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ATLAS AND TEXT-BOOK

OF

DENTISTRY

INCLUDING

DISEASES OF THE MOUTH

BY

GUSTAV PREISWERK, M. D., PH. D.

of the University of Basel.

AUTHORIZED TRANSLATION FROM THE GERMAN

EDITED BY

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Professor of Principles and Practice of Operative Dentistry,
Pennsylvania College of Dental Surgery.

With 103 colored figures on 44 plates and 152 text-illustrations.

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EDITOR'S NOTE.

An American edition of Preiswerk's "Text-Book and Atlas of Dentistry," translated from the German, will be welcomed by both students and practitioners. The author is one of the chief exponents of the modern trend of dental thought in Germany; and, while we may not entirely agree with all of his views as here expressed, the book will be much appreciated as a fair presentation of dental practice in that country.

Our thanks are due the author for the large number of splendid illustrations, indicative of extended clinical experience, much labor, and great care. They will add much to the student's interest in the subject.

The editor has had much interest and pleasure in preparing the book for publication.

PREFACE.

THE publisher, Mr. J. F. Lehmann, being, as I well knew, ever ready to comply with any reasonable wishes on the part of his authors, it was with enthusiasm that I undertook to write an illustrated text-book of dentistry, and my expectations in this respect were not disappointed —on the contrary, I look back on our correspondence relating to the preparation of the book with the greatest satisfaction.

Mr. Lehmann's liberality enabled us to turn out an excellent set of illustrations, which greatly add to the beauty of the book. A number of artists contributed to the preparation of the plates and figures. Most of the colored plates were painted by Mr. Fink. Mr. Oser contributed, in addition to several drawings in black and white, Plates 28 to 37, while Plates 7 and 9 are the work of Mr. Büchli. The drawings for Figures 4, 5, 6, 9, and 10 were prepared by Mr. Fiechter, and Figure 133 by Mr. Albrecht Meyer.

The efforts of all these gentlemen were as honest and untiring as their results are successful.

By far the greater number of the specimens from which the illustrations were copied were furnished by myself. I received much valuable assistance in this part of the work from Professor (Dr.) Jos. Arkövy, who placed at my disposal fifty-nine water colors painted by Dr. Marikovszky. With the aid of some clinical specimens of my own these were reduced to a smaller scale by Mr. Fink, and reproduced in Plates 25 to 27 and 39 to 44. I am also indebted to Professor (Dr.) Jul. Kollmann for the use of several specimens from the anatomical collection in this city (Plates 1, 2, and 4, and Figure 82). From Professor (Dr.) Ed. Kaufmann I received the cyst represented in Figure 54, and Professor (Dr.) Friedrich Müller kindly supplied me with a case of typhoid ulcer from his clinic (Plate 13 *a*). The section of an alveolar process and root of a tooth reproduced in Plate 5, Figure 1, was obtained from the collection of anatomical specimens of Dr. Römer, Docent in Strassburg; while the examples of hypoplasia shown in Plates 19 and 20 were sent to me by Professor (Dr.) Billeter in Zürich. The following are borrowed from text-books: Figures 40 to 42 (Röse), Figures 6, 8 and 9 (Merkel), and Figure 97 (Miller).

In the correction of proof I was assisted by my colleague Dr. Paul Witzig, Dr. Gustav Leimgruber, and my brother Paul Preiswerk, to all of whom I wish to express my warmest thanks for their untiring labors.

Illustrations of such high merit deserved to be associated with reading-matter of corresponding excellence, and I have honestly tried to produce a book which should prove useful and stimulating to students of dentistry as well as physicians engaged in dental practice. If I have failed to realize these good intentions in every particular, I hope to be judged with some indulgence in consideration of my many duties in dispensary and private practice, which leave me little time and opportunity for the concentration so necessary to literary production.

The subject of laboratory technic has been omitted, as it does not properly belong in a "Medical Atlas."

GUST. PREISWERK-MAGGI.

LIST OF LITHOGRAPHIC PLATES

CONTENTS

DENTISTRY.

HISTORICAL.

References in literature point to the existence of a well developed form of dentistry among the Egyptians, in corroboration of which we are referred to the gold-filled teeth which have been found in mummies. This observation is not convincing as the Egyptians, in embalming the bodies of their departed, covered the tongue and teeth with thin gold leaf for the purpose of preservation. However, examination of many ancient skulls, notably an Etruscan skull, exhibited in the museum of Orvieto, give evidence of early dental practice. The famous papyrus of Eber gives a list of remedies such as liverroot, dough, honey and oil which are indicated in certain dental affections. It may be assumed that artificial teeth were used in those ancient days from the fact that a favorite mode of punishment designed to bring disgrace upon the culprit, was the extraction of a front tooth. Therefore, when a tooth was lost through accident or disease, to avoid this disgrace it became necessary to resort to the employment of artificial substitutes. The ancient Egyptians were skilled mechanics and able to model teeth from wax, wood or clay, and the perishableness of this material would account for the scarcity of proof of ancient dental practice.

We learn from the Bible that when Moses led the chosen people through the wilderness to the Holy Land, he was obliged to issue penal and hygienic laws to protect the people, who were already broken in health from slavery, from the ravaging pestilences. It is notable that in these careful regulations concerning the nourishment, clothing and cleanliness of the body, no mention is made of the teeth. I can only account for this by the supposition that the old Hebrews had perfect teeth, a fact possible considering the enormous difference in races in regard to the relative frequency of caries. We must not conclude, however, that this race neglected or disregarded their teeth, for Moses, elsewhere in the laws speaks thus,—"And if any mischief follow then thou shalt give life for life, eye for eye, tooth for tooth, hand for hand, foot for foot, burning for burning, wound for wound. And if a man smite the eye of his servant or the eye of his maid that it perish ; he shall let him go free for his eye's sake. And if he smite out his man-servant's tooth, or his maid-servant's tooth, he shall let him go free for his tooth's sake."

It is indeed wonderful that so much importance was attached at that time to a complete set of teeth, in as much as the loss of a tooth was judged equal to the loss of an eye. Not until thousands of years later, did man realize the eminent importance of teeth for the body economy. The ancient Greeks, if one may judge from the sparse literature of their time, seem to have possessed better teeth than the Egyptians. Their methods for the relief of toothache were very primitive and consisted in the fasting of the patient and in the worship of their gods. They also sought to alleviate their dental pains through various sleight of hand tricks and music.

With Hippocrates (460–355 B. C.) began a great revolution in both medicine and dentistry and it is highly probable that the first reform in the latter consisted largely in the extraction of teeth. It seems that only loose teeth were drawn at that time since in the Temple of Delphi a pair of forceps were found which being made of lead could not possibly have been employed for the extraction of soundly imbedded teeth. Hippocrates already at that time laid great stress upon cleanliness of teeth and prescribed the following powder, which had perhaps a mystical as well as a physical effect : "A charmed rabbit's head and three charmed mice ground into a powder." He recognized various dental affections with serious sequellæ resulting from neglect of the teeth and writes as follows: "If gangrene of the teeth be accompanied by fever and delirium the result is fatal. If, however, the patient should recover ulceration remains and the bone is destroyed." He illustrates the story by the following case.—The son of the Metrodor developed acute gangrene of the jaw after a toothache. The swelling of the gums became purulent and the teeth and the bone were destroyed.

The oldest information on Roman dentistry is found in the laws of the Twelfth Tablet which states: "Add no gold to the corpse, but if the teeth be already bound with gold, it is not unlawful to bury or burn the body."

According to Geist-Jakobi we find the founder of dentistry among the ancient Romans, namely, the learned Cornelius Celsus who lived at the time of Christ. In his celebrated work "Re de Medica" he devoted certain articles to the pathology and therapy of teeth, subjects which at one time were combined with general medicine. He was perhaps the first to practice the filling of carious teeth. He inserted in the cavity pieces of slate wrapped in cotton, endeavoring thus to check the caries. The cause of caries was sought for even at that time, and Scribonius Largus (50 A. D.) advances the theory that worms destroyed the substance of the teeth. Hence the parasitic theory reaches back to that age.

A true investigator of the combined medical and dental science was Claudius Galenus (131–200 A. D.). This skilled physician of that ancient age presented some new and accurate observations on the anatomy and pathology of the teeth. He accurately differentiated between disease of the pulp and that of the root-membrane. He reports from personal observation that in a painful tooth he plainly felt a pulsation like that which occurs on inflammation of soft tissues, and was "surprised that a tooth also could become inflamed." Further he says: "When I again had toothache I realized that not the tooth but the inflamed gum was the cause. From which observations I learned that a certain pain may have its seat in the tooth and another in the gum."

For the preservation of the teeth Galen prescribed a large number of tooth powders and mouth washes. In the middle ages when culture suffered retrograde changes in Greece and Rome, science received contributions from the Arabians. In our specialty, however, this did not amount to much. Dental therapeutics were thus enriched by adopting Abulkasa's method of checking the toothache by means of a hot iron with which he probably cauterized the pulp, and by employing arsenic.

If we desire to learn of more modern and practical results, we must return to Italy where in the year of 1500, Johannes Arculanus energetically recommended the conservative treatment of diseased teeth. He was the first to fill teeth with gold for the sake of preserving them.

Dentistry received a marked impetus at the end of the sixteenth century through Ryff who wrote a book, divided into the following parts: 1—The eyes. 2—The teeth. 3—The teeth of suckling infants. In this treatise he called attention to the relationship existing between diseases of the teeth and the eyes, and the effects of decayed teeth upon the general health of the organism. With commendable foresight and energy he urged the people to observe the laws of hygiene and especially those which concerned the thorough care of the teeth.

Eustachius, who lived in Ryff's time is closely associated with the embryology and anatomy of teeth. He taught that the tooth was developed from a dental sac, and that the second or permanent teeth were developed from special germs and not from the roots of the temporary set. He described a number of the elements of a tooth and called attention to the enamel, which covers the dentine like a bark, and stated that the interior of the tooth was filled with a pulp, richly supplied with nerves. He also wrote on the anomalies of teeth and described a case of fourth dentition. It is impossible to describe in detail the investigation of the remaining earlier authorities in dentistry, but I wish to make mention of the most important ones. Highmore (1613–1684) discovered that the superior maxilla was a hollow instead of a solid bone. Leeuwenhoek (1632–1723) by various improvements in the microscope made considerable progress in dental histology.

A decided advancement was made in 1800, in Frankfort through Fauchard, who is everywhere honored as the father of modern dentistry. In his epoch making work of 1728, "Le Chirurgien Dentiste ou traité des dents," he laid the foundation for the anatomy, physiology, pathology, and therapy of the mouth and teeth. Founded on these fundamentals, there has arisen a massive structure, the materials of which have been collected from all the civilized lands of the world, the structure of the well established, although not yet complete international science of dentistry.

COMPARATIVE ANATOMY OF THE TEETH.

We must not neglect a review of the most important forms of mammalian teeth, as their relationship to the whole skeletal structure is of considerable importance. That in doing so we shall be forced to resort to paleontology and to go back to fossil teeth as the sole remains of an extinct fauna, is rather an advantage than otherwise, for the scientific odontologist should not be ignorant of paleontology.

The teeth of all mammalia, are formed in the mucous membrane of the mouth ; as their development progresses the alveolar processes of both jaws grow about the teeth thus bringing them in close connection with the skull. They are, however, never joined to the skull by a firm bony growth, for a layer of connective-tissue always remains between the roots of the tooth and the bony structure.

The teeth of the majority of the mammals consist of enamel, dentin, and cement. They are hollow within and contain the tooth pulp or marrow. The *enamel* is a hard substance which usually covers the crown completely. Exceptions to this rule are seen in the incisor teeth of rodents of the proboscidian type, in which only the anterior surface is protected by enamel, and also in the toothless edentata in which the enamel is never perfectly developed. *Dentin*, the main part of the tooth, consists of a more or less solid substance giving the typical form to the tooth, and encloses the pulp. The roots are covered with a thin layer of *cement*, which is the softest of the three hard dental substances.

In many of the mammals, especially the herbivora, this cement extends over the crown of the tooth and is called the crown-cement.

If the crown of the tooth is low, roots are developed which contain the pulp in their narrow apical foramina: such teeth are termed *brachyodont*. If a tooth is long and of cylindrical shape with wide root canals it is called *hypsodont*. The human molar (Fig. 1, *a*) is an example of the former and the molar of a horse an example of the latter (Fig. 1, *b*). According to their physiological functions, teeth assume certain characteristic shapes. Complete absence of teeth occurs only in those animals which are not required to cut their food into small pieces, as the cetacea, the anteater, and the duck-billed platypus. Animals which need only to seize and retain their food are furnished with simple teeth all of which are alike in form. This is the "isodont" type of tooth, and is found in the sea mammals (toothed whales and the delphinus).

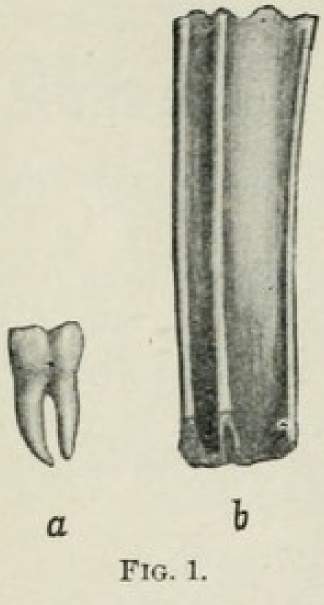


FIG. 1.

The majority of mammals possess *anisodontous* teeth, the shape of which depends upon their situation in the jaw and upon the special functions they are required to perform. The function of the front part of the mouth is to secure and sever the food, therefore, the teeth in this location are usually sharp, while the teeth in the back portion of the mouth have a flat wide surface for the purpose of crushing and grinding the food.

Aside from the function of acquisition and mastication of food, teeth serve occasionally for other purposes. It is known for instance that the stallion has a hook tooth which is not found in the mare. A similar condition is found in musk deer. His teeth are his strongest weapon and he employs them to defend his mate. According to the laws of reciprocal relation, the canine teeth of the horned deer decreases in size as the horns grow larger, until finally the function of defense is transferred from the teeth to the horns. Animals must frequently remove obstructions from their paths, for this purpose they are supplied with long projecting tusks. Such animals are the mammoth, the elephant, the walrus, the hippopotamus and the male narwhal, which also uses them in defense when rutting.

According to the demands made upon them the incisor teeth present many variations in form. To fulfill their function the incisors of all gnawing animals are considerably elongated. They are somewhat curved and in order to have sharp edges, only the front surface is covered with enamel. To this class belong the majority of the rodents, tillodonts, allotheriæ, and the diprotodontic animals of prey. The before mentioned tusks of the elephant and narwhal are also differentiated forms of incisors. In pigs the lower incisors grow horizontally upward and forward, a formation necessary to grub nourishing roots, while the lower incisors of certain members of the lemuridous tribe of monkeys are finely niched that they may be used as combs in their daily toilette. The sirenia are characterized by large upper incisor teeth with which they pull up various water plants for their nourishment.

When an incisor tooth develops excessively in size, the remaining incisors are usually fewer in number. Hence we may find that in many animals of the proboscidian type, the lower incisors have completely disappeared. This phenomena may occur, however, in the absence of such a condition, for example we know that the ruminantia, the dinocerata and the chalicotheridæ, have no upper incisors, while in the majority of the edentata both upper and lower incisors fail to develop.

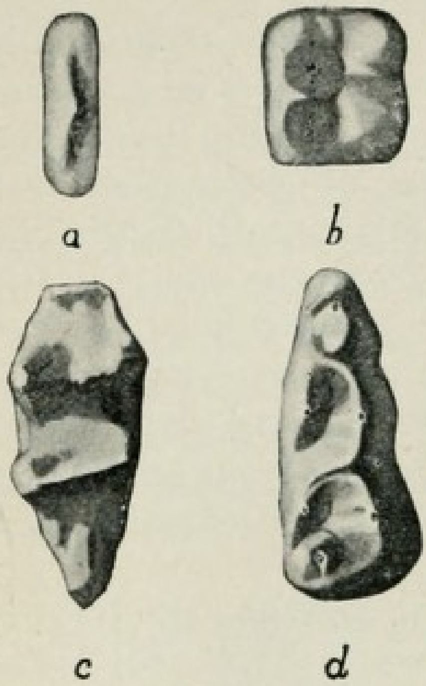


FIG. 2.

The molar teeth are divided into:

1. Teeth with sharp points and edges (secodont) Fig. 2, *a*.

2. Cusped teeth (bunodont) Fig. 2, *b*.

3. Teeth with straight crests of enamel (lophodont) Fig. 2, *c*.

4. Teeth with crescentic ridges on their crowns (selenodont) Fig. 2, *d*. An example of the secodont tooth is the molar of the beast of prey, and is found in animals which are required to sever and tear their food into pieces (carnivora, marsupialia, chiroptera, insectivora). The molars of the insectivora are approximately of this type. Meat nourishment is easily digested and hence the whole alimentary tract of these animals is very simple in construction. In carnivora, whose dental crowns are narrow and provided with sharp horizontal edges, the intestinal canal is but from three to five times as long as the body, while the herbivorous animals possess an intestinal canal twenty times as long as their body.

Bunodont, or humped teeth are found in the fruit eaters and the omnivora. The nutritious value of fruit is much less than that of meat, therefore, the alimentary system of such animals is more complicated. Their molars are wider, supplied with cusps and shorter than the other types. The dental apparatus of the fruit-devouring monkey resembles decidedly that of the human being, on account of which many investigators, among them Baume, concluded that fruit formed the primitive nourishment of man. Although the human teeth, with reference to the shape of the molars, indicate fruit as the main article of diet, yet the length of the human intestines argues against this supposition. In frugivorous monkeys, the intestinal canal measures ten times the body length while that of man equals only five to six times its length, therefore, the human being inclines toward carnivorism. Baume argued against this theory as follows: "The intestine of man is less developed than that of the frugivorous animals because it has less heavy work to perform. Man, indeed, eats fruit, but he avoids those fruits which, on account of their indigestibility, require a larger alimentary apparatus. He, therefore, ingests in much smaller quantities those foods which are of less nutritive value than meats. Hence it may be concluded that increased development in the size of the intestines is dependent upon the bulk of the ingested food."

According to his theory then the length of the intestinal canal was reduced as a result, secondary to the use of meat as a nourishment. I cannot wholly agree with this observation. Although there are reasons to believe that we may inherit, to a certain extent, various parts of the body which have atrophied through disease, yet the intestines possess such old evolutional characteristics that it is hard to believe that the intestinal tract could have become so considerably shortened. I have in mind the cæcum which has been carried down to us from our most distant ancestors and which might have been eliminated long ago. Before we can assume that the length of the intestinal tract is influenced by the nature of the food, we must experimentally attempt to reduce the length of the intestines of a monkey in captivity by feeding him meat. Such experiments, however, are hardly practicable as they would have to be continued for a long period of time.

I do not believe that we would obtain a positive result for if Baume's theory held true decided differences would exist between the intestines of poor peasants and those of the meat eating city inhabitants, the former having existed for generations upon field and milk products and only on Sunday obtained a small portion of bacon. Such a difference, however, has never been found: on the contrary, the linear intestinal dimension of the human being is always about eight meters or from five to six times the body length. Therefore man, because of his bunodont, frugivorous set of teeth and his carnivorous intestines belongs to the same class as did his ancestors, namely, the omnivora.

The motion of the jaws, in mastication, in the carnivora as well as in the insectivora and omnivora is vertical, from below upward.

The nutrititious value of vegetables is less than that of fruits, and in order to extract it, the molars of the herbivora are more complicated in form. In the lophodont mammals, of which the best representatives are the now extinct lophiodon and the extinct tapir, the cusps are united by arches which enables them to grind the food more easily than the bunodont type of tooth with its less complicated pattern. When the arches are concentric in shape, as in many of the ruminants they are called *selenodont* teeth. The position of these arches varies with the movements of the inferior maxilla in such a way as to be perpendicular to the direction of movement. Accordingly the enameled plates of the teeth of the ruminants, in centrifugal and centripetal mastication, lie obliquely to the longitudinal plane of the alveolar process. In the gnawing animals the inferior maxilla glides from in front backward (proal) and accordingly the arches lie transversely to the longitudinal axis of the alveolar process. The latter is also true of the proboscidea (of which the elephant is a good example) in which the mastication is palinal, that is from behind forward. In these cases we do not find a transversely, but a longitudinally set condyl which slides in a groove at the base of the temporal bone. The majority of the mammals have two sets of teeth and are therefore called *diphyodont*. The sirenia, the toothed whales and the edentata are the only mammals to retain their original set of teeth throughout life, during which time they remain useful. Such animals are therefore *monophyodont*. When primary teeth are replaced by a new set of teeth, the latter is composed of a greater number, and larger teeth than the temporary set.

According to Baume the shortening of the jaw bone in the course of evolution forces the milk teeth out of the tooth row. He considers, therefore, the milk teeth as a part of the permanent set, the difference being only one of time. Other authorities also believe that the diphyodont type, that is having a milk and a permanent set of teeth, develops from the monophyodont type and that this occurs only in the mammals.

In Zittel's opinion, with which I agree, it has not been proven that the diphyodont mammals are developed from the monophyodont, for on the contrary many monophyodont types are known whose predecessors possessed two sets of teeth. As examples we need only to mention the proboscidea, many of the rodents, the insectivora and the edentata, in all of whom the shedding of the milk teeth is evidently a retrogressive process in comparison with that of their ancestors. According to the important contributions of Kückenthals the embryos of monophyodont mammals very often possess milk tooth germs which, however, never reach development or eruption. Other observers, among them Kollmann, have noticed the same occurrence in man. In this case it is supposed that the tooth ledge produces supernumerary milk tooth germs which, however, only occasionally develop into supernumerary teeth. We hold a convincing argument against Baume's theory, if it is concluded from the above statements and from the observation of Rütimeyers that the milk teeth inherit the evolutionary forms of their ancestors and what seems most plausible that the monophyodont forms descend from the diphyodont and perhaps the diphyodont from polyphyodont. Therefore, from the perpetual shedding of milk teeth, which for example is typical in the shark, the diphyodont type develops and from it the monophyodont type. Through differentiation and perhaps occasional retrogression in the development of the individual tooth it appears that the number of sets of teeth become constantly smaller. At first simple teeth were supplied which were continually shed, then when the type of the teeth became more complex nature became more economical in this respect, until finally only one set of teeth developed. We may feel satisfied then that man has not yet arrived at the final stage of his development for he has still to look forward to the monophyodont state.

All of the various types of teeth may blend with one another and become complicated through the addition of grooves and cusps of many varieties. Applying this law to the human molar we may look upon it as belonging to the bunodont and brochyodont type. The human dental apparatus is called anisodont because of the difference between the incisors and the molar teeth, a characteristic which it shares with the majority of the mammals. On the other hand the human teeth lie in juxtaposition to each other and form rows in which no diastem occurs, an arrangement which not many animals and none of the primates have in common with the human being. With reference to the shedding of his milk teeth, man is considered diphyodont, and according to the movements of mastication, orthal.

We are then confronted with the question as to the nature of the evolutional changes through which the teeth pass before reaching the present stage of high differentiation. Those investigators who accept the observations of Lyell and Darwin conclude that the summing up of all the small changes which occur from time to time finally amount to enormous differences in the forms of all living creatures and their teeth. There exists no fixed form, no state of perpetuation, in nature; all forms of life is either passing into or out of existence.

I will attempt to make clear, as Cope and Osborn determined by mechanical laws, the gradual development of mammalian teeth from their original state. As a primitive type we may accept the simple cone tooth (haplodont type). This tooth consists, as is seen for example in the toothed whales, of a pointed crown with a simple elongated root (Fig. 3, *a*).

A small pointed tip develops on the anterior and posterior sides of this cone shaped tooth. This is the protodont type of tooth and occurs in the beasts of prey of ancient times. In the course of time these tips become large, develop into a tooth having a strong median point with two accessory weaker points, one in front and one behind, which is called the *triconodont* tooth and is found in the mesozoic beast of prey. The root of this tooth has two branches (Fig. 3, *b*).

In the fourth stage the crown becomes wider, so that the median cusp no longer is in a straight line with the accessory cusps but lies either to the outer or inner side of it. This is the tritubercular tooth (Fig. 3, *c*). Such a tooth with three tubercles or cusps which is only seen in the mesozoic beasts of prey, develops through the addition of new cusps into the quadritubercular, quinque-tubercular the sextubercular and finally multitubercular tooth which is found in the allotheriæ (Fig. 3, *d*).

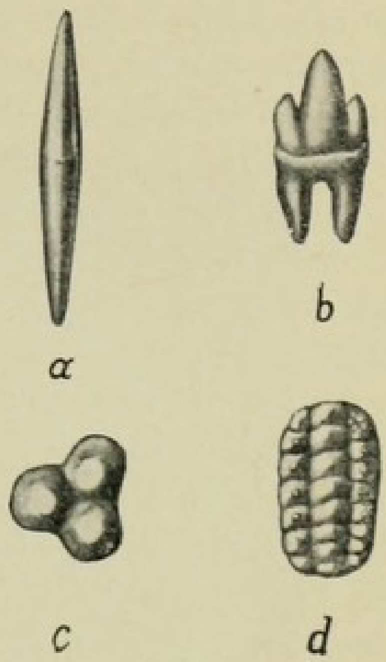


Fig. 3.

I will not consider in further detail the evolution of teeth, for we may easily imagine, through the rearrangement of the position of their cusps and their union through arches and ridges, how the modifications are obtained, which exist in the vertebrates in such manifold forms.

ANATOMY.

THE ORAL CAVITY EXTERNALLY.

We will consider the topographical anatomy of the oral cavity, for it is assumed that the reader is already acquainted with its general anatomy. Externally the oral region is distinctly outlined from the neighboring structures (Fig. 4). Laterally it is bounded by the *sulcus nasolabialis* which extends from the ala nasi to the angle of the mouth; below it reaches the *mentolabial fur-*

FIGURE 4.

Outer surface of the mouth.

a. The nasolabial sulcus. *b.* Labiomental sulcus. *c.* The philtrum.

---

row which is curved convexly upward, and above it extends to the nose. These grooves or furrows are more sharply defined in the old than in the young, and in people, who on account of their occupation, are required to open their mouths widely, such as actors. They are also more marked in chronic diseases.

Normally the upper lip protrudes slightly more than the lower. When the upper lip is excessively thickened it is often indicative of a scrofulous condition with adenoids in the nasal region. If the lower lip protrudes abnormally one may suspect an unusual forward extension of the lower row of teeth. We meet quite frequently in practice, cases in which the upper lip is so short that during conversation the gums are constantly visible. This results in a chronic local irritation of the gums in this location through the thermic and desiccant influence of the atmosphere, especially during the night. The many microörganisms of the air are deposited on the mucous membrane as well as on the front teeth resulting in the formation of a destructive accumulation on the anterior surfaces of the teeth, especially on the incisors.

THE ORAL VESTIBULE.

Back of the outer wall of the mouth and the cheeks lies the horseshoe shaped oral vestibule (Fig. 5, *a*). There exists in reality usually no such space, for the mucous membrane of the cheeks rests directly upon the teeth; but through inflation one may determine the amount of space which the elasticity of the outer walls permits the vestibule to occupy. This is of great importance in the examination and treatment of dental affections. It is curious that in mastication the cheeks do not collapse between the molar teeth. Henle accounts for this by the presence of a firm membrane which is so intertwined with

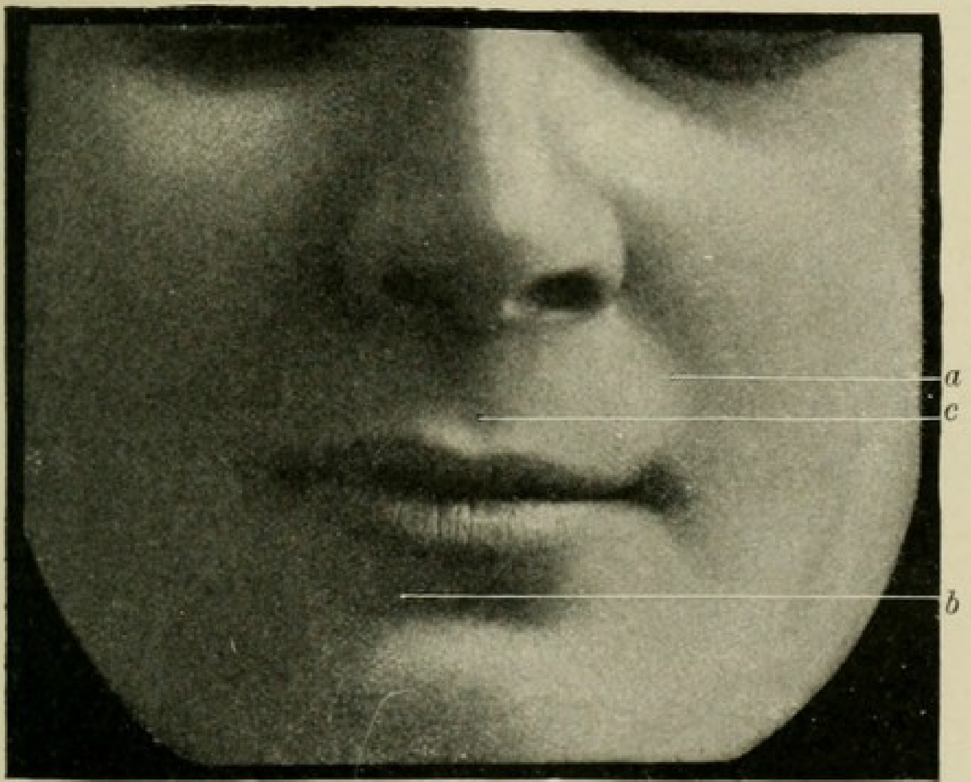


FIG. 4.

the buccinator muscle that it causes the mucous membrane to form into folds thus preventing it from falling between the teeth when they are closed.

The fold by Merkel the "fornix" which consists of a layer of tissue reflected from the external to the internal

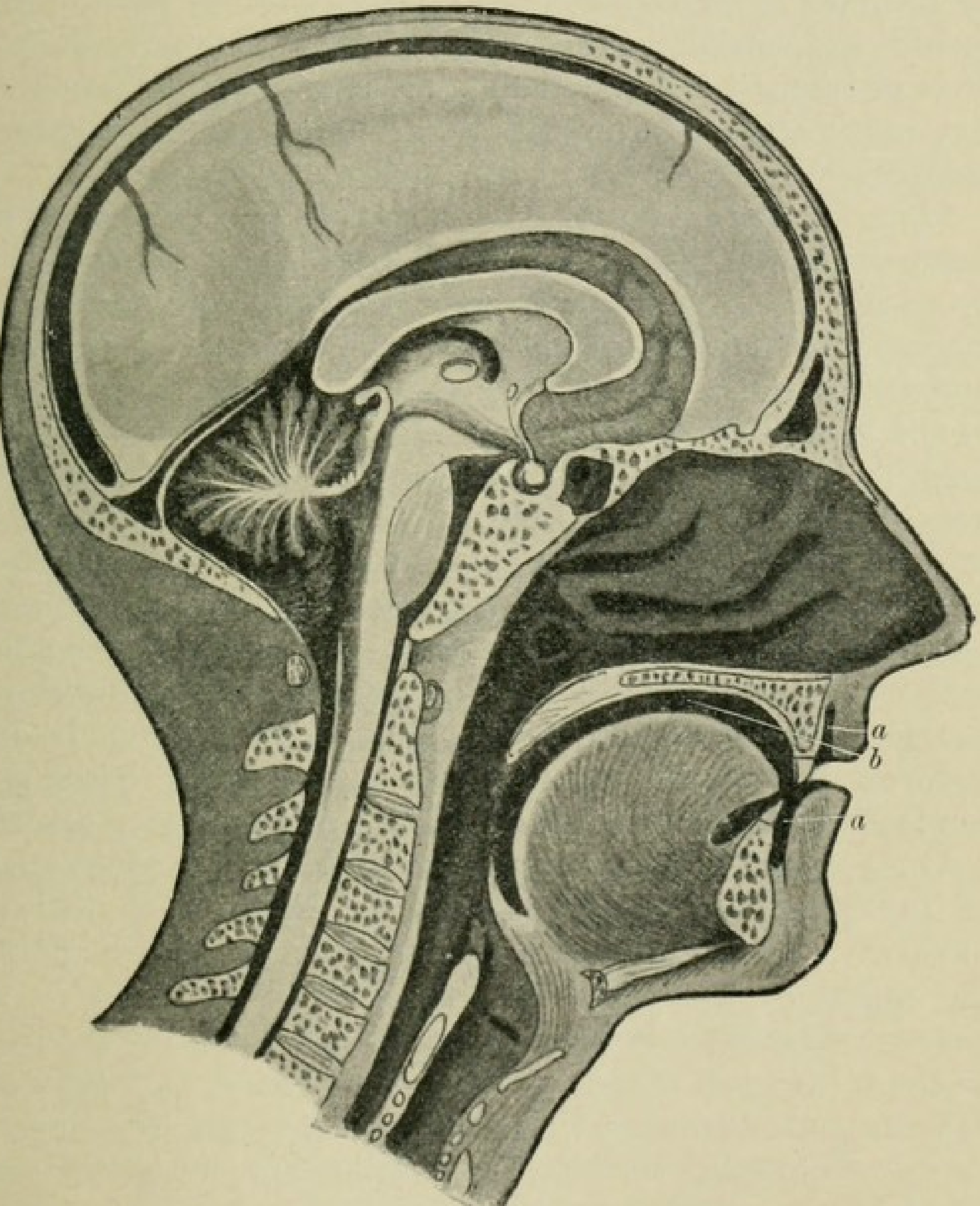


FIG. 5.—A median section of the human head. *a*. The oral vestibule. *b*. The oral cavity.

walls of the vestibule, has the greatest amount of elasticity. The mucous membrane at this point is considerably relaxed and hangs particularly low on the superior maxilla between the bicuspid and molar teeth. In front a tighter fold of the mucosa, called the frænum, connects the inner with the outer wall of the fornix, in both the upper and lower jaw. In the practice of prosthetic dentistry this relationship must be remembered and the artificial plate cut accordingly. To one side of the posterior part of the fornix, the coronoid process of the lower jaw may be felt. It is of interest because it may occasionally interfere with the application of the cofferdam clamps to the second molars.

Opposite the first and second molars one notices a pinhead sized caruncle which is pierced by a fine hair-like opening, the excretory duct (*Stenson's duct*). The parotid, the largest of the salivary glands, lies in front and below the ear occupying the space behind the ramus of the lower jaw. Its largest mass, which is multilobulated, lies between and around the muscles, blood-vessels, nerves, bony prominences, etc. Posteriorly it is bounded by the sternocleidomastoid muscle and the mastoid process; a little below it reaches the digastric muscle and surrounds the styloid process. A few lobes lie also in front between the pterygoid muscles. Above it encloses the temporo-maxillary joint. The part which is not covered by muscle rests on the zygomatic process and sends a wedge shaped thin lobe over the masseter muscle.

On account of the excessively soft, flabby consistency of the gland substance, it is even difficult to feel by pressure that part of the gland which is lodged against the angle of the jaw. A negative observation in an emaciated subject is much more satisfactory, for then the angle of the jaw stands forth prominently, and between the ear and the ascending ramus of the maxilla a deep furrow exists due to the disappearance of the gland substance.

In chewing and speaking, the movable parts, that is, the lower jaw and its musculature press the parotid gland against the fixed bony parts, so that it is flattened like a sponge. When the mouth is held quietly open, normally but little liquid appears, in comparison with the large size of the gland. Hence in short dental operations the upper jaw may be kept perfectly dry by the placing of absorbing materials over the mouth of the duct of Stenson.

Foreign bodies, especially microörganisms may travel from the oral cavity through the excretory duct to the parenchyma of the parotid gland. Therefore chronic swelling of this gland occurs not infrequently in consequence of badly neglected teeth. In epidemic parotitis the infection also probably effects an entrance through the oral cavity.

According to Tillmann[1] inflammation of the parotid gland is originally caused by degenerative changes in the secretion of the mouth. As the parotid gland is enclosed on all sides by a firm fibrous capsule, which is thickest where the gland lies upon the muscles, and, as it is also partially enclosed by bony walls, a slight swelling soon causes pain which the patients usually attribute to the back molars. When the movements of the lower jaw are interfered with, patients are especially inclined to consider the third molar tooth as the cause of the trouble. To establish the diagnosis palpate the gland externally, and if no swelling can be found in front of the ear, or on the masseter muscle, then examine the submaxillary angle, where a swelling may be early detected, for in this area according to König the fibroid capsule is thinnest.

THE ORAL CAVITY.

Strictly speaking when the mouth is closed the oral cavity is not a real cavity for the tongue touches the walls on all sides (Fig. 5) excepting at its posterior end where an open space occurs for the free flow of liquids. Even when the mouth is open one can hardly consider it a cavity, for being in direct connection with the pharynx it forms a canal rather than a hollow space. Its boundaries are equally uncertain and are best outlined by the hard structures. Hence its boundaries in front are formed by

[1] Lehrbuch der spez. Chirurgie, 1897, page 424.

the incisor and cuspid teeth and laterally by the molars. Above it is limited only in front by a firm structure, the hard palate, while further back is the soft palate which has a certain amount of mobility.

The floor of the oral cavity is occupied by the tongue. In order to mark the point or better the surface, where the mouth ends and the throat begins, the mylohyoid muscle is employed as the anatomical boundary. As is well known, this muscle stretches diaphragmatically between the rami of the inferior maxillary and the hyoid bone. That is, it arises from the mylohyoid line which runs diagonally from the upper posterior end to the lower anterior end of the inferior maxilla. The majority of the muscle bands run to the median fibrous raphe which extends from the symphysis of the lower jaw to the hyoid bone. The smaller part of this muscle inserts directly into the body of the hyoid bone.

Posteriorly the oral cavity reaches to an imaginary plane which is drawn between the palatine arches, the so-called *isthmus of the fauces*. We will only consider in detail here the anatomical structures of the mouth which do not stand in close relationship with the teeth, the anatomy of which will receive especial attention elsewhere.

The roof of the oral cavity (Fig. 6) is formed by the palate, the anterior portion of which is surrounded by teeth and called the hard palate on account of its osseous base while the posterior or muscular part is called the soft palate.

On palpation the palate feels as if a thin mucosa were stretched directly over the bony plate of the hard palate. This, however, is not true as a thick cushion of trabeculæ and laminæ filled with flat lobules and acinus glands lie between the mucous membrane and the periosteum. This cushion is thickest between the true palate and the alveolar process and gives the rounded form to the palatine arches. The palatine arch is subject to many variations in different individuals, it may be perfectly flat, or that of a gothic vault, or of the varying forms between these two. The pathology of narrow and high palates will be discussed under the anomalies of the teeth.

Back of the middle incisors on the hard palate a pear shaped eminence is found which is known as the *papilla* of the *palate* and from which a linear ridge or raphe extends backwards. Latterly this raphe is joined by

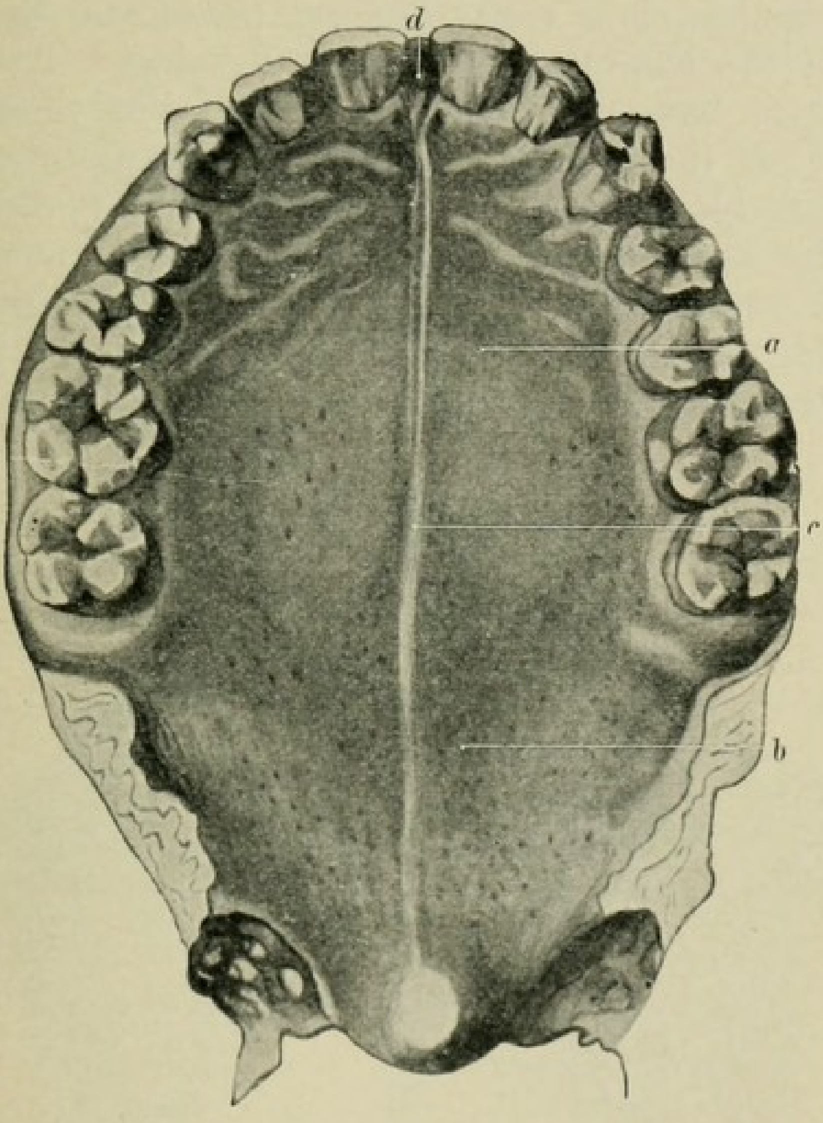


FIG. 6.—Roof of the oral cavity. *a.* Hard palate. *b.* Soft palate. *c.* Raphe. *d.* The palatine papilla.

little ridges which run obliquely to the dental arch and which are called *plicæ palatinæ*, or folds of the palate. These eminences are all richly supplied with tactile nerves, which easily explains why people wearing artificial teeth lose some of the enjoyment of tasting their food.

The papillæ which are everywhere present in the oral

FIGURE 8.

The Vessels and Nerves of the Hard Palate.

a. The greater palatine artery with the greater palatine nerve. *b*. The incisor canal through which the greater palatine artery anastomoses with the terminal branch of the sphenopalatine artery. The nasopalatine nerve reaches the hard palate through this canal.

mucous membrane are taller and greater in number in the anterior part of the mouth than near the soft palate. The epithelium is a many-layered pavement epithelium in which the stratum corneum is missing. The superficial layers have not become cornified like those of the skin but on the contrary the nuclei are plainly visible. The tissue lying between the mucosa and periosteum is not of the same nature everywhere; the acinous glands are more numerous in the posterior part and especially in the tissue, mentioned above, which lies between the hard palate and the alveolar process. The palatine arch is

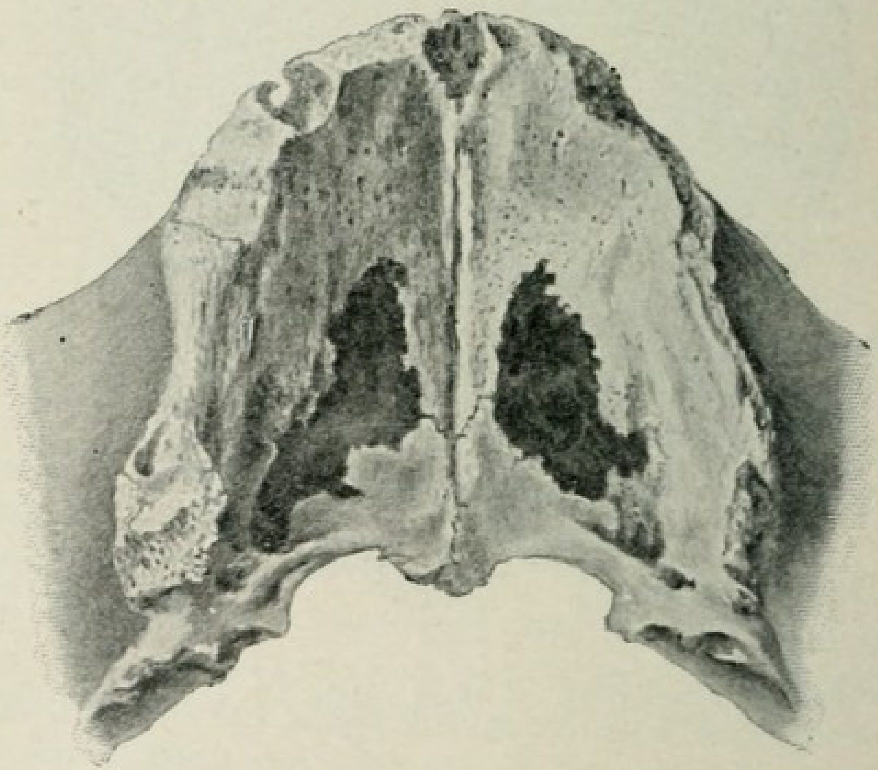
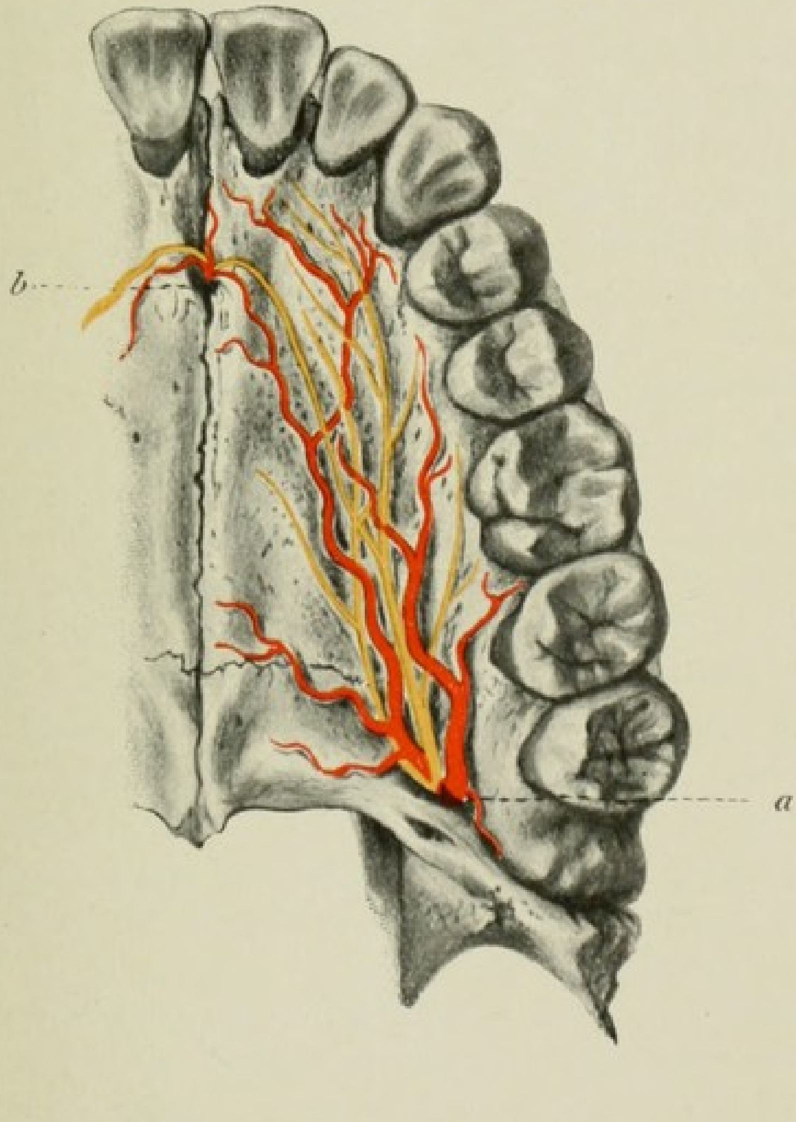


FIG. 7.—A senile superior maxilla with perforations of the palatine plate.

composed, aside from the cushion-tissue which lies between the mucosa and the periosteum, of dense bands of connective-tissue which are closely interwoven with each other and intergrown with the mucosa and periosteum.

Fig. 8.



In old age and through the loss of teeth the alveolar process undergoes absorption and the palate loses its vault. This absorption causes the bony substance to wear away so that in extreme cases the nose is separated from the oral cavity only by soft tissue, as may be seen in the macerated preparation in Fig. 7.

The *arteries* which supply the hard palate pierce that bone to the posterior and to the medial sides of the third molar teeth through the pterygopalatine foramen. This vessel, spreading into many branches, lies directly upon the bone and runs forward in a direction parallel to the tooth row (Fig. 8). This is the *greater palatine artery*, which, as the largest branch of the pterygopalatine artery comes from the internal maxillary artery. The two former arteries unite by means of their smaller branches in the neighborhood of the incisor teeth where a small subdivision passes into the incisor canal to anastomose with the sphenopalatine artery.

The *nerve supply* is derived from the superior maxillary branch of the trigeminal nerve and from the nasal or sphenopalatine ganglion. The most important is the *greater palatine nerve* which leaves the pterygopalatine foramen with the greater palatine artery, the width of which is about equal to that of the nerve. This nerve undergoes anastomosis in the foramen incisivum with the *nasopalatine nerve* which passing through the spheno-palatine foramen runs forward along the nasal septum.

The soft palate begins about a finger breadth back of a line connecting the incisor teeth of the two jaws. As it is composed of muscle tissue its form changes constantly during observation; it rises and falls alternately. The uvula is suspended from above into the isthmus of the fauces where its presence narrows the size of this opening. The palatine arches spread out on either side and form a space in which the tonsils rest. The posterior palatine arch is the *arcus palatopharyngeus* and the anterior is the *arcus palatoglossus*.

The floor of the mouth (Fig. 9) is formed by the tongue and the sublingual tissue which stretches between the rami

FIGURE 10.
The Superior Maxilla.
a. Alveolar process. *b*. Zygomatic process. *c*. Frontal process. *d*. Alveolar eminences. *e*. Anterior nasal spine. *f*. Canine fossa. *g*. Infraorbital foramen. *h*. Maxillary tubercle and the alveolar foramen (not plainly shown here) through which the blood-vessels and nerves pass to supply the molar teeth.

of the inferior maxilla. These structures are united with each other by the frenum of the tongue. This frenum is sometimes so taut in children as to interfere with suck-

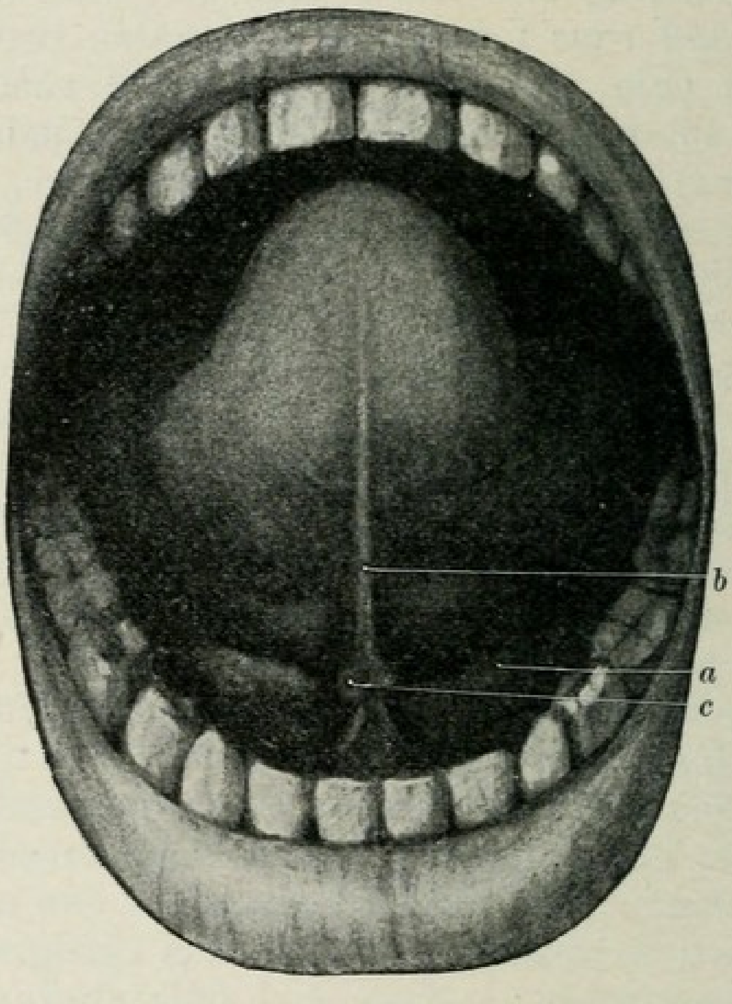


FIG. 9.—Floor of the mouth: *a*, sublingual gland; *b*, frenum of the tongue; *c*, salivary caruncle.

ling; in such cases it is cut with a pair of scissors. In some abnormal cases the frenum may extend to the two lower incisor teeth adding, later in life, to the difficulty in using artificial teeth. This may be overcome in a measure, however, by cutting suitable notches in the lower border of the plate to accommodate the frenum.

