I do not intend to take up your time with any abstruse idea of the subject. I have prepared a little paper as a record, which we all like to have for our meetings, and then I propose to give some demonstrations of the X ray, and perhaps it would interest you to actually take a picture before your eyes and have it developed on the spot; then we have some fluoroscopic demonstrations to make, which I trust will be visible to you, and we will show some lantern slides which demonstrate the work done and recorded by the X ray, and will then speak of the X ray in relation to its use in dentistry.

When the astronomer discovers a new star he adds nothing to the actual facts of nature, for the star has always been in existence; but he adds something to the sum total of human knowledge, for the existence of the star had not, until then, been known. So it has been with the X ray. Those who worked with excited high vacuum tubes, called Crookes tubes, had this ray or radiation ever about them; but they failed to note or discover its existence. But at length comes along an observer who, intentionally or by accident, arranges a mechanism to detect the hitherto undetected stream, and behold the world is illumined, not as by a torch which flares from its mountain tops but as by a new sense of perception, which enables its possessor to see into solid matter. The covered becomes uncovered, the concealed stands revealed, the invisible is visible; man may see and study his own skeleton, the surgeon may watch and count by aid of his eyesight alone the beatings of the heart.

No wonder that not only the scientific world, but also all the thinking human race have been captivated by this marvel.

It is therefore with great pleasure, fellow-members of the Odontological Society, that I bring the subject before you to-night in a brief and elementary manner, and ask you to witness both the general methods of producing the X ray and some of the results of its work registered on sensitive plate and upon fluorescent screen. And it may prove, as the evening’s work progresses, that we shall find that the X ray possesses an unusual interest for the dental profession. Indeed, I am of the opinion that it may prove of equal, if not greater, interest to the dental than to the general surgeon.

HISTORICAL.

As far back as 1819 the illustrious Faraday, after pointing out the familiar classification of matter into solid, liquid, and gaseous, advanced the then remarkable hypothesis that a further and fourth state existed, and this he termed “radiant matter.” In 1879 Professor William Crookes recalled this speculation, and in a series of epoch-making papers and experiments demonstrated that, apparently, matter actually did exist in a fourth state or condition which was as distinct “from the state of gas as a gas is from a liquid.”

Up to Crookes’s time vacuum tubes whose vacua were comparatively low were in familiar use; they were called Geisler tubes. Crookes increased the vacuum and rearranged the entering electrodes,
and thus sprung up the now familiar Crookes tubes. He ascertained by the employment of high vacua these remarkable facts:

That in high vacua the molecules of matter, instead of being so close together that their mass was practically continuous, were so far apart and so few that they might be regarded individually. Such molecules actually seemed to have what Crookes termed a "mean free path." That is to say, they were able to be thrown across the vacuum tube from the poles with incredible velocity and great force, moving with but few or no collisions with each other and striking the sides of the glass to cause it to become heated and to exhibit vivid fluorescence. The effect of the projection of the molecules of air may be compared to a hail-storm, or to a bombardment by extraordinary fine shot. Crookes's radiant matter proceeded in straight lines, cast shadows of intervening objects, and could be deflected by magnets.

The work of Crookes has furnished the splendid inspiration for all that has followed in relation to the electric phenomena exhibited in high vacua. Some years later on Hertz restudied the Crookes tube effects, and Lenard, his pupil, discovered that the radiation from the tube was capable of exciting fluorescence outside of the tube, and of showing the presence of opaque objects in closed boxes upon a fluorescent screen. But such purely physical experiments attracted little attention outside of strictly scientific circles. It remained for Roentgen to make the sensational announcement that the bones of the living body might be photographed, so to speak, and at once the radiation from a Crookes tube became a wonder.

The scientific world is yet at a loss for a theory to account for the Crookes tube effects. Roentgen himself modestly termed it the "X, or unknown ray." Whether it is a ray at all is doubted. Opinions are divided largely into two camps, the one considering the X ray to be a vibration, transversal as in the case of light, or longi-
tudinal as partly inclined to by Roentgen; the other adopting the Crookes, or English view, that it is a stream of electrified particles moving at a high rate of speed. It is on the whole doubted if the rays are light in any ordinary acceptation of the word. Edison and others think it to be of the nature of sound waves.

And thus the battle and conflict of opinion as to the nature of the X ray progresses. Man chafes under restrictions to his knowledge, and out of this mental restlessness come the great achievements of science and the final ameliorations of hardships and suffering to the entire race.