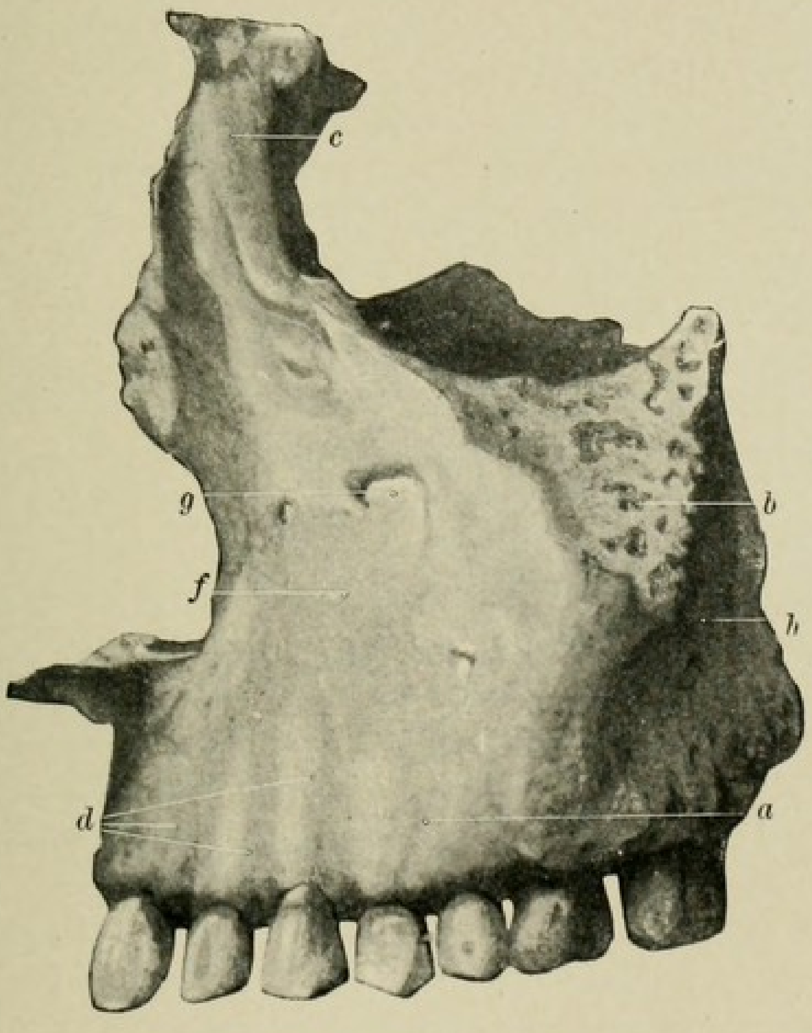


Fig. 10.

Of the two laterally placed eminences between the tongue and the ramus of the jaw, we will only consider the one formed by the sublingual gland with its covering of mucous membrane. This gland rests below directly upon the mylohyoid muscle which separates it to a great extent from the submaxillary gland. Internally it rests upon the geniohyoglossus muscle. The excretory ducts of this small gland open into the mouth (8–12 in number) in the above mentioned eminence as the *ducts of Rivinus.* Aside from these another larger excretory duct, the *duct of Bartholin*, enters the mouth through a pea sized eminence, the *salivary caruncle,* which is situated under the tongue at the back end of the frenum. The excretory duct of the submaxillary gland, *the duct of Wharton*, usually enters the mouth through the same orifice. The submaxillary gland may be felt (but only when swollen) partly below and in front of the submaxillary angle. It lies in a triangle which is formed by the edge of the jaw and the two bellies of the digastric muscle. A small group of lymph glands are found back of the lower front incisors; these are termed by Merkel (*glandula incisiva*) the incisor glands. These glands all secrete reflexly even when the muscles of mastication are only slightly active. This accounts for the flooding of the mouth in operations on the floor of the oral cavity.

The *tongue* is attached only at its posterior end while its tip is freely movable. Its color is rather grayish in comparison with the bright red of the rest of the oral mucosa. This shade is due to a deposit of flat epithelial cells. The dentist has an opportunity to observe the appearance of his patient's tongue daily and although a lingual coating is no longer considered of as great significance as formerly, yet, its condition in association with other symptoms is often of considerable diagnostic value. The coating of the tongue usually represents an increased proliferation of the epithelium which gives the tongue a rough grayish appearance. This phenomenon is explained by Sahli in the trophic change of the lingual mucous membrane brought about by disturbances in the alimentary system. For this reason a coated tongue is an important diagnostic sign in dyspepsia. It occurs in fever and in other conditions accompanied by anorexia and only exceptionally does it occur in good health (in the writer's experience only on the tongues of smokers). Acute and chronic gastric catarrh is nearly always accompanied by a coated tongue.

When the salivary secretions are restricted as in the severe febrile affections, the thickened mucosa becomes dry, fissured and encrusted, and if hemorrhage exists, it is discolored brown or black. This picture of a fuliginous coated tongue, with which we are well acquainted, always portends a severe constitutional disturbance.

If fresh and scarred teeth wounds are seen on the tongue, which are not traceable to a rough tooth, inquiries should be made as to the occurrence of epileptiform or genuine epileptic attacks. If the patient is subject to such convulsive seizures and no tooth marks exists on the tongue, hysteria or feigning (malingering) may be suspected.

The *arteries* of the floor of the mouth, to be especially considered, are branches of the lingual artery which is a division of the external carotid. This main branch, the *ranine artery*, runs superficially along the middle of the tongue to its tip. As this vessel is of considerable size large hemorrhages may follow injuries to the tongue, an accident which must not be considered impossible in dental procedures. The dorsal artery of the tongue and the sublingual artery being small branches are only incidentally mentioned in passing.

Of the *nerves* the hypoglossal, the third branch of the trigeminal (from which the lingual is derived) and the glosso-pharyngeal are to be considered. The hypoglossal lies to one side and underneath the submaxillary gland and sends its branches to the musculature of the tongue of which it is the motor nerve. The tractile sense is supplied by the lingual nerve, a terminal branch of the third division of the trigeminus, which through union with the chorda tympani receives both secretory and gustatory stimuli from the facialis. As is known the facial nerve is in reality a motor nerve; and therefore the gustatory fibres of the chorda tympani are probably received from the glosso-pharyngeus, through the minor superficial petrosal nerve, or through the anastomosis of Jacobson from which fibres are conveyed to the otic ganglion and from there through the chorda tympani to the lingualis. The tongue fibres of the glosso-pharyngeal nerve also serve in a lesser degree to carry impulses for the sense of taste.

THE UPPER JAW (MAXILLA).

The superior maxilla is the largest bone of the face. It helps to form the roof of the oral cavity, and partly forms the lateral walls of the nose and the floor of the orbit. It consists (Fig. 13) of a body (corpus) and four processes.

The lateral process is called the *zygoma* because it connects with the malar bone. The *palatine process* extends in a medial direction and constitutes with its opposite fellow the largest part of the hard palate. The lower border of the maxilla, in which the teeth are inserted, is the *alveolar process*. Above and in front lies the *frontal process* which joins the nasal, frontal and lachrymal bones.

The body of the upper jaw is not a solid bony mass but, on the contrary, contains a hollow space, the *maxillary sinus* (antrum highmori). This cavity is connected with the nose by an aperture in the inner wall called the *maxillary hiatus* (ostium maxillare). On the anterior or facial surface of the alveolar process a number of eminences exist which correspond to the teeth and are known as the *alveolar arches* (juga alveolaria) (Fig. 10, *d*). Little depressions are noticed between these protuberances, one of which existing in front of the well developed root of the cuspid or so-called canine tooth is called the *incisive fossa* (fossa incisiva). The shallow depression (*canine fossa*) which lies between the eminence formed by the canine tooth and the base of the zygomatic process gives origin to the *canine muscle*.

FIGURE 11.

Superior maxilla with the antrum opened.

To show the relationship between the latter and the roots of the teeth. *a.* Maxillary sinus. *b.* Maxillary process of the inferior turbinated bone. *c.* Perpendicular portion of the palatine bone. *d.* Ethmoidal process of the inferior turbinated bone. *e.* Unciform process. *f.* Orbital surface. *g.* Fossa for the lachrymal sac. *h.* Sphenopalatine foramen. *i.* Pterygopalatine fossa. *k.* Third molar tooth erupting posteriorly.

The *infraorbital foramen* lies a few millimeters beneath the orbital ridge, approximately over the root of the first bicuspid tooth. This foramen contains the infraorbital nerve, the branches of which enter the bony structure to supply the teeth.

A rough eminence on that portion of the maxilla which lies back of the zygomatic process is called the *maxillary tuberosity*. In front of the zygomatic process the anterior or facial surface ends in a pear-shaped notch marking the beginning of the nasal cavity, which is called the *pyriform aperture.*

The orbital surface (superficies orbitalis) is smooth and slopes gradually outward. Its regularity is only interrupted by a groove, the *infraorbital sulcus,* which passing forward into a similarly named canal terminates in the above described infraorbital foramen. Another small depression, to be mentioned, lies in the inner and anterior part of the orbital surface and gives origin to the internal oblique muscle.

On the inner or nasal surface of the superior maxilla, near the base of the frontal process, is the crest for articulation with the inferior turbinated bone. The foramen which connects the antrum of Highmore with the middle meatus of the nose lies in the upper portion of the nasal surface and is partly covered by a curved cartilaginous plate called the *lamina lacrymalis.* The *pterygo-palatine groove* which helps the palate bone to form the pterygopalatine canal runs obliquely forward and downward, its lower rough edge connects with the palate bone. Of the various processes of the superior maxilla, the frontal and zygomatic interest us less than the palatine and the alveolar.

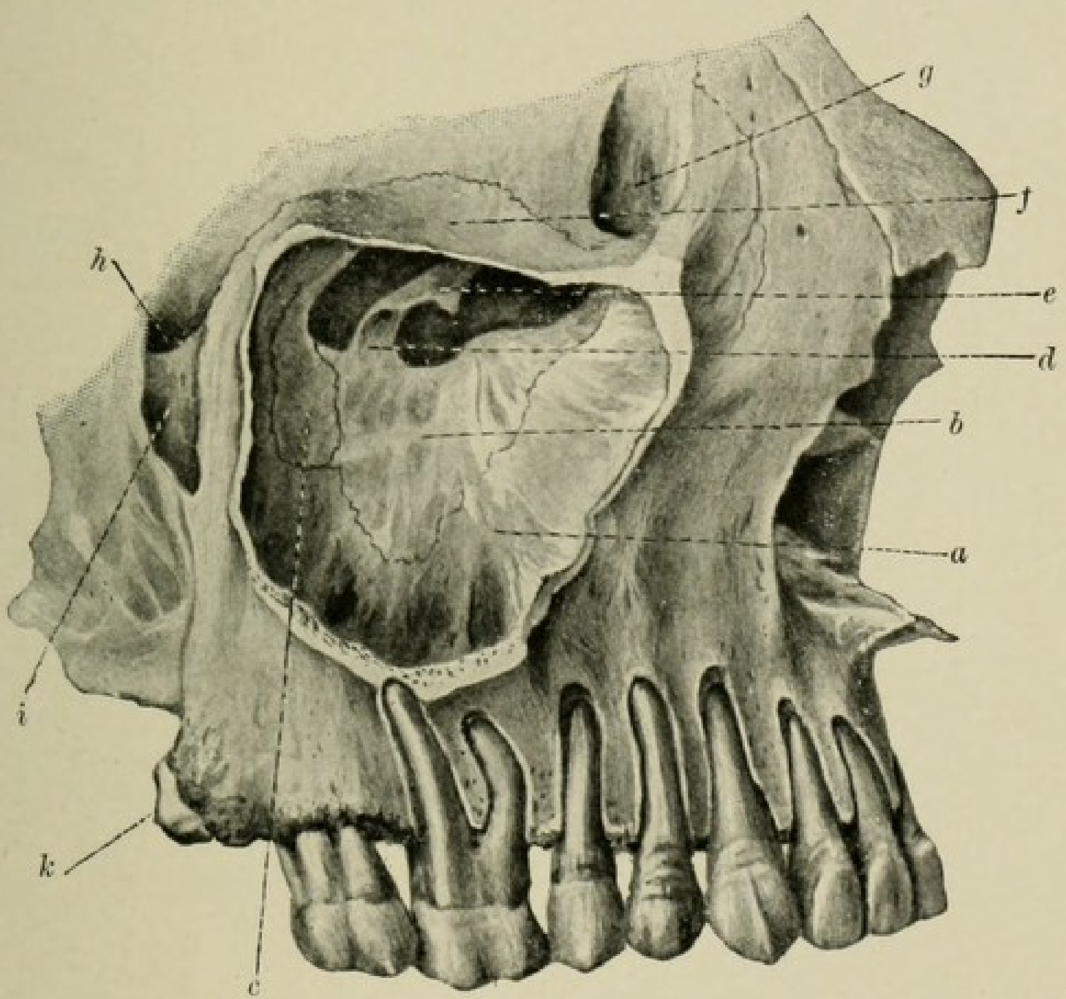


FIG. 11.

The *palatine process* extends as a quadrangular shaped bony plate in a horizontal direction from the lower medial surface of the superior maxilla. The two palatine processes meet in the middle line and form three-fourths of the hard palate; the other quarter being formed by the horizontal portion of the palate bone. The lower or oral surface is arched, rough and grooved for the transmission of blood-vessels and nerves. Posteriorly the serrated

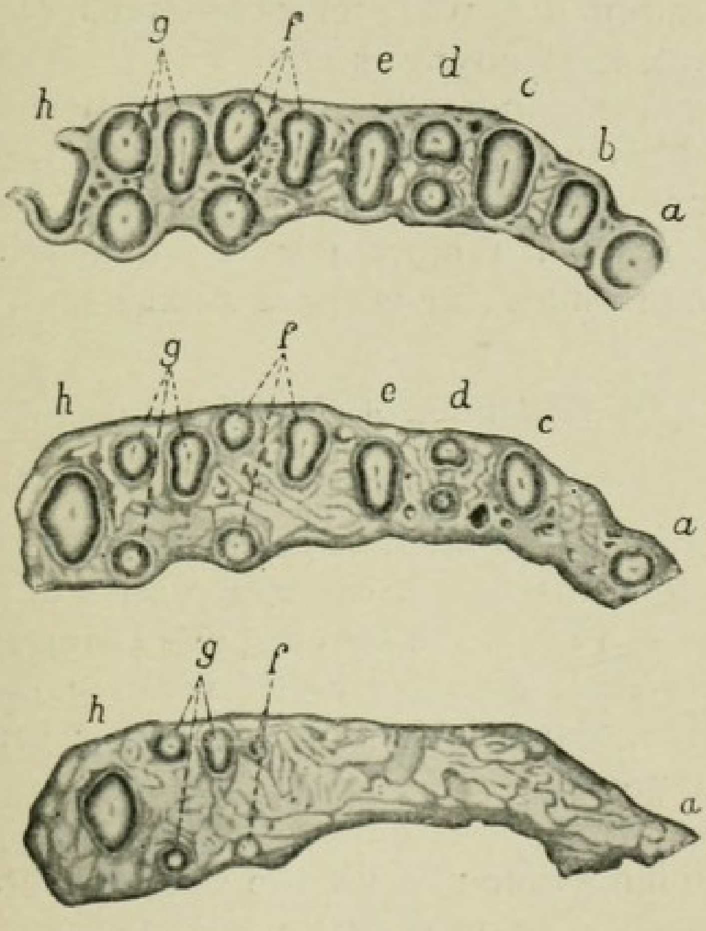


FIG. 12.—Horizontal sections through the alveolar process of the superior maxilla. *a*. Central incisors. *b*. Lateral incisors. *c*. Cuspid teeth. *d*. First bicuspid. *e*. Second bicuspid. *f*. First molar. *g*. Second molar. *h*. Third molar tooth.

edged palatine process of the superior maxilla connects with the horizontal plate of the palate bone, while in the middle line the upper surface bears a crest for union with the vomer. A canal pierces the plate of the palate bone near the incisor teeth (*canalis incisivus*) and enters the oral cavity as the *foramen incisivum*.

The lower border of the alveolar process of the superior

FIGURE 13.

Röntgen ray photograph of the superior maxilla and its neighboring structures.

maxilla contains the alveoli in which the roots of the teeth are inserted. It is of the greatest import both for extraction and treatment of the roots to possess an exact knowledge of the topographic relationship of these alveoli. This can be obtained in no better way than by making horizontal sections similar to those shown in figure 12. For a description I will refer the reader to the text accompanying the illustrations.

A Röntgen ray photograph of the normal superior maxilla and its neighboring structures is reproduced in Fig. 13, for not until the reader is acquainted with the appearance of such a picture is it possible to recognize pathologic conditions as shown in a skiagram.

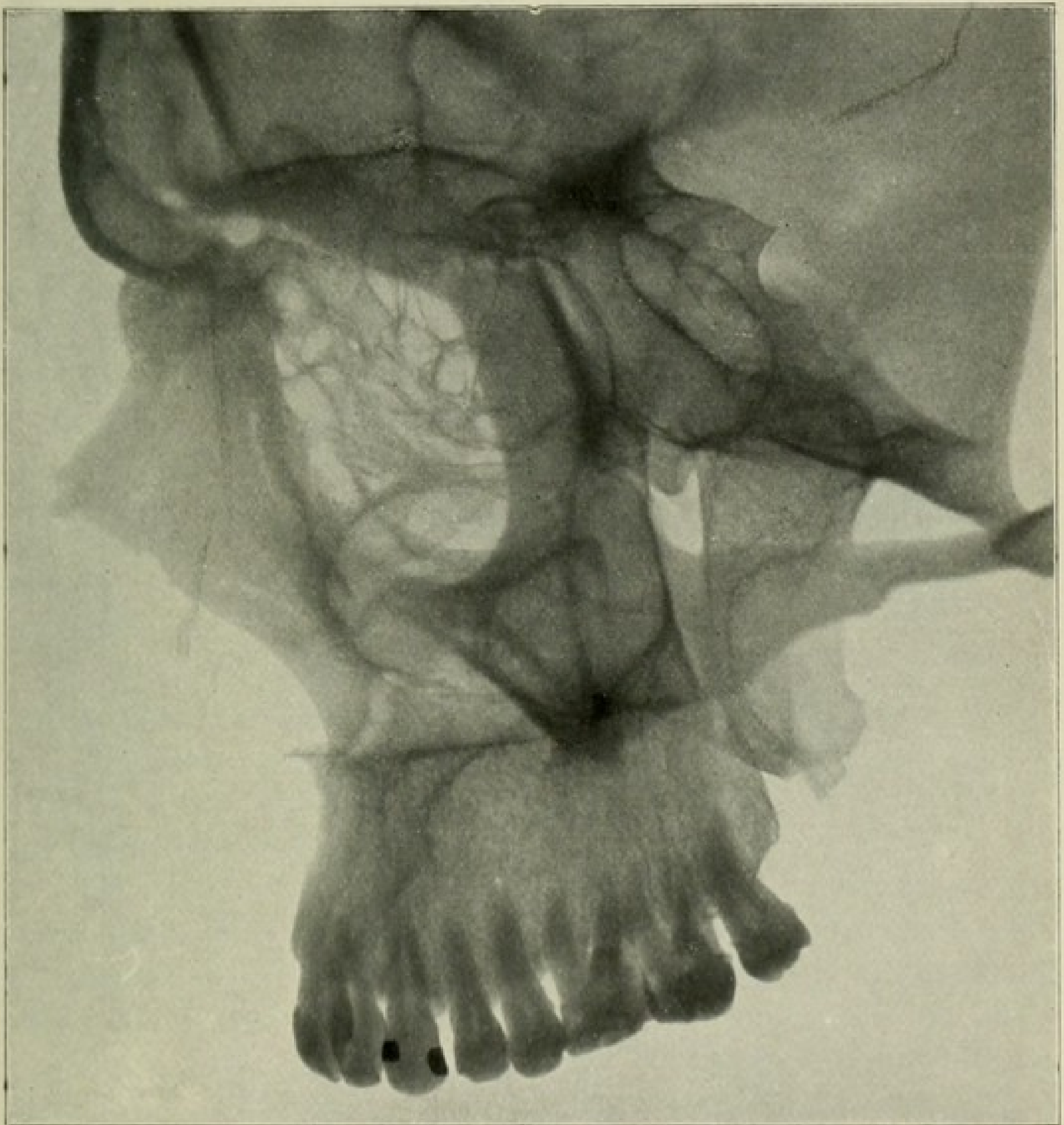
THE INFERIOR MAXILLA.

(Mandibula, Plate I.).

The inferior maxilla is not attached to the upper jaw through bony union but is connected with it by an articulating joint. This is the heaviest and strongest of all the bones of the head, and is divided into the body or horizontal portion, and two rami or ascending branches, and the alveolar process.

In old age atrophy of this process and flattening of the angle of the bone accounts for the apparent protrusion of the lower jaw. The outer walls of the alveoli are generally thinner than the inner, for which reason in extraction of the lower teeth, the force is principally directed outward. The jaw bone is thickened in the region of the second and third molar teeth through the oblique line which lies on the buccal surface. This is especially noticeable when the roots are removed, yet sometimes it cannot be detected until resection forceps are applied (Fig. 14). A cross section of the body of the jaw, as presented in Fig. 14, shows an outer hard compact mass surrounding an inner spongoid substance with wide

Fig. 13.



meshes, the trabeculæ of which form the *mandibular canal* and assist in supporting it. The medullary space extends close to the tips of the roots and surround it on both the buccal and lingual sides. This explains the rapid extension of affections of the periodontium to the jaw bone, and also accounts for the relatively rapid absorption from the apical foramen of soluble poisons which are placed in the tooth cavity. Severe intoxications of a greater or less degree may thus develop especially in those who are subject to idiosyncratic tendencies. Figs. 15 and 16 illustrate the topographic relationship of the alveolar process, in which the position and direction of the roots are well shown as well as the alveolar and spongy cavities.

The ascending ramus is thinner and flatter than the body of the jaw. At its upper end it divides into two processes the *coronoid process* on which the temporal muscles are inserted, and a posterior process, the *condyloid process* which articulates with the cranium by means of a transversely placed condyle.

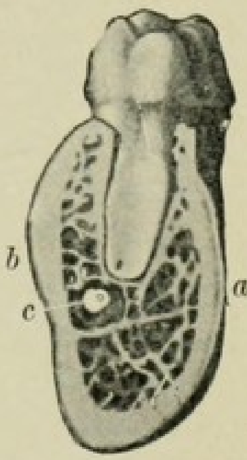


FIG. 14.—Cross section of the ascending ramus of the inferior maxilla. *a*. Buccal. *b*. Lingual. *c*. Mandibular canal.

The joint of the inferior maxilla bone is most interesting. It is like a double joint in which, however, the articulations of the two sides must act simultaneously since they are incapable of independent movements. An eminence in front of the glenoid cavity is called the *articular tubercle.* The glenoid cavity contains an interarticular cartilage, and when the mouth is opened the condyle of the inferior maxilla glides forward with its interarticular cartilage over this tubercle. In as much as the inferior maxilla possesses two articulations ankylosis may fail to develop even if both joints are considerably diseased, provided that one joint is less affected than the other.

Backward luxation of the inferior maxilla is prevented by the tympanic plate of the temporal bone, and lateral displacement by the spine of sphenoid bone. The only dislocation possible is in the forward direction which is

PLATE I.

Lower jaw of an adult: The upper picture shows the buccal, and the lower, the lingual side: *a*, mental foramen; *b*, mental protuberance; *c*, alveolar eminence; *d*, oblique line; *e*, coronoid process; *f*, condyloid process; *g*, mandibular foramen; *h*, digastric fossa; *i*, mental spine; *j*, sublingual fossa; *k*, mylohyoid line; *l*, lingual; *m*, submaxillary fossa.

FIGURE 15.

Horizontal sections through the alveolar process of the lower jaw: *a*, central incisors; *b*, lateral incisors; *c*, cuspid teeth; *d*, first bicuspid; *e*, second bicuspid; *f*, first molar; *g*, second molar; *h*, third molar.

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comparatively easy since the physiological forward movement of the condyle on the articular tubercle is strictly speaking already a subluxation, and only a slight violence is then necessary to force it over that eminence in the infratemporal fossa. The condyle once displaced into this position requires considerable strength to reduce it

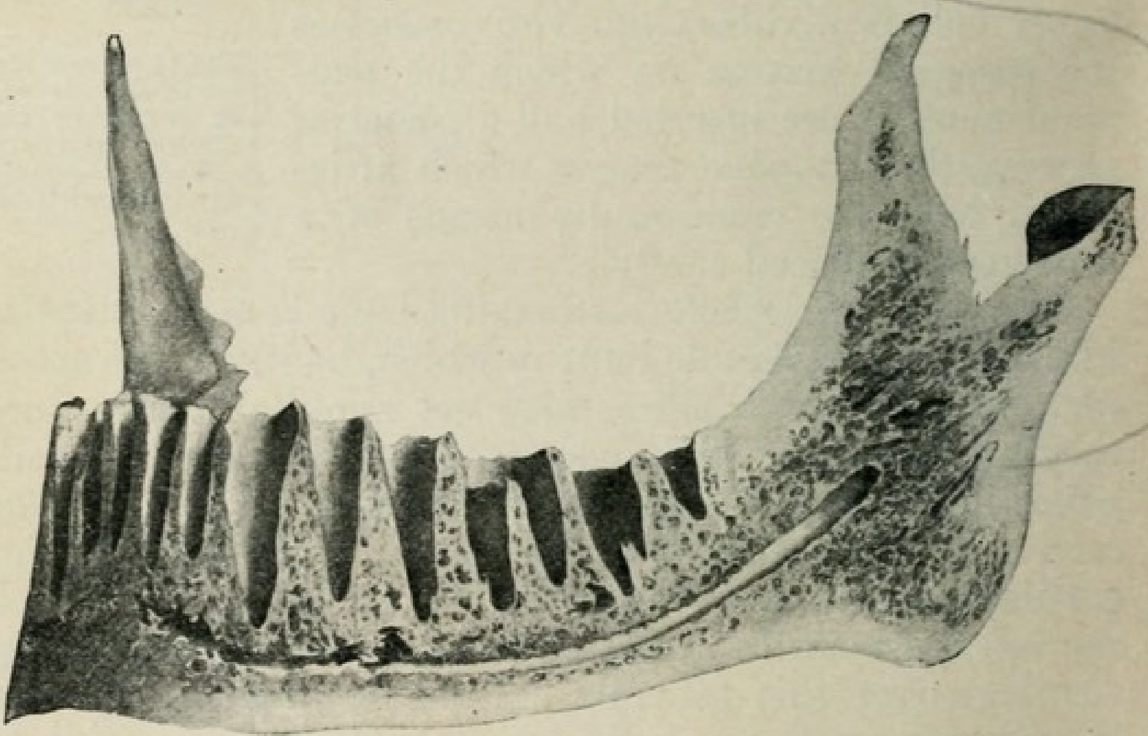
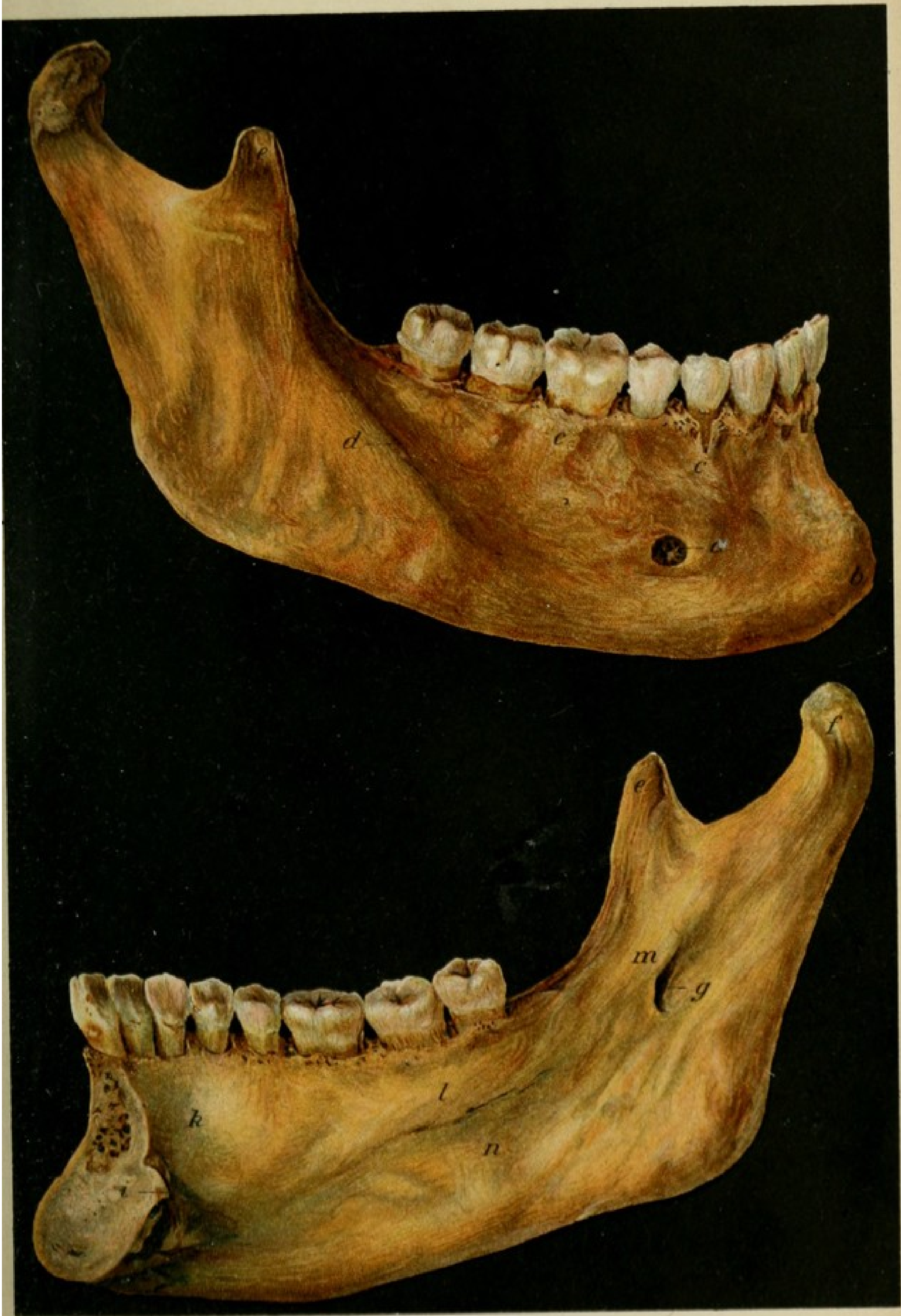


Fig. 16.—Lower jaw, from which the buccal plate has been removed in order to show the distribution of the spongiosa and the course of the mandibular canal.

on account of the contraction of the strong muscles of mastication. The lower jaw is habitually displaced when the accessory ligaments and the muscles of mastication



Lith. Anst. F. Reichhold, München.

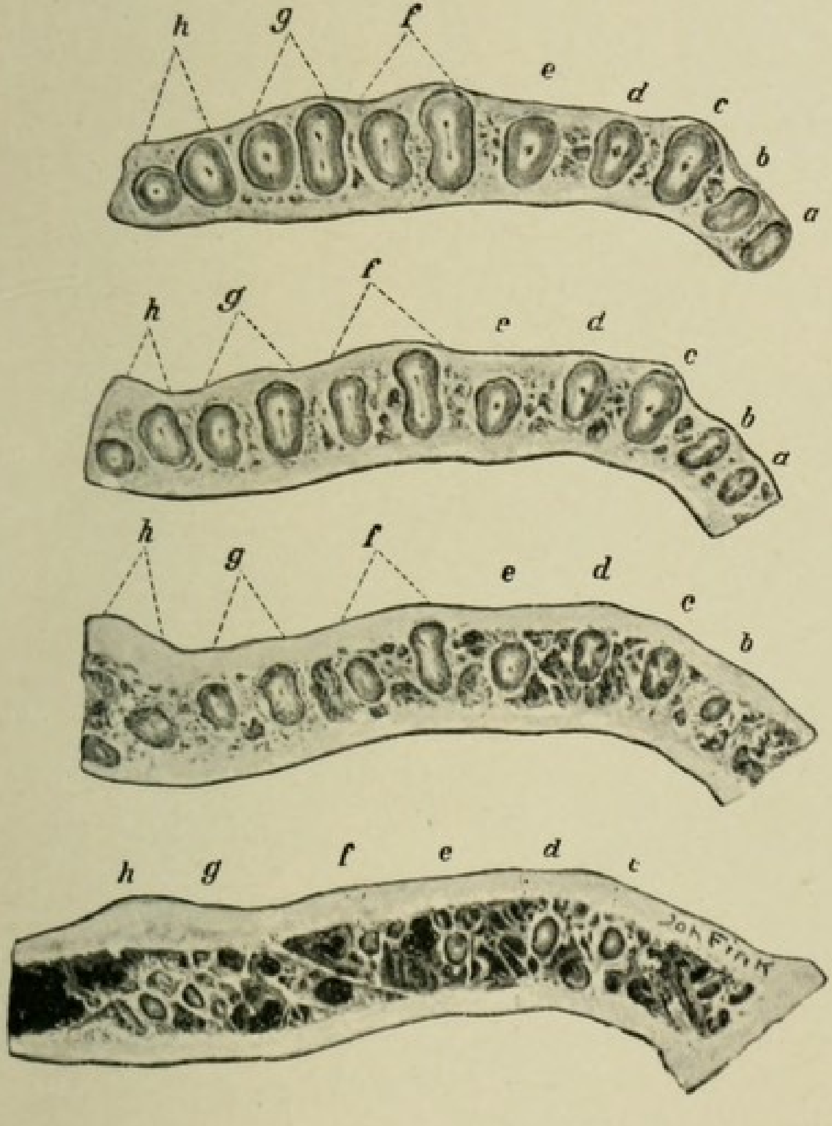


Fig. 15.

are relaxed, otherwise this bone is dislocated only through forcible opening of the mouth through a fall, blow, etc.

In old age when all the teeth have disappeared the alveolar process of the inferior maxilla becomes absorbed and only the body together with a more or less serrated, sharp bony ridge remains, the latter indicating the former

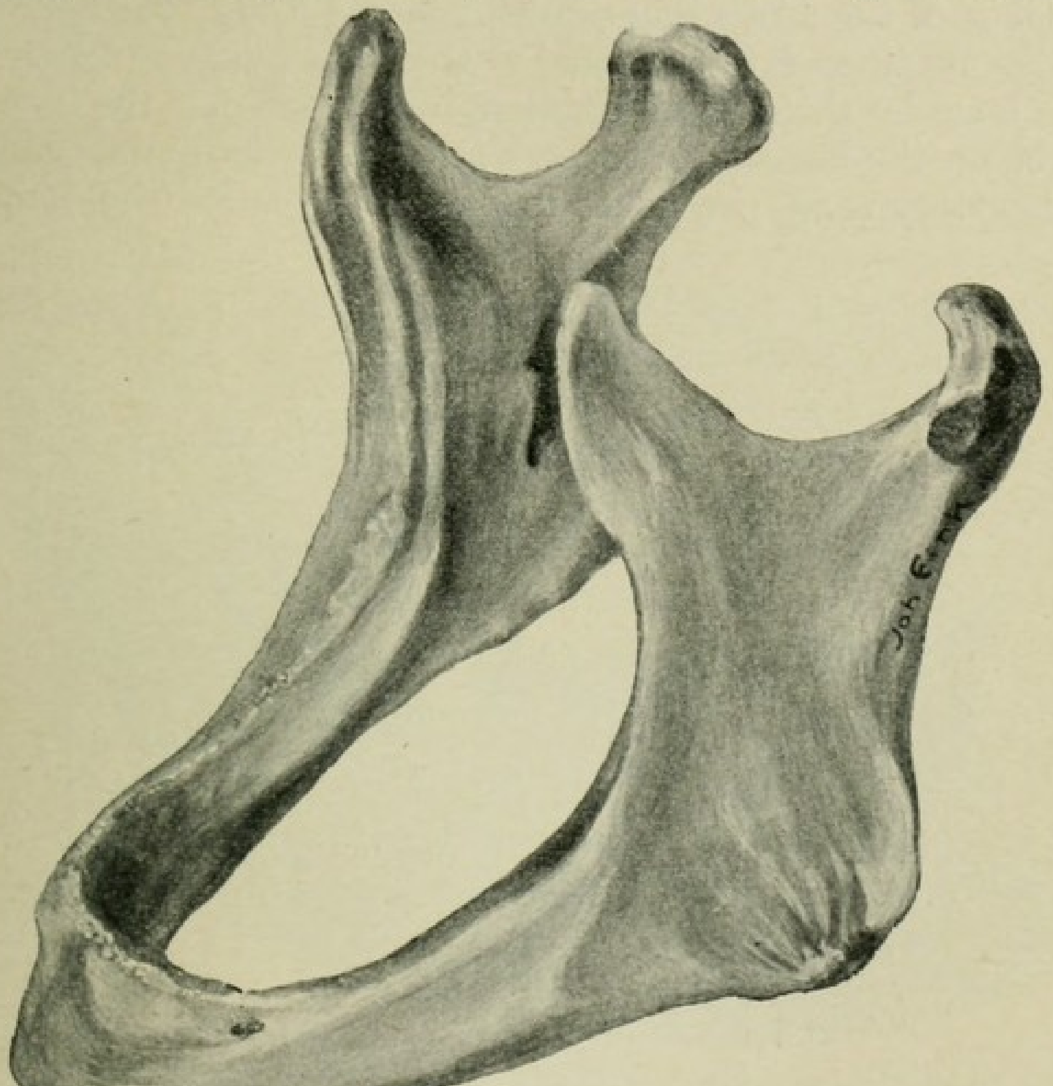


Fig. 17.—A senile lower jaw with atrophy of the alveolar process.

position of the alveolar process. Under such circumstances an artificial denture is retained with difficulty. The Röntgen ray picture in Fig. 18, like that of the upper jaw, gives the normal radiographic appearance of the inferior maxilla.

THE BLOOD-VESSELS AND NERVES OF THE TEETH.

The *internal maxillary artery*, through its branches, supplies blood to all of the teeth and their neighboring structures. The lower jaw gets its blood supply from the inferior dental artery, which runs along the lingual surface of the ascending ramus, passes through the mandibular foramen into the canal of the same name and leaves the bone by the mental foramen, in the region of the bicuspids, on the buccal aspect. From the mandibular canal this artery sends branches to the teeth, called the dental

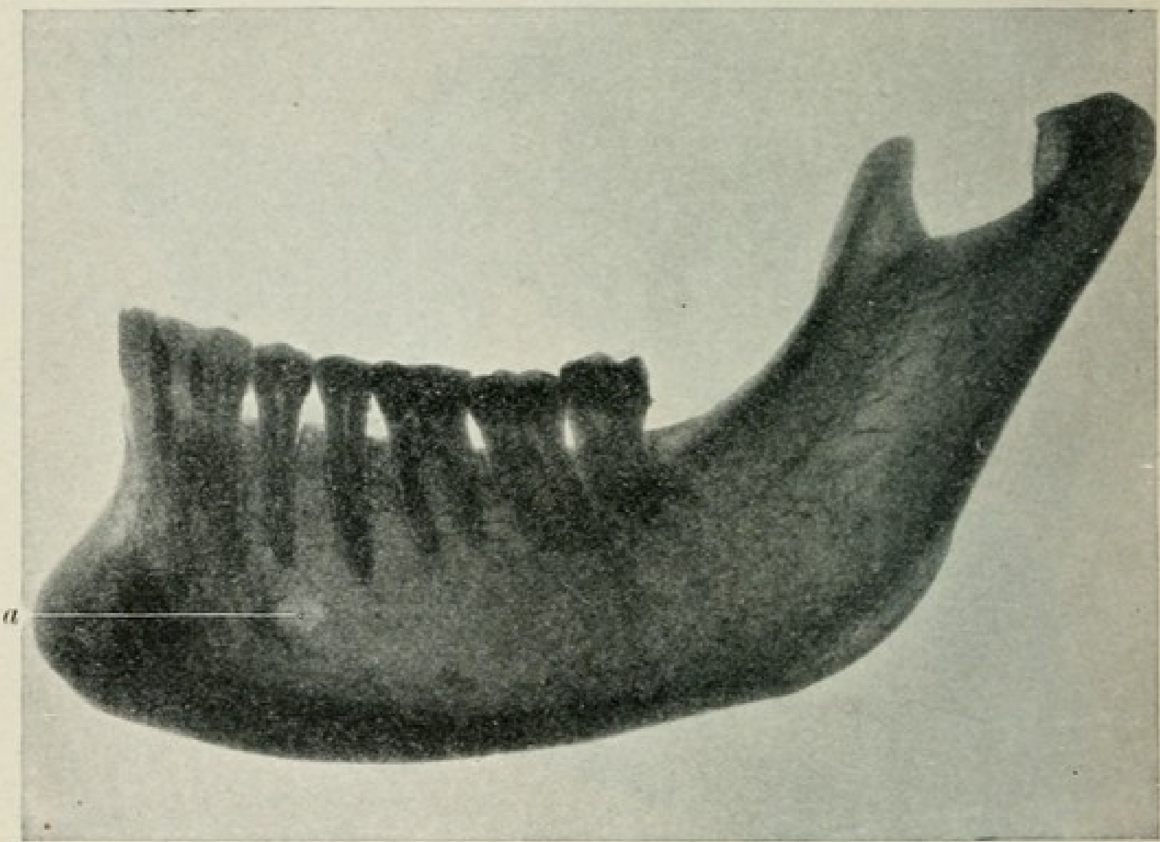


FIG. 18.—A Röntgen ray photograph of the lower jaw. *a*, mental foramen.

rami, and also branches between the teeth, known as *interalveolar rami*. The latter subdivide into the *gingival perforating branches* which supply the gums and the *alveolar perforating branches* which supply the alveoli and the periosteum. A rich anastomosis exists between the dental and the interalveolar rami, an arrangement which accounts for the transmission of circulatory disturbances from one part to another. The blood-vessels of the upper jaw are subdivided into terminal branches like those described for the lower jaw and therefore need not be referred to here.

The alveolar process of the upper jaw is supplied by the *infraorbital artery* which arises from the third division of the internal maxillary artery. The superior posterior alveolar artery arises either directly from the latter or from the infraorbital. When it arises from the infraorbital, it is subdivided in the region of the pterygopalatine fossa where it passes through the inferior orbital fissure into the orbits. Near its origin it divides into minute ramifications (*superior posterior alveolar arteries*) which at the maxillary tubercle enter the alveolar canals through the alveolar foramina and pass forward into the maxillary sinus. From here these small arteries reach the upper molars and their surrounding structures. During the passage of the infraorbital artery through the infraorbital canal it sends off abundant anastomosing branches, the *anterior superior alveolar arteries* which enclosed in complete and semi-complete canals, supply the bicuspid, the cuspid, and the incisor teeth.

As the veins correspond to the arteries a description of them will be omitted. Attention, however, is called to the beautiful plexus formed by the mandibular vein which lies in the inferior dental canal (Plate 2). All maxillary veins empty into the *internal pterygopalatine plexus* which is situated in the pterygo-maxillary fossa. This plexus sends its blood into the external jugular vein.

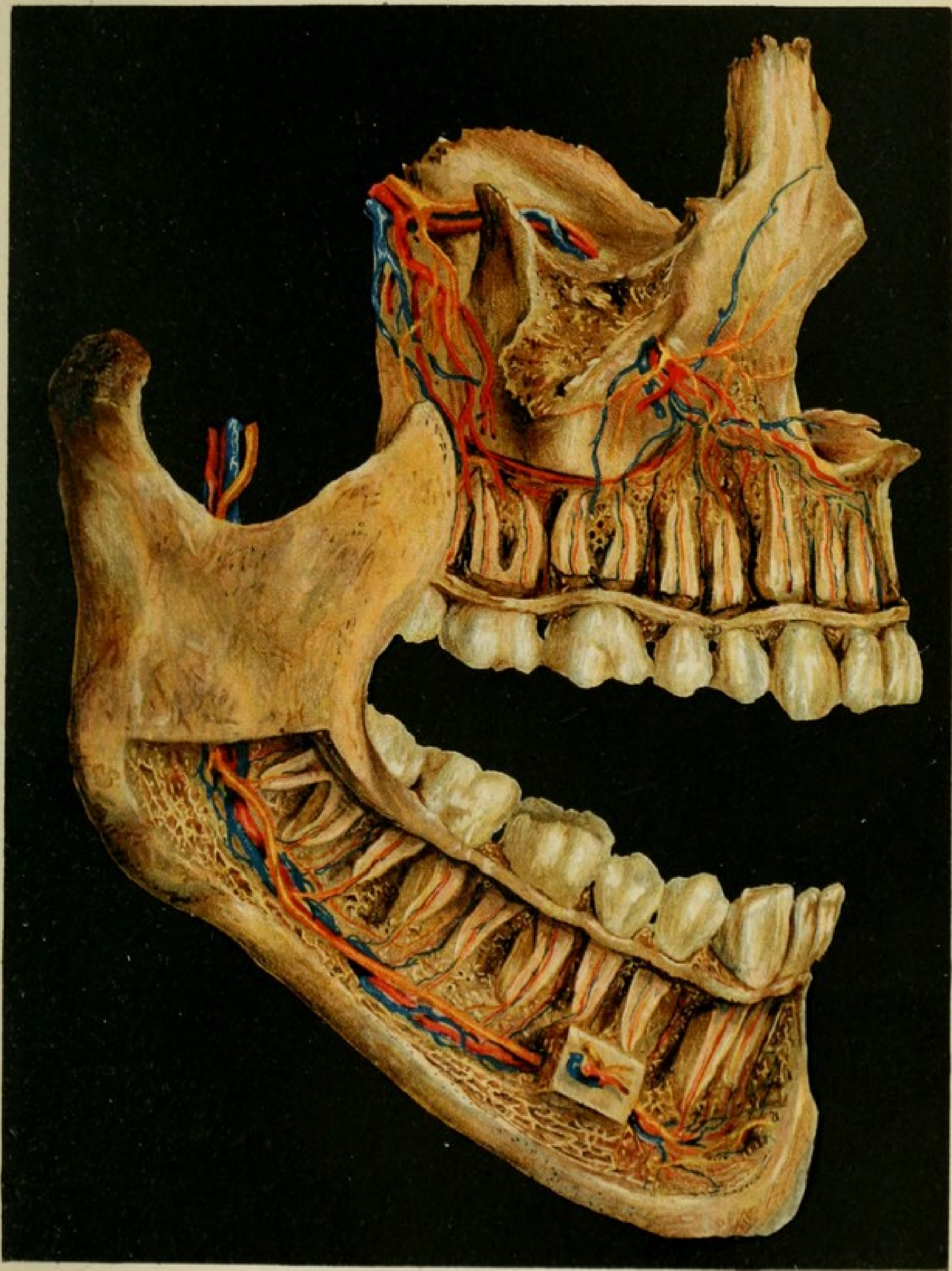
The trigeminal, the fifth cranial nerve, supplies the teeth with fibres for sensation. As is well known, three branches issue from the Gasserian ganglion : (1) Ophthalmic, (2) Superior maxillary, and (3) Inferior maxillary. The superior maxillary nerve passes out through the foramen rotundum. Its terminal branches, the *infraorbital nerve*, runs practically the same course as the similarly named artery. This nerve supplies the molar teeth with its posterior alveolar branches, the bicuspid teeth through the median alveolar nerves and the cuspid and incisor teeth through the anterior alveolar nerves.

PLATE 2.

The blood-vessels and nerves of the teeth. This semi-schematic preparation shows, through partial removal of the buccal plates, the distribution of the blood-vessels and nerves within the spongy portion of the bone. By grinding the roots of the teeth, their most important contents (arteries, veins and nerves) are shown.

The *posterior branches* which spring from the infraorbital nerve before its entrance into the orbit, enter the bone at the maxillary tuberosity and unite through loops with the anterior branches. Small branches called the "medii" run from these loops (*arcus supramaxillaris*) to the bicuspid teeth. Just before issuing from the infraorbital canal, the infraorbital nerve gives rise to the origin of the *anterior alveolar nerves ;* these by fusion with one another and with the offshoots from the supramaxillary arc form a ganglion (supramaxillary) which lies over the root of the cuspid teeth. Small branches from this ganglion supply the cuspid and incisor teeth. (According to J. Scheff the term "ganglion" is not absolutely correct as typical ganglion cells are not present).

The inferior maxillary nerve leaves the base of the skull through the foramen ovale. Its terminal branch, the *mandibular nerve*, passes into the inferior dental foramen in which, covered by the lingual nerve, it disappears with the lingual artery and vein. Before it enters the lower jaw it furnishes the mylohyoid muscle with motor fibres. It leaves the inferior maxilla through the mental foramen where it supplies the skin of the lower lip and the chin with fibres for sensation. Exactly like the arteries, this nerve during its course through the inferior dental canal gives off dental rami for the tooth pulp and interalveolar ramifications for the bony septum.



Lith. Anst. F. Reichhold, München.

CORROSION ANATOMY OF THE TEETH AND THE PNEUMATIC CAVITIES OF THE FACE.

CORROSION ANATOMY OF THE TEETH.

The technic for the corrosion of the teeth consists at first in thoroughly macerating the teeth for three weeks at 30° C. The roots are then wrapped in blotting paper and set upright in a moderately thick layer of plaster of Paris. A hole is drilled through to the pulp, in which a stiff paper funnel about 1 decimeter long is inserted and

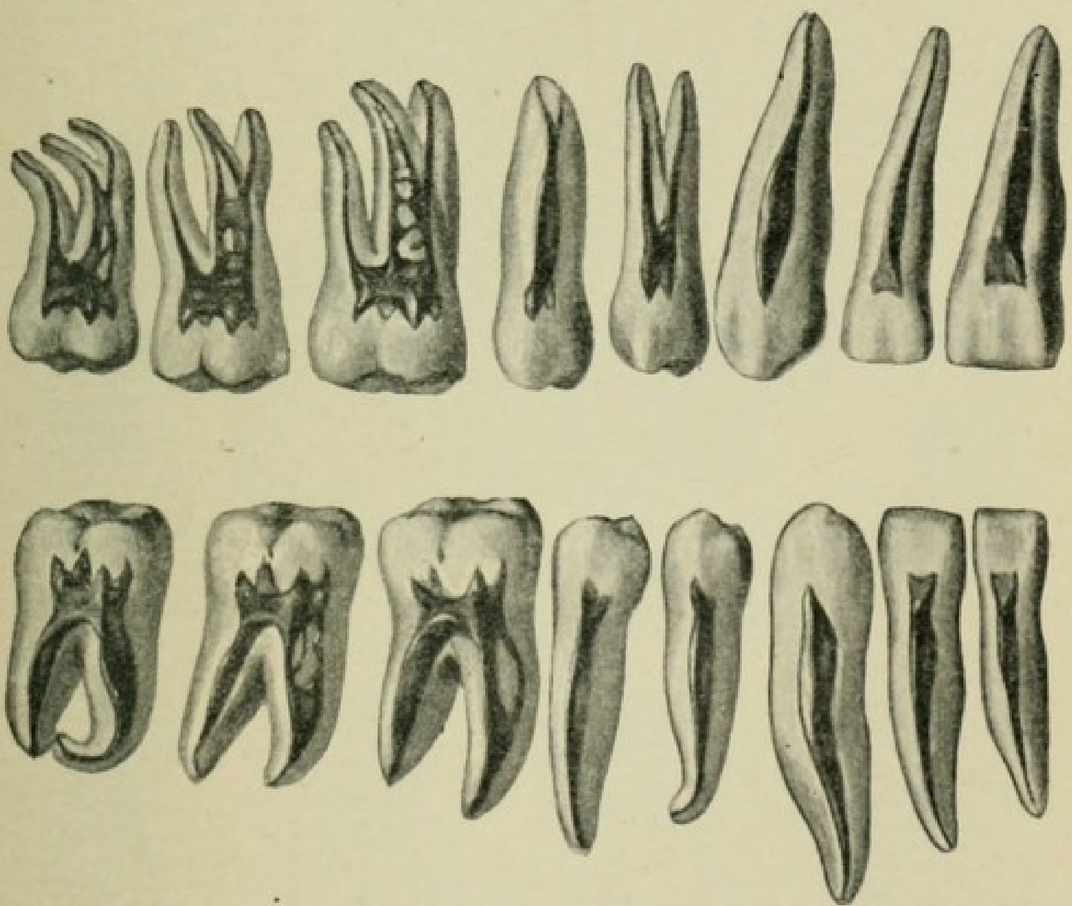


FIG. 19.—Metallic casts of the teeth of the upper and lower jaws. The tooth belonging to each cast is presented as being transparent.

fastened with gelatine. After the plaster of Paris and gelatine are thoroughly dried by heating, the whole is carefully heated to such a degree that when a small bit of Wood's metal is placed in the funnel it begins to melt. This metal is added until the column of metal has reached

PLATE 3.