I will refer very briefly and concisely to the apparatus,—I will not say necessary to produce the X ray, but to the apparatus which I personally have found essential to produce it. A great diversity of opinion exists as to what you need. One man will talk of one form, and one of another. I am presenting to you to-night what I have found to be a good working combination. The X ray may be produced by the aid of an influence machine, and one might have been brought here to-night, where it is essential to me; but it seems that we must produce our work with the induction coil. I was obliged to devise a tube of my own, which worked very well, because I had no Crookes tube. I put on the cathodic end a disk of aluminum, and on the anodic end also an aluminum disk. The anodic aluminum disk did not intercept the ray, and, more than that, it seemed to direct it and bring it down to a point. I produced some very good pictures of the hands and feet. I do not know but some time we may go backward and make use of this after all. The best form of apparatus is some form of the Ruhmkorff coil. As you use these vacuum tubes, their vacuum increases, that is to say, it becomes more and more difficult to induce the current to go by the pathway of the inside of the tube, and after a while the vacuum rises to a point where the current will jump through the air space rather than go through the tube. It is well to get a spark coil of about six-inch spark. This one has a length of about four and one-half inches.

As to the Crookes tube, it seems many of them can now be obtained. I have here some interesting ones made by Hicks, of London. These are of the recent type known as the focus tube. When we began and the fluorescence played like a stream of water against the tube, there was no definite picture, and everything was blurred. To a certain extent that was obviated by using diaphragms with apertures made in them; to another extent it was remedied by placing the Crookes tube at a greater distance from the object; but a greater distance from the object means a vastly increased exercise of power, and to-day we lack the power to do the work as it should be done. I have always believed that Mr. Tesla would be the one to exhibit the Crookes tube or some form of the X ray radiation with extraordinary power, such power as to extend to great distances, and so it has proven. He has produced effects with greater power than any one else in the world, probably. Mr. Swinton, of London, has also produced some very powerful effects; but even with such limited powers as amateurs like myself possess, we are able now to see through the human body with absolute ease.

I believe these tubes are a step in the direction in which we must all work. They are called in this country "reflecting tubes." They
SKYGRAPH OF FRONT OF SKULL, SHOWING THE DENTURES, PULP-CHAMBERS OF INCISORS, ETC.
Artificial crown on molar.

Teeth *in situ*, pulp-canals, etc.

Artificial crown on left central, and bridge-work on right side.

Artificial crown on molar, lingual filling on lateral incisor.

*Skiagraphs of Portions of Superior Denture.*
have two electrodes, one the cathode, a concave mirror, and the other the anode, a flat disk of platinum. The cathodic stream is so arranged that it impinges upon the platinum and intercepts this stream, and the X ray is thrown off in every direction anterior to its plane. I call all these tubes "spatter tubes," simply because the effect is exactly as if you would turn a hose pipe with a strong stream of water against a wall. The water scatters in every direction, and some of it comes back. If you look with your fluoroscope behind this little piece of platinum, there is a dark area, showing that the radiation comes off from the plane surface.

I would advise any one who is going to buy the tubes to get the focus tubes. With them you get a most beautiful definition of your object.

When I use the term "fluoroscope" I presume every one is familiar with what is meant, still a word of explanation might be important. As I mentioned some time ago, it was long since observed that fluorescent substances outside of the Crookes tube were excited to activity by the radiation from the tube, but it was not then called the X ray. As soon as the X ray interest spread over the world people tried to find all the different forms of detection, and no one was more energetic than Mr. Edison. We all began with photography, which is only another form of detection of the X ray. It is supposed that the silver on the plate is excited into a state of activity in such a way as to set up the chemical action that is usually set up by light. The fluoroscope is only another detection of this ray. In order to bring it to a point where it could be used in the medical profession, because this X ray seems to be most useful to doctors, Mr. Edison stated the property of the different fluorescent substances. He announced that the tungstate of calcium was the most fluorescent substance he found. Some friends and associates of Mr. Edison at Menlo Park, Messrs. Ailsworth and Jackson, took up the practical manufacture of the screens, and to them we are indebted for the use of this large screen before you.

The crystals of calcium tungstate were at first coarse. As skill has progressed the crystals have been produced finer and finer, until here the surface is almost as smooth as enamel; and there is a purpose in getting it as smooth as possible.

In this connection I wish to read a special bulletin that Mr. Edison sent out from his laboratory when our representative visited him in the interests of our profession. He says,—

I find by manipulating the coil, the break and the rate of break, that the form of the wave can be changed; crystals that fluoresce strongly with one kind of wave are weakened when the wave is changed, while other crystals increase, notably mercury diphenyl, which scarcely fluoresces with one form of wave, but comes out strongly when the wave is changed.