Metallic cast of the combined pneumatic cavities of the face. *a*, inferior nasal fossa; *b*, middle nasal fossa; *c*, superior nasal fossa; *d*, sphenoidal sinus; *e*, internal carotid artery; *f*, sheath of the optic nerve; *g*, antrum of Highmore; *h*, infundibulum; *i*, nasolacrymal canal; *j*, ethmoidal cells; *k*, frontal sinus.

FIGURE 22.

Metallic cast of the maxillary sinus, showing the relationship of the teeth to the antrum Fig. 22. *a*, cast of the pulp cavity of a young, and *b*, of an old individual.

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such a height as to furnish sufficient pressure to force the metal into the smallest canals.

After cooling, place the metal filled tooth in a solution of 20 per cent. liquor potassæ at a temperature of from 40–50° C., for from three to four weeks. In this manner the tooth substance becomes softened and the metal cast

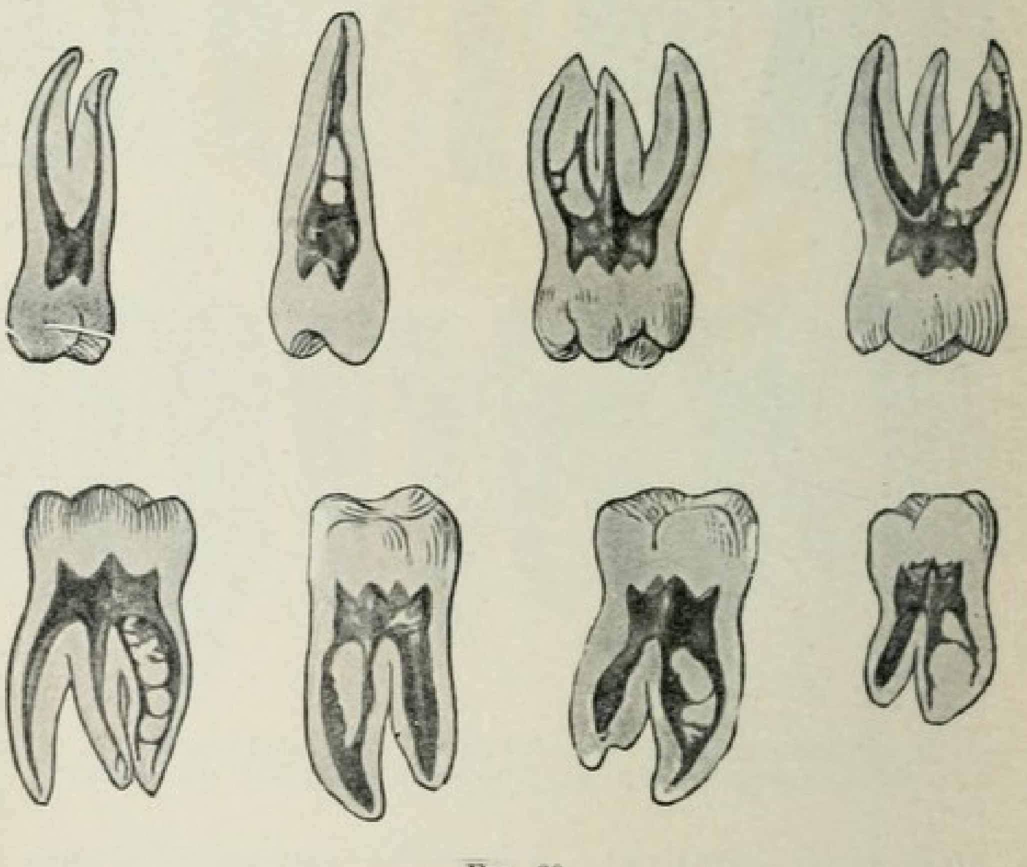
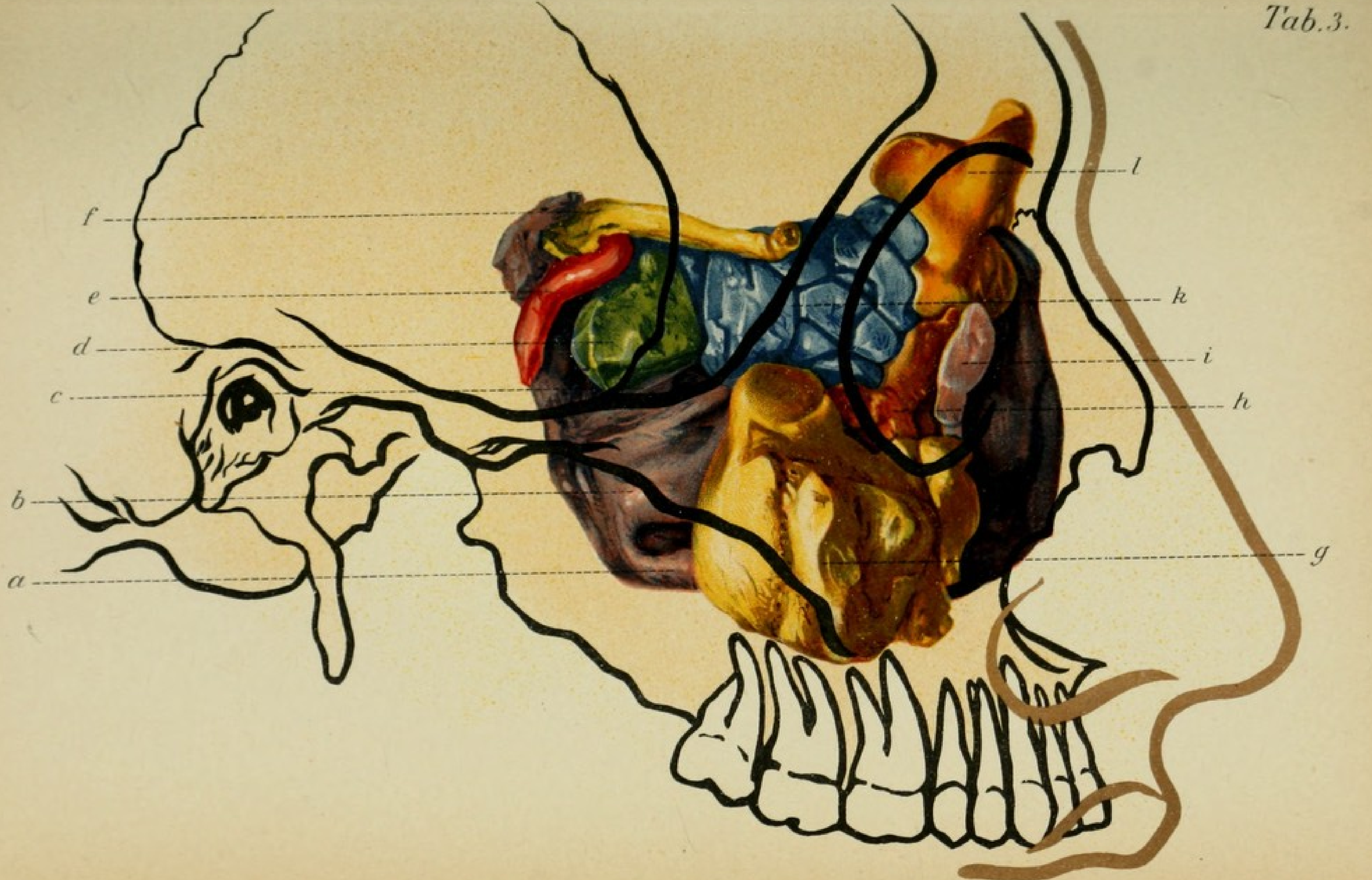


FIG. 20.

which occupies the pulp cavity may be easily removed. The accompanying figures show preparations obtained in this manner. In order to better show the topographical

Tab. 3.



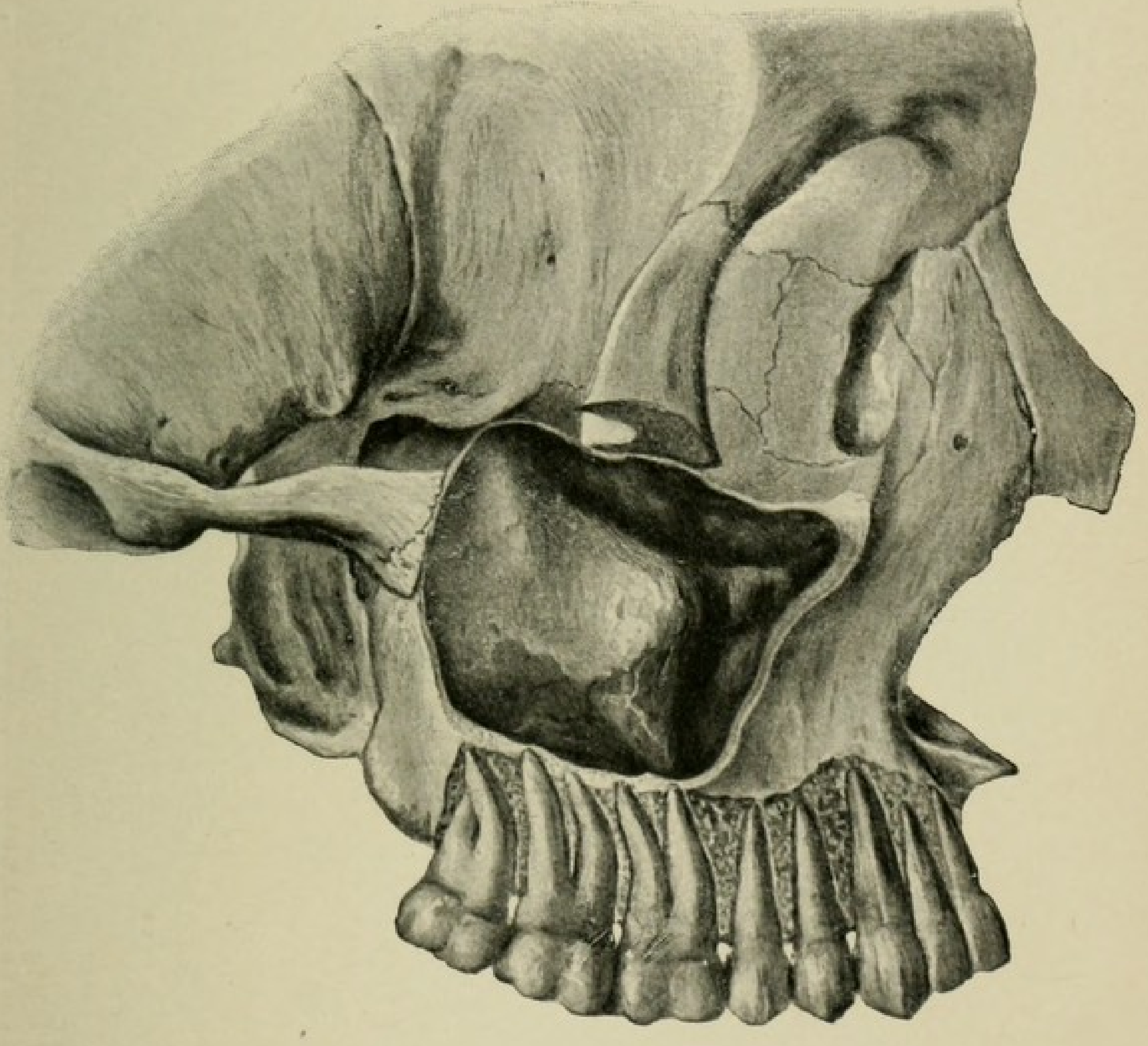


Fig. 22.

position of the pulp cavities the contours of the teeth are traced around the casts.

For the conservative practice of dentistry a thorough knowledge of the pulp cavity and the root canals is absolutely necessary, and there is probably no better method for showing their various characteristics than in the above manner. Fig. 19 shows the corrosion of the whole upper and lower row of teeth. It is seen in these drawings that the metal cast assumes the form of the tooth, only smaller in size, thus the metal cast of the cuspid tooth is shovel shaped, that of the molar teeth, multicuspidate, etc. Equally as important, at least from a clinical point of view, is the form of the metal cast of the root canals. This shows a surprising and hithertofore unknown condition, namely that not rarely in certain roots an anastomotic canal system exists which may be demonstrated by the richly branching network in the cast. The buccal and mesial roots of the lower molars possess this peculiarity most frequently.

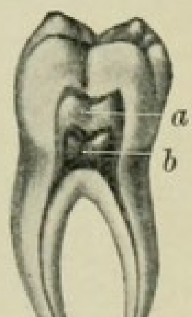


FIG. 21.—Metallic cast of pulp cavity: *a*, in a young subject: *b*, in an older individual.

A tooth showing an anastomotic canal system especially well, is illustrated in Fig. 20. It is also noted from the casts presented in Fig. 19 that the volume of the pulp cavity differs in the three molar teeth, both in the upper and lower jaw. The cast of the pulp cavity of the first molar is the smallest in comparison with the size of the crown while the casts of the other molars increase in size consecutively from the second to third. This is explained by the fact that the first molar is the oldest, and, as is known, the pulp cavity in the course of time becomes smaller through concentric growth of the solid portion of the tooth. This concentric growth is not the same in all directions, but as Szabo teaches, in a 60 year old individual it measures 3 mm. in the length and only 1 mm. in width. This is shown in Fig. 21.

CORROSION ANATOMY OF THE PNEUMATIC CAVITIES OF THE FACE.

In order to obtain models of the facial cavities it is advisable to treat the head with alcohol for a long time, and only when it has become thoroughly dehydrated, should it be impregnated with turpentine, according to the method of Semper-Riehm. When the parts are thoroughly dried they are placed in plaster of Paris and Wood's metal is poured in through an opening drilled through the facial surface. The corrosion then occurs as in the teeth through the action of liquor potassæ.

A cast of the right half of the head of a male adult is presented in Plate 3. A number of other cavities than those considered as belonging to the face are included in this cast, such as the sheath of the optic nerve, a convolution of the internal carotid artery and the nasolacrymal canal. The facial, the posterior and the orbital walls of the antrum of Highmore are seen in this illustration.

The frontal sinus which was reached through the infundibulum of the ethmoid bone and the short nasofrontal canal is seen above and in front. The frontal sinus in this figure is poorly developed in comparison with other preparations. The outer aspect of eleven ethmoidal cells which are separated from one another by deep grooves may also be recognized in this preparation. Immediately behind these cells and extending some distance in a lateral direction is a cast of sphenoidal sinus which is shaped like the body of that bone.

The model taken as a whole teaches us to recognize the connection which exists between these various hidden cavities and explains how easily an affection of one cavity can be transmitted to another. It also shows us their relations to the teeth, especially the three molars which because of the danger of starting an empyema must be treated with special care. In order to show the close relationship of the molar roots to the antrum, a corrosion specimen (Fig. 22) of the skull has been prepared which shows the exact position of the antrum of Highmore.

SPECIAL ANATOMY OF THE TEETH.

(Plate 4.)

Man, who is diphyodont, develops two sets of teeth, one which appears early in life, the deciduous set, twenty in number, and a subsequent permanent set which is composed of thirty-two teeth.

From a topographical-anatomical standpoint, each tooth may be divided into three distinct parts which are sharply defined from one another. The part which is inserted in the alveolar process of the jaw is termed the *root* (radix); the portion surrounded by the gum is the *neck* (collum), and the free part which stands in the mouth is the *crown* (corona). These divisions also show histological differences. The root is covered with *cementum* a substance somewhat similar to bone, which gradually becomes thinner as the neck of the tooth is approached, where it forms a structureless sheath of paper thickness. The crown is covered with the hardest of all animal substances namely, the *enamel.*

It is very useful for the sake of exact localization to distinguish the following areas on each individual tooth. The outer surface of the tooth which is exposed to the lips or cheek is called the *labial* or *buccal surface*, the opposite surface which is exposed in the oral cavity to the tongue, is called the *lingual* or *palatine surface.* As the teeth are arranged one after the other in the form of a horse-shoe, it is easy to explain why the surface of the tooth turned to the middle or median line of the face should be called *mesial*, and the side turned away from the middle line, the *distal* surface. A mesial and distal surface together form an *approximal* surface. At the neck of the tooth one speaks of a cervical or marginal localization. The free ends or edges of the incisor and the cuspid teeth are called the *cutting* or *incisal surfaces*, while the corresponding parts of the bicuspids and molars are called the *grinding* or *masticating surfaces.* The roots of the teeth are conical in shape, flattened laterally, and gradually taper to a point. They fit tightly in the alveoli

PLATE 4.

Upper illustration. Lateral view of the permanent teeth. Lower illustration. Lateral view of the milk or temporary teeth.

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and are separated from the bone only by a thin sheath of connective-tissue, the *alveolar periosteum.* The chief function of this membrane is to hold the teeth firmly in place through dense bundles of fibrous tissue which extend from the alveoli to the cementum and the gums. The teeth are inserted in the alveoli in this manner, in order that the pressure in masticating is not alone brought to bear upon the apex of the root, through which the blood-vessels and nerves enter the tooth, but that it may be shared by the whole wall of the alveolus. Aside from the foregoing mentioned hard substances, the cementum and enamel, we must still consider a third which is the most important substance of all teeth, namely, the dentin. This material encloses the tooth pulp with its rich cellular odontoblastic sheath.

THE PERMANENT TEETH.

(See Plate 4. Upper Illustration, and Figure 23.)

The completed permanent set consists of thirty-two teeth which are arranged as follows:

M	B	C	I	I	C	B	M	
3	2	1	2	2	1	2	3	=32
3	2	1	2	2	1	2	3	

The two jaws then possess in all ; 8 incisors (I) [cutting teeth] ; 4 cuspids (C), 8 bicuspids (B), and 12 molars (M).

The shape of the teeth in the different sections of the jaw depends upon the duties they are required to perform; thus the front teeth which sever the food form sharp chisels which overlap like a pair of shears, while the masticating teeth are supplied with broad, cusped crowns which crush the food.

Lith. Anst F. Reichhold, München.

Incisors.—The crowns of the upper incisors are shovel or chisel shaped. The horizontal edge is like that of a dull knife, which in youth becomes easily indented. These indentations (usually 3), however, soon wear away through use. There are in each of the upper and lower jaws four incisors, that is eight in all. In the upper jaw the central incisors are larger than the lateral while in the lower jaw the lateral are larger than the central incisors. The labial surface is slightly convex and relatively smooth while the lingual is concave and possesses a fold of enamel which in the laterally placed incisors forms a fossa known as the foramen cœcum, an area which predisposes to caries. In many mammals, especially the horse, an enamel shell which is filled with cementum exists on the labial surface of the incisor teeth; this peculiarity called the "mark" is a criterion of the animal's age.

In man the mesial border joins the horizontal edge at a sharp turn forming almost a right angle with it, while the distal edge, on the contrary, is more rounded. From the neck of the teeth, which is separated from the crown by a ring of enamel, a simple slender root extends downward which is stronger in the central than in the lateral incisors. The roots of the middle incisors, on cross section, are seen to be round while the lateral ones are oval (Fig. 12); a condition which should receive special attention in extraction. The pulp cavity is relatively spacious and its extension downward is easily probed.

The lower incisors stand vertically in the jaw; they are much smaller than the upper ones, and the central are even smaller than the lateral incisors. The roots are closely pressed together on each side and cannot be removed through twisting, as can for example, the central upper incisors.

Canine or Cuspid Teeth.—The cuspid teeth are four in number; two in the upper and two in the lower jaw. They are strongly developed, especially the upper ones, which represent the most powerful of the cutting set of teeth. The crown shows a convexity of considerable degree on the labial surface, while on the lingual surface

FIGURE 23.

Permanent teeth seen from above: *a*, upper, *b*, lower tooth row. The upper set approaches an elliptical, the lower set a parabolic form.

a small tubercle is presented which resembles the lingual cusps of the bicuspid teeth and forms a connecting link between the narrow incisors and the broad molars.

The labial edge of the cuspid tooth slopes into a sharp point. It is easy to distinguish the right from the left tooth by the fact that this point does not lie in the middle of the tooth but rather to the mesial side, and hence the distal edge of this tip is longer and steeper than the mesial edge. This also holds true for the lower and somewhat smaller teeth. The roots of the upper cuspid are especially well developed and on cross section are oval shape. Those of the lower teeth are somewhat weaker and are more flattened laterally (Fig. 12). The pulp cavity is spacious and more easily accessible than in any of the other teeth.

Bicuspids (Premolars).—Two bicuspid teeth stand next to the cuspid teeth on both sides of each jaw, and accordingly there are altogether eight in number. They are somewhat weaker than the cuspid teeth which they resemble on their labial aspect. Through the addition of a short lingual cusp their bodies are increased in size and tend in this respect to approach the molars in shape.

The upper bicuspids possess two well developed cusps, of which the labial is somewhat longer and sharper than the lingual. The first and second bicuspids resemble each other so closely in regard to their crowns that it is difficult to distinguish them from one another. Although the formation of their roots varies considerably, it may be accepted as a general rule in distinguishing between the upper bicuspids, that the first has usually two roots, while the second bicuspid has only a single root which is considerably flattened laterally.

Since the lingual cusp of the first lower bicuspid is simply formed by a tubercle, this tooth closely resembles the shape of the cuspid tooth. It usually possesses only one root which is very weak in comparison with that of the

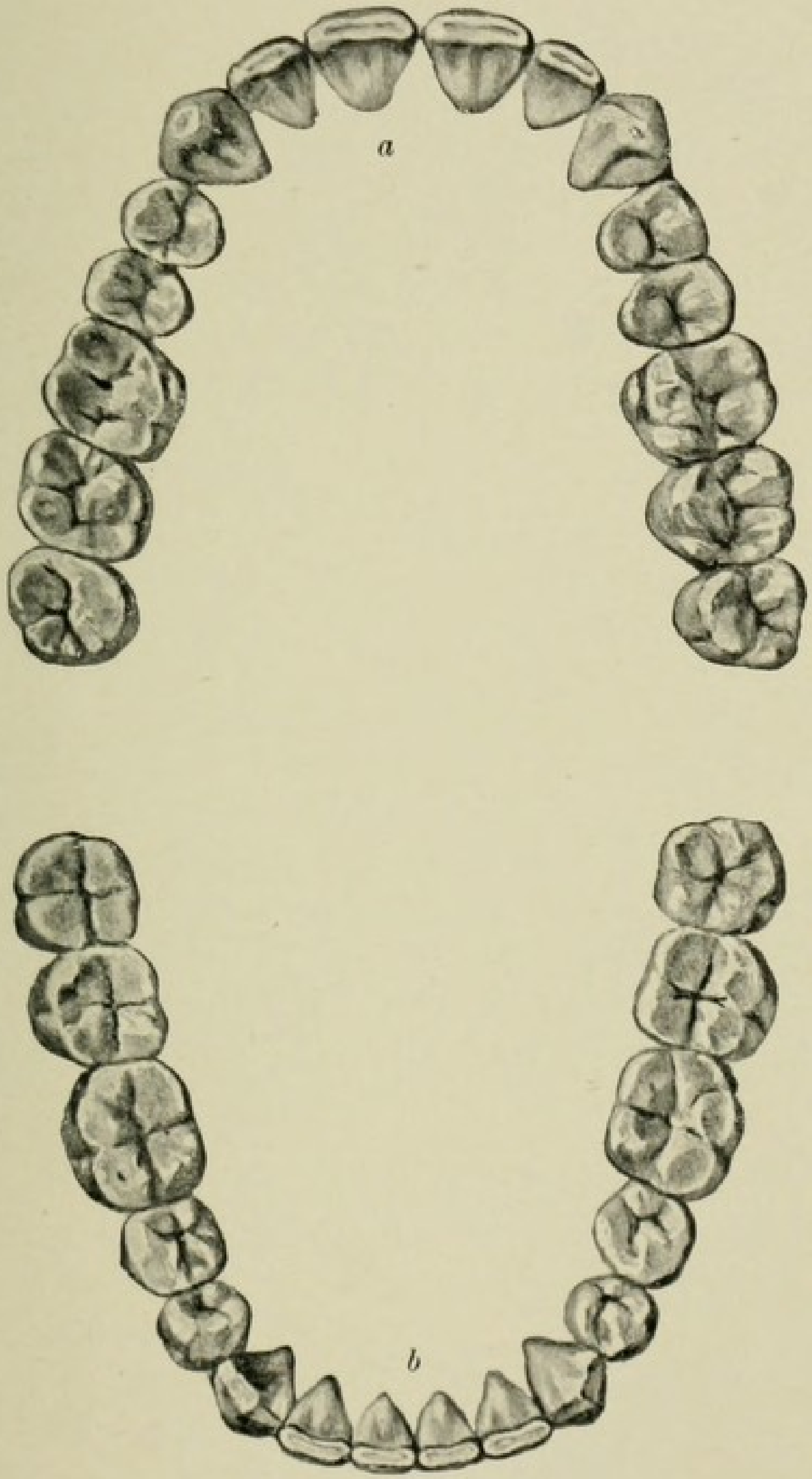

FIG. 23.

cuspid tooth. On cross section it is oval in shape, and shows longitudinal grooves which run from the mesial to the distal surface.

The second lower bicuspids are the largest of the bicuspid group of teeth. Their crowns consist of one strong labial and two smaller lingual cusps, that is three cusps in all. This gives the grinding surface a considerable circumference. Their roots are single, oval and fairly strong. In the lower bicuspids the roots are set vertically in the jaw and consist of one piece, hence it is nearly always easy to pass a sound into the centrally placed root-canal.

Molars (Grinders).—There are three molars on each side of each jaw, twelve in all. They are the largest of the human teeth, and indicate the important position they occupy in mastication by the complicated pattern of the chewing surfaces, which consist of variously developed and arranged cusps with interlying grooves and depressions (Figs. 24 and 25). The molars are about twice the size of the bicuspids, and in comparing their crowns it will be observed that the two molars which grow in juxtaposition to the bicuspids are not very much unlike them; having two buccal and two lingual cusps. The form of a molar is often described as cuboidal, but as its mesial-distal diameter is greater than the labial-lingual, the term "prismatic" would probably be more appropriate.

The first is usually called by the laity the "six year molar," the second the twelve year molar, and the third "the wisdom tooth." The *upper molars* have three roots, while the lower have but two.

The upper molars possess corresponding characteristics yet differ in certain respects from each other. Of the four cusps, as is the case in the bicuspids, the buccal are better developed than the lingual and the mesial-buccal cusp is the longest and sharpest.

The cuboidal shaped first upper molar is the largest tooth of this set and is more nearly square in form. The second molar shows, on cross section, a tendency to a triangular form, which is sometimes better developed in the third tooth. A peculiarity of the first molar is the

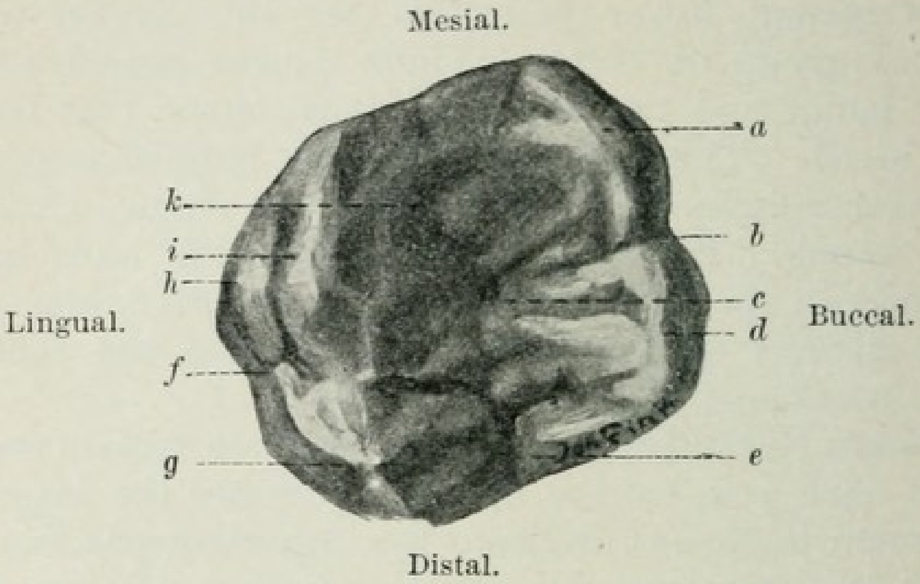

FIG. 24.—Chewing surface of the first upper molar: *a*, mesial-buccal cusp. *b*, buccal groove. *c*, central fossa. *d*, distal-buccal cusp. *e*, distal groove. *f*, lingual groove. *g*, distal-lingual cusp. *h*, a small fifth cusp (cingulum). *i*, mesial-lingual cusp. *k*, mesial groove.

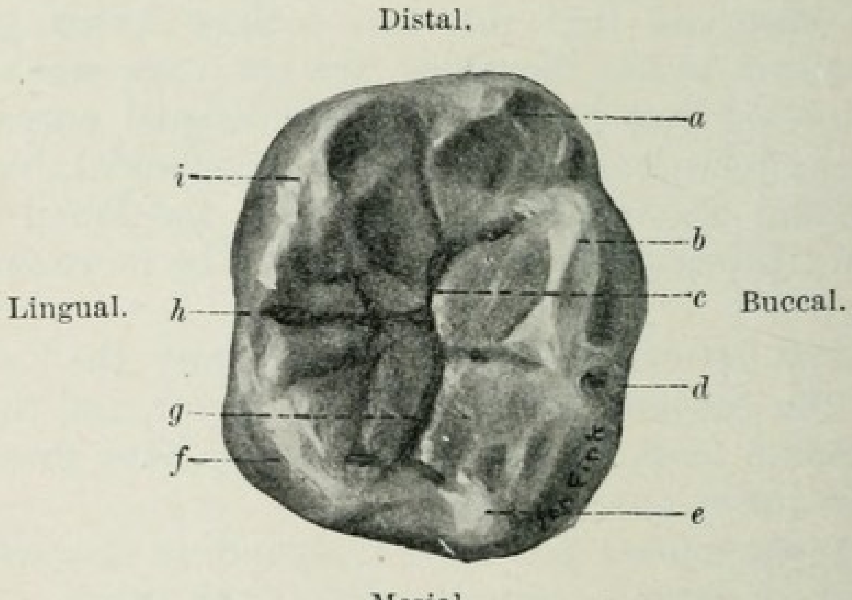

FIG. 25.—Chewing surface of the first lower molar. *a*, distal-buccal cusp. *b*, buccal cusp. *c*, central groove. *d*, buccal fossa. *e*, mesial-buccal cusp. *f*, mesial-lingual cusp. *g*, central groove. *h*, lingual groove. *i*, distal-lingual cusp.

frequent appearance of a fifth cusp at the mesial-lingual edge (Fig. 24, *h*).

This tooth is conical in shape, i. e., broader at the chewing surface than at the neck. Therefore, in the application of rings and crowns a considerable portion of the wall must be ground down, and a large tuberosity on the neck must be cut away with special care.

The buccal wall has a convex surface, with a groove extending between the two buccal cusps (buccal-groove), dividing it into a broad and long anterior, and a narrow and short posterior portion. This arrangement alone, excluding all other characteristics is sufficient to distinguish the right from the left molars. This buccal groove is a frequent seat for the beginning of caries and must not be overlooked in examination.

There is also a groove on the lingual aspect, the lingual groove, which beginning between the lingual-mesial and the lingual-distal cusps reaches nearly to the neck of the tooth. The anterior or mesial portion of the lingual wall presents the before mentioned fifth cusp. This tooth has three roots, a strong diverging one which points toward the palate and two weaker ones which are inserted in the buccal portion of the alveolar process. Of the three root canals, the one which is nearest to the palate, is the widest and most easily accessible to a sound or canal plugger, the other canals are smaller and often constricted laterally. For the details of these canals see the chapter on corrosion anatomy (Page 51).

The second upper molar differs from its preceding fellow in the fact that the disto-lingual cusp is smaller and in many cases entirely absent. Hence, often only three cusps are present two buccal and one lingual, and in which case the lingual groove is usually missing. The roots compared with those of the first molar are somewhat weaker and tend more to point in the distal direction. They also vary more often in form than do the roots of the first molars and not infrequently a deformity of the originally separated roots is observed. Therefore, it may at times be impossible to locate more than two root canals.

The third upper molar, however, is subject to the greatest variations. All the various grades of development may be met with between a well developed molar and a simple peg tooth, and there are many cases in which this tooth never reaches the stage of eruption. In the stunted forms the roots are also poorly developed; they may however, be divided into three distinct parts and show, like the crown, all the possible deviations from normal. Fig. 26 illustrates the arrangement and the relative size of the upper bicuspids and molars as seen in a normal jaw.

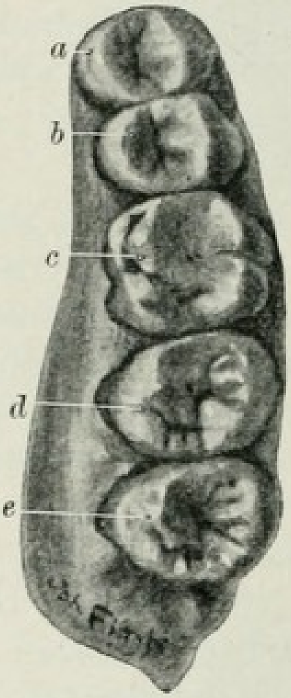

FIG. 26.—Arrangement and relative size of the upper bicuspids and molars: *a*, first bicuspid; *b*, second bicuspid; *c*, first molar; *d*, second molar; *e*, third molar.

The *lower molars* are similar in construction to the upper ones, with the exception that they are square in shape and have two roots. In these teeth the lingual cusps are higher than the buccal cusps, which is contrary to the form of the cusps of the upper molars.

The first lower molar, excepting its antagonist, is the largest grinding tooth, and differs from the upper one by the possession of three buccal and two lingual cusps. These cusps surround, as seen in Fig. 25, a central depression into which the grooves run. The buccal wall shows a groove of considerable depth which reaches half way up to the crown. The lingual surface is smooth and without grooves. The roots lie back of each other, *i. e.*, one on the mesial and the other on the distal side; they are not straight but, on the contrary, are curved backwards. The mesial root is somewhat weaker and more circular than the considerably flattened distal root, therefore an instrument is easily passed into the distal but with difficulty into the mesial root.

The second lower molar has a decidedly smaller circumference than the first. It has four cusps, and in rare cases a fifth disto-buccal cusp may be present. This tooth is subject to greater variation in form than the former. In exceptional cases after extraction, the second lower molar has been found to possess but one root instead of two. The root canals resemble those of the first molars.

The third lower molar, or wisdom tooth, resembles its neighbor more than is the case in the upper jaw, usually however, it is somewhat smaller, very rarely, at any rate

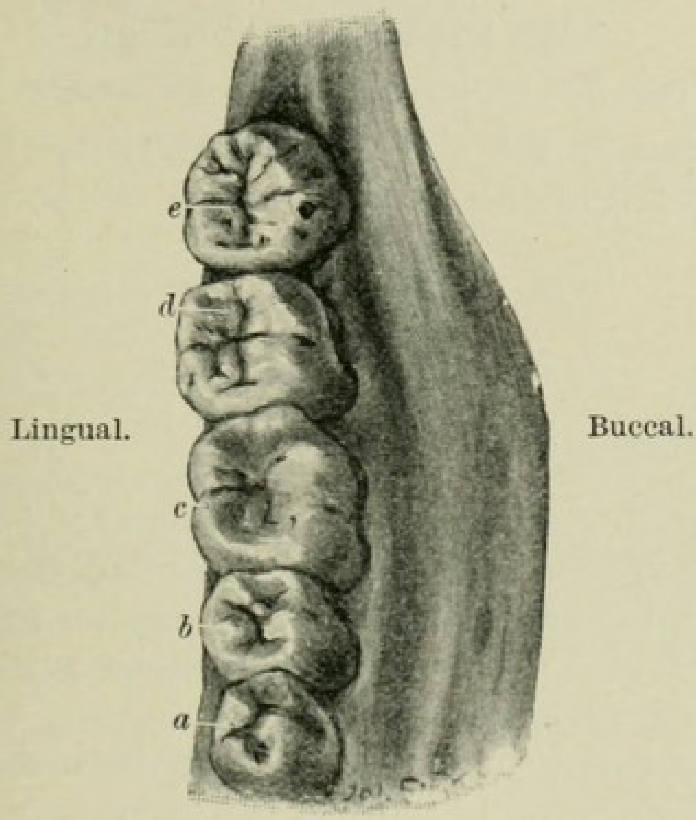

FIG. 27.—Arrangement and relative size of the lower bicuspids and molars: *a*, first bicuspid; *b*, second bicuspid; *c*, first molar; *d*, second molar; *e*, third molar.

more infrequently than in the upper jaw, this tooth is reduced in size to that of a peg tooth. On the other hand the grinding surface is sometimes surprisingly complicated for it may have four, five or even more cusps. This tooth has either the normal number of two roots or an abnormal number of from three to five; occasionally the roots are fused into one stem. When the roots are of large size, extraction may present considerable difficulty for in this region the bone is thickened by the oblique and mylohyoid lines. The root canals like in all other teeth correspond to the form of the roots. These teeth are generally quite susceptible to decay and their tooth germs even at the time they make their appearance frequently present carious changes.

Figure 27 shows the arrangement and relative size of the lower bicuspids and molars. This specimen is obtained from the same normal and powerful skull as is the one shown in Figure 26.

THE DECIDUOUS TEETH.

(See Plate 4, lower picture and Figure 28.)

The temporary set consists of twenty teeth which are arranged as follows:

$$\begin{array}{ccc|ccc} M & C & I & I & C & M \\ 2 & 1 & 2 & 2 & 1 & 2 \\ \hline 2 & 1 & 2 & 2 & 1 & 2 \end{array} = 20$$

There are in all 8 incisors (I), 4 cuspid (C) and 8 molar (M) teeth. These molar teeth resemble the permanent molars with the exception of being smaller and lighter in color. They also possess at their necks a more prominent tubercle than the permanent ones.

The incisor and the cuspid teeth of both the upper and the lower jaws equal in number the corresponding teeth in the permanent set. There are four in each jaw and therefore eight in all. They also resemble their permanent successors in form except that they are relatively shorter so that their length almost equals their width, while their simple roots are more rounded and more conical in shape.

Two molar teeth lie next to the cuspid teeth on both sides and accordingly there are altogether eight in number. The first primary molars of both the upper and lower jaws plainly show variations from the characteristics of the permanent teeth, and resemble the molars of the anthropoid monkeys. The grinding surface of the first temporary molar is especially interesting; it consists of a buccal and lingual ledge which contains a number of notches. The meso-labial border has also an accessory cusp. The roots usually consist of one palatine and two buccal roots, which have grown together.

The second upper molar resembles the first permanent molar, and is indeed a diminutive model of it.

The first lower temporary molars carry from 4–5 cusps which are grouped around two depressions. As mentioned above an additional cusp may occur on the meso-labial border. These teeth possess two roots. The second lower molars resemble the first permanent molar, excepting that they are smaller in size; they too have two roots. In Fig. 28 the upper and lower rows of milk teeth are shown.

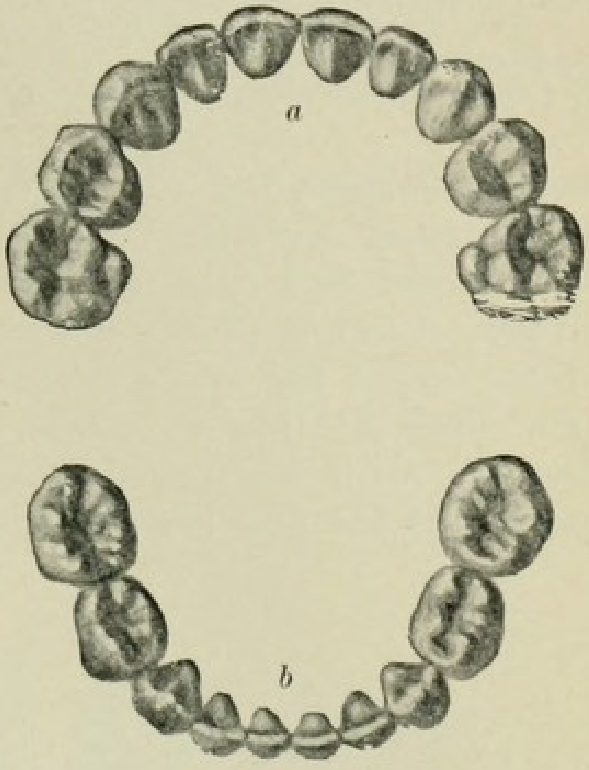

FIG. 28.—The milk teeth seen from above: *a*, upper; *b*, lower tooth rows. In comparison with the permanent tooth rows, the curvature of the milk set of teeth is more nearly that of a semi-circle.

THE ARTICULATION OF THE TEETH.

The two rows of adult teeth, which are practically horse shoe shaped, do not equal each other in size and form, but as is seen in Fig. 28, the upper is the larger and extends on all sides beyond the lower row.

In the act of mastication the incisor teeth glide past each other like the blades of a pair of scissors, the lower passing back of the upper teeth, while the cusps of the bicuspids and molars of both jaws alternately strike the depressions of their antagonists. The teeth are so arranged in size and position that, with the exception of the lower

PLATE 5.

FIG. 1.—**Longitudinal section of a tooth-root and the alveolus**: *a.* Dentin. *b.* Cementum. *c.* Periosteum in which the arteries and veins are indicated by blue and red colored areas. *d.* Alveolus with many transversely and *e,* longitudinally cut Haversian canals.

FIG. 2.—**Cross section of the oral mucous membrane.** Injected preparation. *a.* Epithelium. *b.* Mucous, from the wide meshed vascular net-work of which, capillary loops arise into the papillæ.

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central incisors and the upper third molars, each tooth in articulating occludes with two opposing teeth. This is due to the fact that the incisor and cuspid teeth of the upper set are decidedly wider than those of the lower set, thus causing the upper molars to set further back in the jaw than the lower molars. The first upper bicuspid touches with its mesial masticating surface the distal portion of the first lower bicuspid, and with its distal part

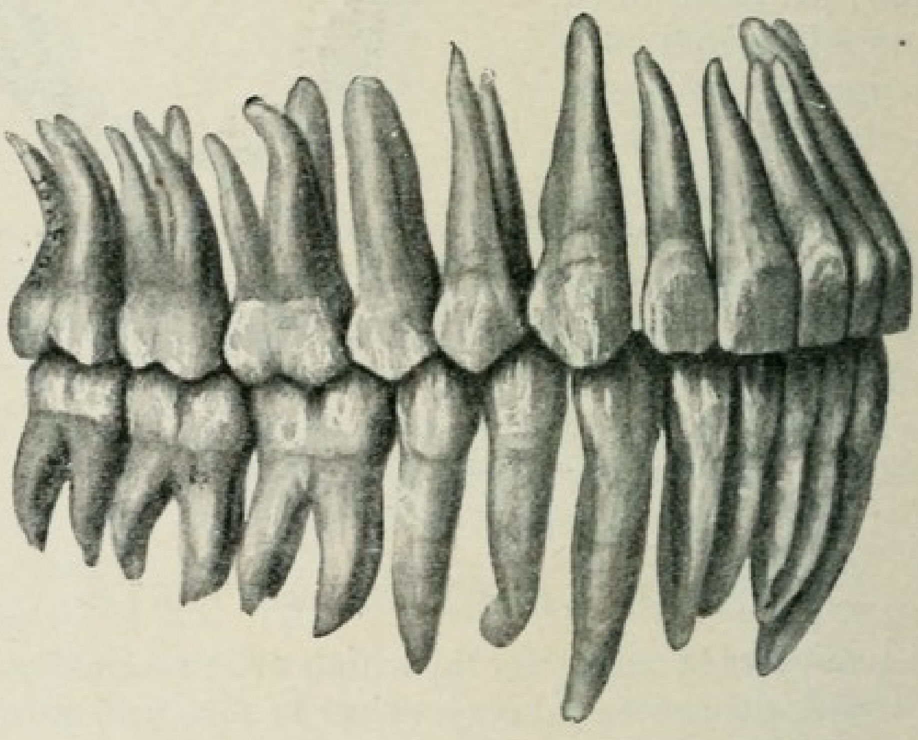

FIG. 29.—Articulation of the two tooth-rows. Lateral view.

it comes in contact with the mesial portion of the second lower bicuspid. This arrangement of the bicuspid teeth is also true of the molars excepting that the displacement is not so great.

It is very important to remember these simple relationships, for without a knowledge of them it is impossible to

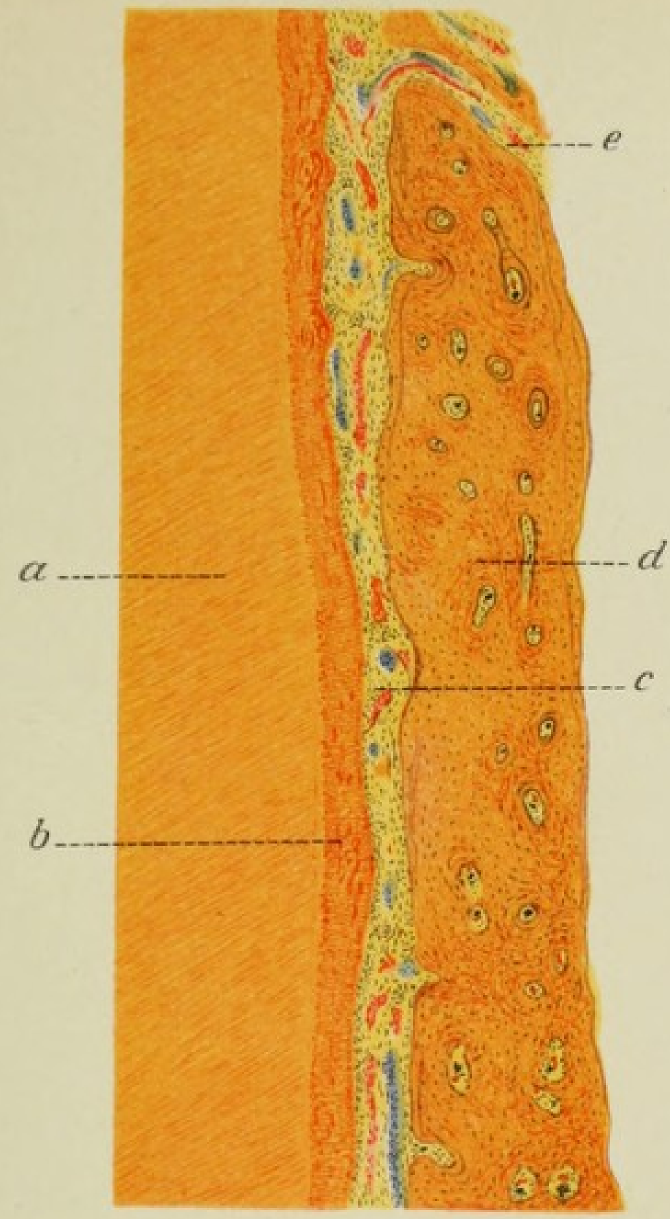

Fig. 1.

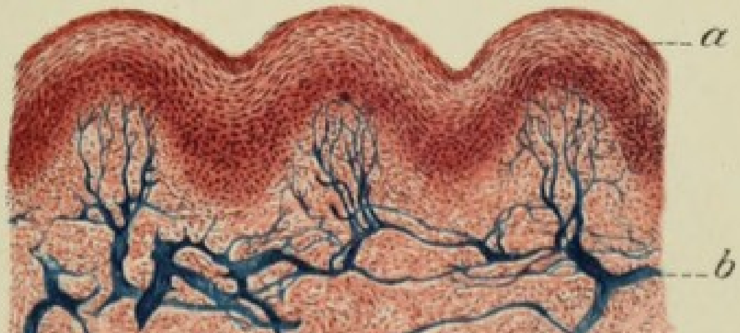

Fig. 2.

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manufacture properly articulating artificial teeth which have a natural appearance. Fig. 29 shows the normal articulations of the teeth.

HISTOLOGY.

THE MUCOUS MEMBRANE OF THE MOUTH.

The outer skin (integumentum commune) merges gradually into the mucous membrane of the mouth (mucosa oris) at the red portion of the lips, and the corium of the true mucosa is a continuation of the corium of the skin, from the epidermic covering of which the epithelium is derived. The name mucosa is employed because of the large number of mucous and albumin excreting glands which that tissue lodges. The intense red color is very noticeable and is due to the rich vascular system and the transparency of the upper layer. On the tongue this red color blends into gray, for the epithelium is thicker on that organ than in the other portions of the oral cavity.

The mucous membrane forms (according to von Ebner, Köllikers Handbuch der Gewebelehre) a tight and elastic layer from 220 to 450 μ in thickness with numerous papillæ on its upper surface, which resemble those of the skin. (See Plate 5, Fig. 2). The epithelium over the papillæ is smooth, excepting on the tongue where little prominences covered with epithelium form the filiform, fungiform, foliate, and circumvallate papillæ.

The submucosa passes nearly everywhere gradually into the true mucosa without a positive line of demarcation. Loose connective tissue is found in large quantities only in the areas where mucous membrane is freely movable, as on the floor of the mouth, the fræna of the lips and tongue, and it too merges gradually into the denser connective tissue of the mucosa. The mucosa of the cheeks, gums and tongue is somewhat differently constructed, for in these regions the submucosa contains a greater or less number of mucous and albumin excreting glands which lie crowded together. In certain locations

FIGURE 30.

Longitudinal section of a molar. *S*, enamel; *D*, dentin; *C*, cementum; *P*, pulp cavity (from Sobotta).

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where these glands are absent, as for example in the neighborhood of the alveolar processes and in certain situations in the gums, the submucosa, which is homogeneous in appearance, is fastened directly to the periosteum without any noticeable intervening substance.

The connective tissue of the submucosa is arranged in bundles, the thickness of which varies from 4 to 11 mm. Some lie parallel, others vertical and still others obliquely to the surface, an arrangement which forms a felt like structure. In the true mucosa these bundles of tissue become finer and in the papillæ they lie with the elastic fibres as fine fibrillæ on the homogeneous ground substance. The fibrillæ are often associated with branching cells of the loose connective tissue.

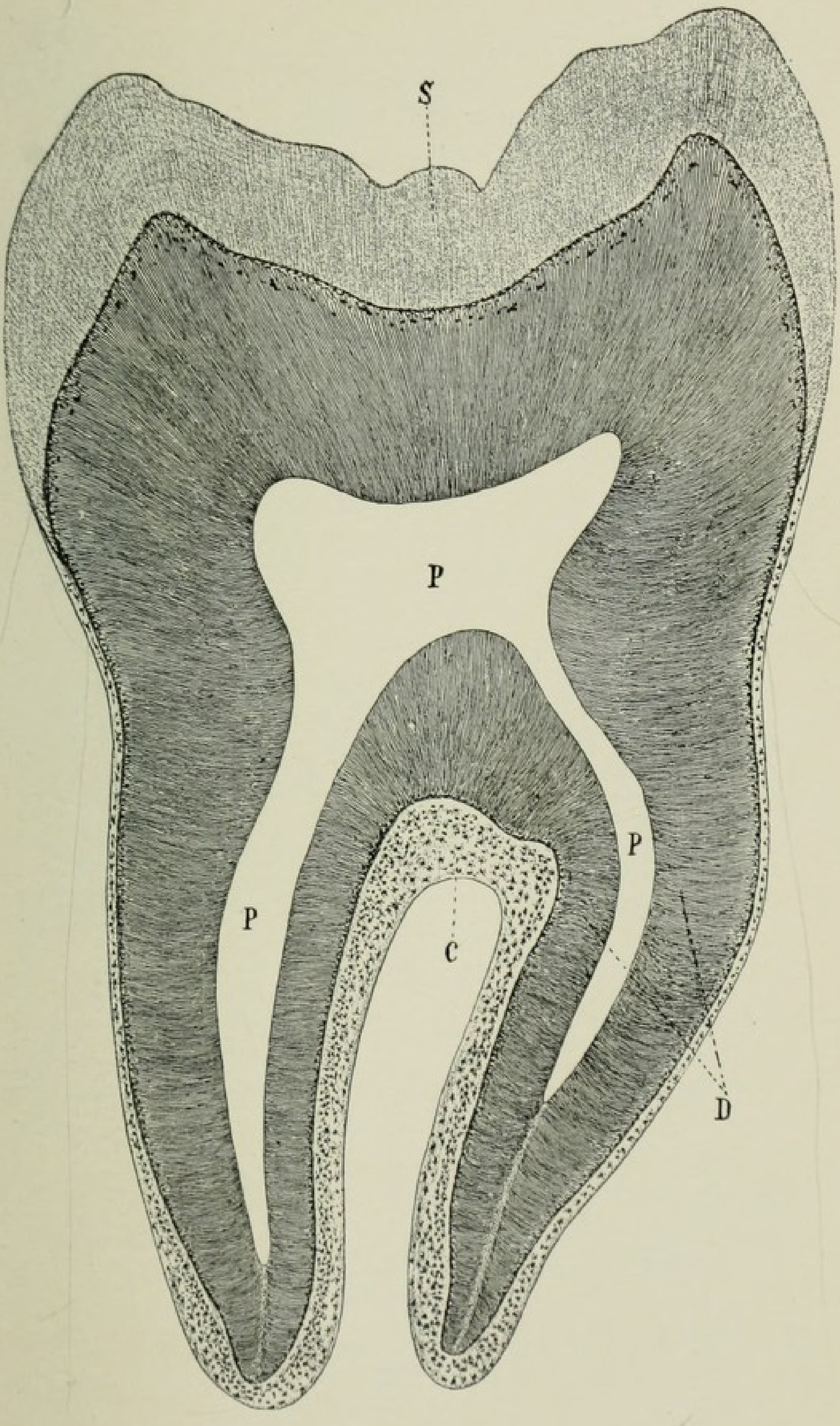
The cellular elements of the mucous membrane of the mouth consists of a rich supply of leucocytes. The tunica propria of the mucosa of the gums is especially the seat of physiological leucocytic infiltration and particularly so in the neighborhood of the back molars. True glandular tissue, however, is not met with until further back in the mouth where in the tonsils it reaches its highest form of development.

In the submucous connective tissue the blood-vessels (see Plate 5, Fig. 2) form a wide meshed network, from which capillaries supply the papillæ. The vessels form simple vascular loops in the papillæ of the hard palate and of the floor of the mouth, while a capillary network penetrates the papillæ of the gums and lips. The blood is carried away by a small vein which forms at the center by this network.

The branches which arise from the nerves in the submucosa form a plexus in the mucosa which gives the following branches:

1. Medullated fibers with or without end bulbs.
2. Non-medullated fibers which build a subepithelial

Fig. 30.



network, from which fibers with slightly enlarged ends penetrate between the epithelial cells.

3. Fibers the branches of which are found everywhere in the submucosa, mucosa, glands, and blood-vessel walls.

The lymphatics build a wide-meshed reticulum in the deepest layers of the submucosa which connects with the true mucosa through anastomosis with a finely meshed network from which small branches with closed ends penetrate into the papillæ. The lymph capillaries of the mucous membrane lie, as is the case in the skin, at a deeper level than do the blood capillaries.

The epithelium of the oral cavity is of a stratified pavement variety (see Plate 5, Fig. 2). The cells of the deepest and youngest layer are cylindrical, those of the middle layer are spherical, while the elements of the uppermost and oldest layer are flattened and compressed. The outlines of the latter cells is that of a rounded polygon. The nuclei of these cells are plainly seen while their cell bodies are opaque because of the presence of fine granules. The upper layer of cells is being constantly shed and its place taken by the layer beneath. This accounts for the presence of such elements in the sputum.

The absorptive faculty of the oral mucous membrane is of considerable importance.

THE HARD AND SOFT DENTAL TISSUES.

The hard portion of the tooth consists of three different but connected structures, namely, the dentin, enamel, and cementum (see Fig. 30). The enamel being a product of the surface epithelium is ectodermic in origin while the dentin and cementum originate in the mesoderm. The soft parts of the tooth are limited to the tooth pulp which occupies the central or pulp cavity of the tooth, and the pericemental membrane or periosteum (periodont) which covers the roots.

The Dentin.—The dentin which resembles in many respects the hard part of bone, constitutes the chief structure of the teeth (Fig. 31). It is covered at the crown by enamel and at the roots by cementum. Its degree of density is midway between that of these two substances, it being harder than the cementum and softer than the enamel. On longitudinal section, dentin has a gloss like that of silk. Microscopical examination shows concentric lines (Owen) in the coronal portion which run almost parallel to the upper surface, and interglobular spaces which lie in the periphery. The so-called granular layer of Tomes occurs near the junction of the dentin and cementum.

The matrix or ground substance is calcified and traversed by the gelatin yielding fibrils. These do not run parallel to the dentinal tubules but form layers, which depending upon the location in the tooth run in various directions. The author agrees with von Ebner that they form lamellæ which follow the outer contour of the tooth's crown, and that at the roots they assume a more cylindrical shape around the longitudinal axis.

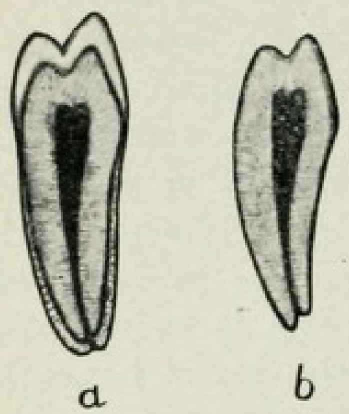
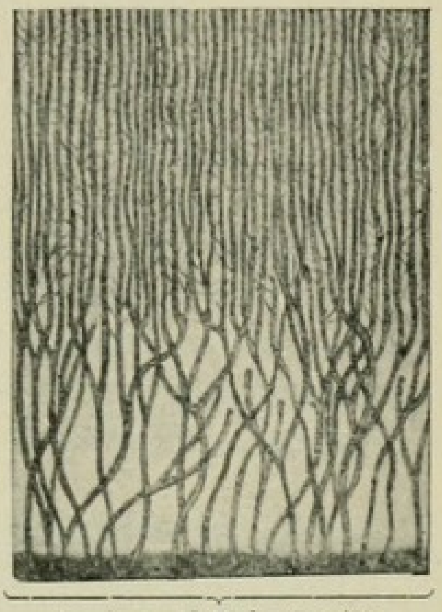


FIG. 31.—Longitudinal section of a bicuspid tooth: *a*, shows all the structures of the tooth ; *b*, shows only the dentin in order to indicate that it is the main substance of a tooth.

In this ground substance, which consists then of a calcified mass and many gelatin yielding fibrils, the *dentinal tubules* are imbedded. These are hollow tubes 3–4 mm. in width which radiate in a spiral manner from the pulp cavity to the periphery (Welcker). In regard to their direction, it may be generally said that they are horizontally arranged in the roots and gradually become vertical toward the crown. The dentinal tubules are connected with each other through numerous minute branches.

Concerning the subdivision of the dentinal tubule, it may be stated, that soon after its origin it branches into a second tubule which runs parallel to the first. This subdivision gives off similar branches, but of smaller caliber, as it runs toward the periphery (Fig. 32). The tubules which have diminished considerably in size upon reaching the edge of the enamel are lost with pear shaped terminals in the interglobular spaces and in the granular layer, or they end with tapering points in the ground substance of the dentin. Not infrequently so-called terminal loops are found between branches of neighboring tubules. The character of the terminations in the enamel deserve special attention, for here several of the tubules develop club shaped ends which penetrate several micromillimeters into the substance of the enamel. Römer as well as Morgenstern believe these thickenings to be nerve endings. But von Ebner, Röse and others are no doubt correct in asserting that this has not yet been proven. According to the careful investigation of Walkhoff the belief in the presence of dentinal nerves is today more uncertain than ever.



Surface of Pulp Cavity.

FIG. 32.—Branching of the dentinal tubules. Longitudinal section.

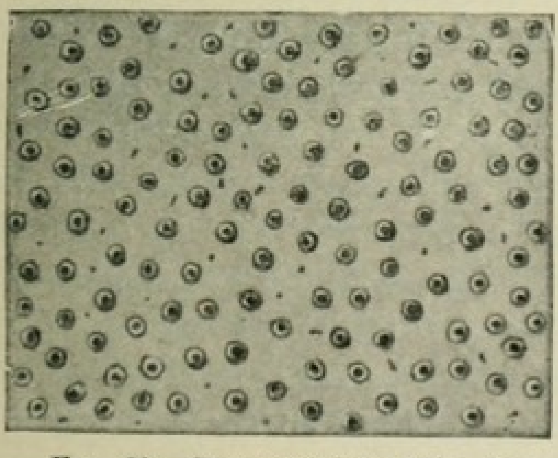


FIG. 33.—Cross section of the dentinal tubules. The pale rings are the sheaths of Neumann and the dark points which are surrounded by the latter, are the fibers of Tomes.

A cross section of a dentinal tubule (Fig. 33) shows a round limiting sheath, the so-called "Neumann's sheath" which is calcified like the ground substance. The lumen of each sheath is occupied by the uncalcified *Tomes' fibres*. That the structures are really arranged in the dentin as just described, has been determined both by Hoppe and Koelliker. By destroying all organic tissues with acids, they were able to isolate in the fossil teeth of mammals such as Neumann's sheaths in the form of minute tortuous tubes.

Concerning the fibres of Tomes', opinion is much divided, and as a compromise we cite the view which seems most tenable. The Tomes' fibers consist of prolongations from the odontoblasts, which remain uncalcified and, being elastic, can be drawn out of the dentinal tubules. The nature of their structure has not yet been positively determined but they are known to be homogeneous in appearance. Their function on the one hand consists in carrying nourishment centrifugally, and on the other, in transmitting sensation centripetally. They may also possess an additional function to be described later, which is to act as a protective or at least as a reactive agency against caries.

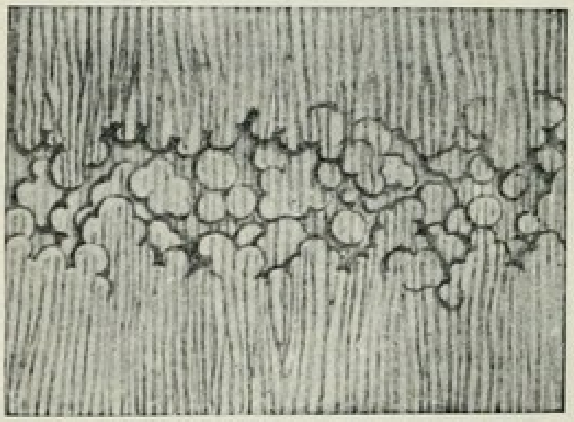


FIG. 34.—Interglobular spaces of the dentin. Longitudinal section.

The *interglobular spaces*, which lie near the surface of the dentin both at the crown and at the roots, derive their name from their similarity in appearance to that of the numerous fused globules. They represent nothing but uncalcified dentin which has retained its segmented calcified lines. The spaces themselves contain organic matter and uninterrupted dentinal tubules. In the crown these hollow spaces are very variable in arrangement and size. In poorly developed teeth they are much larger in size than in the healthy teeth. The author possesses some poorly developed teeth from idiots, the dentin of which is nearly wholly comprised of interglobular spaces. The interglobular spaces of the roots, which consists of fine and regularly sized globules (granular layer) are found also as a rule in a well developed tooth. In certain areas they lie in direct contact with the cementum, while in others a thin layer of homogeneous dentin intervenes. According to von Bibra, dentin possesses the following chemical constituents:

Basic calcium phosphate	66.72
Calcium carbonate	3.36
Calcium phosphate	1.08
Sodium salts	0.83
Organic matter	27.61
Fat	0.40
Calcium fluorid	Traces

Therefore dentin consists of 28.01 parts of organic and 71.99 parts of inorganic substances.

[This table of chemical constituents does not agree with other tables of von Bibra as given in American text-books—Ed.]

The Enamel.—Every tooth is covered by a cap of enamel. The normal enamel has a shiny yellowish white color which may sometimes be bluish, greenish, brownish, etc. In favorable light we recognize, even with the naked eye, the enamel prisms on the surface of the tooth (*perichymates*) (Fig. 35), which lie in the form of horizontal rings around the crown.

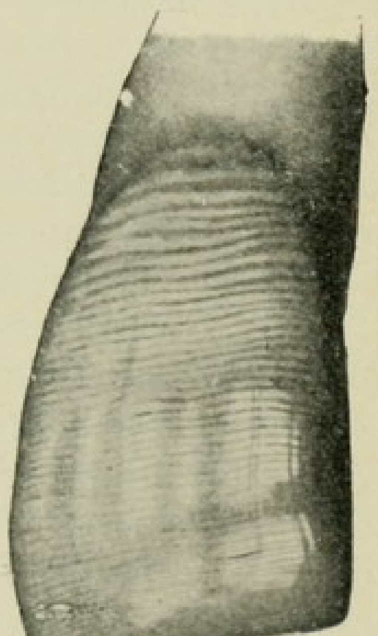


FIG. 35.—Crown of an upper central incisor, with the perichymates (enamel folds).

These prisms are arranged closely together at the neck and the further away they are from this region the greater is the space intervening between the prisms.

The enamel is covered by a *membrane* or cuticle which was first described by Nasmyth. It is easily loosened from the surface of the tooth by a few minutes application of any of the mineral acids. As has been shown by a number of investigators, organic acids also affect this membrane; they cause the enamel cuticle to change in color, to become wrinkled and after a time to loosen. Koelliker and von Ebner believe this membrane to be a cuticular formation, but Waldeyer does not agree with this observation, for he believes that he saw the outlines of epithelial cells upon treating this structure with hydrochloric acid and silver nitrate. Wedl, J. Tomes, A. Tomes, Baume and Magitôt believe the enamel membrane is homologous to the crown cement of certain mammals. It seems, indeed, that the root cement at the neck of the tooth thickens into a homogeneous mass which is continued into the enamel membrane. The author, however, is inclined to accept the view of von Ebner, who referring to the embryology, states that the enamel membrane is derived from the ameloblasts, and that at no period of development does osteogenetic tissue occur in the human enamel.

Enamel differs considerably in structure from dentin. It consists of solid hexagonal or polygonal columns or prisms.[1] These prisms are homogeneous and transparent. Through the action of acids, both organic and inorganic, one can readily demonstrate the transverse striation which hithertofore was only observed and reported in caries and when hydrochloric acid was applied. Such cauterized prisms on account of the alternate dark transverse striations resemble transversely striped muscle fibres.

The enamel prisms are joined to each other by means of an interprismatic cement (*Cortical substance of Walkhoff*), and thus constitute one solid structure. This is richer in organic matter than the prisms themselves, for it is preserved for a longer period of time, and according to von Ebner, it is easily stained with congo solution in early life. It is reasonable to assume that minute currents of liquid traverse the interprismatic substance, for not only the dentin, but also, in a demonstrable degree, the enamel is more fragile in devitalized than in the living teeth.

From personal investigation the writer has found that the direction in which the prisms run is simpler in the lower than in the higher orders of animal life. The haplodont type which represents the simplest formation, is characterized by prisms which have a simple S–curvature. In the human teeth the course of the prisms is usually spoken of as being spiral; this description, how-

[1] As has been reported by Rohan, even the enamel of the lower fish, which was formerly considered homogeneous shows a prismatic structure in polarized light.

ever, is not absolutely accurate, as the spiral is a disproportionate one in which the main curves have numerous side curvatures; therefore it is best to consider the direction of these prisms, as irregularly curled.

Two kinds of striated patterns are particularly noticeable on a polished longitudinal section of the enamel, but we wish to call attention to a third striation which is present upon a much larger scale, namely the brown parallel *striae* (contour lines) *of Retzius.* These occur in all bunodont animals whose tooth crowns possess perichymates, and, less distinctly, in the lophiodonts. In the perissodactylic and the artiodactylic solenodonts the contour lines do not exist, but in place of them broad contour bands are seen.

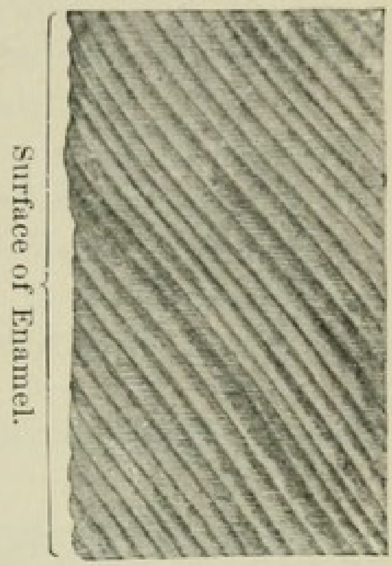


Fig. 36.—The parallel lines of Retzius passing through the perichymates on the surface of the enamel. Longitudinal section of the enamel.

As has been correctly observed by Baume, the brown color of the contour lines is due to the presence of air in the dried sections. In the recent preparations the brownish discoloration is due to the presence in this region of a greater amount of interprismatic cement which is less calcified, a view with which von Ebner also concurs. A uniform curvature of the prisms also assists in forming the contour lines. Zsigmondy shows preparations in which hypoplastic growths of the enamel coincided with the contour lines; this argues favorably for the above observation.

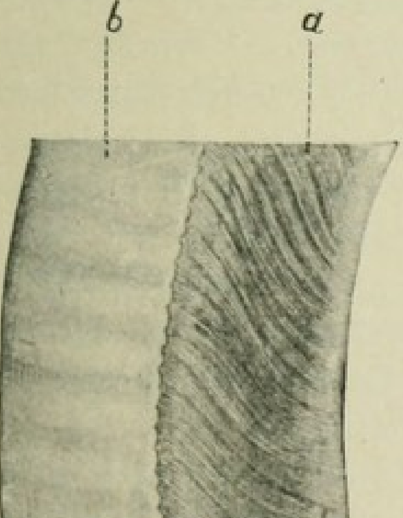


Fig. 37.—*a*, dentin; *b*, enamel with the lines of Schreger. Longitudinal section. Direct light.

The lines of Schreger are alternating dark and light bands with regular interspaces, which traverse the enamel toward its surface in such a manner as to give it a striated appearance (Fig. 37). These lines are not colored, for by azimuthal rotation of 180°, the dark bands become light and the light dark (as was determined by Czermak). Their occurrence is considered by Linderer, with whom Koelliker and von Ebner agree to be due to alternating uniform curvatures of the prismatic bundles. The *lines of Schreger* may be seen to shimmer through the intact enamel of the teeth of the beasts of prey.

We apply the term "zones" to the markings which are seen on a longitudinal section of the enamel under high magnification. They are simply prismatic bands with uniform alternating curvatures that come to view on longitudinal section. When such zones consist mainly of longitudinally arranged prisms, we call them "parazones;" these alternate usually with zones, the prisms of which are seen in cross section and which are called "diazones." von Ebner[1] observed and proved that, as a fact, structural relationships exist here which have nothing in common with the striæ of Schreger.

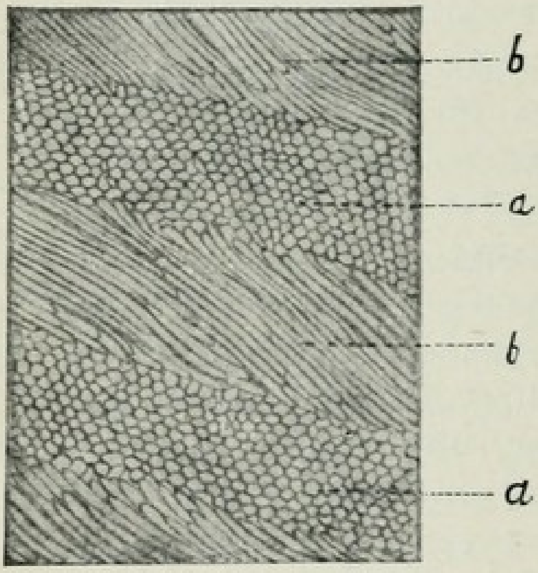


FIG. 38.—Zones of the enamel. *a*, diazone; *b*, parazone. Longitudinal section.

In certain animals, especially in the carnivora and rodents, these relationships are better seen than in man. The incisor tooth of the squirrel, for instance, shows a classical picture of this zone formation, each zone being formed by a single prismatic layer. We are indebted to J. Tomes for a masterful description of this condition. The arrangement of these zones is so characteristic of different classes of animals that it is of considerable value

[1] von Ebner, Koelliker's, Handbuch der Gewebelehre, 1899, page 89.

in tracing their evolutionary history and determining their genesis.

According to von Bibra, enamel consists of the following chemical constituents:

Calcium phosphate	89.82
Calcium carbonate	4.37
Calcium fluoride	Traces
Magnesium phosphate	1.34
Other salts	0.88
Organic matter	3.39
Fat	0.20

Therefore enamel consists of 96.41 per cent. of inorganic, and 3.59 per cent. of organic substances.

The Cementum.—The cementum is the softest of the calcified dental substances. Both in this respect and histologically it closely resembles bone.

It decreases in thickness from the roots toward the crown, and overlaps the enamel as a thin layer. In animals, especially the ungulates and rodents, the cementum covers the crown of the molars as the so-called crown-cement.

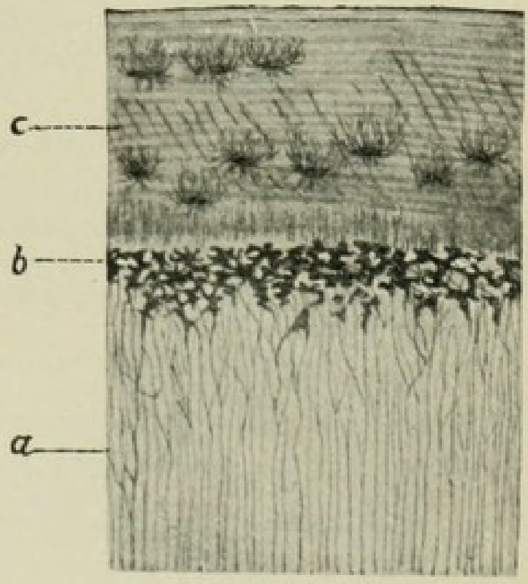


FIG. 39.—*a*, dentin; *b*, interglobular spaces on the border between the dentin and cementum; *c*, cementum with the cement bodies and the fibers of Sharpey running obliquely to the surface of the dentin. The curved lines indicate the layer-like construction of the cementum.

In the thin regions its structural formation differs from that in the thicker areas. The thin portion of the cement appears on section to be structureless and diaphanous, but when decalcified and stained it shows perpendicular bundles which resemble Sharpey's fibers.

Such uncalcified fibers also traverse the ground substance of the thicker layers of the cementum, but associated with them are seen *cement corpuscles* which differ from the bone corpuscles by their long processes. The processes of neighboring cement corpuscles are joined

PLATE 6.

Histological Preparations of the Pulp.

FIG. 1.—*a*, ordinary pulp tissue; *b*, bundles of fibers which follow the nerves and vessels; *c*, small blood-vessel on longitudinal section; *d*, longitudinal section of a large blood-vessel filled with corpuscles; *e*, odontoblastic layer. Longitudinal section. Hematoxylin—Eosin.

FIG. 2.—*a*, round cells of the pulp; *b*, spindle shaped cells. Longitudinal section. Hematoxylin. Highly magnified.

FIG. 3.—*a*, ordinary pulp tissue; *b*, nerve bundles on longitudinal section; *c*, blood-vessels surrounded by nerve bundles. Longitudinal section. Hematoxylin—osmic acid.

FIG. 4.—*a*, nerve bundles on cross section; *b*, blood-vessels surrounded by bundles of nerves. Cross section of the root-pulp. Hematoxylin—osmic acid.

PLATE 7.

Distribution of the blood-vessels of a young cuspid tooth. The arteries are colored red and the veins blue. The light yellow stripe on the periphery indicates the odontoblastic layer. Injected preparation. Reconstructed from serial sections.

PLATE 8.

FIG. 1.—Section through the border between the dentin and the pulp. *a*, Tomes' fibers (red) in the dentin (yellow); *b*, pulp; *c*, odontoblasts; *d*, Tomes' fibers, which have been torn from the dentinal tubules. Longitudinal section. Koch's hardening process (Canada-balsam). Picric acid. Carmin.

FIG. 2.—Network of the connective tissue in the embryonal dental papilla. Methylene blue.

FIG. 3.—Ameloblasts (enamel constructors) in activity. *a*, ameloblasts; *b*, layer of prisms with cuticular zone. The so-called Tomes' ameloblastic processes; *c*, intercellular substance, in the form of a honey comb, which is undergoing dentification. Hematoxylin—Eosin. High magnification.

FIG. 4.—*Isolated odontoblasts (dentin constructors)*. *a*, cell bodies; *b*, cell nuclei; *c*, process directed toward the pulp; *d*, process directed toward the dentin (Tomes' fibers). Methylene blue. High magnification.

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together so that an uninterrupted canal system traverses the cementum. According to Bödecker this system stands in direct communication with the dentin. Inasmuch as the cementum is composed of lamellæ which are arranged parallel to the surface its appearance is similar to that of bone. Haversian canals are not present in the cementum during youth but occur later in life associated with senile changes and hypertrophy of the cementum.

According to von Bibra the chemical constituents of cementum are:

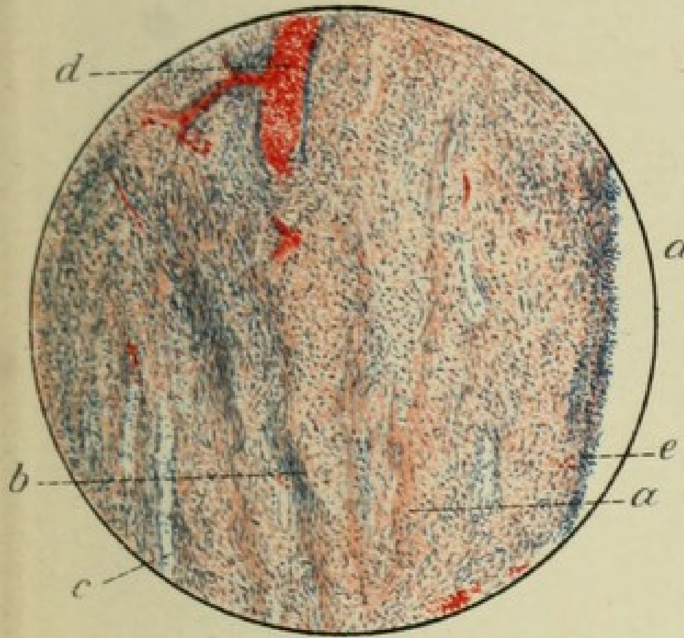


Fig.1.

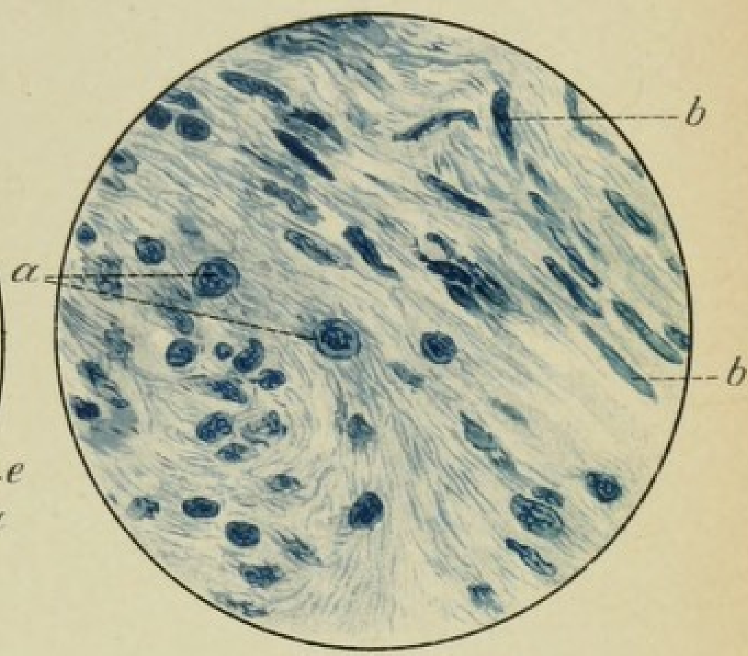


Fig.2.

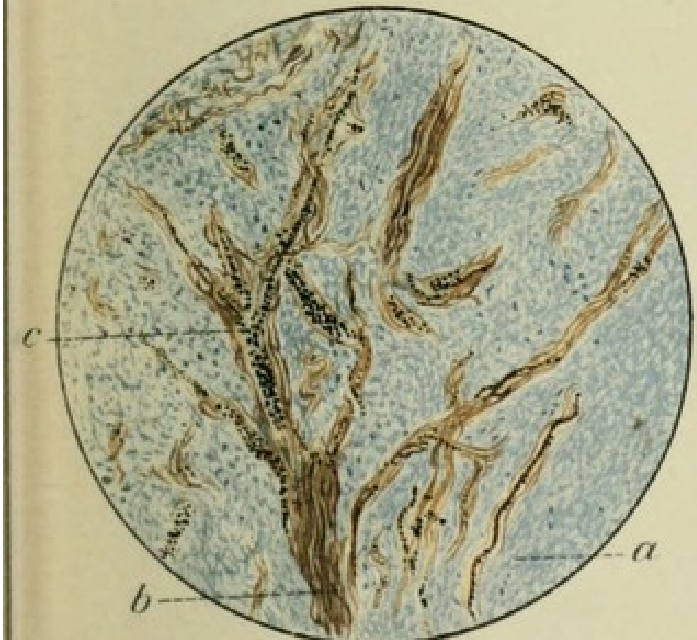


Fig.3.

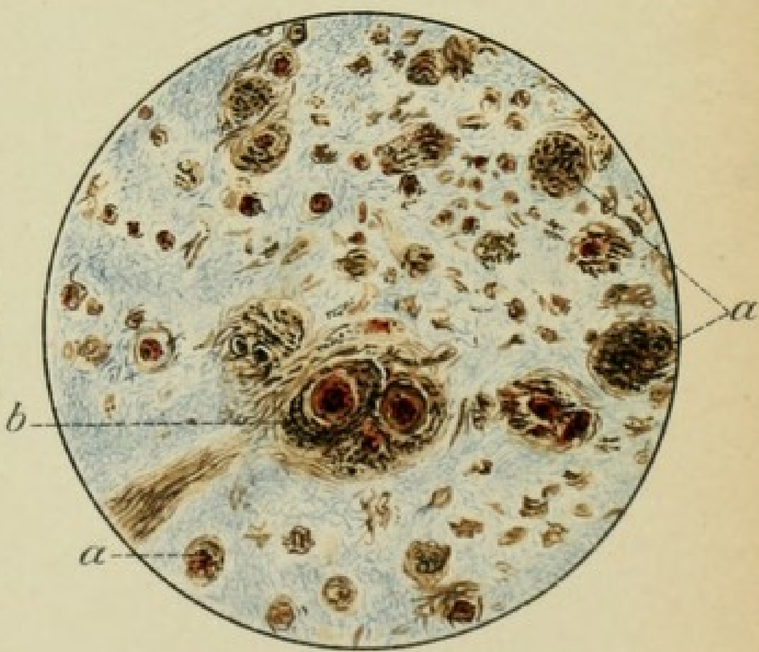
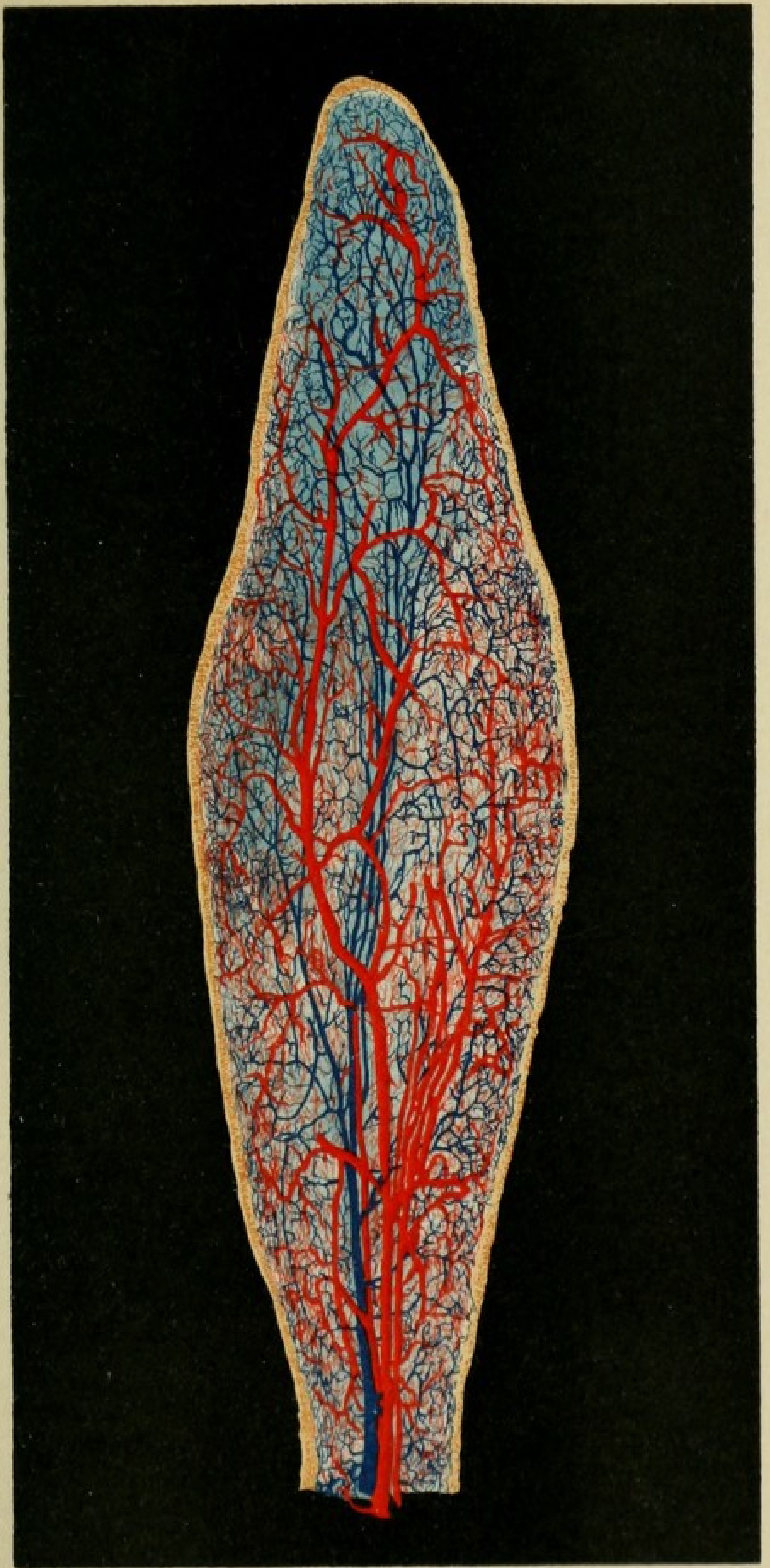


Fig.4.



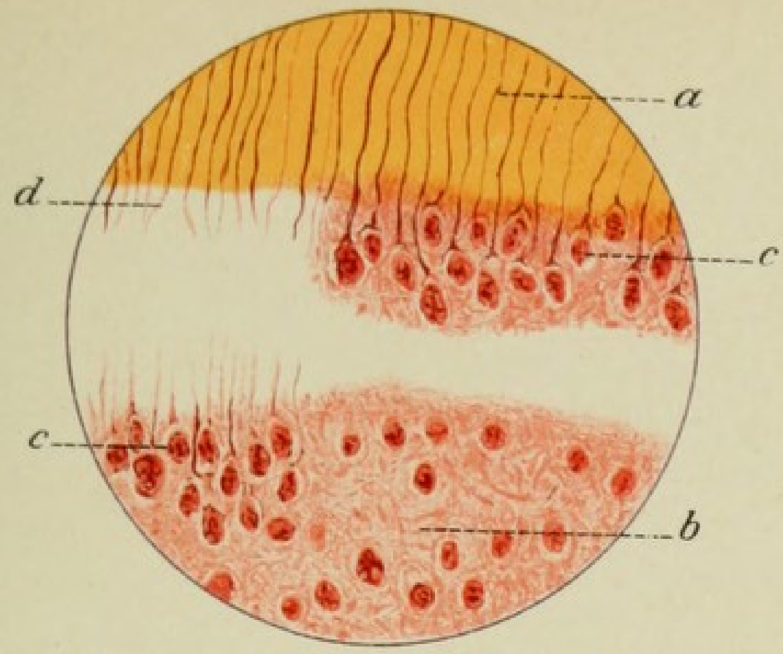


Fig. 1.

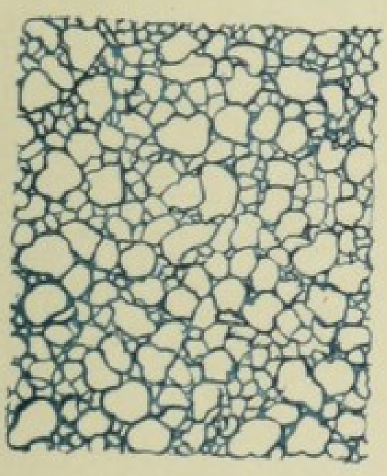


Fig. 2.

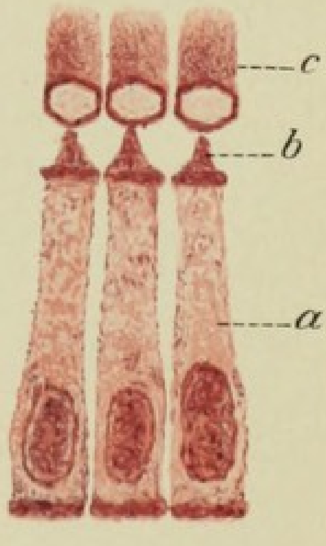


Fig. 3.

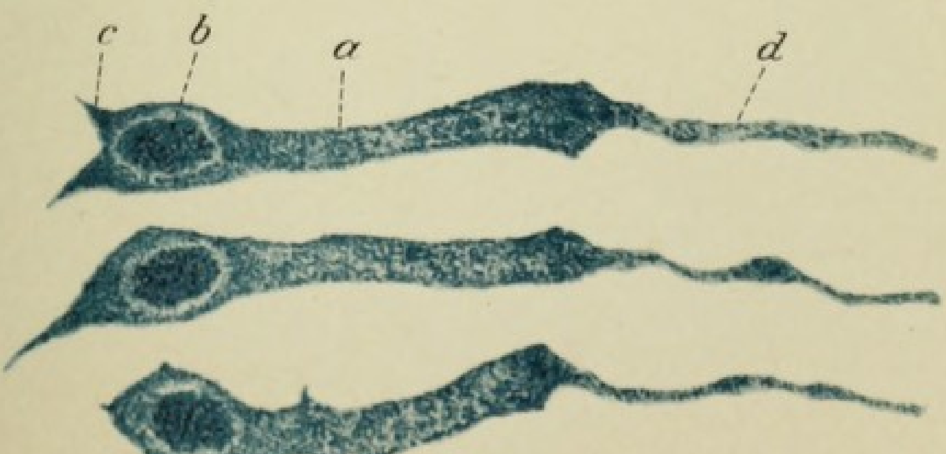


Fig. 4.

Calcium phosphate	58.73
Calcium carbonate	7.22
Magnesium phosphate	0.99
Other salts	0.82
Organic matter	31.31
Fat	0.93
Calcium fluorid	Traces

Hence cementum consists of 67.76 per cent. inorganic, and 32.24 per cent. of organic substances.

The Dental Pulp.—The central cavity of the tooth contains the dental pulp, which is the persisting but altered dental papilla, and which during development excreted the dentin. It is divided into a crown and a root. The former assumes the outline of the crown only it is smaller in size, while the latter extends in strands down the root canals to the *apical foramina*. The color of a recently removed healthy pulp varies from whitish to pale rose. Squeezing the pulp causes a drop of fluid to appear, which coagulates in the air.

Histologically (compare Plate 6, Figs. 1, 2, 3, and 4, also Plate 7, and Plate 8, Fig. 1) the pulp consists of a gelatinous tissue which, however, differs from that of the umbilical cord, because it contains no free bundles of connective tissue. Many loose fibrils lying across each other in all possible directions, are embedded in a homogeneous jelly-like ground substance, which, according to von Ebner are supposed to be gelatin-yielding fibrils.

The majority of the cells possess many branches, and are: (1) Polygonal cells; the processes of which may be single or subdivided and connected by branches with neighboring cells. (2) Between the polygonal cells many round cells occur in the young pulp. (Plate 6, Fig. 2, *a*). (3) Various spindle shaped connective-tissue cells (Plate 6, Fig. 2, *b*) lie on the nerves and blood vessels. These elements accompany connective-tissue bundles and appear only in connection with the nerves and blood vessels which they serve to support. Elastic fibres do not occur in the pulp. Aside from these elements, cells are found at the surface of the pulp with large nuclei which have the form of cylindrical epithelium. (4)

PLATE 9.

Frontal section through the head of a new-born child.

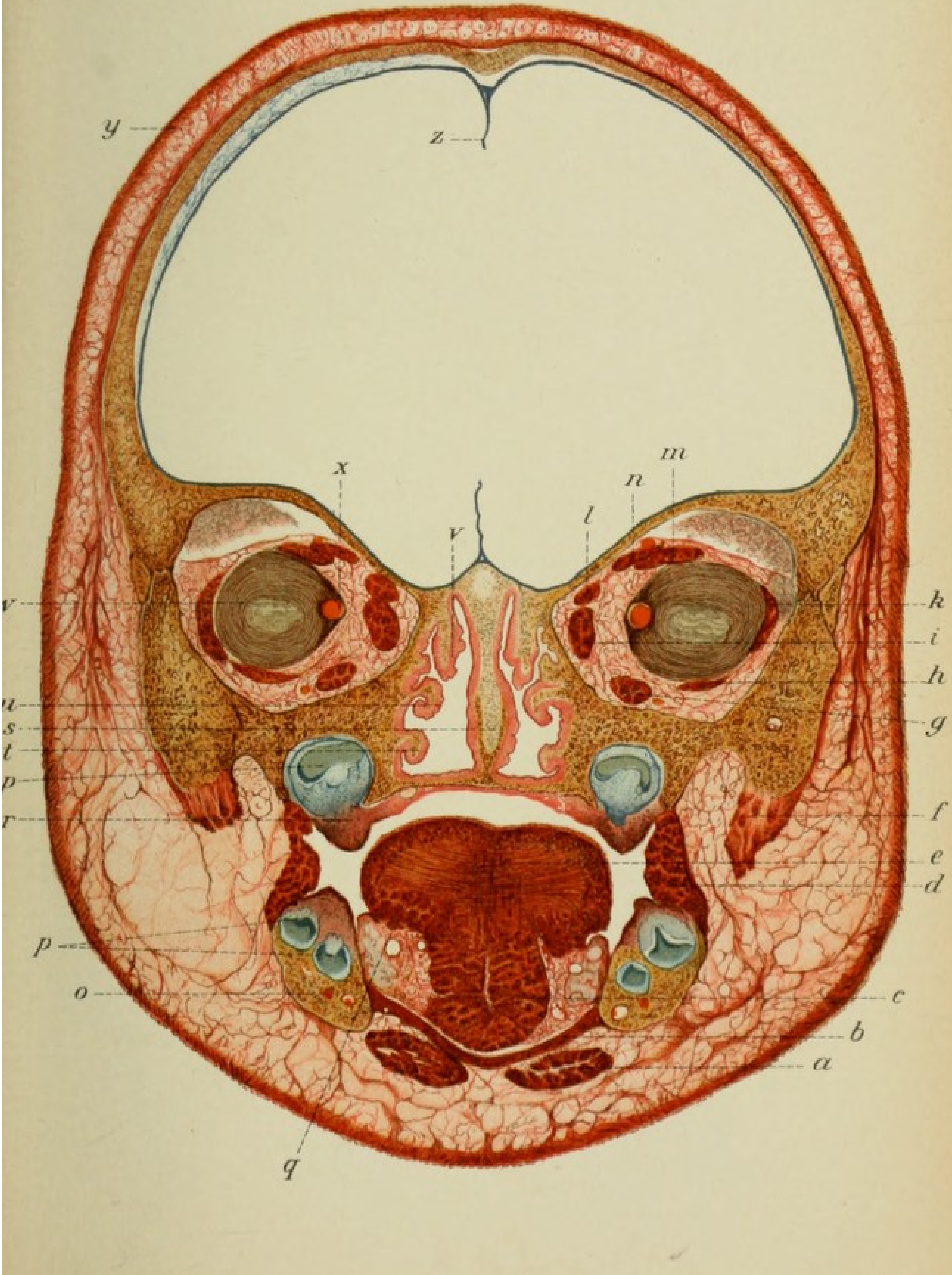
(Region of the molars).

a. Digastric muscle. *b.* Mylohyoid muscle. *c.* Geniohyoid and genioglossus muscles. *d.* Buccinator muscle. *e.* Tongue. *f.* Masseter muscle. *g.* Inferior rectus muscle. *h.* Inferior oblique muscle. *i.* Medial rectus muscle. *k.* Lateral rectus muscle. *l.* Superior oblique muscle. *m.* Superior rectus muscle. *n.* Levator palpebræ muscle. *o.* Mandibula. *p.* Tooth-germs. *q.* Sublingual gland. The guiding line points to a large white spot which represents the deep lingual artery. A smaller white dot lying in the medial direction indicates the submaxillary duct. *r.* Gums of the upper jaw. *s.* Nasal septum. *t.* Inferior turbinated bone. *u.* Middle turbinated bone. *v.* Superior turbinated bone. *w.* Eye-ball. *x.* Papilla of the optic nerve. *y.* Scalp. *z.* Falx cerebri.

Odontoblasts (dentine constructors) (Plate 8, Fig. 1, *c*) which, even in the completed tooth, continually tend to calcify the periphery of the pulp; but less so than during the developmental period. They send protoplasmic processes, the fibres of Tomes, through the dentinal tubules, and are separated from the pulp by a crowded layer of round cells.

Some of the *blood vessels*, as described by Weil, enter the pulp, from 3 to 10 in number, in a groove formed by the nerve bundles, while other vessels undoubtedly enter through a tube-like formation of the nerve bundles. They divide below, and in the odontoblastic layer, into capillaries from which veins carry off the venous blood. Plate 7 presents a reproduction of the course of the blood-vessels as was seen in a large number of serial sections.

As was stated above, the *nerves* of which there are five or ten bundles, enter with the blood-vessels, and at the crown of the pulp spread out in a rich anastomosis. Near the surface of the pulp they become unmedullated and penetrate the cells of the odontoblastic layer as fine primitive fibres. In spite of careful and conscientious attempts to corroborate the findings of Römer and Morgenstern, the writer was unable to trace the nerves into the dentin. Nor was he able to confirm Boedecker's observation that *lymphatics* are present in the pulp tissue. On the contrary this tissue is everywhere free of lacunæ. Even in cross section of the root pulp (Plate 6, Fig. 4,)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where a lacuna is least likely to escape notice, nothing resembling a lymph-vessel was to be detected.

Calcareous concretions are often found in normal pulps, especially in advanced age. They occur partly as granules which are deposited in the blood-vessel walls or, more frequently they form globules which on section show a number of layers concentrically arranged like in an onion. Late in life the pulp tissue is substituted by dense connective tissue in which only a few cellular elements remain.

The Root Membrane (Periosteum, Periodontium).—(Plate 5, Fig. 1, *c*). The periosteum forms a comparatively thin membranous layer between the cementum of the tooth and the bone. This root membrane is not wholly identical with the ordinary periosteum, either histologically or physiologically. It assists in holding the tooth in place, yet allows it a certain amount of movement. Malassez considers this movement to be due to a joint formation in which he characterizes the periosteum, and not altogether incorrectly, as the *alveolar ligament.*

The alveolar ligament represents the continuation of the above described bundles of fibrous tissue which traverse the cementum perpendicularly to its surface, and then pass over to the bony alveolus to penetrate it as the fibres of Sharpey. At the dental cervix these fibres radiate toward the bone in nearly a horizontal direction, but as the tips of the roots are approached, according to many authors, their direction becomes more and more oblique so that the tooth appears to be suspended in a socket by thousands of cables. One is not, however, always fortunate enough to see these relations so clearly for, on the contrary, only a maze of connective-tissue fibres is usually seen. Firm bands of union exist between the alveolar border and the neck of the tooth which form, according to Kœlliker, the *circular ligament.*

Loose connective tissue lies between these tight bands, which is especially abundant at the tips of the roots where it furnishes protection to the entering nerves and blood vessels. The root membrane is richly supplied with nerves and blood-vessels. In certain areas the latter form characteristic vascular glomeruli, which were first described by Wedl.

Of especial interest are the *epithelial nests* (masses epithéliaux) which are disseminated more or less abundantly throughout the above described tissue. They represent separated fragments from the epithelial layer (Von Brunn) which is concerned in the development of the roots. These fragments may cause the formation of periosteal cysts, etc.

PHYSIOLOGY.

THE DEVELOPMENT OF THE TEETH.

Plate 8, Figs. 2, 3, and 4, also Plates 9, 10, 11, and 12.

The human embryo prepares for the development of teeth about the fourteenth day. At this time the tongue is already probably formed but the rudiments of the lips and jaws form as yet only a smooth mass, while the Meckel's cartilage is indicated only by a few and scattered round mesodermic cells. At this time the ectoderm of the embryonal oral cavity passes down into the mesoderm of the rudimentary jaws, forming a narrow band into it. (Fig. 40 *d*). Since this epithelial band, in the course of development, produces the enamel, it was termed the *enamel organ* by Kœlliker; with regard to its shape it was called by Waldeyer and Hertwig, the enamel band.

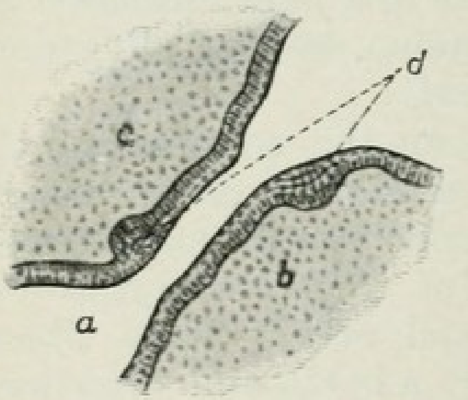

FIG. 40.—(According to Röse.) *a*. Entrance to the mouth. *b*. The rudimentary lower jaw. *c*. The rudimentary upper jaw. *d*. Enamel organ.

The enamel organ gradually undergoes longitudinal division, the front part grows perpendicularly downward and forms the lip groove, which separates the lip from the jaw germ. The posterior part grows in a horizontal direction backward and becomes specialized into the tooth germ, it is therefore the true *tooth-band*. (Fig. 41, *h*).

After it has built the upper and lower maxillary eminences, this tooth band sends ten bud like eminences into the mesoderm ; these are the germs for the milk teeth. The mesoderm, however, does not remain inactive during this time, it sends connective-tissue papillæ, the origin of the future pulp, toward these eminences and indents them. These invaginations are not in the plane of the tooth band but to one side and, as Röse properly described, in the upper jaw from above backward, and from below forward ; in the lower jaw from below backward, and from above

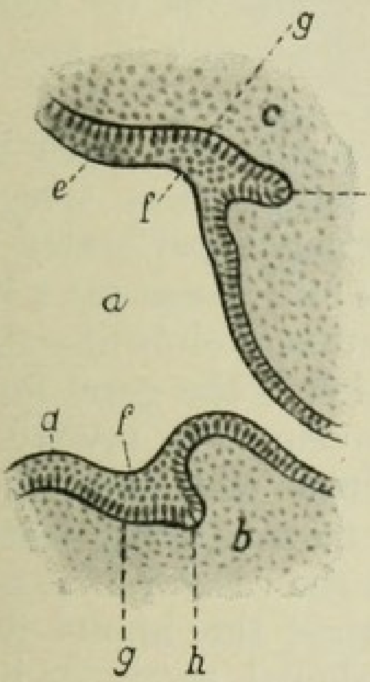

Fig. 41.—*a*. Entrance to the mouth. *b*. Rudimentary lower jaw. *c*. Rudimentary upper jaw. *d*. Rudimentary lower lip. *e*. Rudimentary upper lip. *f*. Labial sulcus. *g*. Labial sulcus band. *h*. Tooth-band.