If you give any thought to the effects of the X ray on a photographic plate or a fluorescent screen, you will find that there is a great amount of truth in what Mr. Edison has stated in this brief communication. I often notice in working that I may get a beautiful effect on the fluoroscope and a very poor effect on the bromide of silver plate. Sometimes I think I get a very poor exposure, but when I develop the plate I find a very excellent development. Sometimes apparently the waves are longer and sometimes shorter. There
is a particular ray adapted to certain substances which are to be excited by them or put into a state of fluorescence. In that connection the sensitive plate that one uses is of great importance. I have tried nearly all the plates, and am informed to-night by Professor Goodspeed, of the University of Pennsylvania, that Mr. Carbutt, of Wayne Junction, near Philadelphia, is making a plate that is very well adapted to this work. Every one wants to do this work well, to do it quickly, to get good definition and strong negatives. The question of speed largely depends on the plate you use. I have taken different objects and placed them upon a large plate, and, in my interest to see what the X ray was doing, have gotten under the table with the fluoroscope and looked through the plate and the object, and then developed that plate and found absolutely nothing upon it. The trouble I think was in the sensitive plate itself. I have found films to be very sensitive to the X ray. That was of particular interest to us, in regard to dental applications, because in taking many of these pictures in the mouth it is important to use the film. For making X ray pictures of living tissue containing teeth, the film is important. The way I devised was to cut a pattern in gutta-percha or cardboard, or anything that the patients could wear in the mouth without gagging too much; if they gag too much I use the cocain spray. Having cut this pattern, I took it into the dark room and cut the film in the same shape and folded it into three folds of paper, and then ran it into a pocket of gutta-percha tissue and adjusted it to the roof of the mouth. The picture could be taken almost instantaneously. I say "almost" instantaneously, because that depends on the workings of your tube. Any area of the mouth could be depicted by the X ray in that simple manner. The use of the glass plate of course would present considerable difficulty.

Sometimes the vacuum of the Crookes tube is good, and sometimes bad. There are times when its force is wondrous, and thirty feet away you can detect the X ray; and at other times you can get nothing out of it.

You will find that the lithographic prints in publications are very inferior to the photographic prints, and what is more pointed still, the photographic prints are vastly inferior to the negative. The real beauty of the X ray work is only to be found in the negative itself.

APPLICATIONS IN DENTISTRY.

And now, gentlemen, a few final words as to the applications of what we have seen.

The application of the X ray will, I believe, greatly aid the art of dental surgery. In general surgery it is difficult to over-estimate the importance of ascertaining the exact outlines of imbedded bones, of foreign bodies, to differentiate between a dislocation or a fracture, or to ascertain the co-existence of both. The X ray already makes these cardinal issues an open book; it does more, it locates tuberculous deposits now known to frequently invade the osseous tissue and to be impossible of detection except by exploratory incisions; it locates also sarcoma and accompanying erosions of the bone within the narrow cavities, and it is more than possible that, thanks to the labors and the practical mind of Edison, these triumphs of localizing and diagnosticating records upon photographic plates will be supplanted,
at least for quick and ready examinations, by the new art of X ray fluoroscopy. It was one thing to note that fluorescent substances outside of a tube were excited, it was quite another to find a working fluorescent substance and build it into a practical screen. This Edison did, and the efficacy of this screen and its revelations grow apace; its definition and degree of illumination increase week by week. Tesla already reports that he has seen through three men, that he has seen the great bones of the body, and seen the heart beat. Again and again I have looked through the human body and seen not only the vertebrae, the ribs, the hip-joint, but also located larger and denser organs like the liver; nay, more, I have watched the heart in its beatings. Who can guess to what lengths the visual exploration of our interior organization may reach when so much is already possible?

This enumeration, brief as it is, is a great triumph for the X ray, and these same questions of diagnosis and of localization are equally applicable to dental surgery.

The radiographs presented to you here to-night are but a first step toward taking pictures of the living teeth. They open out to your view a wondrous field for investigation and study and diagnosis. Each errant fang is distinctly placed, however deeply imbedded within its alveolar socket; teeth before their eruption stand forth in plain view; an unsuspected exostosis is revealed; a pocket of necrosis, of suppuration, or of tuberculosis is revealed in its exact outlines; the extent and area and location of metallic fillings are sharply delineated, whether above or below the alveolar line. Most interesting is the fact that the pulp-chamber is beautifully outlined, and that erosions and enlargements may be readily detected. A new method of studying pathology in the living subject is laid before you.

To what perfection, gentlemen, may not the science and art of dentistry reach if some of the new things which press upon your attention are fully realized. Already painless dentistry is within your grasp by aid of electricity and simple anesthetics, and now the X ray more than rivals your exploring mirror, your probe, your most delicate sense of touch, and your keenest powers of hypothetical diagnosis.

Strange to say, both advances are poured forth to you from the fertile lap of electricity. It behooves you to be up and doing in this matter; and if the seed here sown to-night shall bear fruit, I shall be more than glad that it has been my good fortune to have called to your attention the new and wondrous field of investigation opened out to your view by the discovery of the X ray.

THE ORAL EXPRESSIONS OF MALNUTRITION.

BY M. L. RHEIN, M.D., D.D.S., NEW YORK, N.Y.

(Read before the New York Odontological Society, March 17, 1896.)

DEFECTIVE nutrition resulting from imperfect assimilation of food and faulty metabolism is generally termed "malnutrition." Without going into a résumé of the physiological functions of the alimentary tract, it might be well to call your attention to the indispensable