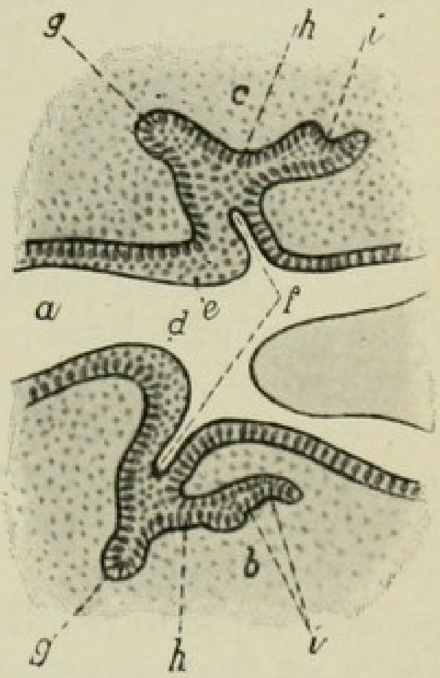

Fig. 42.—*a*. Entrance to the mouth. *b*. Lower jaw. *c*. Upper jaw. *d*. Lower lip. *e*. Upper lip. *f*. Labial sulcus. *g*. Labial sulcus band. *h*. Tooth-band. *i*. Tooth papillæ.

forward. Depending upon this arrangement the temporary teeth germs lie nearer the periphery of the maxillary eminence to permit the tooth band to spread without hindrance in the lingual direction for the upbuilding of the permanent teeth (Fig. 42, *i*).

The germs of the deciduous teeth are originally joined to the tooth band by means of a wide neck. But as development progresses this neck is drawn out and lengthened and in areas the mesodermic tissue grows

PLATE 10.

FIG. 1.—*a*. Tooth-germ in three different stages in one preparation. *b*. Enamel-organ, which becomes invaginated by the growing mesodermic cells. *c*. These mesodermic cells have formed here the tooth-papilla (dentin-germ). *d*. Enamel pulp, which *e*. is surrounded by the tooth sac. *f*. Connecting band. *g*. Epithelium of the oral mucous membrane. Hematoxylin-Eosin, with retouche.

FIG. 2.—Tooth-germ. *a*. Tooth-papilla. *b*. Enamel pulp. *c*. Outer epithelial layer of the same. *d*. Inner epithelial layer of the same. *e*. Connecting bridge between primary and secondary enamel germs. *f*. Secondary enamel germ. *g*. Connecting band. *h*. Epithelium of the oral mucosa. Hematoxylin-Eosin.

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through it. Hence the *connective bridge*, as the neck is called, consists of a greater or less number of fine connective fibers.

In the course of further development the tooth band loses its smooth surface and its compactness, irregular thickenings develop which are alternately perforated like a sieve. Only its posterior portion still possesses a layer of smooth epithelium ; in this position a club-like thickening grows toward the tongue which is the germ for the first permanent molar tooth. To one side, toward the lips, a row of successive thickenings now arise in the tooth band from which originate the remaining teeth of the second dentition. Here, as in the case of first teeth, connective-tissue papillæ press against the knotty thickenings so that sometimes the epithelial layer fits like a hood to the connective-tissue eminence.

The germ for the permanent incisors develops in about the sixth fetal month. The germs for the grinding teeth which are postembryonal in development, develop during the first year of life. The further destiny of the tooth band consists in an increased perforation with the result that it loses more and more of its texture. Nests of epithelium remain imbedded in the connective tissue which may later develop into cysts, atheromata and other growths. There may also occur an abnormal development of enamel and, indeed, it has not rarely been observed that connective-tissue proliferation occurs in such epithelial nests analagous to normal tooth construction,

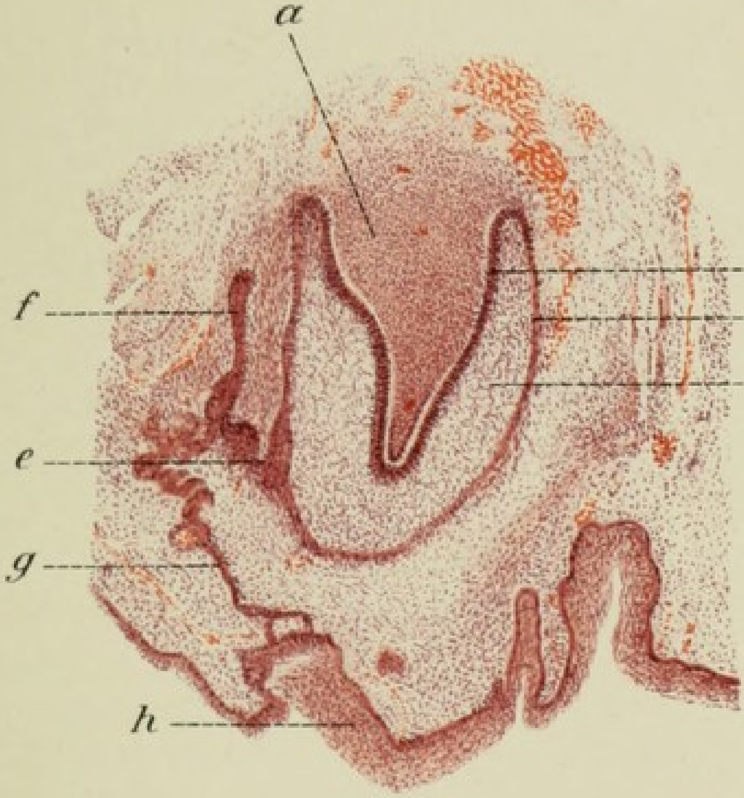

Fig. 2.

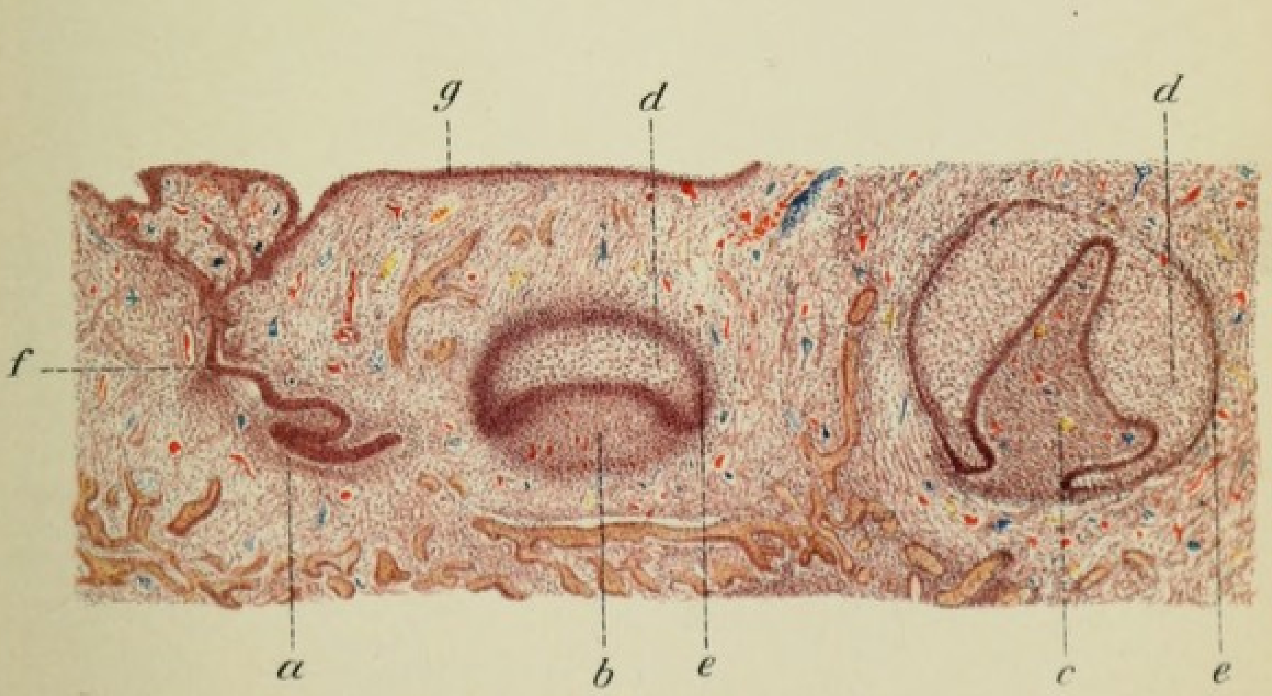

Fig. 1.

from which more or less well developed supernumerary teeth may arise.

The tooth bands are separated from their surroundings by the *tooth sac*, a connective-tissue envelope, which consists of two layers, one, the inner which lies directly upon the tooth germ, consists of loose connective tissue with many blood-vessels, and the other, the outer layer, is free of blood-vessels and composed of dense bands of connective tissue. The above described mesodermic papilla grows through an opening at the base of the tooth sac into its interior and forms the *dentin-germ*. The function of the dentin-germ is to generate the dentin during development of the tooth. When it is fully developed it forms the *dental pulp*. On its surface a layer of tall cylindrical-shaped cells are formed, the *odontoblasts* which produce dentin.

The formation of dentin is similar to that of bone, the odontoblasts excreting a protoplasmic uncalcified ground substance which in turn becomes progressively calcified from its periphery toward the odontoblasts. However, a diffuse calcification of the whole tissue does not occur, for the dentinal tubules as well as their connecting branches and the interglobular spaces remain uncalcified. The *sheaths of Neumann* which line the dentinal tubules seem to possess a peculiar chemical composition for they resemble neither the calcified ground substance nor the organic dental substance, but are strongly resistive against all methods of decomposition and, therefore, resemble horn-like bodies. The *Tomes' fibers* are homogeneous protoplasmic processes which lie in the dentinal tubules ; they represent peripheral elongations of the bodies of the odontoblastic cells. Aside from these enormously long drawn out processes, the odontoblasts also possess very short lateral offshoots by means of which they connect with each other. These branches are later looked upon as the lateral-connective tubules of the fully developed dentin. The majority of the odontoblasts are moreover supplied with a third variety of processes which are very short and are fastened centrally. The calcification of the dentinal

PLATE 11.

FIG. 1.—**Tooth-germ of a young cat.** *a.* Tooth-papilla. *b.* Enamel pulp. *c.* Tooth-fragment. *d.* Epithelial layer which, according to von Brunn, has a form-giving function in the formation of the root. *e.* Meckel's cartilage. *f.* Epithelium of the oral mucosa. *g.* Bony trabeculæ of the lower jaw. *h.* Wall of the tooth-sac. Hematoxylin—Eosin.

FIG. 2.—**Secondary tooth-germ of a young cat.** *a.* Tooth-papilla of the secondary germ, which will form the true pulp. *b.* Milk-tooth, whose roots are prepared to become absorbed and to be forced out. *c.* Enamel pulp. *d.* Resorption organ. *e.* Gums. Hematoxylin—Eosin, with *retouche.*

FIG. 3.—**A section of a human tooth-germ which shows all the layers.** *a.* Tooth-papilla. *b.* Odontoblasts (Membrana eboris). *c.* Preformative membrane. *d.* Ameloblasts (inner epithelial layer of the enamel organ, membrana adamantina). *e.* Stratum intermedium. *f.* Gelatinous tissue of the enamel organ. *g.* Passing of the stellate cells into *h*, the outer epithelial layer of the enamel organ. This outer epithelial layer is, however, not limited by the similarly shaped epithelial cells which are designated by *h*, but stands in close union with the tooth-sac by means of off-shoots of round cells which are penetrated by blood-vessels. *i.* Tooth-sac. Hematoxylin—Eosin. High magnification.

PLATE 12.

Tooth-fragment from a deciduous canine tooth.—*a.* Ameloblastic layer. *b.* Enamel undergoing dentification; the Tomes' processes of the enamel constructing cells are shown, as well as the tubes of the calcified intercellular substance, which are superimposed upon each other in the form of a honey comb. *c.* The dentin in the process of dentification, with the multiple branched terminals of the Tomes' fibers. *d.* Odontoblastic layer. Decalcified in hydrochloric acid.—Alcohol. Hematoxylin.—Eosin. High magnification.

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ground substance (dentinogene substanz) is brought about by deposits and, therefore, the surface line between the calcified and the uncalcified substance is not a plain rounded surface but is formed by spherical segments; for this reason the interglobular spaces, which follow a momentary disturbance in the normal process of calcification show on section a spherical limiting border.

It is only from this one cellular layer that the whole dentinal covering arises during the course of development. This fact had already been determined by Kœlliker, and in spite of many attempts to weaken this theory it has successfully withstood all attacks. At a more recent date Walkhoff corroborated this observation by means of carefully prepared microphotographs of tooth germs.

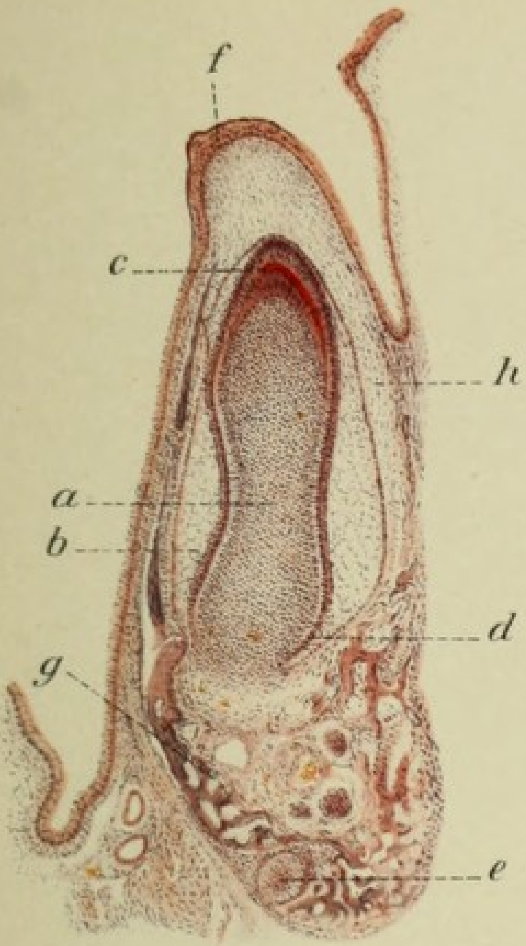


Fig. 1.

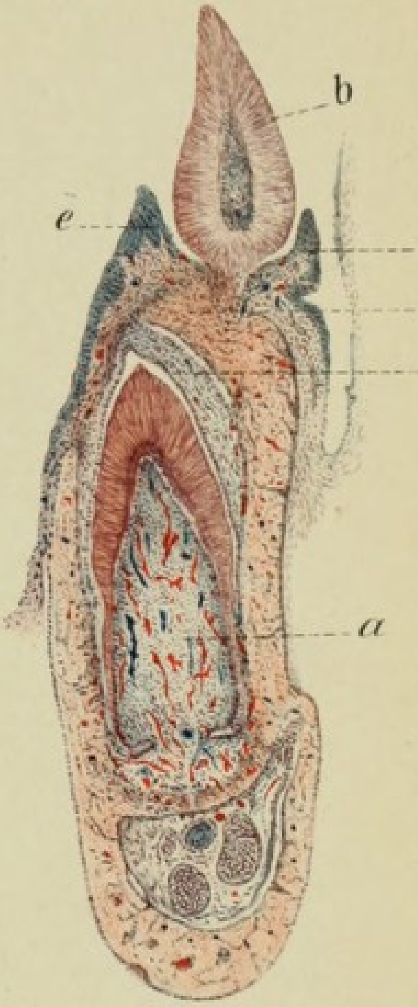


Fig. 2.

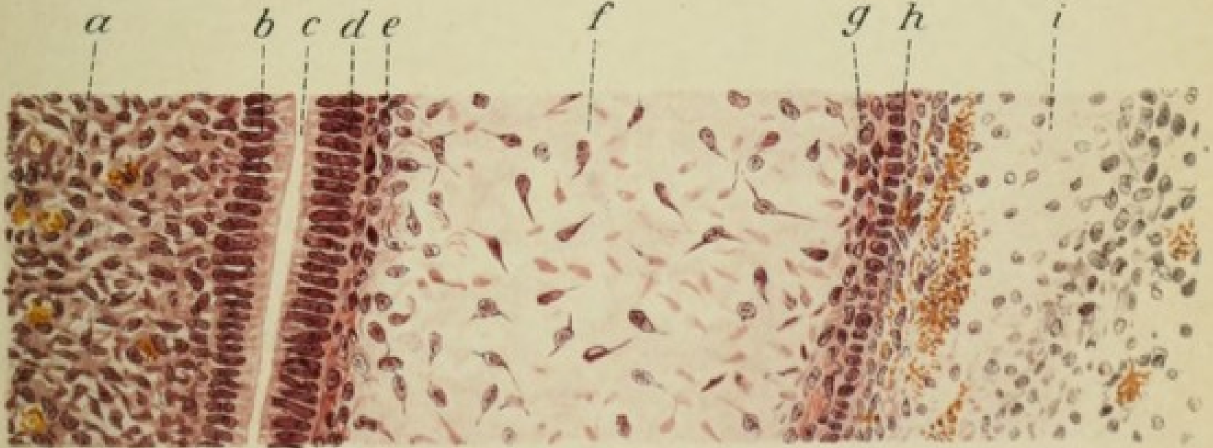
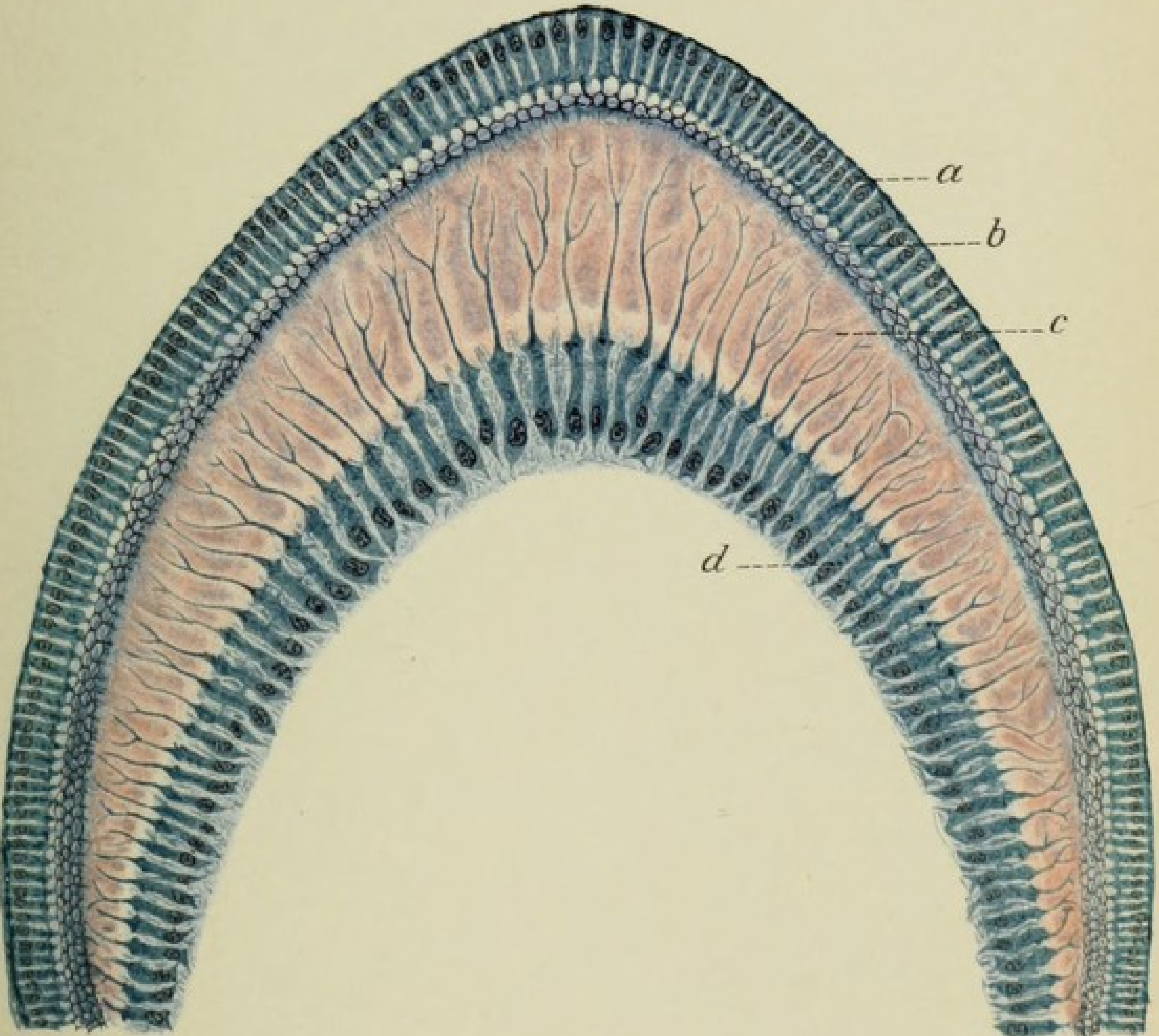


Fig. 3.



Lith. Anst. F. Reichhold, München.

Covering the tooth papilla which arises from the floor of the tooth germ is the *enamel germ* or *enamel organ*. It is composed of several different layers which are distinctly separated from one another (Plate 11, Fig. 3). The odontoblastic layer lies directly upon the papilla and next to it is the inner epithelial layer (Kœlliker) which, analogous to the odontoblastic layer, is composed of stratum of cylindrical cells, the *ameloblasts* (enamel constructors). Near the base of the dentin germ, the inner epithelial layer folds back outwardly and thus covers the inner wall of the tooth sac with a layer of low epithelial cells (*outer epithelial layer*). The enamel pulp which is enclosed between both epithelial layers simulates connective tissue because of its star-shaped cells whose wide-meshed interspaces are filled with an albumin-like liquid. According to von Ebner, however, these cells are simply altered epithelial cells, and it is possible to trace the gradual conversion of the star cells in the region of the *stratum intermedium*, which lies upon the inner epithelium, into true stratified pavement epithelium.

Just as the dentin is composed of a single layer of specified cells so is the whole enamel produced from a single ameloblastic layer from beginning to end. At first a limiting band is formed on the enamel constructing cells, which originally shows only a pale cuticle-like border next to the young dentin. This cuticle border increases in thickness and thus gradually forces the ameloblastic layer away from the dentin.

The ameloblastic cells are joined to the enamel, which is at first only slightly calcified, through their *Tomes' processes*. These are branches from the cell body which become gradually solidified from within toward the periphery by deposits of brilliant calcium granules. By union of these calcium granulations, the cell processes assume that form and consistency which is manifested later in the finished enamel prisms.

These processes are inserted as may be seen in Plate 8, Fig. 3, and Plate 12, in hexagonal shaped husks which taken collectively, on cross section appear like a honey-comb; these represent the modified intercellular substance which is preparing for tooth development. The shiny processes constantly increase in thickness and the tubes become atrophied; in the completed enamel they exist only as the small amount of interprismatic cement substance.

The various events of tooth formation begin about the fifth fetal month and are ushered in by the construction of a small hood of dentin at the tip of the tooth, and in multicuspid teeth, simultaneously at the different cusps; to this hood of dentin an external layer of enamel is annexed (Plate 12). These *tooth fragments* constantly increase in circumference and thickness, while the additional deposits of dentin continually decrease the size of the dentinal pulp, the development of the enamel externally causes the enamel pulp to atrophy.

THE DEVELOPMENT OF THE ROOT.

After the crown is developed and the tooth prepares for eruption the construction of the root begins. In this connection, according to von Brunn, the enamel organ, in place of its former function of constructing enamel, is now concerned in forming the root. In the neighborhood of the neck of the tooth the inner epithelial layer unites with the outer epithelial layer so that the intermediary layer and the enamel pulp become displaced. The membrane which is composed of only two layers of epithelium and called the *epithelium membrane*, extends downward in a tube-like fashion into the depths of the mesodermic tissue until finally a connective-tissue cone is formed which has the length and form of the future root (See Plate 11, Fig. 1, *d*).

The connective tissue undergoes alteration into typical pulp tissue, on the periphery of which lie odontoblasts, exactly as was described in connection with the primitive tooth papilla. Later the epithelial layer becomes absorbed, a small portion of it, however, remains in the form of the before mentioned epithelial nests in the periosteum of the root. The odontoblasts which are developed in the newly-formed epithelial layer furnish the dentin for the root. As soon as some of the dentin is deposited, the *cementum* of the roots begins to form. This is brought about by cells being detached from the inner wall of the tooth sac, which become the osteoblasts. They wander through the epithelial layer and attach themselves to the surface of the dentin and at first generate upon the same only a thin coat of cementum, which gradually becomes thicker. Fig. 43 gives a macroscopical representation of the process of root development in an uncompleted molar.

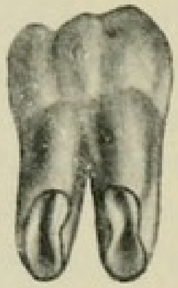


FIG. 43.—Lower molar, whose roots are not yet completely developed.

At the time of root development the tooth sac is grown fast at its crown with the gum. During the period of tooth eruption the summit of the tooth sac remains intact, and is the first part to penetrate the gum and enter the oral cavity. Then this covering is pierced by the upward growth of other teeth, and falls back around the neck of the tooth, where it grows fast to the gums and forms the *circular ligament.* The remaining portion of the tooth sac is hemmed in between the alveolus and the tooth root, where it forms a union between the two, and in the course of time becomes the alveolar periosteum.

The mechanism concerned in the *eruption of teeth* is not yet fully understood. It seems that a number of factors are combined in this process; these include longitudinal growth of the roots, proliferation of the cells of the pulp eminence, and phenomena of growth in the surrounding tissues.

CALCIFICATION OF THE DECIDUOUS TEETH.

Calcification of the deciduous teeth occurs in the order in which they come to eruption. Hence the incisors first become calcified and the molars not until later. The ages at which the primary teeth become calcified are graphically demonstrated in the upper illustration of Fig.

47, which is reproduced from the copy of Pierce, in "Amoëdo's Legal Dentistry." The records of this table do not agree absolutely with those of other authors. This is probably due to the fact that variations in the process of calcification are as frequent as they are in the time of eruption. According to Pierce the calcification begins in the 17th fetal week, exactly at the period when the back part of the tooth band begins to undergo the invagination process for the permanent molars. At birth, the crowns of the incisor and cuspid teeth are almost completed, while only two-thirds of the crowns of the molars are developed. Complete development of the roots does not occur until between the eighth and twenty-second month after birth. As has already been mentioned, the calcified part of the tooth is called in the early stage, the tooth fragment. This is composed of a deposit of dentin and enamel, which lies like a hood upon the tooth papilla. The uplifting of the dentin begins, according to Röse, simultaneously with that of the enamel. The tooth fragment which is thin at the beginning, gradually becomes larger through a constant growth in thickness both at the hood and at the sides.

ERUPTION OF THE DECIDUOUS TEETH.

It is of importance in the practice of dentistry to know exactly the time at which the first teeth erupt, for each tooth eruption is the cause of much worry to the anxious mother. As disturbances in the general health of the infant are not infrequently associated with the eruption of a tooth, a certain amount of anxiety is justified.

The normal period of eruption for the central incisors of the lower jaw is about the sixth month, while that of the same teeth of the upper jaw is a little later. During the eighth month the upper lateral incisors reach the eruptive stage, being closely followed by the lower lateral incisors. The first molars of the lower jaw appear about the twelfth month, while those of the upper jaw erupt a little later. The cuspid teeth come to eruption in the sixteenth month, and finally, the second molars complete the row of deciduous teeth at about the twentieth month. These dates, however, do not always hold true. Cases are reported in which the fetus was already provided at birth with a complete dental apparatus. On the other hand, the eruption is sometimes much delayed, so much so that even in the second and third years of life no tooth has made its appearance. This may occur in perfectly healthy children; often, however, the cause is attributable to some form of disease, such as syphilis, scrofula, and perhaps also rachitis. Also the teeth of poorly nourished children are frequently later in eruption than those of well cared for children. For our country the following periods of eruption of the deciduous teeth may be accepted as being normal:

Central incisors	6 to 8th	month.
Lateral incisors	8 to 12th	"
First molars	12 to 16th	"
Cuspid	16 to 20th	"
Second molars	20 to 30th	"

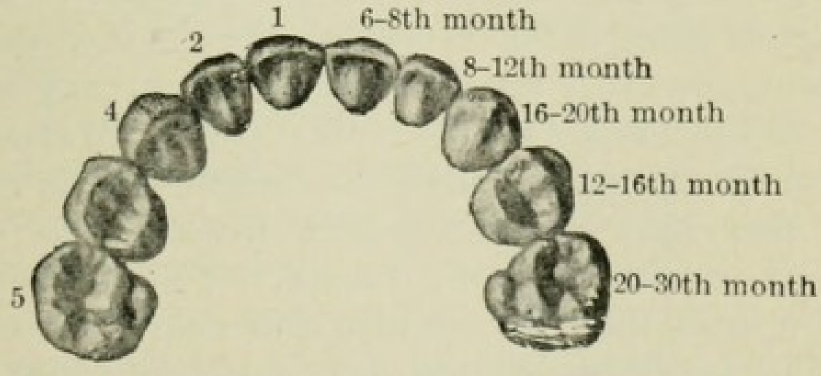


FIG. 44.—Dates of eruption of the deciduous teeth.

For the better understanding of the subject I have presented in Fig. 44 a diagram of the deciduous teeth with dates of eruption.

DISTURBANCES ACCOMPANYING ERUPTION OF THE TEETH.

A certain amount of pain in connection with eruption of the teeth seems to be physiological. Rarely does eruption of the incisors lead to important disturbances.

The molars, however, are more likely to cause trouble while the cuspid teeth too are not altogether innocent in this respect. The intensity of the child's suffering is not always in proportion to the pain; sensitive children often cry furiously during a perfectly easy period of eruption, while children of a less sensitive nature make no outcry whatever even though disturbances of eruption are present. Hence it is a difficult matter to decide in the different cases between physiologic and pathologic eruptions. It has been attempted to avoid this dilemma by simply considering an eruption a difficult one when symptoms of disturbances in the general health of the infant accompany it.

The following three different forms of disturbances accompanying eruption of the deciduous teeth are recognized:

Infantile Odontalgia.—This is due to the toughness of the gum which offers great resistance to the erupting tooth. Pressure is thus caused upon the still exposed dental pulp and therefore the child suffers toothache even before the tooth has penetrated the gums. In such cases the gum itself is not involved, that is, it is neither red nor swollen, but it is anemic and tightly strung over the summit of the tooth's crown. The pains are especially severe when an attempt is made to suckle, this is recognized by the fact that the child cries furiously as soon as it is placed at the mother's breast. Under these conditions too, a mild form of constipation nearly always exists.

The *treatment* should be expectant, that is, postpone treatment and watch whether the tooth will appear in the mouth without interference. As soon as this occurs all pain disappears. If, however, the symptoms of general disturbance become pronounced it is advisable to relieve the condition by making a deep incision through the tightly stretched gum. Before the incision, as well as afterwards, and especially after meals, the child's mouth should be carefully swabbed out with clean cotton soaked in a 20 per cent. solution of boric acid. To combat the constipation the following is prescribed:

℞ Inf. sennæ comp.
Syrup. mannæ āā f℥j (30.0).
M. et Sig. One tablespoonful hourly until a bowel movement follows.

Infantile Odontitis.—In this type of difficult tooth eruption contrary to the preceding form, symptoms referable to the gums are the most prominent. In infantile odontitis the pain is not caused by the compressed dental pulp but by the condition of the gum. This structure is primarily inflamed at the seat of eruption, later, however, the inflammatory process spreads to the surrounding tissue so that finally a large area becomes involved and highly sensitive. The affected region is reddened, swollen and not infrequently covered with ulcers. The inflammation may also extend inwardly and lead to a periostitis and osteitis of the jaw.

Symptoms attributable to constitutional disturbances are usually less severe than in odontalgia. Disturbances in alimentation nearly always accompany infantile odontitis. A considerable increase in local temperature exists in the neighborhood of the cheeks, and saliva flows freely from the mouth.

Treatment is not always necessary since like in odontalgia, the disease process often ceases when the tooth has erupted. Under no circumstances should the gum be incised, for such a procedure may easily result in sepsis of the irritated mucous membrane.[1] It is better to try to lessen the inflammation with a mild antiseptic solution. A favorite mixture is the following:

℞ Boracis ʒj (4.0).
Aquæ rosati f℥j (30.0).
M. et Sig. For painting the gums.

[[1] This is not in accord with dental teaching in America. Accumulated clinical experience demonstrates that when this form of irritation becomes pronounced, the mouth becomes hot and dry—the secretions having become checked, ulcerations appear upon the mucous membrane of the mouth, eruptions upon the face and scalp, in fact sometimes over the whole body, and, if prompt relief is not given by *free lancing* of the gums, the child may lose his appetite, suffer from nausea, diarrhœa, or even convulsions. The free use of the lancet and even cutting off sections of gum-tissue over molars, in some cases, may save the child a serious illness.—Ed.]

Convulsions.—These result during the eruption of teeth because of the increased nervous irritability of the child. They are reflex in nature and may therefore occur independently or associated with other disturbances of difficult dentition. The spasms are clonic and tonic in character which either involve individual muscle groups or spread over the whole body.

That these convulsions are associated with dentition is recognized by nearly every layman. According to Baume it has not been scientifically proven that such attacks are always due to the difficult eruption of teeth, for during this period the brain and spinal cord undergo important developmental changes so that it is quite possible that any interference with health may result in spasmodic seizures of the muscles. Therefore in order to establish the etiology it is necessary to inspect the oral cavity in such cases. If the inflammation is found to be present with marked sensitiveness of the area covering the tooth's crown it is safe to consider that process the cause of the convulsions.

The *therapy* of these convulsions, sometimes termed tooth cramps, is often quite useless. If an odontalgia accompanies them an incision in the most tense portion of the gum may give relief, also an associated odontitis must be specifically treated. If these complications are absent the treatment must be symptomatic, which, consists in treating the irritated nerve by local applications of a narcotic. For this purpose the following is recommended :

℞ Spiritis vini	f℥ijss (10.0).
Chloroformi	f℥ss (2.0).

M. et Sig. Rub as a liniment into the gum and cheek.

THE RESORPTION OF THE DECIDUOUS TEETH.

The last of the primary teeth have hardly made their appearance in the mouth before the resorption process commences in the incisors. This consists first in exertion of pressure upon the deciduous by the permanent crowns, which by this time have become more calcified. Undoubtedly the developing permanent teeth are the first factors concerned in bringing about this change. An argument in behalf of this theory is the observation made quite frequently, that in certain situations where the permanent teeth fail to erupt, the corresponding deciduous teeth are not lost. They retain their healthy root, remain viable, and stand in the row of permanent teeth until extreme old age. Another feature which speaks favorable for this supposition is the fact that the portions of the root wear away which are pressed upon by the crowns of the permanent teeth.[1]

FIG. 45.—A central and a lateral deciduous incisor tooth showing partial absorption of the roots.

According to Baume and Wedl the resorption process includes the bone marrow as well as the periosteum of the milk teeth. von Metnitz also believes that this process is shared by the periosteum but he is not convinced of any active change in the bone marrow. Waldeyer informs us of a proliferation of the milk tooth sac, by which, however, he evidently means the root periosteum of the deciduous teeth, for at the time of the resorption process the primary tooth sac has disappeared. Robin advocates an altogether different theory in which he ascribes to the follicular sac of the permanent teeth a resorptive action upon the surrounding tissues, including the alveoli and the roots of the first teeth.

von Metnitz who has given this subject a close study, made the observation that in freshly extracted deciduous teeth, which were undergoing absorption the cavity caused by the absorption process presented a soft red tissue, which even with the naked eye could be seen to consist of proliferative granulations.

If this granulated tissue is forcibly removed a rough

[[1] The position taken by the author regarding the cause of the resorption process known as decalcification of the teeth, is not altogether in accord with the accepted theories of American dental teachers. It is not now generally regarded that the presence and advance of the permanent teeth plays any part in this interesting action. In other words, it is conceded that it is simply a physiological action and not the result of a mechanical force.—ED.]

surface is exposed, which is comprised of numerous fine recesses which are surrounded by little pointed projections of varying length. Under the microscope these recesses show a close resemblance to the Howship's lacunæ which accompany a rarefying osteitis. They are filled with giant cells, the majority of which contain multiple nuclei. With reference to their function Koelliker calls them osteoclasts (Fig. 46, *b*). Numerous blood vessels and, to which von Metnitz called especial attention, long bands of newly formed connective-tissue fibrils pass between the osteoclasts. These fibrils may be traced through the pores of the bony alveolus into the bonemarrow. In many areas the defects following absorption are filled with cement which, however, already present absorption lacunæ of varying size and which in the course of this process again undergo complete dissolution. The interrupted absorption process then begins anew. I believe that this depends upon the activity of the periosteum, which up to this time remained almost intact. Only after some time does the root periosteum change into granulation tissue, after which the process in the cementum proceeds more vigorously. The dentin is affected more rapidly but here too no smooth absorption surfaces develop but the border line of the abrated area has, on longitudinal section, the form of joined segments, similar to the calcification border of the dentin. After the greater portion of the root has been destroyed, the pulp of the milk tooth becomes exposed. Its elements degenerate completely and the afferent blood vessels become constricted. But if by chance vascular connection is main-

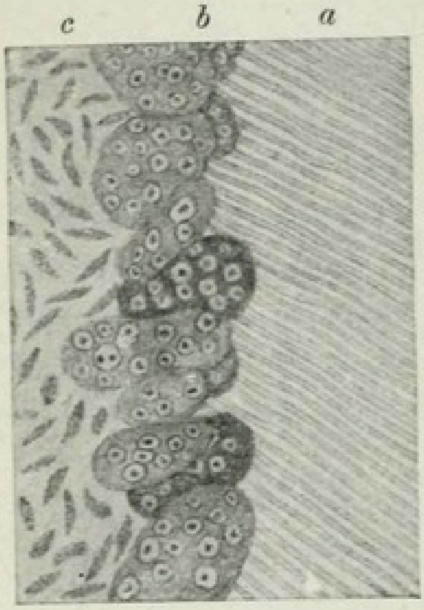


FIG. 46.—A deciduous root undergoing absorption. *a*. Dentin with absorption lacunæ. *b*. Osteoclasts. *c*. Connective tissue cells. Hydrochloric acid.—Alcohol.—Decalcification.

tained after the dentin surrounding the pulp has been lost, then osteoclasts may develop in the tissue of the pulp which bestow upon it the function of an absorptive organ.

The various authors do not agree as to the more minute changes in the absorptive process of the hard tooth substances. Baume believes that the blood plasma acts as a chemical agent and states that "It is plain to see that the blood plasma which circulates about the resorption surface dissolves and carries off the hard tooth substances. The blood plasma has, as is known, the power to hold in solution before depositing them, calcium salts which are needed for the upbuilding of the bones and teeth. A chemical body which holds a substance in solution can, under certain circumstances absorb it. These conditions develop as soon as the tooth loses its life. The granulations are therefore the indirect cause and perhaps also primarily the result of the loss of the tooth substance."

Tillmann assumes that the osteoclasts are capable of excreting carbonic acid which dissolves the calcium salts, and that the organic residue is then assimilated by the osteoclasts. Schaffer also considers carbonic acid as the absorbing agent and according to him this gas is filtered through the venous capillaries by means of the osteoclasts.

Resorption lacunæ may also result by mechanical means and indeed they may be due to ameboid movements, as is believed by Wedl, but the possibility has not been excluded that these processes go hand in hand with excretion of the substances which dissolve lime salts.

If in conclusion the changes in the absorption of the human teeth are again studied it will be concluded according to the author's observation that the phenomena observed are wholly analogous to those which occur in the physiologic bone absorption, as determined by von Koelliker (in development of bone). As we know, he advanced the proposition that bone development from a periosteal as well as an endochondral and a membranous base, consists in the apposition of bone on the one side, and the absorption of bone on the other side, the processes

FIGURE 47.

Upper illustration. A graphic presentation of the dates of calcification of the milk teeth.

Lower illustration. A graphic presentation of the dates of calcification of the permanent teeth.

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alternating with each other. Through the apposition of bone elements the bone derives its thickness, width and length, and through absorption it loses its form externally while internally the various spaces are constructed. von Koelliker determined in his investigations that this absorption process is brought about by large multi-nucleated cells, the above mentioned osteoclasts, which vary considerably in shape. Tomes had already observed these giant cells in the absorption of the tooth roots and the question of the origin arose in his mind.

According to the observation of Virchow and Rindfleisch such osteoclasts arise from a body in the living bone, and Kassowitz also considers them as a residue from the bony tissue. Arguments against this theory are the resorption processes in the deciduous roots and in the artificially implanted ivory pegs. In reference to the latter, Tillmann stated that resorption fossæ occur in such artificial pegs similar to those of living bone. This fact plainly indicates that the agent concerned must be looked for elsewhere than in the bone. Some authors, among them Schwalbe, Wegener, and Pommer are of the belief that the osteoclasts may arise from osteoblasts as well as other cells, while von Koelliker considers them as being modified ordinary connective-tissue bodies. Wegener's decision that the osteoclasts originate in the cells of the adventitia of the blood vessel walls does not argue against that conclusion, for these elements signify nothing more than connective-tissue cells.

Therefore osteoclasts may arise from all the different varieties of cells which occur in the connective-tissue substance surrounding the roots of the deciduous teeth, and are the direct cause of absorption. This does not, however, exclude the fact that, like the absorptive processes in normal bone development so also in this connection,

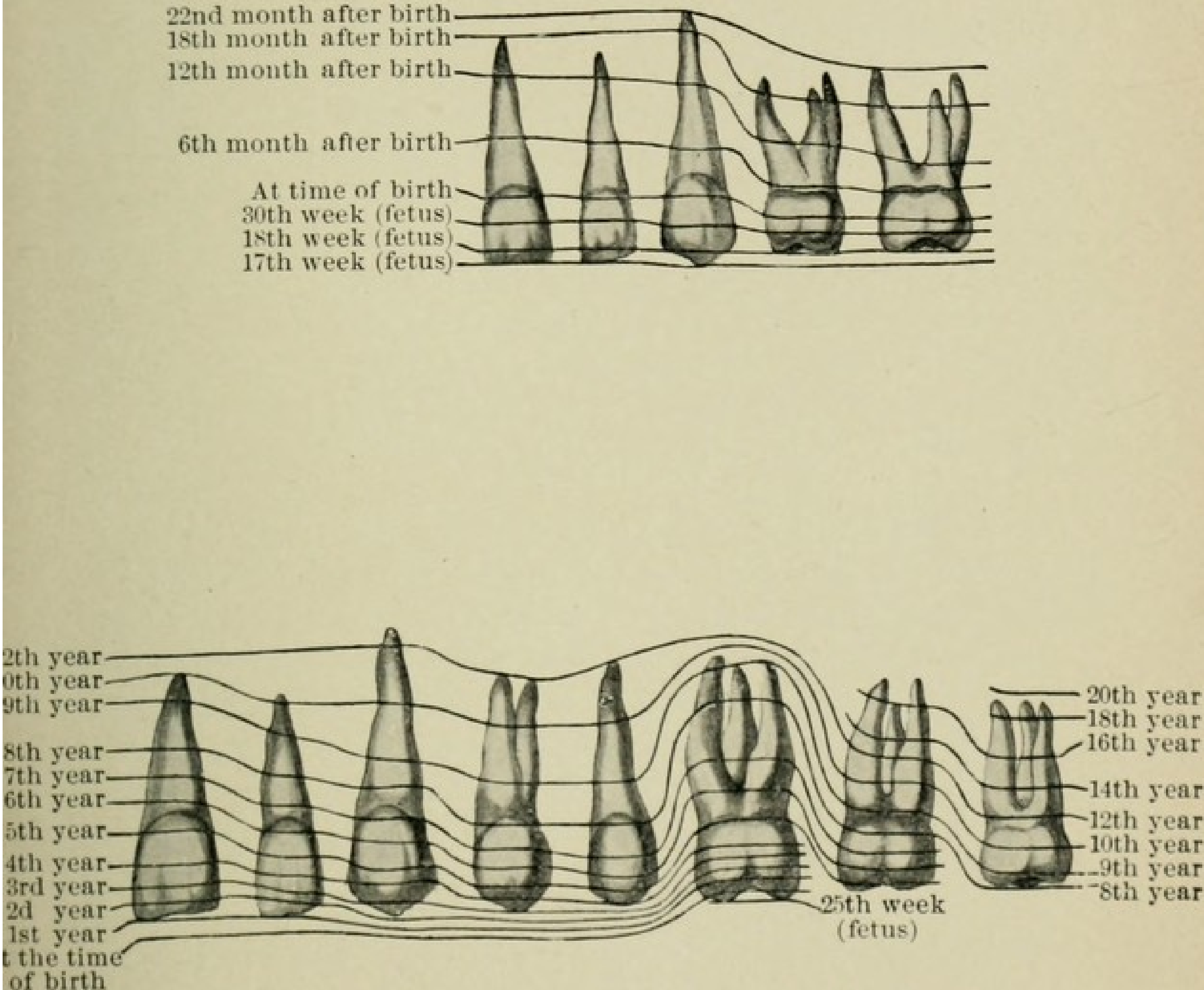
22nd month after birth
18th month after birth
12th month after birth
6th month after birth
At time of birth
30th week (fetus)
18th week (fetus)
17th week (fetus)
2th year
0th year
9th year
8th year
7th year
6th year
5th year
4th year
3rd year
2d year
1st year
t the time
of birth
25th week
(fetus)
20th year
18th year
16th year
14th year
12th year
10th year
9th year
8th year

FIG. 47.

the osteoblasts may be transformed into osteoclasts. At any rate, sufficient numbers of osteoblasts exist in the resorption lacunæ on account of the before described apposition of newly formed bone.

CALCIFICATION OF THE PERMANENT TEETH.

The crown of the first molar begins development at the time of birth, as is shown in the lower illustration of Fig. 47. Calcification of the crowns of the incisors begins during the second year of life, and that of the crowns of the cuspid teeth during the third year. In the fifth year of age the cusps for the second molars develop and those for the third molars in the ninth year. With the exception of the wisdom teeth calcification of the crowns ceases about the ninth year, but at this time the roots are not yet completely calcified. Calcification of the roots of all the teeth is not completed until between the twelfth and eighteenth year.

A full knowledge of the periods of calcification is of considerable practical value. It is well known that disturbances in health of any kind influence the teeth, and may cause defective calcification of the tooth tissue. Such disturbances in health occur naturally more frequently during the early years of existence than later in life, therefore we find frail, poorly calcified molar and incisor teeth more frequently than similar conditions in the other groups of teeth. Cases are not infrequently met with in practice which show defective development of the enamel (*hypoplasia*) only in the incisors, while the remaining teeth are covered with beautiful glossy enamel. In these cases we are usually able to trace the cause of the phenomena to some disease existing during the first years of life.

ERUPTION OF THE PERMANENT TEETH.

The dentist is consulted more frequently in eruption of the permanent teeth than in that of the deciduous set, for disturbances in normal tooth substitution are very frequent for various reasons. About the sixth year the first

FIGURE 49.

Position of the permanent tooth crowns before absorption of the deciduous roots.

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permanent molars of the lower jaw appear in the mouth, and are followed soon after by the eruption of those of the upper jaw. The central incisors erupt in the seventh year, and the lateral incisors in the eighth year; and as is true of the molars, those of the lower jaw appear first. Beginning with the ninth year the first bicuspids appear, and the upper are usually the first to make their appearance. In the tenth year they are followed by the second bicuspids, and about the eleventh year by the cuspid teeth.

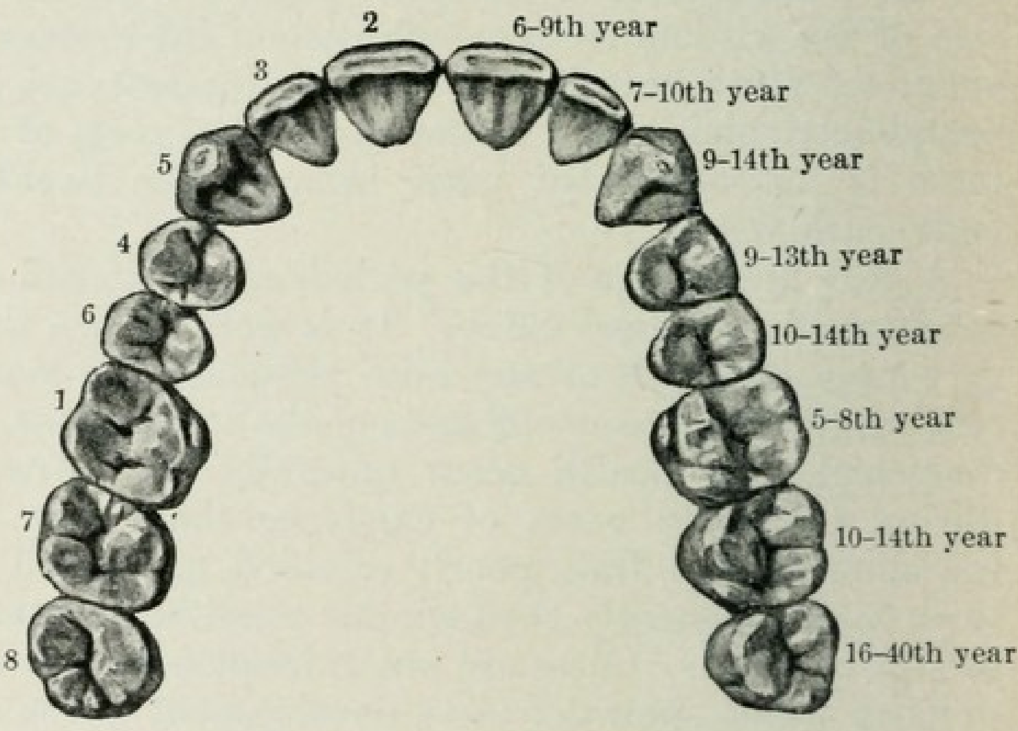

Fig. 48.—Periods of eruption of the permanent teeth.

In the twelfth year the second molars, and between the eighteenth and the twenty-fifth years the third molar or so-called wisdom teeth appear. The dates are subject to various influences, according to circumstances, such as the condition of the general health, the nourishment, race, etc. In order to indicate the limits within which the normal periods of eruption vary, the data given by Berten are reproduced below:

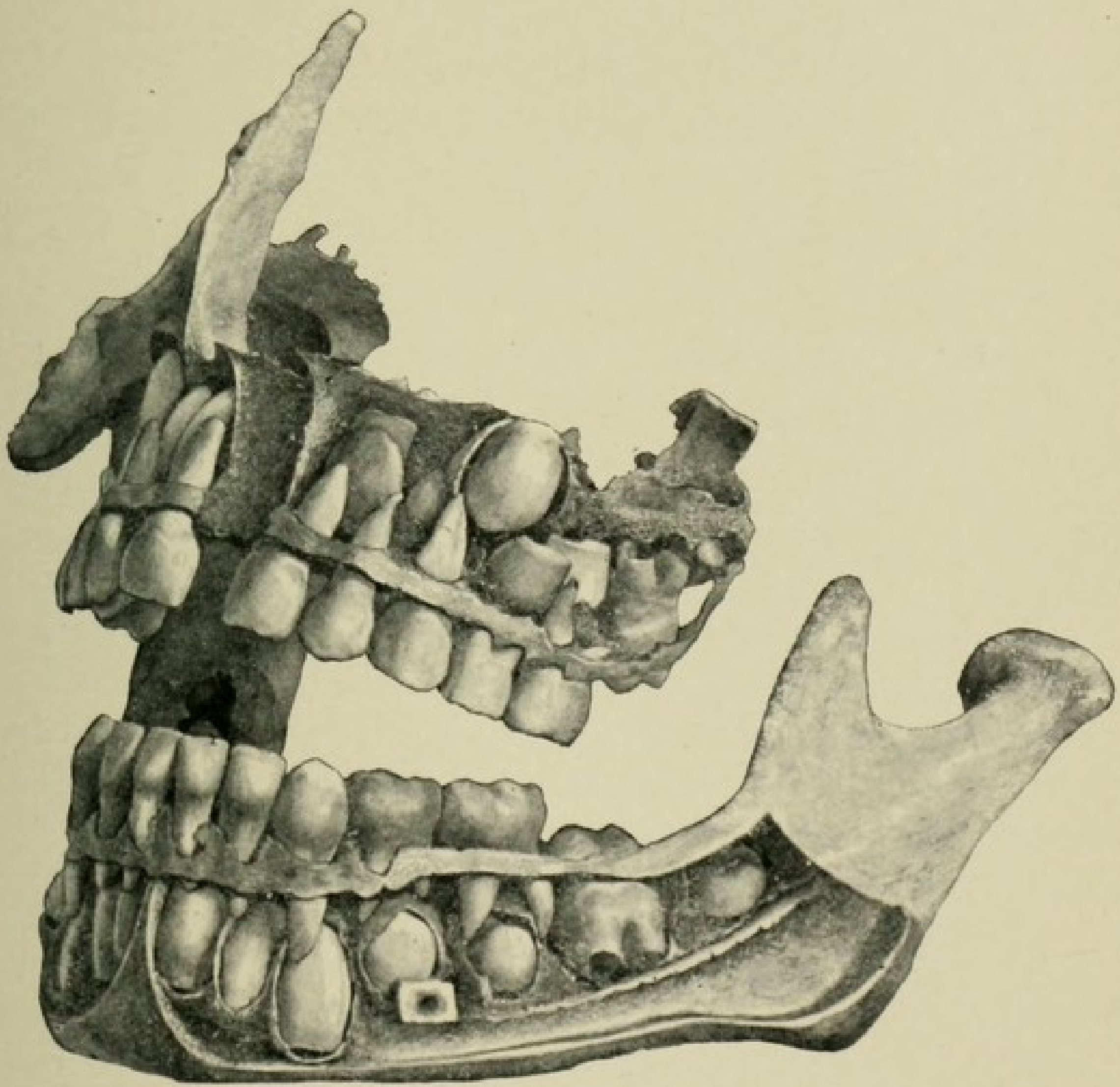

Fig. 49.

Eruption	of	the first molars	occurs	between	the	5– 8	year.
"	"	middle incisors	"	"	"	6– 9	year.
"	"	lateral incisors	"	"	"	7–10	year.
"	"	first bicuspids	"	"	"	9–13	year.
"	"	cuspid teeth	"	"	"	9–14	year.
"	"	second bicuspids	"	"	"	10–14	year.
"	"	second molars	"	"	"	10–14	year.
"	"	third molars	"	"	"	16–40	year.

In Fig. 48 we present a diagram of the permanent set of teeth with the dates of eruption appended.

LOCATION OF THE PERMANENT CROWNS BEFORE THE ABSORPTION OF THE DECIDUOUS TEETH ROOTS.

By studying the maxillary preparations of children from four to seven years of age, in which the outer alveolar plate, both of the upper and of the lower jaw, has been chiseled away, considerable information may be obtained regarding the process accompanying the substitution of the deciduous by the permanent teeth. Such a preparation is presented in Fig. 49. The most prominent feature observed is the position of the permanent teeth, which lie below and back of the first teeth, and it is further noted that the permanent incisors lie on the lingual aspect, back of the deciduous incisor and cuspid teeth. The permanent molars are placed directly under and also somewhat to the lingual side of the deciduous molars. The broad crowns of the permanent teeth have hardly sufficient room in the young jaw, and therefore slide over each other like the tiling of a roof. The exceptionally large cuspid teeth lie in a high position in the neighborhood of the infraorbital foramen. Later when this tooth makes its appearance in the mouth its position again attracts attention, for the point at which it pierces the alveolar process is much higher than in the case of all the other teeth.

We are often consulted on account of the high position at which the upper cuspid appears in the alveolar process, and the patient is nearly always astonished to hear that it is a normal condition. The same is true of the lower permanent incisors, which break forth back of the deciduous incisor teeth, a relationship which is shown in Figs. 49 and 50. In Fig. 50 a child's inferior maxilla is presented,

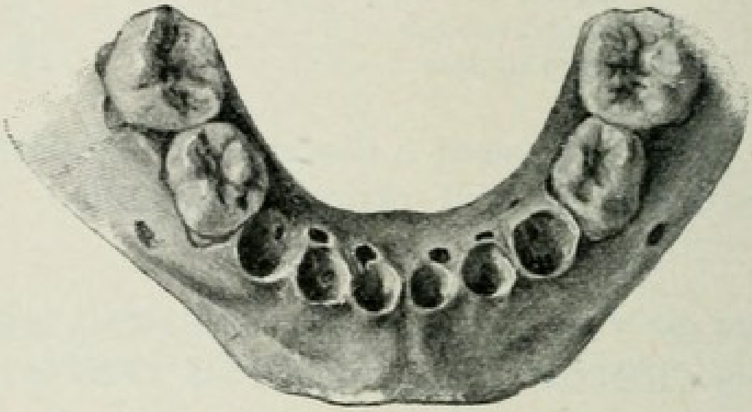

FIG. 50.—Deciduous alveoli and alveoli for the permanent front teeth.

from which the six front teeth have been extracted in order to show the alveoli for the permanent front teeth which lie back of the deciduous alveoli.

BACTERIOLOGY.

Since the mouth offers a place of abode for the development of an endless number of micro-organisms, we are not only justified, but also obliged from point of duty, to discuss to a certain extent the bacteriology of the oral cavity. The existing conditions are especially favorable for the propagation of micro-organisms, in as much as the mouth offers moisture and nutritive material in sufficient quantities at a satisfactory temperature.

Circumstances are more favorable for the entrance of micro-organisms into the mouth than perhaps in any other human organ. With each inspiration through the open mouth, bacteria or other spores are deposited on the sticky surface of the mucous membrane. Aside from the air germs a large number of heterogeneous organisms are transported into the mouth through food and drink, and by means of various objects which are carried into, or to the mouth, such as cigars, tooth picks, postage stamps, envelopes, and even dental and surgical instruments, etc.

By these various agents infection may be carried into the mouth from without.

The body itself may produce the germs, a possibility which must not be forgotten, for occasionally it may be of assistance in establishing a diagnosis. This is true, for instance, in pulmonary tuberculosis, one of the most frequent signs of which is the infected condition of the mouth. In this case the bacilli reach the oral cavity, either through ciliated movements or by coughing, and are found in the mucous of the mouth or in the expectoration. In a similar manner, bacteria which have developed in the stomach occasionally may be carried up through hiccough or vomiting.

In conclusion, hematogenetic infection infrequently consists in the entrance of bacteria into the circulation through erosion of the walls of the blood-vessels and their transmission to distant organs. Such an infection may occur, for example, in phthisis and in white tumor of the knee.

MORPHOLOGY AND BIOLOGY.

We will refer here to the morphology and biology of the *schizomycetes*, and for this purpose use the modern and classic treatise of the subject, as presented by Lehmann and Neumann. (Published by J. F. Lehmann, München, 1899). The term schizomycetes represents small organisms measuring from 2–5 m. in width, which are free of chlorophyll, unbranched and multiply by cell division in a vegetative manner. They are usually looked upon as belonging to the vegetable kingdom, for up to the present time they have not been found to possess any other organ than the motion-giving ciliæ. That this is altogether true has not yet been proved, for a number of the elements in this class have a marked similarity to the flagellates which belong to the animal kingdom.

On account of their minute size no satisfactory investigation of them has been accomplished. This is especially true of their mode of propagation. Whether all microorganisms may be included under the title of bacteria is most doubtful, for the various micro-organisms show extraordinary differences from a biologic standpoint.

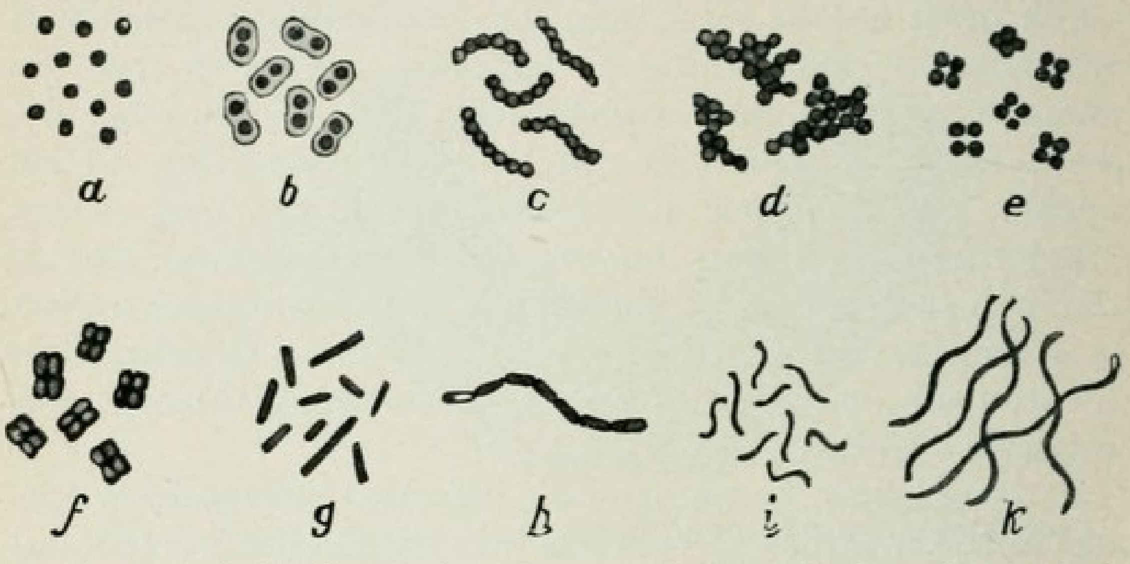

FIG. 51.—*a*, cocci; *b*, diplococci; *c*, streptococci; *d*, staphylococci; *e*, tetrads; *f*, sarcinæ; *g*, bacilli; *h*, streptobacilli; *i*, vibriones; *k*, spirilla.

According to their form the schizomycetes are divided into the following groups:

1. Cocci which are bullet-shaped spheric cells. The small ones are micrococci; the large ones macrococci.
2. Bacteria which are short rods.
3. Bacilli which are long rods.
4. Leptothrix which are thread-like in shape.
5. Vibriones which are spiral or comma-shaped bacteria.
6. Spirilla which have a long spiral form.

According to their grouping in growth, the schizomycetes are classified as follows:

1. Diplococci—micrococci occurring in pairs.
2. Streptococci—a chain of micrococci.
3. Staphylococci—grouped like a bunch of grapes.
4. Tetrads—plate-like clusters of four, eight, or sixteen micrococci.
5. Sarcinæ—forming packet-like groups of eight-celled cubes.
6. Diplococci—bacilli in pairs.
7. Streptobacilli—a chain of bacilli.

We are especially interested in the *chemical action* of the bacteria. This activity occurs in many ways for the production of chemical substances which make the culture medium on which they thrive more assimilable. Such substances are called *bacterial ferments*. They also generate real metabolic substances; that is, they excrete chemical bodies that are entirely different from those which they assimilate from their surroundings.

The bacterial ferments or enzymes as they are popularly called, are those substances which in the smallest amounts are capable of effecting great chemical metamorphotic changes without undergoing any change themselves. According to Fermi, bacteria may be destroyed with certain antiseptic solutions, which, however, in no way affect the ferments. Such antiseptics are carbolic acid, 3 per cent.; thymol, 1 per cent.; chloroform and ether.

The *action of the ferments* may be observed through the liquifaction of their gelatin media. This peculiarity of dissolving gelatin, an albuminoid substance, is a property of the majority of bacteria; hence we have an *albuminoid dissolving* or *proteolytic ferment*. For this enzymotic action an alkaline is the most favorable medium. Acids disturb its function considerably. It was formerly believed that the ferment concerned was *pepsin*, a bacterial product, but as pepsin acts only in an acid medium it is highly probable that *trypsin* is the active agent, for it requires an alkaline reaction to develop its function of dissolving albuminoid bodies. We shall learn later that, as the author had determined in his experiments, this bacterial trypsin plays an important role in such dental defects as occur in the alkaline reaction of the oral cavity.

The *diastatic bacterial ferment* which occurs in the mouth has yet to be considered. This ferment converts starch into sugar. Nearly one-third of all the bacteria investigated by Fermi possessed this capacity. The sugar thus formed becomes injurious to the teeth after it has undergone further conversion into acid by the same or by other bacteria which may happen to be present.

The Metabolic Products of the Bacteria. Many of the bacteria have the faculty of producing *pigments*, which are either limited to the culture or scattered through the nutritive media. These pigments may produce the most beautiful colors of the spectrum as well as blurred tinted mixtures. The *carotin group* produces a pretty yellow pigment which is related to, if not identical with, the coloring substance of carrots. The *bacillus prodigiosus* produces a light red pigment called *prodigiosin*. *Xanthin* is the violet pigment from the bacterium violaceum. *Fluorescin* and *pyocyanin* are beautiful fluorescent colors, the former is characteristic of many forms of bacteria, while the latter is found most frequently in cultures of the bacterium pyocyaneum from which it is extracted with chloroform.

We are especially interested in the *brown and black pigments* for they play an important part in caries of the teeth. They have as yet received comparatively little study. The dark discoloration of the carious portion of a tooth, when no other dirt exists, is claimed by certain authors to be due to the presence of the *sulphid of iron*, while others believe it to be caused by bacterial pigment. Both views are correct, for Mayrmann has proved that the dark bacterial pigments form only in the presence of iron, and that they are nothing else than granular excretions of the sulphid of iron.

A peculiar *activity* of the bacteria is necessary for the development of dental caries. This activity develops in an albumin-containing nutritive medium which is free from sugar, and consists in the alkalinization of the medium. Depending upon this phenomena Miller and Arkövy drew conclusions as to the etiology of caries. Arkövy has even demonstrated that the *bacillus pulpæ pyogenes* is capable, in alkaline media, of destroying the tooth substances. He terms this process, in which probably the organic constituents of a tooth are alone affected, *disintegration*, the contrary of decalcination, which occurs after treating the tooth with acids.

The majority of the different varieties of bacteria have the capacity of converting the sugar, which is found in the nutritive medium, into *acids*. This conversion of sugar into acid progresses rapidly under various influences with the formation of *gases*, on account of which the process may also be looked upon as fermentation. The chief acid formed is lactic, although formic, acetic, butyric, and propionic acid are also produced. Lactic acid occurs in the form of a so-called fermentation lactic acid, which is know as *ethylidene lactic acid*, CH_3—CHOH—COOH. Remnants of food constantly remain in the mouth which contain carbohydrates. The latter, according to modern teaching, form acids which decalcify the tooth substances, and lead to caries. The remaining organic portions of tooth tissue are then destroyed through other bacteria. The chief exponent of this theory is Miller, and as a matter of fact it is tenable in most cases.

The belief of some authors that the acid comes from the tooth itself through the decomposing action of the bacteria is entirely erroneous. Granting that a certain amount of sugar is found in the animal tissues, its supply is not enough for conversion into a sufficient amount of acid.

Bacteria also cause a degenerative process in the mouth, popularly called *putrefaction*. This is, generally speaking, a process in which the albuminous bodies are decomposed into a foul smelling substance. This change is begun by the above described proteolytic enzyme which peptonizes the albuminoid bodies; the resulting substance is still further decomposed by the activity of various bacteria.

The *products of putrefaction* are: albumose, ammonia and amine, leucin, tyrosin and other amido-bodies; fatty acids, indol, skatol, phenol, mercaptan, sulphuretted hydrogen, carbonic acid, hydrogen, and occasionally pit gas.

Dental caries is also usually designated as putrefaction, a term which various authors have protested on the ground that the typical signs accompanying putrefaction, particularly the putrefactive odor, fails in caries of the dentin. It must be admitted, of course, that putrefaction does not occur in the teeth in the customary sense. The tooth substances are too hard for this, and the conditions of the mouth are not favorable, as the teeth are being constantly bathed in saliva. We can, however, hardly apply any other term to a process in which the tooth substances become softened and destroyed, and in which this destruction is brought about by bacteria which are able to destroy the organic ground substance of teeth. It is this peptonizing of the albuminoid substance which is strongly indicative of a real putrefactive process.

Specific putrefactive bacteria are, as a fact, found in large quantities in carious teeth; they can be cultivated from the sections of the softened dentin. If in the course of progress the caries affect the pulp, the putrefactive bacteria will also be found to be the exciting factor of the septic process. They are the agents which generate a greater or less amount of gas by means of the decomposition products of the tooth pulp. When this putrefactive gas cannot escape it exerts pressure upon the root periosteum, and thus causes painful sensations. The presence of such imprisoned gases may be detected by applying heat which causes the gas to expand, and therefore the pain to increase. Likewise the pain is relieved by opening the pulp chamber and permitting the gas to escape.

Following are the most important of the gases generated by bacteria:

Sulphuretted hydrogen which is derived from the albumin of the pulp. Its detection is simple. Paper which has been soaked in lead acetate, if held in the presence of this gas when still moist, is stained black.

The vapors of the *putrid mercaptan*, which are recognized by the fact that they change the reddish isatin-sulphuric acid into green. They also originate from the albumin.

Carbonic acid, *hydrogen* and *pit gas*. These are developed from the carbohydrates and fat.

THE PATHOGENIC ACTION OF BACTERIA.

Pathogenic or disease-producing bacteria are those which, through the formation of poisonous ferments or poisonous metabolic products, are able to injure the animal organism. Hence the bacteria described above are pathogenic to the oral cavity ; for, by forming acids, generating gases, and destroying albuminoid substances, they act upon the teeth and cause them to present visible pathologic phenomena.

Several bacteria which are known to be pathogenic have been found to generate poisonous substances. These include the diphtheria bacillus, bacillus of tetanus, cholera bacillus, the pus-forming bacilli, etc. In other bacteria this chemical process has not been demonstrated, and up to the present time their action has remained unexplained. This is true, for instance, of swine-erysipelas and anthrax. Up to the present time no bacteria have been discovered in any part of the healthy human organism, excepting in the lymph glands. Various signs, however, indicate that micro-organisms may circulate in the blood stream. This explains the occurrence of secondary pulp inflammation and root periosteal disease, which may occur months and even years after treatment. This demonstrates the fact that a tooth which has once been diseased always presents a *loci minoris resistentæ*, which the bacteria, circulating in the capillaries select in preference as a habitat.

Inasmuch as in an apparently intact tooth the pulp may occasionally become diseased or undergo complete gangrenous decomposition, it must be concluded that bacteria are at times found in the healthy pulp tissue. The author decided to determine this point by studying a number of healthy teeth in reference to the presence of bacteria. A bacteriologic investigation was made of a number of absolutely healthy teeth which had to be removed for special reasons. The freshly extracted teeth were washed in hot soda solution, then dried, rubbed with ether, and passed through a flame in order to destroy the superficial bacteria. Next, the tooth was split longitudinally with a pair of sterilized forceps, and the pulp immediately placed in a medium of gelatin and agar. In splitting the tooth precaution was taken to exclude the micro-organisms of the air by protecting the tooth with cotton from which it was allowed to fall directly into the culture medium. This was then placed in an incubator. Out of ten cultures, seven remained sterile and three developed bacteria. Of the three positive cultures, one culture grew twice, and two cultures once. *Hence it is demonstrated bacteriologically that micro-organisms may occasionally be found in perfectly healthy teeth.*

Whether these apparently healthy individuals from whom these teeth were obtained were in reality not subject to some latent disease through which the presence of the bacteria might be accounted for could not of course be determined. For us, however, this question, as well as that of the origin of the bacteria, is wholly irrelevant. The fact that in healthy teeth the pulp may harbor bacteria, which probably are carried thither by the blood stream, is sufficient for the explanation of the etiology of pulp diseases, and associated periostitis which formerly were unsatisfactorily accounted for.

STAINING METHODS.

The dentist should be thoroughly familiar with the technic of staining, because it is necessary to detect the most important of the micro-organisms occurring in the sputum and in the oral cavity. Detection of the *tubercle bacilli* requires particularly precautionary methods. Because of the importance of the subject we will discuss the methods of staining this bacillus in detail. The principle of staining the tubercle bacilli depends upon the faculty that it possesses of becoming slowly but intensely impregnated with certain staining substances, and contrary to the majority of other bacteria, retaining the stain after it has once been absorbed with much tenacity. The technic usually employed is as follows :

A minute portion of the sputum is dropped on a cover slip and a second cover slip passed over it, so that both are covered with a thin film. The specimens of sputum are allowed to dry in the air and then rapidly passed a number of times with the smear side up, through the flame of a Bunsen burner. The cover slips are then immersed for two minutes in a heated staining solution. For this purpose the best is the *Ziehl-Neelsen,* which is composed of

Fuchsin, 10 gr.
Alcoholus absolutus, 10.0 c.c.
5 per cent. carbolic acid, 100.0 c.c.

At first, as a result of this stain, all the morphotic constituents of the sputum form a diffuse colored mass, so that it is impossible as yet to detect the tubercle bacilli. To bring them to view a 30 per cent. solution of nitric acid is allowed to act upon the preparation, until it appears colorless to the naked eye. After it is thoroughly washed in water and again dried, the cover slip is fixed upon the slide with a drop of Canada-balsam. The microscopic examination of a specimen of sputum prepared in this way will show the red stained tubercle bacilli standing forth prominently from the surrounding decolorized area.

The *bacilli of influenza* which, according to Pfeiffer, occur in large numbers in the sputum of patients afflicted with that disease, are best stained with carbol fuchsin. They are observed to be short rods about 0.4 mm. long, the rounded ends of which are more intensely stained than the central portions. If it be desirous after staining to substantiate the diagnosis by cultivation of the bacillus, it must not be forgotten that the bacilli of influenza thrive best in a nutritive medium containing hemoglobin.

The *diplococcus pneumoniæ* of Fränkel is frequently seen in preparations that are obtained from the mouth; and, indeed, even though few in number, they may occur in a perfectly healthy oral cavity. This micro-organism is characterized by two lancet-shaped cocci (diplococci) surrounded by a capsule, and so placed that their blunt ends lie in juxtaposition. They are best demonstrated by first staining with anilin water and fuchsin, and then with a weak aqueous solution of methylene blue. Stained in this manner the cocci show a pretty blue color, and the capsules a rose-color.

The diplococcus pneumoniæ is the exciting cause of a whole series of disease. Those which interest us the most are the following: Pneumonia, both croupous and catarrhal; parotitis (mumps); osteomyelitis; periostitis; abscess and general sepsis.

Löffler's *bacillus of diphtheria*[1] is not only found in the mouth of a diphtheritic patient, but also occasionally, although few in number, in a healthy person. They form fairly long curved rods the ends of which are somewhat thickened, and frequently two lie together. They are best stained according to Gram's method, by which procedure other bacteria which may be accidentally present are decolorized, while the bacillus of diphtheria retains its stain.

The *leptothrix buccalis* which occurs in the mouth in large numbers and probably without any pathologic significance, is easily recognized by its thread-like form. This micro-organism is of interest inasmuch as it undoubtedly takes part in certain destructive processes in the oral cavity. The majority of the bacteria of the leptothrix genus are colored blue by Lugol's iodin solution.

Other bacteria, such as the *cocci, bacilli, sarcinæ,* etc., also probably take part in the destructive processes.

Actinomyces bovis (Harz) have been rarely found and to the present time, only in the mouths of patients suffering with actinomycosis. These fungi are found in the pus from actinomycotic abscesses in cattle. They are composed of small greenish-yellow granules, 1 mm. in diameter, and consist of threads and nodular fungi. These threads are intertwined like a skein, from which, as a

[1] Bernheim has found two organisms constantly present in *stomatitis ulcerosa*, from which it may be judged that they bear an etiologic relationship to each other. The one resembles the diphtheritic bacillus, except that it is larger and has closed pointed ends, and does not stain with Gram's method. The other organism is a spirochæta which also fails to stain according to Gram's method.

center, they radiate in all directions like thickened needles with club-shaped extremities. Most frequently the infection follows the chewing of grasses and grains, and there is danger of its transmission to those working around cattle.

The point of entrance of this organism into the body is occasionally a cuspid tooth, first penetrating the root canal and from there traveling into the substance of the jaw. As this micro-organism is easily recognized, it is not necessary to stain it.

Of the mould fungi which occur in the mouth, we are chiefly interested in the pathogeny of the *oïdium albicans* (Rees considers this as belonging to the yeast fungi-*saccharomyces albicans*—while Plaut classifies it with the torulacæ—*Monilia candida.*) This fungus gives rise to a mycotic disease known as *thrush.* It forms circumscribed whitish specks on the mucosa of the mouth. The best method of examining the thrush fungus is to scrape off a bit of the white deposits, but in so doing avoid injuring the mucous membrane as much as possible. The scrapings are placed in a drop of a watery solution of liquor potassæ in order that the fungus may separate from the epithelium. Without staining the preparation, it is then placed under the microscope. Morphologically, two constituent parts are to be distinguished. The one is a round to oval formation reflecting light strongly and is plainly seen to be budding, like the real yeast fungus. These buds are the spores. The other part consists of masses of threads which, lying between the sphericles are branched and considerably intertwined, and are called the *mycelia.* The myeclia do not develop on our artificial nutritive media; a slight acidity seems to favor their cultivation.

DISEASES OF THE MOUTH.

CATARRHAL STOMATITIS.

Catarrhal inflammation of the oral mucous membrane is usually the result of neglect in the care of the mouth and teeth. Mechanical influences such as the sharp edges of a tooth, tartar, and occasionally a poorly fitting plate

PLATE 13.

a. Typhoid ulcer on the anterior surface of the anterior palatine arch. Tongue coated. *b.* Mercurial stomatitis. Gums reddened, relaxed and swollen.

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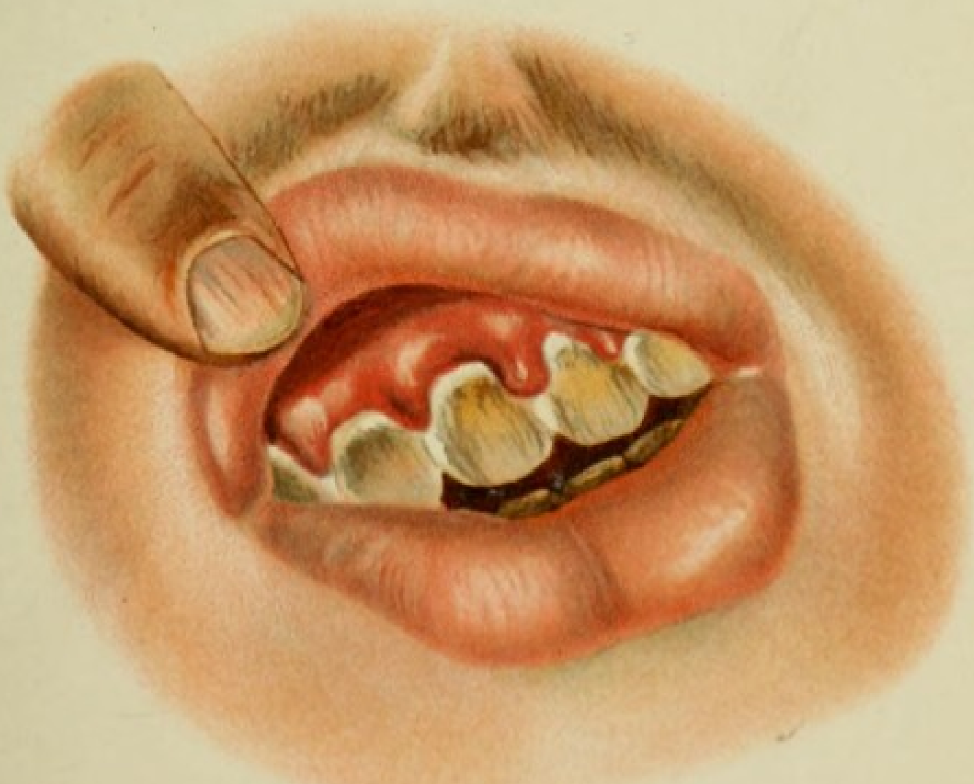
cause a chronic irritation of the mucosa of the mouth. Tobacco and alcohol, when indulged in to excess, irritate by their chemical action. In chlorosis and anemia, as well as in all of the cachetic diseases, we often notice inflamed areas. It is generally known that diseases of the stomach are frequently accompanied by inflammation of the oral mucous membrane.

Early in the disease the *symptoms* consist only of a reddening of that portion of the gum which surrounds the neck of the tooth. Reddening of other parts of the mucous membrane, such as the regions about the arch of the palate, occurs very rarely at the beginning. Gradually the inflammatory process spreads to the neighboring areas, the redness is accompanied by swelling and increased secretion, and the gum becomes relaxed and lies loosely upon the teeth. Although in many cases a considerable increase in the secretion of a thin and watery saliva occurs, yet we have also observed cases in which the whole mucous membrane was covered with a tenaceous, stringy mucus. The tongue is usually coated, while in severe cases, the remaining surfaces of the mouth, are covered with a whitish coat. The patients have an offensive fetid breath. The sensitive mucous membrane interferes with speaking and mastication, and the general health may be impaired, especially if fever develop.

Under the microscope a bit of the coating scraped from the mucosa shows various cell formations which consist of desquamated epithelium and extravasated white blood-corpuscles (pus cells). Altered remnants of food are also always present together with numerous cocci, bacilli, leptothrix, and mould fungi.

Bearing the etiology and the patho-anatomic findings in mind, the treatment consists first in a thorough cleansing of the mouth. All deposits should be carefully removed from the teeth and the mucous membrane; the

a



b

Lith. Anst. F. Reichhold, München

tartar should be loosened from the teeth with suitable instruments, and then the teeth thoroughly cleaned with brush and powder, or washed with a weak acid solution. If the latter be employed, it must be immediately neutralized by applying powdered chalk. If the mucosa is not too tender, the coating may be removed with a pledget of cotton soaked in ether. Sharp edges of teeth must be ground smooth and diseased roots extracted.

The *after treatment* consists in ordering an antiseptic mouth wash like potassium permanganate of which enough crystals are added to a glass of water to produce a rose-red color. Other efficient mouth washes are, a 2 per cent. solution of potassium chlorate, a 3 per cent. solution of hydrogen peroxid, and a 1 per cent. solution of chinosol applied daily to the patient's mucous membrane by means of a brush.

In chronic cases iodoform powder should be rubbed into the relaxed gums. Painting the gums with sublimate (0.05 : 50.0 water) is also advocated.

ULCERATIVE STOMATITIS.

Ulcerative stomatitis, (*stomacace, cancrum oris*) is often an accompaniment to catarrhal inflammation, but it occurs only rarely as a local affection. Usually it is caused by various general diseased conditions. In scorbutus it occurs regularly and is accompanied by frequent profuse hemorrhages from the mucous membrane. This is called the *scorbutic form* of ulcerative stomatitis. In mercurial cures the continuous excretion of mercury through the salivary glands has an injurious effect upon the oral mucous membrane and sets up a severe inflammation which is known and dreaded as the *mercurial stomatitis.* (Plate 13, *b*). A severe type of cancrum oris frequently follows *leukemia;* its form is similar to that observed in workers in chemical factories who have become diseased from the poisonous products. Another peculiar type of stomatitis is characterized by circumscribed yellowish specks on the velum palati in *typhoid fever.* Plate 13 shows a photograph of such a case, which Professor F. Müller kindly furnished.

This disease, which is rarely uniform, is especially characterized by more or less scattered ulcers covering the mucous membrane, which has been altered by inflammation. The chief location of the ulcers is the border of the gums which becomes swollen, relaxed and later undergoes necrosis. Sometimes, although rarely, the gums remain comparatively intact, while the buccal mucosa, especially in the region adjacent to the teeth, as well as the rest of the oral mucous membrane, is attacked in preference. The most obstinate and the last to respond to treatment are those ulcers which are situated at the angle of the lower jaw.

Cancrum oris occurs quite frequently in children at the time when they shed their first teeth. Frequently all the children of a school suffer simultaneously from this affection, and the epidemic-like manner in which it has been observed to spread among soldiers, factory employees, etc., favors the probability of its contagiousness.

Patients suffering from ulcerative stomatitis feel very weak and depressed. The odor of their breath is even more offensive than in the catarrhal form. Nourishment can be taken only with considerable pain and the disease is frequently complicated by an increase in temperature. In consequence of the suppurative process the periosteum is gradually destroyed. Then follows the destruction of a portion of the hard and soft parts of the alveolar process, which causes the teeth to become loosened and finally to fall out.

The *treatment* is identical with that of catarrhal stomatitis, only in addition potassium chlorate must be administered internally. Adults receive every three hours a teaspoonful of a solution of potassium chlorate consisting of 15 grains to the ounce. Children, on account of the toxic action of this preparation, should not receive more than a teaspoonful of a 2 per cent. solution every two hours. The ulcers should be thoroughly touched with a caustic stick. Patients undergoing mercurial treatment (inunctions) should wash out the mouth regularly with potassium chlorate even before inflammatory phenomena occur.

DECUBITAL ULCERS.

Circumscribed pressure ulcers and decubital indurations develop not infrequently in the oral mucous membrane, and are due to tight dental plates or too tight corrective apparatus, as well as hard tartar and the points of carious teeth. According to the location of such mechanical irritants, either the alveolar covering, the cheek, or occasionally the tongue will be affected.

At first the epithelium is lost, and later, under the influence of inflammatory irritants, an infiltration of the subepithelial tissue develops. In time a firm nodule is formed in which a depression occurs at the point of greatest pressure, and which undergoes ulceration. According to many authorities, these ulcers have often been the origin of benign as well as malignant growths. In Fig. 65 is shown a photograph of such a case observed by the author in which a decubital ulcer caused by a sharp-edged tooth developed into a walnut-sized fibroma.

Treatment.—Such pressure ulcers are usually painful and therefore do not exist without the patient's knowledge. Sharp edges to tooth plates, rough teeth, etc. must be eliminated before any harm has been done. If a surface be already ulcerated, it must be touched with the silver nitrate stick or with tincture of iodin, and the mouth should be washed with an antiseptic solution.

APHTHOUS STOMATITIS.

Aphthous stomatitis occurs most frequently during the first two years of life in children who have been reared under unhygienic conditions. It presents itself with rounded, originally small specks of grayish-white color which later become fixed together. They do not project beyond the surface, but on the contrary are surrounded by a somewhat elevated red area. They bleed easily and are very painful when an attempt is made to scrape them off. Hence they do not form a coating to the mucosa but consist of an exudate of fibrin into the mucous membrane and a thickening of the epithelium which becomes opaque. The surrounding area of each aphtha is richly infiltrated with round cells. This disease is not likely to be mistaken for thrush or syphilitic plaques as the aphthæ, unlike these patches, are so sensitive that the ingestion of food causes pain.

The favorite seats of aphthæ are the cheeks and tongue, yet they are not confined to these locations.

Treatment must be early instituted as fresh relapses of aphthous eruptions tend to develop. Painting the aphthæ with silver nitrate is considered quite effective. For this purpose a solution composed of silver nitrate 0.10 and of glycerin 25.0 is employed. It is important also that the mouth be washed after each meal and at bed time with five drops of weak solution (0.1 : 30.0) of potassium permanganate to a glass of water. If this treatment is followed by a disappearance of the aphthæ, no loss of substance results, for a *restitutio ad integrum* of the destroyed mucosa sets in.

MYCOTIC STOMATITIS.

Mycotic stomatitis, (*stomatomycosis oidica*) which is known to the laity as *thrush* occurs chiefly in nursing infants, although occasionally it occurs in adults who have been weakened through disease. At the beginning of the disease snow-white minute but prominent spots develop in favorable areas of the most frequently inflamed portions of the mucosa. These spots rapidly spread and unite to form larger areas, the color of which in time becomes dirty gray. This coating, unlike the aphthæ, is easily removed unaccompanied by hemorrhage. Microscopic examination shows a thread-like mycelium as well as a variety of yeast fungi which many authorities consider spores (*conidiospores*).

The constant cause of thrush has not yet been established with certainty. Some investigators believe the etiologic factor to be a sprouting fungus and others a mould fungus, while Plaut believes it should be classed with the torulaceæ. Although these deposits form a superficial coating which is easily removed, yet their trabeculæ which are many times intertwined, pass through the epithelial layer into the mucosa.

The *prognosis* is favorable if the thrush deposits remain localized in the oral cavity, but if they occur in the pharynx and esophagus, as may be expected, this condition will cause considerable body-weakness. If no severe stomatitis be associated with the thrush, the deposits cause little trouble.

Treatment consists in painting the deposits with a disinfectant followed by washing with alcohol. Borax is very useful for this purpose. It is given to children in the form of honey of borax, which because of its sweetness, is distributed unconsciously by the tongue and thus applied to all parts of the mouth. In severe cases borax is also administered internally in a 3 per cent. solution, of which children are given a teaspoonful, and adults a tablespoonful every two hours.

ACTINOMYCOSIS.

This disease, which is contracted from the *actinomyces bovis*, the ray-fungus of cattle, occurs more often in animals than in man, and less rarely in cities than in the country. It results very frequently from chewing grains in which the fungus develops. There is risk of infection even in working about stalls and barns. Neglected oral cavities in which a gingivitis with relaxed gums exists are especially favorable to infection; and, according to a communication from a physician, the first signs of the disease begin with preference in the immediate neighborhood of a badly diseased tooth. It seems, therefore, that the fungus is able to multiply in the irritated and inflamed bony tissue. It is highly probable that the fungus often reaches the interior of the bone through the pulp cavity and the root canal. The lower jaw is the seat of preference, probably for mechanical reasons.

The first external *symptom* which can be seen and felt is a slowly developing board-like infiltration over which the skin of the face is discolored bluish-red. In the course of time this part of the skin breaks down at one or more points, and a thin watery or a thick pus-like discharge appears. The characteristic constituents of this pus are yellowish-green, pin-head sized granules (*actinomyces kernels*) which, microscopically, show lumps of matted threads from the periphery of which club-shaped elements grow in all directions.

The *prognosis* is not always as bad as one is accustomed to believe, since spontaneous recovery even in advanced cases has been reported. Yet we must not place too much reliance upon such an outcome for the disease may be transmitted to other organs, or even when the process remains localized upon the face or neck, it causes disfiguration through discoloration and fistulous formation.

Treatment.—All suspicious teeth must be immediately removed for the successful combat of this disease. The fistulæ and pus foci must be widely opened and cleaned with a sharp curet. In order to destroy the etiologic factor as completely as possible, these areas must also be thoroughly cauterized with the thermocautery. After surgical intervention the infected areas should be freely powdered with iodoform, which seems almost to be specific in its action.

It has also been recommended in place of the operative treatment that the diseased tissue be frequently injected with tincture of iodin. However, operative treatment seems to be the most reliable and according to Mikulicz and Kümmel, it should be followed by the internal administration of potassium iodid, which manifestly accelerates the healing process. The dose of the potassium iodid, depending upon the age of the patient, varies from 15 to 45 grains per day.

NOMA.

Noma, or *cancrum oris*, is a rare disease which usually attacks children reared under unfavorable conditions of life. Those patients are the most vulnerable, who develop cancrum oris at the close of a severe illness.

Its first indication is a bluish-red vesicle, on the buccal mucous membrane opposite the first upper molar. This vesicle rapidly changes to black, and is soon followed by considerable swelling of the cheek. The affected area in the cheek becomes discolored and gradually turns dark, forming a hole with serrated edges. The perforation of the cheek is caused by gangrenous destruction, in which both the soft and osseous tissues are changed into a dark black granular mass.

Inasmuch as this disease occasionally occurs endemically in children's hospitals, it is believed to be contagious. In fact, Petruschky was able to cultivate diphtheritic and pseudodiphtheritic bacilli from the diseased foci; while C. Schmidt, on the other hand, found constantly an organism that strongly resembled the necrosis bacillus of Jensen.

The *prognosis* is unfavorable (70 per cent. mortality rate), for the disturbance spreads rapidly and finally becoming general, develops into and causes general sepsis or pneumonia. If the process remains stationary, facial defects and scars result in most of the cases. Rare indeed are the cases, such as one observed by the author, in which the patient had water cancer when a child. This healed so thoroughly that when she became an adult nothing remained except a small groove in the cheek which did not affect her beauty. In a second case the patient was an eight-year-old girl, in whom the process reached a standstill, but a defect resulted about the size of a hen's egg.

Treatment. It is advisable to destroy the gangrenous area with the thermocautery and to paint it with tincture of iodin. Internally, alcohol and quinin are given in the form of the wine of quinin, from one to three tablespoonsful three times a day. Washing the mouth with an antiseptic solution must not, of course, be neglected; for this purpose potassium permanganate is employed; or salol in the following prescription:

℞ Salol ʒjss
Spirit. ad. oz. iij
Sig.—A teaspoonful to a cup of water, to be used as a mouth wash.

On account of the seriousness of this disease an experienced surgeon should be consulted at once.

PYORRHOEA ALVEOLARIS AND ATROPHIA ALVEOLARIS PRAECOX.

Literature furnishes very contradictory statements regarding the *etiology* of alveolar pyorrhea, a condition which Arkövy, because of the patho-anatomic findings, wished to call *specific alveolar caries* (*caries alveolaris*

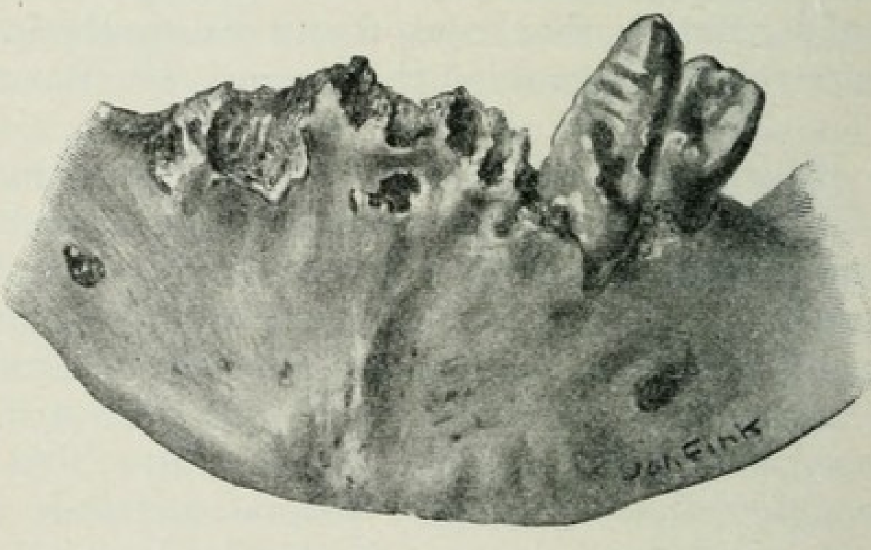


FIG. 52.—Anterior portion of a macerated lower jaw, which shows partial destruction of the alveoli through pyorrhœa alveolaris.

specifica). Riggs, Galippeu, and others consider this disease to be caused by purely local injuries, and believe that deposits of tartar, through pressure upon the gums and periosteum, cause chronic suppuration of the alveolar process. According to Baume, disease of the periodontium and the gum spreads to the alveoli, which become involved secondarily. Michel looks upon pyorrhea as the expression of a constitutional disease associated with sugar in the urine. Arkövy remarks that pyorrhea is especially likely to occur in anomalies of the position of teeth, because of the unequal pressure. Römer also agrees with this opinion, and refers to the fact that not until old age, when the bones have become rigid and no longer yield to the pressure, does pyorrhea follow the effects of it.

It has not been proved that a specific micro-organism is the cause of this disease, and this can hardly be expected. However, it has been determined by Miller that micro-organisms are associated with this disease process.[1]

The *symptoms* are not always alike ; sometimes the gum is swollen, relaxed, and reddened ; at other times the gum sticks to the neck of the tooth as a thin, pale layer. Pressure upon the gum about the tooth, however, always causes some pus to ooze from the so-called pocket of the gum. Early in the process the teeth remain tight in their cells ; later, however, they become loosened and finally fall out. The patients notice a disturbance first when the loosened teeth interfere with mastication ; occasionally they feel a light pricking sensation or slight pain.

According to Römer, the following *patho-anatomic changes* may result. In the first stage no other change is noticed than an infiltration of round cells into the gum and in the marginal portions of the periodontium. It should be remembered that in this area a thick bundle of fibers extends from the surface of the tooth to the periodontium and gums, forming a dense, tight ring around the neck of the tooth. These fibrils are the first to be destroyed by the round cells, and as a result, the ligament becomes loosened about the tooth, the pocket referred to above is formed, and further extension of the infection is unobstructed. Under the influence of the pyogenic micro-organisms, which are found in the mouth,

[[1] This statement is in a measure misleading. It is to be expected that micro-organisms are present in pus from pyorrhal pockets, but Prof. Miller distinctly states in his "Micro-organisms of the Human Mouth" that he has been unable to discover any specific bacterium in connection with this disease.—Ed.]

assisted by the deposits of tartar, the alveolar border gradually disappears. The hard crusts of tartar, which may be felt as a roughening of the surface of the root in the pockets, (the latter having now become increased in size), do not originate from the saliva, but are, according to Arkövy, dissolved calcium salts that have been reprecipitated. In the neighborhood of the tooth-root granulation-tissue develops, which, similar to a root granuloma, is richly supplied with epithelial cells. The latter originate chiefly in the epithelium of the gum, but some of them come from the epithelial nests in the root membrane. The dissolution of the bone occurs, as is beautifully shown in Römer's preparations, by a destruction of the calcium salts. In this process bundles of the fibers of Sharpey remain intact in many areas. Finally, these fibers are also substituted by granulation tissue.

It is highly improbable that, after the removal of the tooth, a restitution process occurs in the bony tissue, for the periosteum has also been destroyed. Therefore, the scar which forms is composed exclusively of connective tissue.

Treatment during the first stage has favorable results; but if loosening of the teeth has progressed too far, no permanent relief can be offered. The most important point in the treatment consists in thoroughly cleansing the gum pocket, removing all deposits and other foreign substances from the roots, and in destroying all granulation tissue. If, after this treatment, the pockets are daily disinfected, the alveolar ligament may again become tense, and the process recede in many cases. Berten assists the tightening of the ligament by excising a bit of it, in order that the ensuing scar may contract and increase the tightness.

The superficial concretions are removed with special instruments, which, however, cannot be used to remove the deposits on the more distant portions of the root. Such concretions may be dissolved by the injection of a few drops of some acid. The author employs for that purpose a 30 per cent. solution of hydrochloric acid which, through its caustic action, destroys a large number of the bacteria, and also the neighboring granulation tissue. The thorough destruction of the latter is of the greatest importance to insure a permanent cure. This may be obtained by chemical or mechanical means. Walkhoff, Römer, and others cauterize with chlorphenol crystals, while Baume and other observers advise burning the tissue to a considerable depth with the thermocautery.

To avoid a *recurrence* the wound, which has been established by this time, should be washed out daily. For this purpose hydrogen peroxid (30 per cent.) or chinosol (5 per cent.) is employed. Both of these preparations may be given to a patient without hesitation, so that he may personally undertake to wash carefully the wound daily.

If constitutional disease be at fault it must be attended to by a specialist.

Atrophia alveolaris præcox, the premature disappearance of the alveolar process, manifests itself in a loosening of the teeth. All signs of inflammation of the gum and immediate neighborhood are absent. The circular ligament remains normal, does not become relaxed, and pressure is not followed by the appearance of pus; the teeth become elongated—that is, they seem to be lengthened, while the tooth alveolus becomes contracted; and finally, the teeth loosen to such an extent that the patient wishes to have them extracted, or they fall out of their own accord. It will be observed, therefore, that this process is exactly like that accompanying senile atrophy of the alveolar processes.

This disease consists, patho-anatomically, in an osteoporosis of the alveolar plates with subsequent atrophy of the bones; and hence, in this respect, also, it is identical with the senile form. The roots of such extracted teeth frequently have a peculiar, speckled, transparent appearance.

Atrophia alveolaris præcox, contrary to alveolar pyorrhea, defies all *treatment*. Symptomatic relief may be given by fastening the loose teeth to the remaining firm ones by means of some form of bridge or band system.

PAROTITIS (MUMPS).

Inflammation of the parotid gland follows either a severe infection (metastatic), or it occurs as *primary idiopathic parotitis*. Adults as well as children are subject to this disease, which occurs either epidemically or endemically. Old people and infants seem to be immune.

After an incubation period of fourteen days one side of the face, and more rarely, both sides, become swollen, both in front and below the lobe of the ear, which is drawn upward. Fever develops and the swelling rapidly increases so that, together with a collateral edema of the cheek, the face becomes considerably deformed. The patient suffers less from the pain than from difficulty in speaking, chewing, and swallowing.

The *prognosis* is favorable, since complete recovery occurs generally in from eight to fourteen days.

As infection may travel from the mouth through the duct of Stenson, disinfection of the oral cavity is indicated. Other therapeutic measures consists in the regulation of the bowels and in the rubbing of potassium iodid ointment into the affected regions, in order to check the spread of the disease, and to accelerate the resolution.

SYPHILIS.

The oral cavity is very frequently the seat of the primary lesion of syphilis, but secondary and tertiary luetic processes may also select this part of the body.

Many cases are recorded of *primary affection* in the mouth. This fact is not at all extraordinary when it is considered how frequently the lips are the seat of erosions and rhagades, and how frequently the oral mucous membrane presents more or less slight injuries.

The infection is transmitted either *directly* from person to person (in infancy from the breast of the wet-nurse), through kissing, by the hands of the operator, etc., or *indirectly* by various things which have come in contact with syphilitics, such as eating and drinking utensils, cigars, pipes, surgical or dental instruments, toothpicks, etc. Since attention has been called to these various means of infection, the literature has brought to light an endless number of cases of luetic primary infection of the oral cavity. From much experience it may be asserted, without exaggeration, that the majority of all extragenital hard chancres occur in the mouth.

The *appearance* of such a primary affection is, first of all, a small superficial defect, which consists of a round, hard but elastic, shallow depression surrounded by a reddened eminence. This defect spreads rapidly and becomes covered with a hard adherent scab of a yellowish-brown color. An infiltration of more or less degree of the immediate neighborhood occurs nearly always in the course of the process, as well as swelling of the regional lymph glands.

The *subjective symptoms* usually do not vary in proportion to the severity of the disease, and manifest themselves only through a certain amount of stretching of the neighboring tissues ; and, indeed, depend largely upon the site and extension of the affection. A disturbance in speech and mastication may result.

If convinced that the condition is a hard chancre and not a tubercular or decubital ulcer, a malignant growth or a tertiary syphilitic lesion, it is necessary to inform the patient immediately, and refer him to a physician for energetic treatment.

The *prognosis* is favorable when treatment is begun immediately, provided the affection does not assume a phagedenic character.

The dentist also observes *secondary symptoms* quite frequently, and therefore it is necessary to refer to them, although briefly. The characteristic signs of secondary lues are the so-called mucous patches (*plaques opalines*), which, in their developmental stage, consist of milk-white and pearl-gray whitish round specks. These patches are somewhat elevated above the surface of the mucosa and are surrounded by a hyperemic limitating zone. They are adherent at their lower surfaces, and therefore attempts to remove them cause hemorrhage. They occur most frequently near carious teeth, the rough edges of which irritate the tissue. In a like manner irregularly set teeth, especially those which exert pressure upon the mucosa, are likely to set up an irritation and thus favor the development of mucous patches.

The *symptoms* vary considerably; the majority of the patients experience no pain whatever, or they complain only of an itching irritation or a slight burning, and do not take notice of their disease and consult a physician until they observe a swelling of the cervical lymphatic glands.

A peculiar form of this affection consists chiefly in involvement of the gum in the form of ulcerating stomatitis, which is often followed by loosening, and finally by loss of the teeth.

It happens occasionally that the specific patches spread toward each other and becoming confluent, present a clinical picture that may be mistaken for croup or diphtheria.

The *differential diagnosis* is established by the fact that the course of syphilis is slower and unaccompanied by fever. The diagnosis is also substantiated by the fact that the patient gives a history of specific infection, and presents, with rare exceptions, other secondary luetic symptoms, as well as lymphatic enlargements. These also serve to differentiate between syphilis and decubital ulcers, which may similate each other. The duty of the dentist is limited to calling the patient's attention to his condition, which is so highly contagious.

The *tertiary syphilitic symptoms* develop about three years, occasionally even much later, after the appearance of the primary lesion. The most frequent seat of these gummatous changes in the mouth is the hard and soft palate; they occur chiefly in the form of ulcers, the immediate neighborhood of which is firmly indurated; or they consist only of a diffuse infiltration. The ulcerations show a great tendency to eat into the nearby structures or into the deeper tissue, with the result that openings of varying size develop between the oral and nasal cavities.

The process usually progresses more rapidly in the nose than in the mouth ; a characteristic foul odor issues from the nasal orifice (*ozæna syphilitica*), and in further course of the disease, the nasal septum is destroyed, which, permitting the roof of the nose to cave in, produces the typical picture of a *syphilitic saddle-nose.*

Tertiary processes rarely involve the lips, cheeks, and gums. The tongue, however, is more frequently affected, and as a result its lateral aspects which come in contact with the teeth are covered with a whitish layer of thickened epithelium. These areas usually ulcerate and are slow to heal.

In conclusion, it should be stated, that, so long as the inunction or the potassium iodid cure does not heal this condition, dental treatment should be excluded, on account of the great danger of infection both for the dentist and his patients. After unavoidable and necessary interference, which permits of no postponement, the hands should be disinfected with extraordinary care, as well as all appliances which come in contact with the patient. These appliances must be boiled in a solution of lysol for at least one hour. Such preventive measures are not superfluous when we stop to consider the sad records in the literature of accidental infection.

TUBERCULOSIS.

Unlike lues, tuberculosis rarely occurs in the mouth. This can only be explained by assuming that the mouth is relatively immune to the tubercle bacilli, for abundant opportunity is given for infection through the air, through food (especially milk and butter), and in phthisical patients through the sputum which contains masses of the bacilli. It has been reported that lupus of the skin of the face has extended to the mucous membrane of the mouth, but much rarer are the cases in which the point of origin is the mouth. In such cases, at first single minute nodules develop on the mucous membrane, which later result in ulcers, the surfaces of which excrete a thin watery pus. Later, through union of several ulcers, an extended, ulcerated surface develops which has indented edges and is covered with a crust. Removal of the crust never causes hemorrhage, for it lies directly upon a small collection of pus, at the base of which the eminence of the subsequent tubercle may be seen.

If the gum be involved, the periosteum of the alveolar processes may be destroyed. As a result the bone undergoes necrosis and is softened *in toto,* or sequestra are formed which gradually suppurate and are discharged. The roots become exposed and a considerable number of the teeth are lost.

Tubercular rhagades are furthermore found on the dorsum of the tongue and on the lips, especially when hereditary, progressive, pulmonary phthisis is present. These rhagades may lead to considerable loss of tissue in the course of time if the patient survive the tuberculous process, which is rarely the case, for tuberculosis of the oral cavity belongs to the gravest of the symptoms.

TUMORS OF THE ORAL CAVITY.

BENIGN GROWTHS.

CYSTS.

We wish primarily to give a systematic review of the cysts, for on the one hand, they play an important role amongst the growths of the oral cavity, and on the other hand, their condition is still subject to much and almost incredible confusion.

The most satisfactory *classification* of oral cysts depends upon their origin, and therefore the following varieties are distinguished.

Retention Cysts.—Retention cysts have no connection with retained teeth in cavities, but are a form of cyst which develops from the retention of the products of normal secretion, as may occur when the exit duct of a lymphatic gland becomes obstructed. In this manner the small glands of the mucous membrane become cystic as well as the larger glands, like the sublingual, which may form large cysts on account of obstruction to the ducts of Bartholin and Rivinus (Ranula).

In rare cases patients are met whose tongues present small elastic growths at the tip, which are simply cystic dilatations of the glands of Blandin and Nuhn.

Dilatation Cysts.—Dilatation cysts consist in a dilation of previously existing or newly formed cavities, into the interior of which some irritant causes the secretion of an excessive amount of exudate.

Of the dilatation cysts, those described by Magitot will be considered. They are as follows :

Periosteal cysts, which originate from small growths on the periosteum, consist of granulation and epithelial cells. The interior of these growths is easily destroyed.

Follicular tooth cysts which originate in normal or supernumerary retained teeth germs.

Dermoid Cysts.—These owe their origin to buds of the external skin which, in the course of development, grew into the neighboring tissue, and later became constricted from the epidermal covering. On account of this origin, dermoid cysts not rarely contain various parts of the skin, such as sebaceous glands, hair, nails, and teeth.

Unless certain inadequately described cases in literature, of cysts containing multiple tooth contents, belong to this category, the occurrence, of dermoid cysts in the mouth is very rare. Of most interest to us are the periosteal and follicular tooth cysts.

Periosteal Tooth Cysts (Plate 14, Figs. 1 *a*, and Fig. 53).—Partsch calls this form of growth "periodontial" or "root-cyst". These cysts, one would infer, occur more frequently in the upper than in the lower jaw, and indeed, out of fourteen cases reported by Partsch, only one occurred in the lower jaw, and of the one hundred and five cases collected by Julius Witzel, seventy-six belonged to the upper, and only twenty-nine to the lower jaw. There is no doubt, however, that they are as frequent in the lower jaw as the upper, only in the inferior maxilla, on account of the thickness of the bony cortex,

PLATE 14.

FIG. 1.—Periosteal Cysts.

a. Cystic sac which is attached to the root membrane. The accompanying tooth is badly damaged by caries, the pulp has undergone gangrenous degeneration, and the periosteum is inflamed.

FIG. 2.—Follicular Cyst.

a. Cyst with (*b*) rudimentary tooth structure which was the cause of the cystic development.

PLATE 15.

Microscopic preparation of the root fungosity, which is illustrated in Fig. 53 a.

a. Outer layer of connective tissue. *b.* Proliferation of epithelium. *c.* Leukocytic infiltration. *d.* Small fissures and abscesses which occur as well in the connective tissue as in the epithelium.

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they are not as likely to reach the dimensions of those in the superior maxilla, and are therefore often overlooked.

They also occur more frequently in the neighborhood of the incisor, cuspid and bicuspid teeth than in that of the molars. They extend in the direction of least resistance, and enlarge, therefore, toward the face, where they may be easily recognized. These cysts, depending upon their situation, may also grow toward the antrum of Highmore, and less frequently toward the nasal cavity.

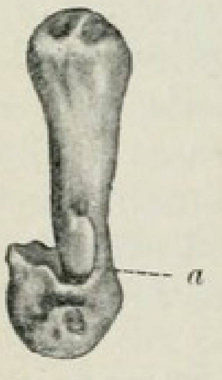


FIG. 53.—First lower bicuspid tooth with a granuloma (*a*), which is drawn slightly away from the tip of the root.

They originate from small, insignificant growths, at the tips of the roots (granuloma), which are called *small abscesses* by the laity, and which are frequently found on extracted teeth, the pulp of which had been totally destroyed by gangrene. The macroscopic appearance of such a cyst is shown in Fig. 53 *a*, and a microscopic section in Plate 15.

The development of such granulomata on badly diseased teeth can be easily explained, for injuries of any kind are likely to extend to the root membrane; and it is surprising, therefore, that Malassez and Kirmisson claimed in their contribution to have observed such root granulo-

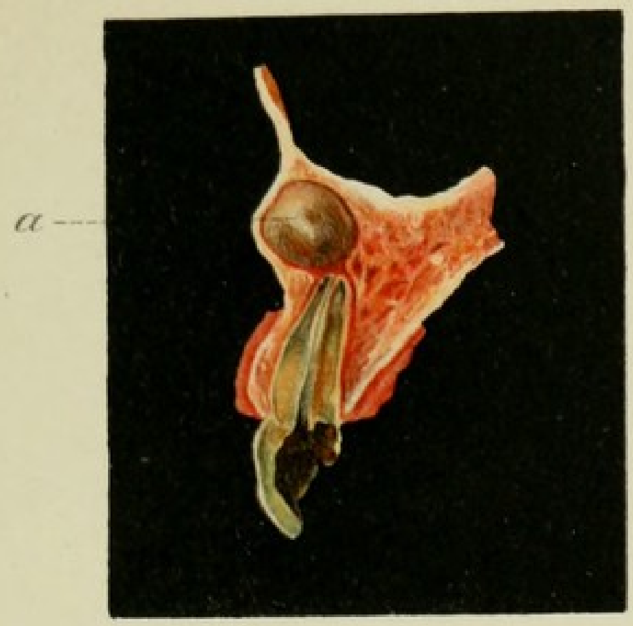


Fig. 1.

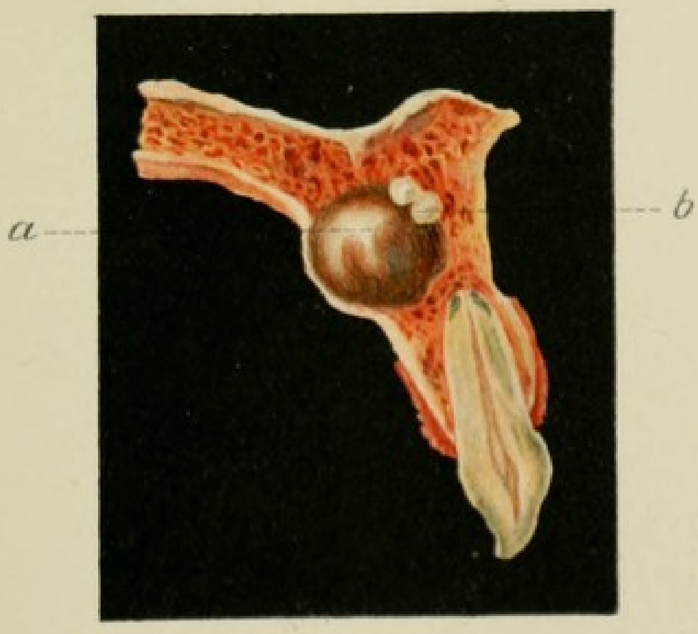
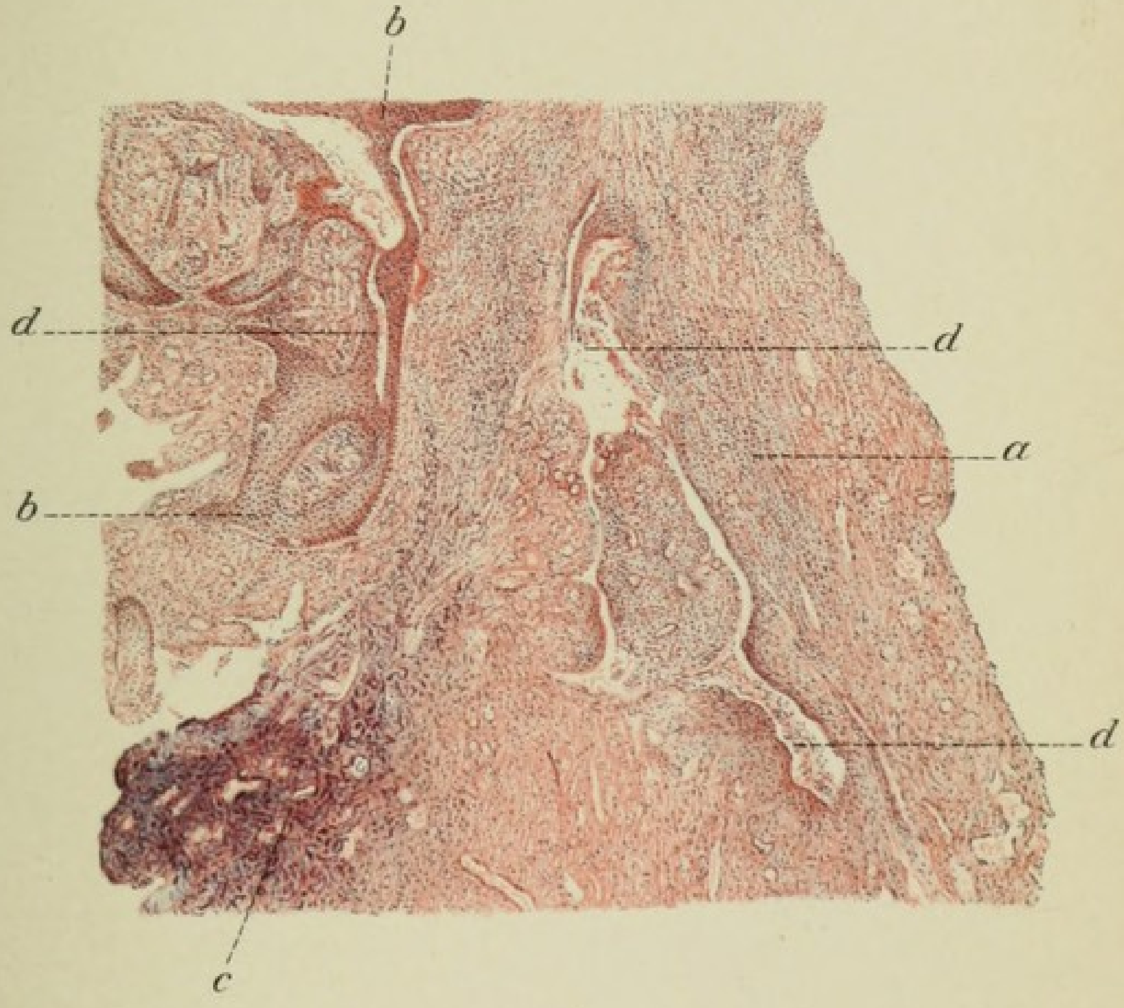


Fig. 2.

Lith. Anst. F. Reichhold, München.



Lith. Anst F. Reichhold, München.

mata in wholly intact teeth. Their development can only be explained by the fact that a hematogenetic infection may have occurred as a result of injury.

In many of the granulomata, cavities may be detected with the naked eye, which in the fresh preparations are filled with more or less cloudy, and sometimes pus-like contents. Several layers may be distinguished under the microscope. The outer layer consists mainly of concentrically arranged dense, connective tissue, which is poor in cells. Under this is a much thicker layer of less dense reticular connective tissue throughout which many round and spindle-shaped cells are scattered. This tissue presents here and there minute abscesses, or, only a diffuse infiltration of leukocytes. Especially characteristic of granulomata is the more or less striking amount of epithelium which passes through the remaining tissue in the form of cords, plugs, or occasionally, trellis work. The epithelial cells generally lie close together, but in some areas they are interrupted by minute lacunæ, which are filled with granular fragments of degenerated cells. Such lacunæ may be considered primitive cysts, for they develop later into large cystic cavities, lined with epithelium. It must be assumed that the liquid within the lacunæ increases in amount, and the pressure caused displaces the connective-tissue layer toward the periphery wherever it forms the outer capsule of the cystic sac. The epithelium also becomes displaced, and is finally altered into the smooth membrane of the cystic sac lining the cavity, which at this time is much enlarged. Further growth is probably influenced by an increase of the cystic fluid, the pressure of which distends the cystic sac and tends constantly to displace more and more the surroundings. As a result the bone becomes progressively thinner, and is finally perforated.

The epithelium concerned is derived from the *masses epitheliaux*, the significance of which was explained by Malassez and von Brunn. During the development of the tooth root, a sheath of epithelium, which is derived from the enamel-epithelium, has a form-giving function. After the root has become ossified a part of this epithelial sheath is absorbed, while another portion remains in the root membrane in the form of small nests, which are the above-mentioned *masses epitheliaux.*

The diagnosis is made by external examination only when the size and situation make it visible, and when the swelling is palpable.

The nearly spheric swelling grows without any pain. Originally it is of the consistency of bone but through the progressive loss in thickness of the bony substance, it may be indented, giving the parchment-like crepitation of Dupuytren.

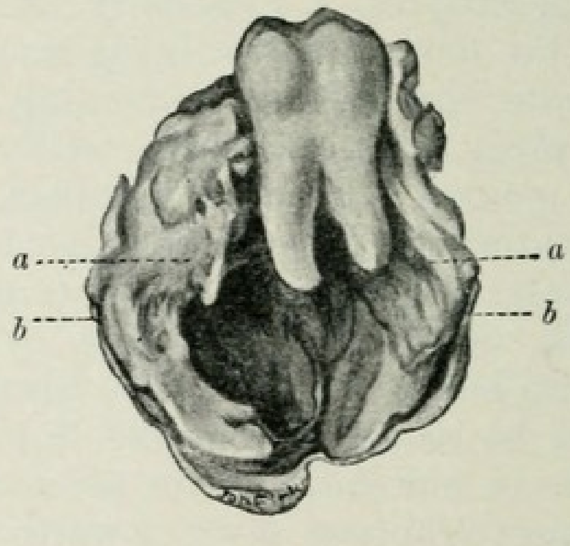


FIG. 54.—Periosteal cyst of the lower jaw. (The diseased portion of the tooth which caused the condition is not shown in this picture.) *a.* The cyst sac. *b.* Bone which has become thin through the growth of the cyst.

Where portions of the bone have become rarefied, it is possible to feel fluctuation of the cystic contents. Such a cyst, with the bony walls arising in the lower jaw, is pictured in Fig. 54. This specimen belongs to the Pathological Institute of Basle, and for the purpose of reproduction was placed at the writer's disposal by Prof. Kaufmann.

If the cyst grows in the upper jaw and penetrates into the antrum, it is sometimes mistaken for empyema of the superior maxillary sinus. Since the differential diagnosis cannot be established by the symptoms, it may be determined by injecting a fluid into the antrum. If the fluid be discharged by the nose, an empyema may be suspected; but if, on the contrary, the fluid does not issue from the nose, the cystic sac presumably closes the ostium maxillare, an opening between the middle meatus of the nose and the antrum of Highmore. Thus the failure of the fluid to flow from the sinus may occasionally indicate the presence of a cyst.

The *cystic contents* are usually described as a clear fluid, which often becomes turbid through the presence of numerous formed elements suspended in it. Old cysts usually contain cholesterin crystals which often occur in such great numbers that the cystic fluid has a glutinous consistency and a glistening lustre. If the fluid becomes infected with bacteria, a large number of pus cells develop, so that an abscess is simulated. Occasionally putrefaction sets in, detected by the foul odor upon opening the sac. Partsch contributes an interesting case in which the cyst was filled with a gelatinous mass composed of degenerated epithelial cells. This is the only case in which that author observed the undoubted presence of epithelium in the cystic contents.

In regard to the *therapy*, the author recommends that of Partsch as being the simplest and the most reliable. According to his method, a large section of the cystic wall is removed; a tampon of iodoform inserted for from three to five days, until the edges of the wound are somewhat healed. At the end of that time the tampon is removed, and if the cyst remain open, no other treatment is required, excepting the washing out of the cyst with a weak antiseptic solution (boric acid 5 per cent.), in order to keep it clean.

There is absolutely no reason for permitting the tampon to remain in the cyst a greater length of time, as is advised by some authorities; for, as is well known, the inner wall of the cyst is covered with epithelium, and therefore needs no protection. Indeed, by doing so, the internal pressure, which existed before the operation, is re-established in an artificial way, and thus shrinking of the cyst is prevented.

If, on the contrary, the cyst be allowed to remain open, it becomes progressively smaller, and, according to the size, completely disappears in from six to eight weeks.

Extirpation of the cyst sac, however, would be a scientific failure, for healing by granulation, especially when accompanied by suppuration, is much less satisfactory and considerably prolonged.

Follicular Cysts (Plate 14, Fig. 2).—These rare cysts are rarely observed by the dentist, both because specialists on surgery are preferred to perform the difficult operation required, and because the growths are often situated in distant parts. They have been seen to occur in the orbits, ascending rami of the jaw, and in the palate bone.

They originate in retained or supernumerary tooth germs, which have been displaced. A root never develops from these germs. However, such a germ gives rise to a more or less completely developed tooth-crown, as is illustrated in Plate 14, Fig. 2 *b*. Follicular cysts often lodge in a varying number of teeth, or the rudiments of teeth which are either loose or fused into a conglomerated mass. The report published by Hildebrand shows how great a number of such rudimentary teeth may occasionally occur. In his case not less than 150 tooth-like elements were found present at one time in the jaw.

Follicular cysts also possess an inner lining membrane of epithelium, which is derived from the enamel organ. These elements are flat, less frequently cuboidal, or low cylindric cells, which in the deeper layers occasionally form a *rete malpighii* like structure.

This form of cyst is accompanied by the same symptoms as the periosteal cyst. It is distinguished, however, from the latter by the fact that it is lower in growth, and not dependent upon caries of the tooth.

von Bramann advises the following *treatment*: A horizontal incision is made down to the bony covering of the cyst, and a large flap of mucous membrane and periosteum is dissected loose. Underneath this a portion of the bony wall is chiselled away so that the cyst may be palpated. The inner cystic wall is then dissected out thoroughly, and the flap of mucous membrane and periosteum is returned in place. A gauze compress is then applied in such a way that the periosteum lies lightly and without pressure everywhere on the concavity of the cyst. This is very important, for when this method is employed the mucous membrane and periosteal flap soon become adherent to the wall of the cavity. In eight days this dressing may be removed.

The most important feature of the treatment consists in the thorough removal of the cystic sac, for otherwise there may be a recurrence. In the case reported by Kaufmann, even after the complete removal of a cyst of the inferior maxilla, a cylindric-celled cancer developed after a number of years. This emphasizes the necessity of taking the above precautionary measure.

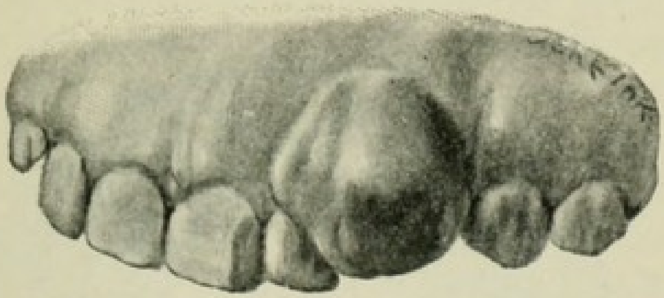


FIG. 55.—Fibroma, due to the irritation of a carious tooth.

FIBROMA.

Of the fibromata we must distinguish betwen the *superficial* and the *deep seated.* The superficial, which are mainly small growths, develop in the gums in the neighborhood of carious teeth (Fig. 55 and Fig. 56, *a*, upper illustration); or they arise from the base of an alveolus. They are often pedunculated, but may possess a broad base. An epulis of the gum is likely to be of soft consistency, for the connective-tissue fibers are strewn with cellular elements. The latter are occasionally so numerous that we are in a dilemma as to whether the growth is a fibroma or a granuloma.

Fibromata cause no direct *symptoms*, excepting their interference with the cleansing of the teeth. Depending

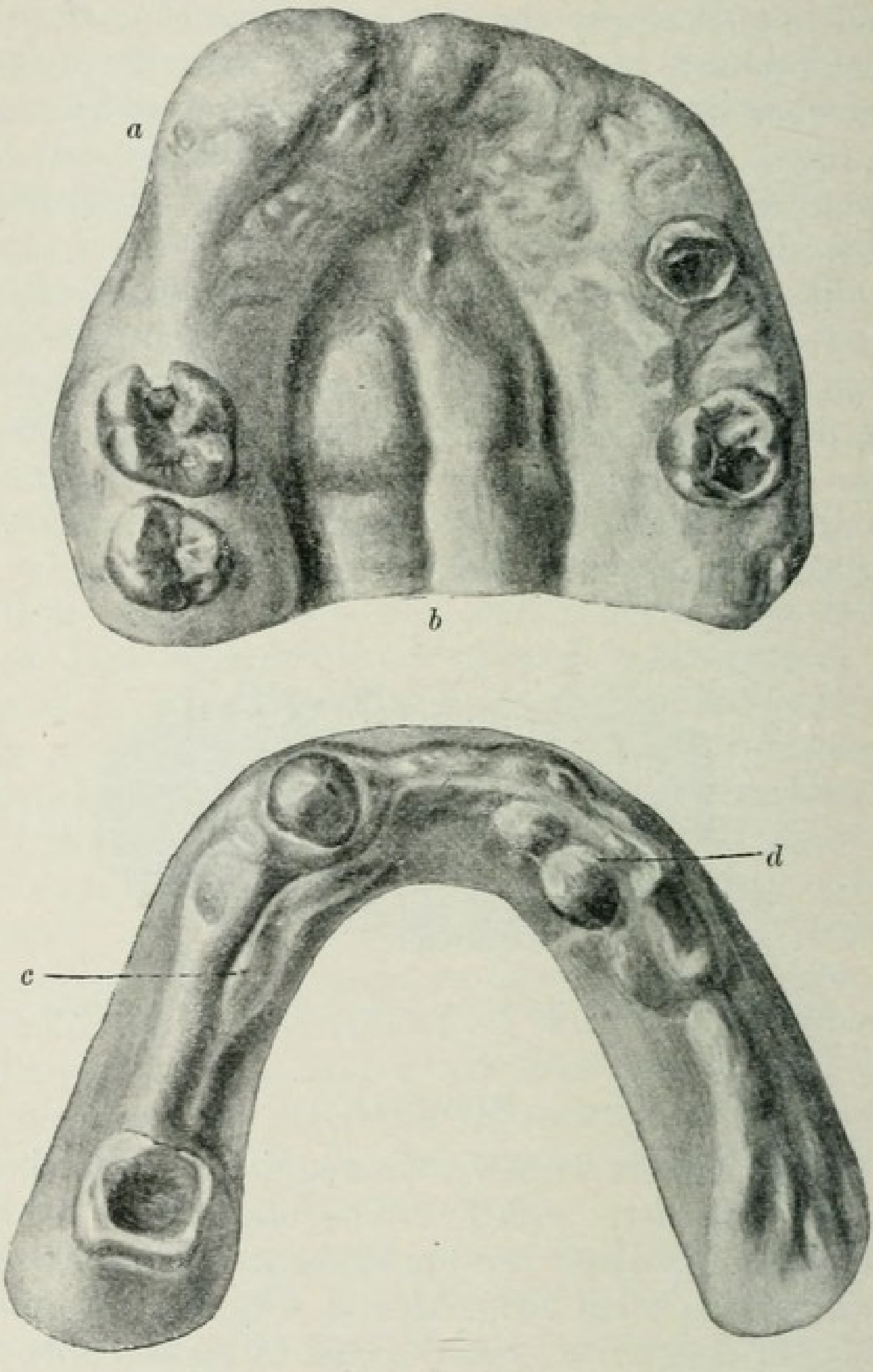


FIG. 56. — *Upper illustration:* *a*, epulis; *b*, abscess of palate in upper jaw. *Lower illustration:* *c*, osteophytic thickening of lower jaw; *d*, genuine exostosis with a neighboring smaller one.

upon their location and size, they may also get between the teeth in mastication. In rare cases they interfere with speech.

The fibromata arising from the *periosteum* of the alveolar process, or from the interalveolar septa, are harder than those of the gums, for they contain genuine bony tissue in the form of spicules, as well as calcareous deposits. They, too, are occasionally pedunculated, or at other times have a broad base.

The most frequent *seat* of a fibroma is the tongue, but it may also occur on the hard and soft palate, the inner side of the lips and cheeks, and, as has been mentioned, on the gums.

Fibromata are easily distinguished from malignant growths because they are slower in growth, unaccompanied by pain, and cause no infiltration of the surrounding tissues.

The *treatment* of *soft fibromata* consists only in their removal with a pair of surgical scissors. Recurrence is unknown. The therapy of the *hard growths* is much more difficult. As the degree of union with the bone can not be determined, it is necessary to resect a considerable amount of the tissue. Attention is called here to the deep seated fibromata, which occur mainly within the jaw bone and are described as *endosteal fibromata.* They select in preference the inferior maxilla, and when occurring in the superior maxilla, they not occasionally grow into the antrum of Highmore.

CHONDROMA AND OSTEOMA.

The *cartilaginous growths* are recognized by their nodular surface and their hard consistency. The latter, determined by puncture, distinguishes them from bony growths. The type of this tumor is often obscure, for it frequently develops as a mixed tumor (chondrofibroma, chondromyoma, chondrosarcoma, osteochondroma). Chondromata occur very rarely in the jaw bones, while osteomata are somewhat less rare. When the latter are composed of an excessive amount of tissue analogous to the bony cortex, they are naturally very hard (*osteoma durum*); but if the spongiosa is in excess (*osteoma spon-*

giosum), they may be more easily pierced by a needle. Such a typical osteoma, located in the right upper jaw, is illustrated in Fig. 57. The term *osteoma* also includes little, hard growths that develop on the alveolar processes as a result of chronic inflammation. They present them-

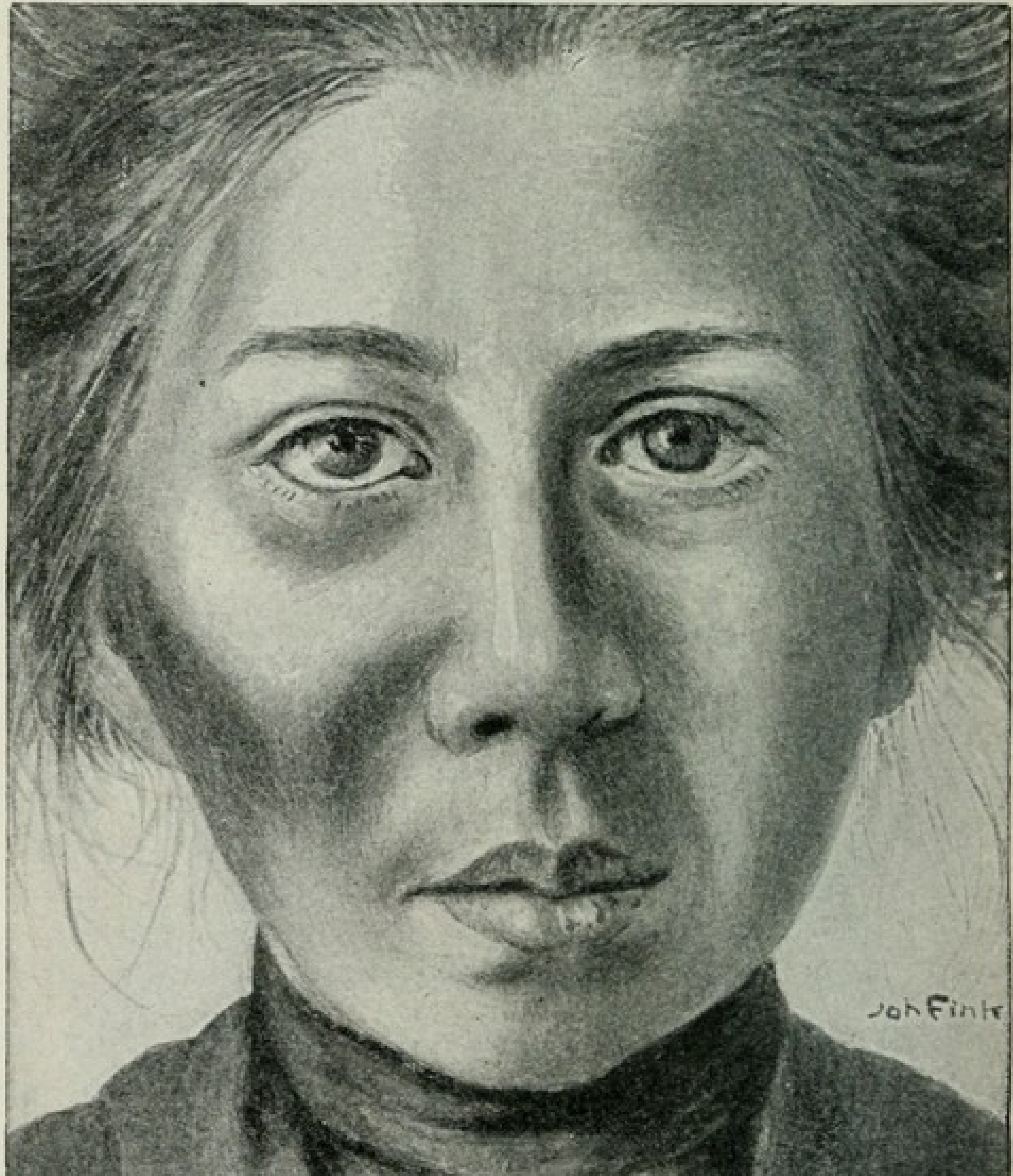


FIG. 57.—Osteoma of right superior maxilla.

selves either in the form of deposits (*osteophytes*), tumor-like excrescences (*exostoses*), or as a diffuse thickening of the cortex (*hyperostoses*). The lower illustration of Fig. 56 shows the lower jaw of an old individual, on which exostoses have developed.

The *prognosis* for both chondromata and osteomata is favorable, yet cases occur in which operation is followed by recurrence.

LIPOMA.

The extirpation of large as well as deep-lying growths must be performed by surgeons. The fatty tumors are usually rounded in form, soft in consistency, easily palpable, and covered with normal mucous membrane. According to Krausnick, they occur most frequently on the tongue, and may assume such a shape and size as to interfere considerably with the movements of that organ. When they occur in the floor of the mouth or on the tongue, speech and mastication are soon disturbed ; and they therefore require early treatment.

The *operative procedure* is easily performed, at least that on the tongue and cheek lipomata, and consists in incising the mucous membrane and plucking the growth out by hand. The manipulation, however, is somewhat more difficult when the lipoma grows in the floor of the mouth. In this case they must be resected in such a manner that the lobular processes, which extend between the hyoglossus and the geniohyoglossus muscles, are completely removed.

MALIGNANT GROWTHS.

SARCOMA.

These tumors, are mainly comprised of elements which resemble the germ tissue of the embryo. They are divided into: *Round-celled sarcomata* and *Spindle-celled sarcomata*. The round-celled sarcoma contains small cellular elements derived from the connective tissue. The *large-celled* or *giant-celled sarcoma* originates in the periosteum and is usually located on the structure. The *spindle-celled sarcoma*, like the round-celled sarcoma, is composed of two forms, in one of which small cells prevail, while in the other large cells predominate.

They frequently occur, not as pure growths, but as mixed tumors, the interior of which often undergoes retrogressive metamorphosis, indicated by the presence of a pulpy mass. The latter is chiefly composed of cells that have undergone fatty degeneration.

The tongue is most frequently the seat of these tumors, which may be pedunculated, have a flat base, or even penetrate deeply into the substance of the tongue. They are also found on the palate, the gums, and in very rare cases on the lips and the cheeks. A sarcoma usually grows very slowly at the beginning, but after a certain age is once attained, they grow much more rapidly. They are not easily palpable as they are diffusely intergrown with the surrounding tissue. The chief point in the *diagnosis* is the causation of pain, which is sometimes quite considerable.

In the *differential diagnosis*, syphilitic gummatous nodules may have to be considered; they, however, contrary to sarcomata, are usually multiple in number.

Concerning the treatment, we must bear in mind that sarcoma is ever more prone to metastatic extension than carcinoma, and that, therefore, it must be removed as soon as possible. The diffuse spreading and growth into neighboring tissue, requires the removal of a considerable portion of the surrounding structure with the growth. It may, for example, become necessary to amputate the tongue, or resect a large portion of the lower or upper jaws, etc.

CARCINOMA.

Carcinomata, or *cancerous growths*, are highly malignant because of their tendency to grow uninterruptedly into the surrounding tissue. The lymphatics become involved; at first the nearby lymphatic glands, and later the more centrally situated ones. Aside from this matastatic extension carcinoma also tends to spread to the healthy mucous membrane near which it is located; for example, it may spread from the tongue to the palate. The patients suffer considerably from interference with mastication, from swallowing products of ulceration, and even at the beginning from pain. The high state of cachexia is caused by the *poison* excreted by these tumors. According to Fr. Müller, the specific action of the cancer poison causes in the organism a gradual destruction of the protoplasm.

Cancerous growths frequently develop in the oral cavity, and because of their great clinical importance we will consider this subject in greater detail. The frequent occurrence of cancer in the oral cavity may be understood when we realize that this tumor, which begins with epithelial proliferation, finds a favorable base for its development in the presence of mucous membrane and mucous membrane glands. In certain cases the growth may assume the character of glands (*adenocarcinoma*). Their development consists in sending gland-like roots into the deeper tissues from the mucous membrane. The inner surface of the trabeculæ is covered with an epithelial layer, which becoming constantly thicker, finally fills this trabeculum with solid epithelial plugs.

The typical forms of cancer grow more frequently in the oral cavity than do the adenocarcinomata. Between dense cords lie nests of epithelium which, although they show no retrogressive metamorphosis, present many cells in the process of mitotic division. The elements of the cancer nests, or so-called cancer cells, undoubtedly represent a type of epithelial cells, which are of a comparatively large size and have large nuclei. Their outer contour, sometimes flat, sometimes cylindric, may assume all possible forms, which result from the reciprocal pressure exerted by each other.

The squamous celled epitheliomata, called *cancroid*, select the mucous membrane in preference because it is covered with squamous epithelium. These tumors grow either above the surface or deeply into the parenchyma of the tissue. Their surfaces become easily inflamed, and hence often contain cancerous ulcerations. Microscopically, the squamous celled epitheliomata consist of alveoli, the trabeculæ of which are of the nature of connective tissue and possess concentrically arranged layers of epithelial cells.

Other forms of cancer also grow in the oral cavity, such as the hard *scirrhous* variety, which is comprised chiefly of a dense connective-tissue stroma, throughout which only a few epithelial nests are scattered. The medullary carcinoma is also met with, but it, on the contrary, is much softer in consistency. It lacks dense connective-tissue stroma and the nests are large and surrounded by only a small amount of connective-tissue fibers. Both the connective tissue and the cell nests are often the seat of leukocytes.

Cancer of the oral cavity grows on the *lips*, the *tongue*, the *floor of the mouth*, the *cheeks*, the *palate* and the *gums*.

Men are more frequently subject to cancer of the oral cavity than women. Out of one hundred cases about thirty occur in women. It is possible that smoking and drinking counts for its frequency in men by causing a chronic inflammation of the mucous membrane.

Partsch believes that the relatively frequent occurrence of *cancer of the lips* in people who are exposed to inclement weather indicates that prolonged irritation of any kind favors the development of this disease. Cancer of the lips is more frequently located on the lower than on the upper lip. It is difficult to recognize in the beginning, as it shows nothing except a circumscribed thickening of the epithelial surface with few characteristics. In the course of the affection this thickening becomes covered with crusts which result from the drying of the sticky secretion. When the crust is removed a red ulcerated surface is seen, which according to the arrangement of the proliferated epithelium, presents yellow specks or larger yellowish areas.

The ulceration soon rises above the plane of the lip from which it is separated by wall-like borders, and at the same time the surrounding tissue becomes constantly harder and stiffer through additional infiltration. Finally, after a number of years, movements of the lip become difficult; usually, however, the process progresses more rapidly and is accompanied by enlargement of the regional lymph glands.

The *prognosis* of cancer of the lips is relatively favorable, since metastasis to the inner organs is not frequent. Partsch obtained a cure in 35 per cent. of all cases through operation.

The *treatment* consists in a thorough extirpation of the involved focus as early as possible, and in curetment of the neighboring lymph glands. Inoperable cases with excessive metastatic extension can only be treated systematically by the employment of analgesics.

Cancer of the tongue is much more malignant than that of the lips, because it spreads more rapidly and is more likely to cause metastasis of the inner organs. Carcinomatous epithelial proliferation develops most frequently after loss of tissue from the tongue ; for example, on the site of decubital ulcer or on an old focus of leukoplacia. Also lingual epithelium, like that which is found in the glands of the tongue, may furnish material for the disease.

Cancer of the tongue begins with a painful ulceration, the border of which rises like a wall and is surrounded by hardened tissue, as in a case of cancer of the lip.

Cancer of the floor of the mouth is frequently secondary to carcinoma of the tongue. In this case the tongue soon becomes adherent to the floor of the mouth, which leads to disturbances in speech and mastication.

The *prognosis* of cancer of the floor of the mouth and of the tongue, even when operated upon early, is less favorable than cancer of the lips on account of the rapid extension to distant lymph glands.

Cancer also arises in the mucous membrane of the *cheeks*, especially in the areas chronically irritated by sharp-edged teeth. At the beginning, the *diagnosis* is often mistaken for tuberculosis or decubital ulceration, which may have caused this condition. Its malignancy is somewhat less than that of the tongue and mouth carcinoma ; however, cancer of the mucous membrane of the cheeks is frequently followed by disagreeable sequelæ, which are due to extirpation of the infected area.

Carcinoma of the *hard* as well as of the *soft palate* is very rarely a primary affection ; it is more frequently due to the extension of this disease from neighboring structures. Cancer of the palate, because of its location, tends to spread to the air containing cavities of the face, including both the orbital and nasal cavities. These growths are but slightly malignant, so that a permanent cure may follow an early extirpation accompanied by resection.

Cancer of the gums is somewhat more frequent than that of the palate. It is a squamous celled epithelioma which grows rapidly into the deep portions of the bone. Its origin is frequently due to the irritation of carious teeth; Mikulicz has seen it develop in the region of an extracted tooth. This originally hard edged and small-sized ulceration constantly increases in dimension, until finally it involves the whole jaw bone, the consistency and form of which can then no longer be recognized. The mucous membrane coating of the antrum of Highmore may also serve as the origin of carcinoma.

It must be assumed that all carcinomata arising in the interior of the jaw bone are related to the epithelial nests of the periodontium and to aberrant buds of the tooth germ. These centrally situated cancerous growths spread with severe neuralgic-like pain and considerable swelling of the bone.

A dentist has frequently an opportunity to restore by operation a portion of the face that has been destroyed by disease. Some useful advice on this subject is given by Claude Martin in his book, "De la Prothèse Bucco-Faciale."

GROWTHS OF THE HARD DENTAL SUBSTANCES.

Growths developing in the pulp and periosteum (polyps, concretions, granulomata, cysts, etc.) are discussed under the title of *Pulp and Periosteal Diseases*, and hence we shall only speak here of such new growths as arise from the specific hard substances of the teeth.

The *cementum* may become thickened in all directions in old age and in certain pathologic conditions, thus giving the roots a thickened appearance (*hypertrophy*).

Histologic sections show this thickening to consist of a deposit of lamellæ of cement which are richly supplied with cement bodies and Haversian canals.

Such diffuse tumors of the cementum may be designated *hypertrophy of the cementum*, while the circumscribed forms of tumors are called *exostoses*. They are usually small and insignificant and only rarely show their presence by the causation of pain (Plate 21, Fig. 1).

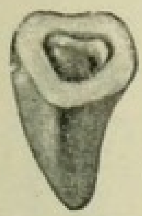


FIG. 58.—A bicuspid tooth, the crown of which has been ground away down to the neck of the tooth in order to show a small dentinal growth arising in the pulp cavity (*internal odontoma*).

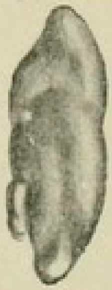


FIG. 59.—A small external odontoma of the root.

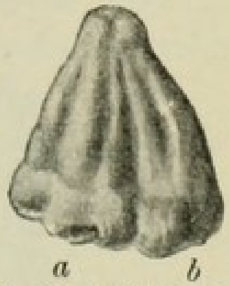


FIG. 60.—(*a*) A regular second molar tooth intergrown (*b*) with supernumerary teeth.

Tumors which originate in the structure of the dentin are distinguished according to their location, as *internal* (*odontoma*) when they lie on the wall of the pulp cavity, and as *external* when they occur on the outer surface of the dentin.

Internal odontomata arise from the odontoblasts and grow toward the pulp cavity as is seen in Fig. 58. They cause neuralgic pains by exerting pressure upon the nerves of the pulp, but, under favorable circumstances they may remain symptomless and undiscovered for years.

External odontomata (Fig. 59) may also originate in the over production of dentin which occurs during the process of tooth formation. More frequently, however, separated rudimentary tooth germs are concerned which are intergrown with any regular tooth. This accounts for the fact that odontomata are frequently composed, not only of dentin, but also other forms of tissue-like cementum (*osteo-odontoma* or *enamel odontoma adamantinum*). Indeed, whole supernumerary teeth may be intergrown with regular teeth, as illustrated in Fig. 60. The wholly dentified odontoma remains stationary but before it has reached that stage (myxoma, fibroma etc.) it tends to undergo extension, and its size may reach that of a hen's egg.

New growths of the enamel (*adamantoma*) originate in the ameloblasts of teeth which are slow in development. They arise from deposits of separated tooth germs, and are therefore congenital. They occur in preference on the border between the enamel and the cementum (Fig. 61); more rarely, in favorable areas of the roots (Fig. 62).

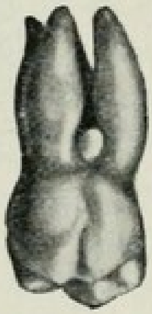


FIG. 61.—An enamel growth (*adamantoma*) at the neck of the second upper molar tooth.

FIG. 62.—An enamel growth near the apex of the first upper molar tooth.

These tumors are pale, shiny, pear-like growths, about the size of a pin head, which rarely cause symptoms, and therefore are only accidentally found on extracted teeth. Neuralgic pains have been frequently attributed to these growths, and it must be admitted that under certain circumstances such pains may arise; but such cases are rare.

FRACTURES OF THE LOWER AND UPPER JAWS.

In comparison with other bones, fractures of the *lower jaw* are very rare; yet of the bones of the face this bone is the most frequently fractured. Either the body of the bone or the ascending rami may be affected. Fracture of the body of the jaw, according to its location, involves either the curved portion of that bone or the alveolar process. The ascending ramus may be fractured either at its base or at the coronoid or condyloid process.

The most frequent fractures of the inferior maxilla are those of its body. They occur with preference near the symphysis, therefore, at the vertex of the curved portion of the body of this bone. Not infrequently, however, and especially accompanying extraction of teeth, small portions of the alveolar processes are broken off. This injury occurred formerly much more frequently and much more extensively when the tooth key was employed.

Fractures of the lower jaw are usually simple, and only occasionally do they occur as comminuted fractures, which are chiefly met with in war.

Fractures of the lower jaw are recognized by pain in a certain area when an attempt is made to chew or to speak. Occasionally, but not always, displacement occurs in the tooth row. Crepitation is only rarely absent. Examination is often made difficult by swelling of the soft parts, especially in complicated fractures in which ankylosis of the joint has set in.

The greatest amount of displacement follows a fracture in the neighborhood of the wisdom teeth ; the musculature draws the posterior fragment upward, while the anterior fragment falls downward as far as the soft tissues permit. We have thus far only considered the vertical fractures ; there occur, also, especially when struck by an animal's hoof, in railroad accidents, or when shot at close range, a combination of vertical with horizontal lines of fracture. *Comminuted* and *transverse fractures*, both equally rare, have also been observed to follow occasionally these accidents.

If the deformity of the tooth row be great, the blood-vessels and nerves in the mandibular canals are injured. As a result of the stretching and tearing of the mandibular nerves, sensation is completely lost in those teeth which lie peripherally to the point of fracture, as well as in the chin and lip.

Fracture of the alveolar process is recognized by the mobility of the fragments. The fracture may involve the

FIGURE 63.

The wire splint of Sauer for fractures of the jaw bone.

Upper illustration. Showing its two parts. *Lower illustration.* In situ.

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outer or inner wall of one or more tooth alveoli. If both the buccal as well as the lingual wall be fractured, the teeth are loosened, provided they are still in their alveoli. It would, indeed, be a great mistake if in fracture of the alveolar process the loosened teeth or loosened fragments of bone were to be removed, for through the enormous vitality that the jaw bone possesses for regeneration, these parts usually grow firm again, and only rarely die.

In case of fracture of the *ascending ramus* of the jaw, the inferior maxilla is displaced backward on the affected side. This is also true when the *condyloid process* is fractured; in the latter case, the patient feels crepitation in the joint when he attempts to chew. Palpation is not of much assistance, for the soft parts are usually much swollen. Fracture of the *coronoid process* is much more easily determined. The palpating finger inserted in the oral cavity easily feels the mobility of the fractured fragments. As the articular process remains intact, no deformity of the lower jaw occurs, but attempts to open the mouth cause sharp pains. As Röse has stated, it is quite possible in these fractures that a false connective-tissue union may occasionally result similar to that accompanying fracture of the olecranon and the patella (*pseudo-arthrosis*). This is due to the fact that the scalp at the coronoid process contains the tendons of the temporal muscle, which being poorly supplied with blood, do not favor the formation of callus.

Treatment of fractures of the lower jaw consists of two important procedures. Primarily the dislocated part must be replaced, and secondarily an absolute fixation must be secured which will keep the fractured surfaces in juxtaposition and immobile for a long time. In many cases the upper jaw serves as an excellent splint for a temporary dressing; for by fastening the lower jaw to the superior maxilla the teeth are forced to articulate properly with each

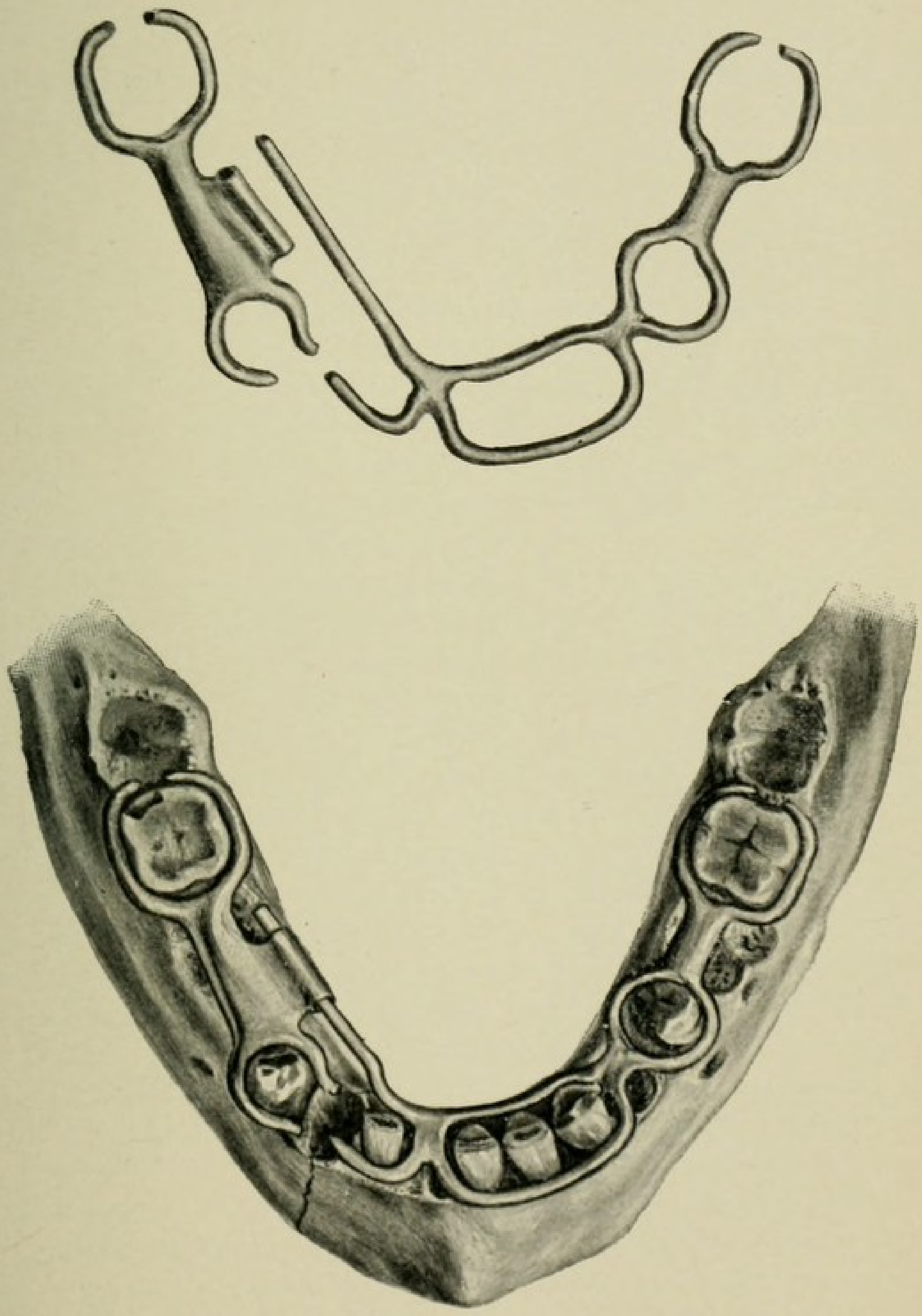

Fig. 63.

other, and the fractured fragments are held in their normal positions. The *wire splint* of Sauer, which, being applied and fastened to the sound teeth, acts as an excellent further dressing. The *tooth splint* recommended by the same author, consisting of two parts, is often more satisfactory. The upper illustration of Fig. 63 shows the two parts of the splint, and the lower illustration shows them united *in situ*. This tooth splint, however, has the disadvantage that it must be fastened to the teeth with a connective wire, which often causes them to become loose ; but this disadvantage may be overcome by employing the tooth splint of Weber, which is made of vulcanized *India-rubber*. This *India-rubber splint* has been considerably improved by Haun through the combination of rubber and gutta-percha. His apparatus, employed with good results in the War of 1866, is applied as follows :

After the jaw has been replaced to its normal position by means of digital pressure, the rows of teeth are covered with a layer of vulcanized India-rubber, removing enough from the surface to permit the crowns of the teeth to perforate it. Another layer of gutta-percha, softened by heat, is then placed in the splint, which is forced upon the teeth of the fractured jaw as rapidly as possible. The patient is then requested to close his mouth. After the gutta-percha has become hardened the splint usually lies tightly in place, and the gutta-percha which has been squeezed out shows the pressure of the antagonistic tooth. In this method even the most severely injured were soon able to chew.

However convenient it may be to prepare and wear an India-rubber splint, its porous nature favors the development of degenerative processes, and therefore Port recommends its substitution by aseptic, chemically pure tin.

The manner of *applying splints* for fractures of the jaw varies for each case, and according to the form of the apparatus employed. In general, however, one should attempt to secure a good impression, whether India-rubber, tin, or wire splints are employed. If, while the impression is being taken, the fragments become displaced, it does not necessarily mean an absolute failure. The plaster-of-Paris model is simply divided at the involved portion, and the parts again so united that the normal curvature of the jaw bone is obtained. The apparatus is then prepared so as to fit exactly this model. The wire splint is fastened with soft florist's wire, and the India-rubber splint is fixed with gutta-percha.

It occasionally becomes necessary to *treat* a badly united fracture of the lower jaw, the fragments of which were displaced. Suersen applies a cap to each part, and pries them gradually into proper position by pressing a hickory peg between them. Best results, however, are obtained in these cases by the application of a properly constructed regulation apparatus.

The *after-treatment* consists simply in thorough cleansing and disinfection of the oral cavity, for septic processes are likely to arise, especially when a considerable portion of the soft tissue is injured. With our modern methods this disinfection is easily carried out. Formerly, when another external apparatus was employed to fix the lower jaw against the upper, this was much more difficult or in fact impossible. It was not only impossible properly to nourish the patient when the mouth was constantly kept closed, but it was also impossible to keep the oral cavity clean, and therefore this method has gone out of use.

Fractures of the upper jaw are much less frequent than those of the lower jaw. This is probably due to the fact that it is less exposed, and is better protected by the soft parts. The body of the superior maxilla itself is rarely fractured, while the zygomatic and alveolar processes are broken more frequently.

Fractures of the *body* of the upper jaw occur chiefly as a result of considerable violence, and therefore are often accompanied by injury to the soft tissues and fracture of the base of the skull ; they belong really to the sphere of surgery.

Of more importance to dentists are the fractures in the region of the *alveolar processes*, which occur quite frequently in the extraction of teeth from the bicuspid and molar portion of the jaw, where the walls are quite thin. The writer has treated numerous cases of fracture of the alveolar processes, and here presents three of the most typical and instructive cases, rather than give a description of the various conditions that might occur.

In the first case, an attempt to extract the second upper molar of a young man was accompanied by the breaking off of so large a piece of the bone that the antrum was widely exposed. When the patient presented himself there was an abundant discharge of pus from the superior maxillary sinus. By antiseptic irrigations the inflammation was soon overcome, and in a short time the wound healed over with scar tissue.

Less common is the second case, in which the patient, a man forty years of age, having been stupefied by the escape of coal gas, fell and struck his face on a foot stool. As a result the alveolar process was fractured and dislocated in such a manner that the four upper incisors, upon closing the mouth, rested back of the incisor teeth of the lower jaw. The jaw fragments were first replaced, and then a gold plate was made for the patient, which forced the incisors somewhat forward, so that the lower teeth were no longer able to strike them. By being thus placed in absolute rest the jaw healed in three weeks.

In the third case, a powerful blacksmith was struck on the neck by a heavy piece of iron in such a manner that he was forced face downward to the ground. Inspection of the oral cavity disclosed a fracture of the right alveolar process of the upper jaw. Externally the line of fracture could be traced from the cuspid tooth to the zygomatic fossa and second molar tooth, and internally it ran close to the raphe of the hard palate. As the patient did not come for treatment until after the callus had begun to form, we were unable with the usual methods to replace the bony fragments, which were already considerably displaced. Therefore, a palatine plate was fixed to the sound side, which, exerting pressure through a gold spring upon the injured teeth, reduced the dislocation in four weeks.

In these short case histories, the most useful methods of treatment are described. Much of what has been said in connection with the lower jaw also holds true for the upper jaw.

DISLOCATION OF THE LOWER JAW.

Luxation of the inferior maxilla occurs most frequently forward. It usually affects both sides, but may occur more rarely only on one side. The articulating head of the bone is displaced forward in front of the articular tubercle, and on account of the contraction of the muscles of mastication is unable to slide back into the socket

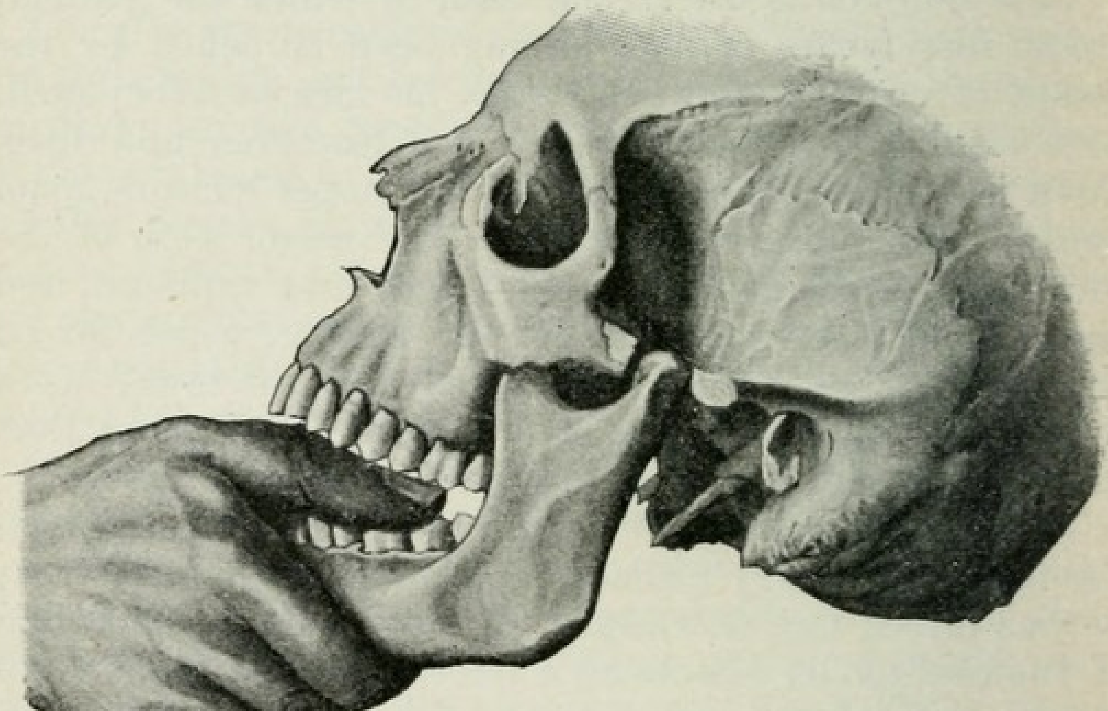

Fig. 64.—Reposition of a dislocated lower jaw.

of its own accord. Tearing of the capsular, the internal lateral, or the stylomaxillary ligament has not as yet been reported ; yet it is not difficult to imagine how such complications may occasionally follow severe traumatism.

The *causes* of luxation are usually similar to those of fracture of the lower jaw bone. A fall or a blow, as well as extraction of teeth, may result in such an injury. Forcible opening of the mouth in which the articulating head glides on the articular tubercle may also lead to luxation. Much force is not always necessary to cause a dislocation, for in some people who have poorly developed jaw bones or thin muscles of mastication, the lower jaw becomes habitually displaced on the slightest provocation.

The *treatment* of this form of dislocation usually presents no difficulty. The head of the patient is held by an assistant, and the jaw is grasped with both hands in such a manner that the thumbs rest upon the molar teeth while the remaining fingers clasp the bone. Strong pressure is then exerted downward and backward, causing the articulating head to glide back over the articular tubercle into its socket. In order to prevent the thumb from being bitten by the too rapid replacement of the jaw it should be protected with a napkin. In strong people it becomes necessary on rare occasions to reduce the dislocation under *chloroform narcosis,* which causes the muscular contracture to disappear.

It is advisable after the bone has been replaced to support it for a time with a bandage, and to give the patient nothing but liquid diet; for at the beginning the dislocation recurs quite frequently when the mouth is opened. Persons subject to habitual dislocation usually reduce it themselves by a blow on the chin or by pressure upon the masseter muscles. von Genzmer recommends inunction of the tincture of iodin into the relaxed articular capsule.

EMPYEMA OF THE ANTRUM OF HIGHMORE.

Empyema is the most frequent affection of the antrum of Highmore. It consists in a collection of pus brought on by inflammatory processes in the mucous membrane lining this cavity. Disturbances in secretion (*hydrops*) are also reported to have been developed by closure of the ostium maxillare either as a congenital defect or from disease. As a result, the quantity of the secretion from the mucous glands finally becomes so great that the pressure resulting in the antrum leads to pain. It cannot be denied that hydrops probably occurs in rare cases, yet it is at any rate frequently mistaken for cysts which have penetrated into a sinus of the superior maxilla, and which on perforation discharges a more or less clear fluid.

The *development* of empyema of the antrum of Highmore depends upon a variety of factors: Inflammations may extend from the nasal cavity to the antrum, or in rare cases the antrum becomes secondarily involved as a sequel to empyema of other air-containing cavities, as the frontal and sphenoidal sinuses. The possibility of this occurrence may be easily understood by studying the metallic casts, in Plate 3, of the air-containing cavities of the face, which show the relationship of these various hollow spaces to each other.

Foreign bodies may be the etiologic factors. These occasionally include bullets, knife points, and even roots of teeth, which, during extraction, slipped from the forceps and entered this cavity. Further destructive process of the alveolar process may lead to suppuration of this sinus; but in the majority of cases the *teeth* themselves are the cause of the empyema. By studying Fig. 22 and Plate 3, in which the relationship with surrounding structures is accurately portrayed, it will be observed that of all the teeth the first and second molars stand in closest connection with this cavity. Both of these teeth are implanted directly underneath the floor of the antrum. In rare cases also the roots of the wisdom and second bicuspid, as well as abnormally developed roots of other teeth, reach close to this sinus.

The *dental cause* is to us the most important one. The disease process is believed to extend from the affected tooth to the lining membrane of the superior maxillary sinus. If we consider the topographic location of the upper molars, it is easily understood how periodontic disease may spread to the antrum. The apices of the roots of these teeth are separated from the floor of the antrum of Highmore by only a relatively thin bony layer, and if the antrum of a macerated skull be opened with a chisel, little cup-like projections will be observed in the floor, caused by the projections of the alveoli in which the roots of the molar teeth are set. Hence the teeth stand in close relationship here with the superior maxillary sinus, and especially so when the alveolar cups and the roots arising in the antrum are covered with almost nothing but soft tissues.

We know that inflammatory processes of the periosteum may easily destroy it, and as a consequence, the substance of the bone. Hence it is not strange that inflammatory affections of the upper molars lead to perforation of the antrum. With the development of this perforation, together with the destruction of the living bony layer, the affection has easy access to the sinus. It does not necessarily follow, however, that this infection must lead to an empyema, for there is abundant postmortem evidence that suppurating apices of roots have perforated the antrum without causing empyema. Why the same factor should cause an empyema at one time and not at another is not very clear. The most plausible explanation seems to be that in one case the vital energy of the superior maxilla is able to resist the attacking micro-organisms and not in another. The pathogeny of the micro-organism also undoubtedly plays an important part.

Baume believes that the more minute processes consist in a rarefaction which, after the development of a periodontitis, involves the floor of the alveoli. Primarily only the Haversian canals are dilated, then the bony lamellæ become constantly more porous until they finally disappear, thus permitting the pus to enter the antrum. Aside from this form of perforation, I have seen two other varieties. Destruction of the periodontium, probably through the influence of specific bacteria, may lead to a real *necrosis* of the bony plate. The latter undergoes suppuration, and in time develops a large opening into the cavity. The sequestra are friable and show all the characteristics of necrotic bone. This form of perforation is seen more frequently after extraction than after a periodontitis, and may, therefore, accompany slight and apparently insignificant fractures of the alveoli. The second form, which is more frequent, consists in the formation of *granulation tissue* in the neighborhood of a diseased molar root. This progresses without interruption into the bony tissue, from which it extracts the calcium salts, so that only the Sharpey's fibers remains. These, too, soon disappear, and in time the bony tissue is completely substituted by the round cells of the granulation tissue. Finally, the mucous membrane of the superior maxillary sinus, which has thus far remained intact, also becomes intergrown with granulation tissue, and an ulcerated area is formed on the floor of the antrum.

At first, the *symptoms* which accompany this disease are not prominent. They consist of pains, distension of the antrum, and the discharge of a foul smelling pus from the nose. The pains, however, are not constantly present. Patients sometimes are afflicted for a number of years with empyema, and yet experience no pain. Some patients complain of a feeling of pressure or weight within the upper jaw, and only occasionally suffer sufficiently from pain to consult a physician. The second branch of the trigeminal nerve, the branches of which run in thin canals within the walls of the antrum, is the most frequently affected. However, the first branch of this nerve is also quite frequently involved, which causes the pains to radiate to the teeth. If such cases are not carefully examined, one is likely to diagnose the condition as trigeminal neuralgia. Pain is more frequently an accompaniment of the acute than of the chronic condition.

Of the walls of the antrum, the thin ones are naturally the first to distend, and hence the nasal wall bulges before the others. However, as this wall is hidden, its condition often escapes detection, and hence in literature, the facial wall is usually stated as being the first to bulge in empyema. In severe cases the patients themselves note that one nasal orifice is obstructed, and examination will usually show that the bulging nasal wall of the antrum, together with secondary swelling of the nasal mucous membrane, has completely closed one nostril. Bulging of the facial wall is more readily recognized, and is sometimes associated with reddening and edema of the cheek. If the bone has become very thin through loss of substance, pressure may elicit crepitation, the bone may even undergo perforation with the formation of a fistula. If the orbital roof bulges, exophthalmos may occur, yet in this case the eye is only slightly forced out. If, however, cellulitis should develop in the retrobulbar space, a high grade exophthalmos will result. Even the roof of the hard palate bulges occasionally, but usually not until the remainder of the antrum is considerably distended, the deformity being easily detected in the mouth. This distension results from a periostitis and an osteomyelitis, which cause the bony substance to soften and become thin. However, the engorgement of the secretion, which follows closure of the ostium maxillare, is often sufficient to account for the distension.

The third symptom, the discharge of pus from the nose, is rarely absent. The patients usually state that they occasionally taste the pus in the mouth upon awakening in the morning, and a foul odor may be detected issuing from the nose. The discharge of pus from the nose is easily explained. When the patient lies upon the healthy side, the contents of the antrum of Highmore empty into the nose either through the ostium maxillare or through accessory openings, which may also connect the superior maxillary sinus with the nasal cavity. The contents consist of a slimy pus, which, however, does not flow easily, because the high position of the ostium maxillare causes it to stagnate in the antrum and then become thickened. This stagnation does not only cause it to become thick and tenaceous, but gives it the characteristic sweetish odor with which all practitioners are acquainted. Under these circumstances it is natural for fever to set in.

The *treatment* of the empyema—that is, of the causal conditions—is under all circumstances imperative, for not only the above described symptoms of more or less severity are concerned, but the possibility of a fatal termination, must also be considered. This may follow general sepsis, or be caused by meningitis, the consideration of which must not be excluded. The development of the latter may be easily understood by examining the corrosion preparation in Plate 3, which shows the close relationship existing between the retrobulbar space and the superior maxillary sinus. The cast of the intervaginal space of the optic sheath alone presents a direct path for the transmission of pyemic processes to the hard and soft cerebral meninges.

It is important above all things that the pus be permitted to discharge freely. This may be done by perforating the antrum at any point. The following *areas for perforation* are preferred: The lower portion of the nasal wall (Hunter); the facial wall (Dessault); the hard palate, the alveolar process (Cooper).

Securing an entrance from the *nasal wall* is recommended as being the most convenient, because here the natural connection between the superior maxillary sinus and nasal cavity may be employed. This is, however, a false premise; on the contrary, it is exceptionally difficult to pass a sound through the ostium maxillare, for it is hidden in the anterior lateral portion of the hiatus semilunaris. Because of the difficulty in finding this entrance, Zuckerkandl recommends piercing the wall at its thinnest portion, that is, in the *middle meatus*, with a trochar. Partsch objects to this method, and justly so, because the anatomic do not correspond to the clinical conditions; for if it be possible, the pus should be permitted to flow at the lowermost point of the cavity. Therefore, Mikulicz overcomes this objection by piercing the nasal wall at its *lower portion*.

Piercing the antrum of Highmore from the *facial surface*, or through the *hard palate*, is frequently recommended. The latter offers no special advantage, and on account of the thickness of the bone it is performed with difficulty. The former is useful when a large portion of the antrum wall has been removed, and when it is desired to give the palpating finger easy access to its interior.

Perforation of the *alveolar process* is preferred by dentists as being the most advantageous. If the molars are absent, an atrophic condition is nearly always present, and as a result the bone consists of a thin compact portion with few spongiose trabeculæ, which may be easily punctured with a trochar. If, however, defective teeth should be present, they may be removed without hesitation—an operation which will give considerable assistance in reaching the goal. A pointed instrument is then forced with a twisting motion through the alveolus into the antrum. It is equally favorable whether the first or second molar tooth be selected; but it must be remembered that if the puncture be made through the first molar, the concavity below the zygomatic process and also the soft tissues of the cheek may be pierced. Therefore, when the instrument is passed through the alveolus of a buccal root, it should be directed slightly inward toward the palate; but if the alveolus of a palatine root be selected, the instrument should be directed straight upward. When the alveolus of the second molar tooth is selected, there is danger of forcing the instrument in front of the maxillary tuberosity. Therefore, it must not be forgotten to direct the puncture toward the *inner canthus* of the eye.

Aside from the ease with which the antrum is punctured from the alveolar process, it offers the additional advantage of opening the cavity at its lowermost point, and thus permitting all the pus to escape. The patient may also be able, when the puncture is made in this region, to wash out the antrum himself, in the manner ordered by a physician.

Immediately after the opening of the antrum, it should be washed out in order to give the patient relief, which will not occur until the pus has been discharged. This operation may be easily carried out by using an instrument, in making the perforation, which is of the same size as the canula of the syringe (for example 6 mm.). Thus the canula will fit well into the opening, which is of importance when it is desirous to exert a certain amount of pressure, as in case of a narrow ostium maxillare or thick pus. There is no indication for the employment of an antiseptic solution; on the contrary it suffices simply to fill the syringe with sterile water slightly heated. During the process the head should be bent forward. At the beginning a more or less viscid mass, according to the character of the collected secretion, flows from the nose. The more frequently the injections are repeated, the less turpid will be the water, until finally it flows from the nose absolutely clear.

It is as injudicious to let the wound alone as it is to insert a drainage tube. In the first case granulation takes place, which closes the opening, so that eventually it becomes necessary to make another perforation. Although the drainage tube permits the outflow of the secretion, it also carries infection into the antrum. The best method, therefore, and one employed by many practitioners, consists in inserting a properly fitting stopper into the perforated opening (see Fig. 65). This little instrument should have the same diameter (6 mm.) as the wound. Since the granulation tissue within the antrum soon grows upward around the stopper, it should be given a sufficient length, that is, about 2.5 c.m.; and in order to prevent it from slipping upward, a small plate is fastened at its base. Partsch constructed a drainage tube with valves which was very effective, but a solid stopper is more effectual than an India-rubber valve in preventing the entrance of food. Less important than the form is the material from which this little obdurator is constructed. For this purpose hard rubber may be employed, which is joined to a dental plate; equally as useful are aluminum, silver, gold, etc.

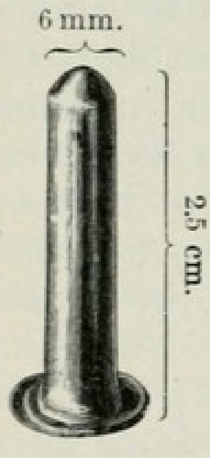

FIG. 65.—A stopper for closing the perforation into the antrum of Highmore. Natural size.

The *after-treatment*, if the above procedure has been carried out, is very simple. The day following the operation the antrum is washed out with warm distilled water injected through the perforation. If the water reappears clear, it may be expected that the process will heal without any further trouble. In most cases, however, the water remains turpid, and it will be necessary to attack the condition with antiseptic solutions. For this purpose a very weak solution of hydrogen peroxid is useful, as are also solutions of the sublimate of mercury, boric acid, etc. Insufflation of iodoform into the antrum has also been attempted, and Baume recommends washing with a glass of water containing a half teaspoonful of tannin.

In spite of the employment of these various remedies, all of which are equally good, healing may sometimes be prolonged for weeks, months, and even years. In chronic cases, at any rate, one has the satisfaction of having relieved the patient of the pressure, so long as he follows the instructions and washes out the antrum daily. Cessation in the excretion of the pus after a period of time does not necessarily imply that the empyema has been cured. Therefore, the stopper should not be removed and the wound permitted to heal until there has been no recurrence after a considerable length of time.

ACQUIRED AND CONGENITAL DEFECTS OF THE FACE.

The *acquired defects* of the face interest the dentist only when they involve the hard and soft palate and the alveolar process. In rare cases they are due to mechanical influences, as from a shot or a blow with a sharp or dull instrument passed into the mouth. Communicating openings between the oral and the nasal cavities occur, however, more frequently as the result of disease processes like syphilis and tuberculosis. Of these, syphilitic ulcerations are the most frequent, because tuberculosis of the mouth is less common than lues. In tuberculosis defects of the jaws are nearly always the sequelæ of facial lupus.

As either wounds or fissures with ulcerating edges accompany acquired defects, the *diagnosis* is easily made.

The *treatment* of acquired defects, as a rule, does not differ from that of congenital defects, and therefore a separate therapy need not be given. An exception is the *luetic defect* which, being sometimes quite extensive, may

FIGURE 66.

Upper illustration.—Front view of a four-weeks old embryo. *a.* Eyes. *b.* Lateral nasal process. *c.* Middle nasal process, with the two globular processes. *d.* Maxillary process. *e.* First branchial arch. *f.* This line points to the region of the olfactory pit. The red line indicates the Y-shaped fissure.

Lower illustration.—Face with a diagrammatic presentation (red) of fissure formation. *m.* Process of the lateral nasal fissure, which begins on the upper lip, at the point of predilection for hare-lip, and which extends toward the nasal opening, and sometimes even to the inner canthus of the eye. It results from failure of the proper closing of the middle (*a*) and lateral (*d*) nasal processes. *i.* Oblique fissure of the face lying between the lateral nasal process (*d*) and the maxillary process (*c*). *h.* Transverse fissure of the face lying between the maxillary process (*c*) and the first branchial arch (*b*). *k.* Median fissure of the superior maxilla lying between the two globular processes. 1. Median fissure of the lower jaw between the left and right branchial arches.

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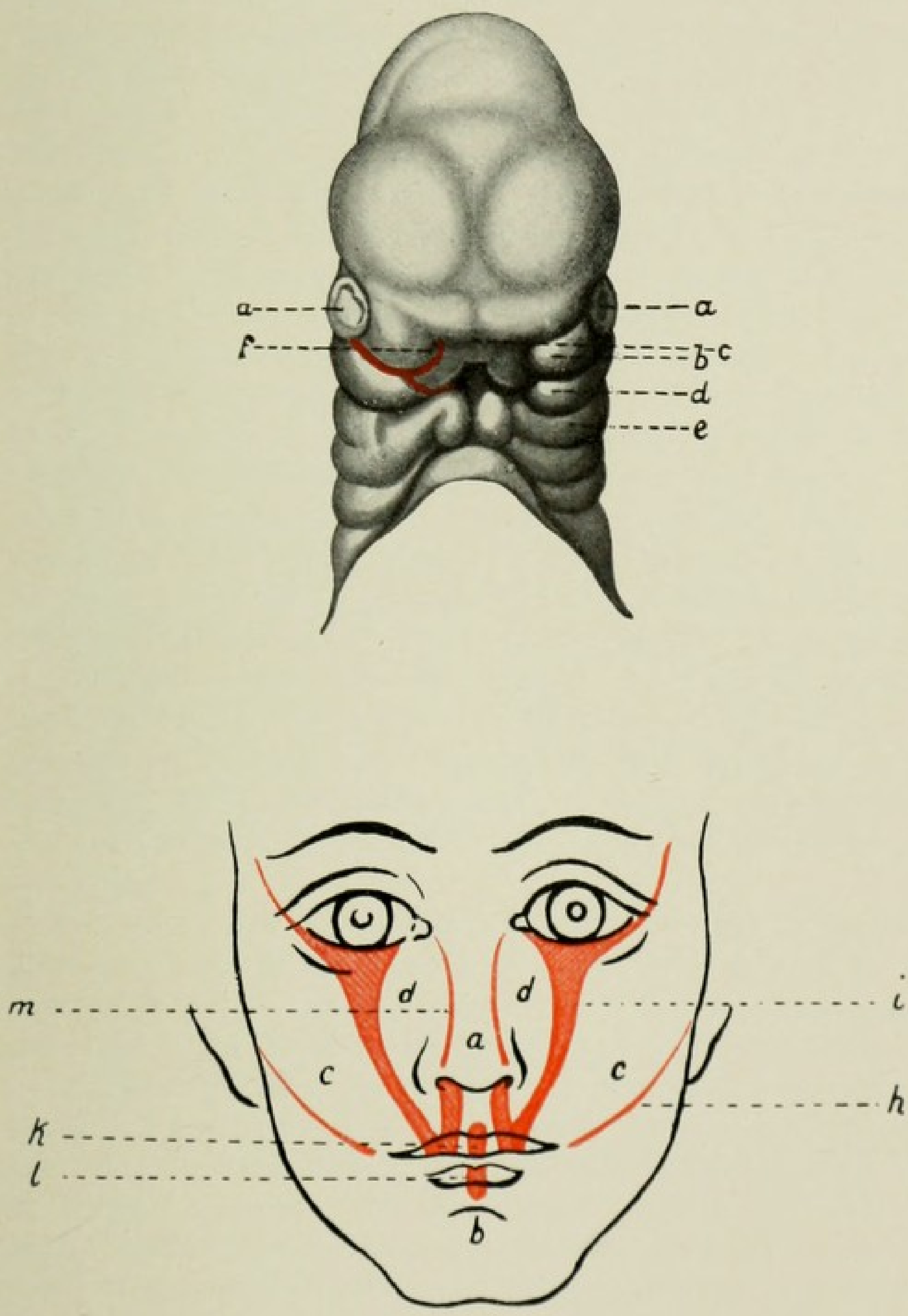
be cured through the constitutional treatment by mercury and potassium iodid.

The *congenital defects* of the face can only be understood by acquiring an exact knowledge of embryology, for they usually result from failure in union of those parts of the face which occur in pairs. Secondary separations of already united parts occur very rarely and are due to mechanical or pathologic causes. For practical reasons then *embryology of the mouth* will be discussed in this place.

Embryology of the Head.—The *head* is distinguishable in an embryo when it has reached a length of 7.5 mm.; that is, in the fourth week of intra-uterine life. At this time its length is about a quarter that of the whole body. The *midbrain* is best developed at this stage while the diencephalon and the prosencephalon, which lie in front of it, and the epencephalon and the metencephalon, which lie posteriorly, are as yet considerably backward in development. From Fig. 66 we observe that the *eye* is located underneath the diencephalon, to which it belongs because of its origin. The *olfactory organ* lies in front of the eyes at the lower border of the prosencephalon. This is at first indicated by a lateral depression, surrounded by a crater-like wall. Passing between the two portions of the organ of smell is a crest which is of great interest to dentists, as will be seen in the description of facial defects to follow. This is the *frontal process,* also

Fig. 66.



called the *middle nasal process*, to either side of which lie the two *lateral nasal processes*. Lying upon the epencephalon on a level with the second branchial arch is a pear-shaped elevation, the so-called *auditory organ*, the thick end of which lies in front, while the smaller end is directed backward. It lies too far posteriorly to be shown in the illustration. The four *branchial* or *faucial arches* are presented as thick swellings, which extend considerably forward. The *first branchial arch* extends the furthest forward, and almost reaches the olfactory organ. The *second* is also well developed, but is somewhat shorter than the first. Both arches are correspondingly lobulated in such a manner that each possesses an anterior and a posterior lobe. The *third arch*, although much reduced in size, shows a deep lobulation dividing it into two parts. The *fourth arch* lies below the cervical prominence, and is completely covered in that region by the third arch. The extent of the grooves lying between the branchial arches depends upon the length of the corresponding arch. Accordingly, it will be observed that the first groove, which lies between the first and the second branchial arches, is very long ; the second, lying between the second and third branchial arches, is decidedly shorter ; the third and fourth grooves are partially hidden within and are still shorter than the foregoing.

The question arises, what is formed by the first branchial or faucial arch in the course of development ? The first branchial arch forms the *lower jaw*. We may conclude at once that the whole face, that is, the part between the mouth and forehead, must develop from the exceedingly shrunken portion lying between the first branchial arch and the prosencephalon. The fissure in front of the first branchial arch may be designated as the *primitive oral cleft*. In the upper illustration of Fig. 66 is seen a swollen projection situated between the first branchial arch and the frontal region, which at this time is already well developed. This is the *superior maxillary process*, which later forms the side of the face. On one side it touches the eye and on the other side the olfactory pit. It lies, therefore, between these organs, and projects with its free rounded end into the primitive oral cleft.

The maxillary process forms the following bones: the upper jaw, the malar, the palate, and the sphenoid. The so-called *frontal* or *nasal process* grows obliquely downward from the lower surface of the prosencephalon in a medial direction toward the oral cleft. The surface of this frontal process is not smooth, but is broken by *a groove on both sides* which run to the olfactory pit and to the eye. These grooves divide the frontal process into a *median* and a *lateral frontal* or *nasal process.* The median broad groove (*nasal groove*), which divides the middle nasal process into two parts, creates two lobulated formations by joining with the groove that divides the middle from the lateral nasal process. These lobular formations project into the oral opening, and are known as the *globular processes.*

The *nasal septum,* which originally consisted of two flaps of tissue and the intermaxillary bone which contains two incisor teeth on either side, arise from the middle nasal process. The lateral nasal processes form the nose; that is, the lateral nasal cartilages, the nasal bone, the lachrymal bone, and the turbinate process of the ethmoid bone.

These various bones begin to grow together when the embryo has reached a length of 11 mm., that is, during the fifth week of fetal life. The maxillary processes by growing energetically forward toward the median line, come in contact with the median nasal process, which by this time has also developed more fully. In a lateral direction it grows around the eye. On the other hand, the lateral nasal process is more backward in development, and becomes compressed into a narrow space which lies between the eye, the frontal crest, median nasal process, and maxillary process. The middle nasal process shows greater development at the sides than in the center. This causes an indentation which is of significance in the later development of the face, and especially of the nose. Gradually the embryotic head assumes a more human form. The finer modulation takes place in the eighth week; the nasal septum becomes narrower, and at the same time higher, which causes the nose to become elevated above the surface of the face. The ears grow slowly upward, the eyes pass from the side forward, toward the median line. The chin begins to project and the oral cleft, formerly five-cornered, becomes a simple slit. The median notch of the upper lip has grown closed and the formation of the *philtrum* begins; the latter is the superficial groove which is directed downwards from the nasal septum.

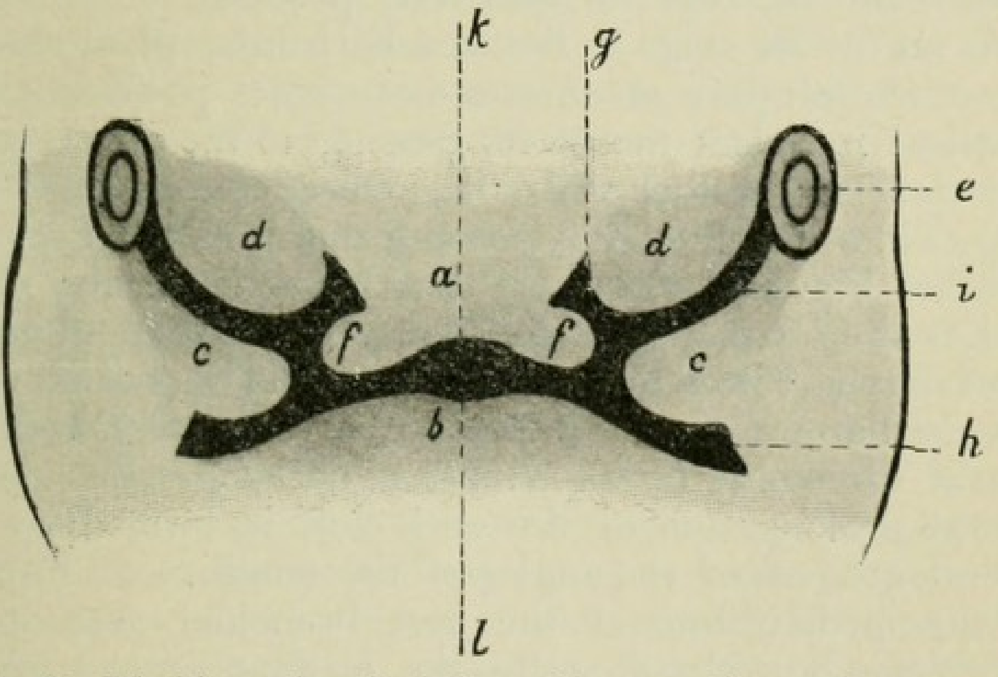


Fig. 67.—Primitive oral cavity (schematic): *a*, median nasal process with (*f*) the globular processes; *b*, first branchial arch; *c*, superior maxillary process; *d*, lateral nasal process; *e*, eye; *g*, lateral nasal groove; the line points toward the olfactory pit; *h*, lateral groove of the angle of the mouth; *i*, oculonasal groove; *k*, median cleft of the first branchial arch.

Aside from these introductory remarks on the development of the face we have still to consider the special formation of the mouth in order to explain the pathologic fissure formations. As we have seen, the mouth did not originally represent a simple slit, but a whole series of fissures radiated from it, which have been obliterated by the accompanying processes. Fig. 67 represents the primitive oral fissures schematically. There exist at this stage five grooves: 1. The *median groove* (*k*) of the middle nasal process, short but yet comparatively wide. 2. A second somewhat longer but narrower groove, the so-called *nasal groove* (*g*), occurring in pairs, and leading from the oral cavity to the olfactory pit; on the median side it is bordered by the inner nasal process, laterally by the outer nasal process, and below by the maxillary process, at the median extremity of which it empties into the oral cavity. 3. The *oculonasal groove* (*i*) which for a short distance from the oral cavity begins and runs in common with the nasal cleft, extending to the eye, which it partially surrounds. It is principally bounded by the lateral nasal process and the superior maxillary process.

At an earlier stage it lies in a horizontal plane, but in the course of time assumes a more erect position. For practical purposes the clefts passing to the olfactory pit and the eye, together with the associated processes that project into the oral cavity, are referred to as the *Y-shaped cleft* (see Fig. 66). Between the two upper limbs of the Y lies the *lateral nasal process.* In a medial direction from the short limb of this cleft lies what has been termed the *globular process* of the median nasal process, and in a lateral direction the *superior maxillary process.* 4. A lateral prolongation of the oral cleft is formed by the lateral grooves of the angles of the mouth. 5. Finally, at the median line of the first branchial arch lies a depression exactly opposite the median groove of the middle nasal process (*c*).

Of the development of the true *oral cavity*, we will consider only that which is of interest in connection with the formation of fissures or clefts. The *roof* of the oral cavity is formed by the maxillary process through its palatine plate, which gradually joins its opposite fellow in the median line. The middle nasal process passes from in front between these plates, and, as the anterior and lower termination of the nasal septum, forms the intermaxillary bone. The latter leaves a small opening on either side where it joins the palatine plate, known as the *foramen incisivum.* The upper lip is formed by the union of the two globular processes with the intermaxillary bone. The globular processes have two processes directed backward, which gradually approach each other, and becoming flattened, form two vertical opposing plates. The latter grow together and give rise to the cartilaginous portion of the nasal septum.

After the above description the explanation of the development of *congenital clefts* in the region of the mouth, provided they are typical and not complicated by other pathologic processes, should present no great difficulties.

The most frequent cleft is that which results in consequence of failure in union of the Y-shaped fissure, as is shown in the upper illustration of Fig. 66. This defect is particularly likely to occur in the union of the medial (see also Fig. 67 *g*) and the lower limbs. The *lateral cleft* of the lip (Fig. 66, lower illustration), also known as *hare-lip*, is due to this failure in union of the medial with the lower limb of the Y-shaped fissure. It indicates, therefore, faulty growth of the middle and lateral nasal processes, and as a result the lip is divided into two parts in the region between the lateral incisor and the cuspid tooth. Hare-lip is commonly one-sided, but if it occur on both sides, the middle portion of the lip, together with the philtrum, intermaxillary bone, and nasal septum may project to a less or greater extent beyond the plane of the face as the so-called *rump* or *Bürzel*. Even Goethe recognized that faulty union of the superior and intermaxillary bones led to the formation of double hare-lip. He did not, however, correctly explain the origin of single hare-lip, for he thought it to be due to imperfect union of both maxillary bones. The reason for this mistake is that he overlooked the lateral position of the hare-lip. He had evidently imagined it to be in the middle line of the upper lip where it occurs only in very rare instances, and then in consequence of improper closure of the median groove of the mesial nasal process.

Hare-lip, instead of terminating at the nasal orifice, occasionally extends vertically upward as the *lateral nasal cleft* to the region of the base of the nose. Analagous to hare-lip this cleft may also occur on both sides, in which case the nose projects prominently forward supported in back only by the septum. Genetically the lateral nasal fissure is due to improper union of the inner line of the Y-shaped cleft, which runs to the olfactory pit. Therefore, the mesial nasal process, which is divided by the nasal groove, cannot unite with the lateral nasal process.

The *oblique facial fissure* is a large groove which begins at the hare-lip, or more frequently to one side of it, and runs obliquely toward the eye and ends in the lower eyelid as a coloboma. Indeed, it may even in severe cases encircle the lower portion of the eye and reach laterally to the ends of the eyebrows. This oblique facial defect follows imperfect union of the lateral limb of the Y-shaped cleft; that is, of the lateral nasal and superior maxillary processes, and represents the *oculonasal groove* (Fig. 67 *i*).

If the space between the first branchial arch and the superior maxillary process remains open, the *transverse facial fissure* results. This represents, therefore, a persistency of the primitive angle of the mouth (see Fig. 76 *h*). An evident contradiction to this statement is the fact that the transverse facial cleft forms an oblique arch (where convexity is above) in its course toward the ear; for the auditory germ lies much lower in the region of the second branchial arch. This direction may, indeed, be first understood when the ear is raised from the second to the first branchial arch.

Cleft formations in the mesial line are much rarer than those of the lateral grooves; they represent a splitting of the upper jaw, of the *mesial cleft of the upper lip*; that is, the formation of the philtrum is retarded and in its place a fossa is formed. The process concerned is a retardation in the ultimate mesial division of the middle nasal processes (Fig. 67 *k*), on account of which the globular processes cannot unite. In fact for embryologic reasons, this cleft can never stretch out beyond the base of the nose. Still in severe cases, for want of a proper base, the development of the nasal tip may be impossible; in that case the nasal orifices spread far apart and between them is stretched a flat, often a concave, area of skin.

The rarest defect is due to failure in union of the first two branchial arches, on account of which a *mesial cleft of the lower lip* results.

Of most interest to dentists are the *lateral labial* or *nasal clefts.* These may be confined to the external soft parts or they may extend to the interior of the oral cavity. In the first case the defect is a hare-lip (*labium leporium*), and in the second a cleft palate (*palatum fissum*). According to the location the following nomenclature has been adopted : If the fissure formation does not extend beyond the limits of the lip, the condition is called *cheilochisma* ; this is the true hare-lip. If this defect be complicated by a cleft of the alveolar process of the upper jaw, the term *cheilognathochisma* is employed. If the abnormality be also accompanied by division of the soft palate, the condition is called *cheilognathouranochisma* ; in this case the whole palate is split. When the division is but partial it is a *uranocoloboma.*

Depending upon the position of the intermaxillary bone a *cleft of the palate* begins between the lateral incisor and cuspid teeth, and reaches the middle line only after it has encircled the intermaxillary bone. This cleft establishes a communication between the oral and the nasal cavity. In the case of double cleft palate the nasal septum projects independently into the oral cavity. In addition to the hard palate the soft palate may be split, and the resulting cleft reach so far back that the uvula is separated into two parts ; and indeed the uvula as well as a more or less large portion of the velum palati may be absent.

From a clinical point of view the *facial clefts* are of great importance, because of their disfigurement and their interference with speech. Children possessing such defects have a much higher mortality rate than normal. They die because of the interference with the ingestion of food or from disease of the respiratory organs because of the unlimited entrance of air.

For these reasons the *treatment* is of great interest to surgeons and dentists. That of *hare-lip* consists in instituting as soon as possible a surgical operation with the object of securing union of the edges of the lip by scraping them and then suturing them together; this is called *cheiloplasty*. The principle of the treatment of the *cleft palate* is similar to the former; in this case, too, the edges are fastened and sutured. This operation on the hard palate is termed *uranoplasty*. As there is always insufficient mucous and periosteal membrane, it does not suffice simply to unite the two edges of the wound, but in addition two lateral incisions should be made parallel to the cleft, one on each side in order that the tissues may be stretched. The operation on the soft palate, called *staphylorrhaphy*, consists in uniting the velum palati with the uvula.

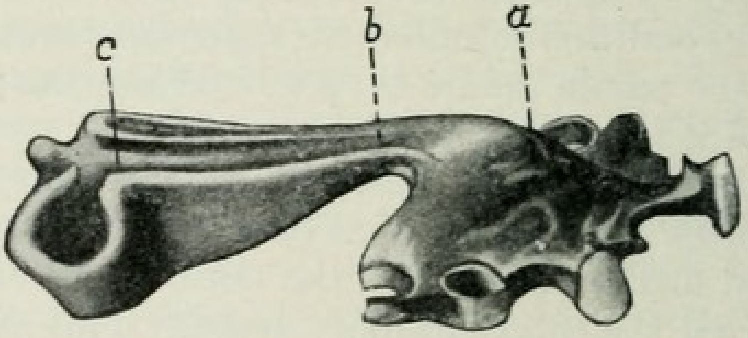


FIG. 68.—Palatine obturator of Suersen: *a*, dental plate; *b*, fixed connecting process; *c*, hard rubber head piece.

It is, however, often impossible, when the defect is too extensive, to secure union by means of the above operations. In such cases it is necessary to employ an *obturator;* that is, an apparatus which will close the defect. If only a coloboma or a cleft of the *hard palate* be present, it is quite easy to close the defect. This is done simply by forming a palatine plate from India-rubber or metal, and attaching it to the teeth by gold clasps. In the case of defects of the *soft palate* the construction of an apparatus is not so simple, because of the functions of this part—talking and swallowing. A simple and useful apparatus for this purpose has been constructed by Suersen. It is based on the physiologic principle that, during speaking and swallowing, the communication between the oral and nasal cavity must constantly close and open.

In the healthy person this closure is obtained, on the one side, by elevation of the lavator palati muscle and with it the velum. Simultaneously, on the other side, the superior constrictor muscle of the pharynx contracts, and thus forces the posterior pharyngeal wall forward. In this manner the velum palati and pharyngeal wall are brought together, and form an air-tight closure which may open at any time or to any degree. Such requirements are fulfilled by the apparatus of Suersen, which replaces the velum palati with a hard mass (hard rubber), shaped like that structure. That portion of the velum which may be present glides into the lateral grooves of the apparatus.

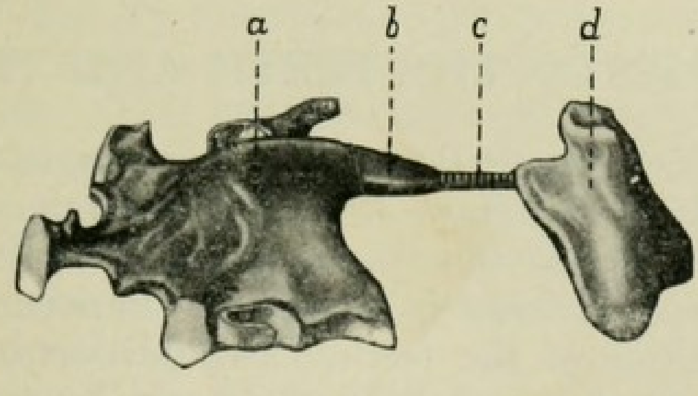


FIG. 69.—Palatine obturator of Schiltsky, in a somewhat altered form: *a*, dental plate; *b*, lock; *c*, spiral spring; *d*, soft rubber bulb.

When the pharyngeal wall bulges forward it presses against the posterior wall of the obturator, and thus divides the nasopharyngeal wall into an upper pharyngo-nasal cavity and a lower pharyngo-oral cavity. Thus the required closure is obtained. The obturator of Suersen can only be employed when the velum palati is absent; if it still exist and still show fairly good union, or when a staphylorrhaphy has been previously performed with some success, we must resort to other remedies.

Schiltsky has solved the problem of applying an obturator in those cases in which the velum palati still partially exists. According to his method, the closing of the nasopharyngeal space is obtained by means of an *elastic balloon* which responds to all the changes in form that occur in speaking and swallowing. By means of a spiral spring the balloon is connected with a plate covering the hard palate ; this arrangement permits all movements of the soft palate to be shared by the balloon. Although more easily destroyed than hard rubber it is better to construct the bladder of soft rubber, as hard rubber tends to cause pressure (Fig. 69). The soft rubber "bulb" should be made as light as possible, in order that its weight will not draw the spring downward, a condition which would prevent its responding to the movements of the soft palate. This is best accomplished by vulcanizing a nucleus of cork into its center.

ANOMALIES OF THE TEETH AND THE JAWS.

With reference to the *causation* of anomalies of the teeth and jaws, Virchow observes that on the one side the normal pressure of the *tongue*, and on the other side, that of the *lips* and *cheeks* is of greatest importance for the proper position of the teeth. In addition to these two influences, we have that of the normal act of *chewing*, which may also affect the position of the teeth. The same writer claims that *prognathism of the upper jaw* occurs in cretins because the tongue becomes enormously enlarged and forces the teeth forward. *Prognathism of the lower jaw* is especially likely to develop in persons possessing a cleft palate, because the stretched upper lip presses on the upper incisors, while the tongue presses upon the lower teeth. Furthermore *adenoid growths* of the pharynx require the mouth to be kept open, and as a result the teeth do not bite upon each other, and the consequent influence upon the buccal pressure may lead to a narrow superior maxilla.

Undoubtedly, the first cause of such anomalies in healthy persons is *insufficiency of space*, due to the fact that children of civilized races inherit small jaws. The teeth then press each other out of position. This argument of Sternfeld is contradicted by Warnekros, who assumes that the inheritance of a small jaw must necessarily mean the inheritance of small teeth, because of the degeneration following inactivity. However, we may accept the theory of the insufficiency of space, for Rütimeyer has determined that the teeth very frequently show evolutionary vestiges, indicating that teeth undergo alteration less rapidly than the surrounding structures. Accordingly we have inherited the large teeth of our forefathers, and the small jaws of our parents. That this is true has also been shown by Walkhoff, who explains it by the character of tooth development. If the outer plate of the human jaw be chiselled away at the time of the substitution of the deciduous by the permanent teeth, it will be observed that the secondary teeth germs are extremely irregular in their arrangement between the roots of the first teeth. This irregularity, however, is found only in civilized people; barbarians retain a perfect regularity in the arrangement of their teeth. In consequence of the irregular position of the secondary tooth germ, the resorption organ is forced out into a false position, or not at all against the deciduous tooth.

The *premature loss of the first teeth* has an extremely disadvantageous influence upon the permanent teeth. This is particularly true of the second deciduous molars which should be retained as long as possible. If these temporary molars are lost prematurely either through extraction or caries, the first permanent molar rises immediately into the alveolus and deprives the bicuspid teeth of their proper space, which therefore must seek a false position when they erupt later. According to Walkhoff, there results a remarkable tendency of the teeth within the curvature of the dental arch to close tightly the tooth row.

If permanent teeth are lost, the remaining teeth become easily displaced. This is especially the case when the articulation of the molars is destroyed, for then the anterior teeth become displaced forward. If an antagonist be absent, the opposite tooth grows in length in its endeavor to reach the other tooth within the space, until it becomes loose and falls out.

Frequently too many germs are constricted from the tooth band which occasionally erupt, and nearly always outside of the normal tooth row, because they can find no place within it. More rarely an *insufficient number* of teeth are formed. This occurs occasionally in cretins and in imbeciles, and also when normally developed teeth become eliminated during the course of evolution. It is well known, for instance, that the third molar tooth tends to disappear in civilized people, while the same tooth in barbarians still possesses its full size. The upper lateral incisors also tend to undergo degeneration, and not infrequently we find people without this tooth (Fig. 62 *a*).

Amoëdo has called attention to the interesting fact that a certain connection exists between the development of hair and that of teeth ; namely, that hairy people have too few and insufficiently developed teeth.

Aberration of the tooth band may lead to heterotopy, that is, one tooth may erupt in the space belonging to another.

Constitutional diseases, for example, rhachitis, scrofula, and inherited syphilis, may cause deformities of the teeth and the jaws, and thus lead to irregularity in the position of the teeth, as well as absence of individual teeth.

Finally, attention must be called to the effect of *traumatism* upon anomalies in the position of the teeth. A *fracture*, in as much as it is associated with dislocation of a portion of the jaw that contains teeth, may lead to dislocation of one or more teeth. To the class of traumatism belong the conditions following the habit of *sucking the thumb* and other objects, both of which may cause in children disharmony of the dental arch.

The disturbances influenced by irregularity of the teeth are of a cosmetic nature ; that is, the appearence suffers to a greater or less extent. Mastication is also interfered with when the occluding surfaces of the opposing teeth do not meet. Furthermore irregularly set teeth may injure the mucous membrane of the lips and cheeks as well as the tongue. They may even occasionally interfere with speech, especially when the tongue strikes on dislocated teeth; indeed stuttering has been observed to follow such an anomaly.

Irregularly set teeth are more susceptible to caries than the normal teeth, because it is more difficult to keep them clean. This is especially the case when the tooth stands within or without the dental arch. In *prognathism* and in *orthognathism*, in which the incisors of the upper and lower jaws articulate improperly, the teeth are ground down prematurely. This also frequently occurs when the molars fail to articulate properly. The anomalies may present the following varieties.

ANOMALIES OF FORM IN INDIVIDUAL TEETH.

The form and the size of the crown as well as of the roots of the tooth may show considerable variations. The roots are especially likely to be the seat of abnormal conditions.

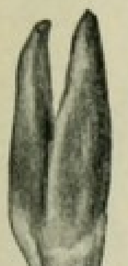


FIG. 70.—Upper lateral incisor tooth with two roots.

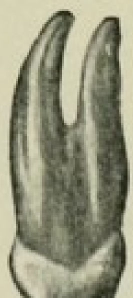


FIG. 71.—Upper cuspid tooth with two roots.

FIG. 72.—Lower bicuspid tooth with a hook-shaped curvature of the root.

Incisor and cuspid teeth frequently have two roots, (Figs. 70 and 71). Their roots also occasionally show great irregularity. This is true also of the bicuspid teeth. In Figs. 72 and 73 are shown bicuspid teeth with crooked roots. A peculiarly constructed first upper bicuspid tooth, composed apparently of two individual teeth, is shown in Fig. 74.

The cases are rare in which the first upper bicuspid which usually possesses but two roots have three roots. Such a tooth is shown in Fig. 75.

FIG. 73.—Lower premolar with peculiarly curved root.

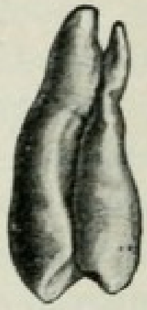


FIG. 74.—First upper bicuspid, which is curved to such an extent on its longitudinal axis as to give the impression that it consists of two teeth grown together.

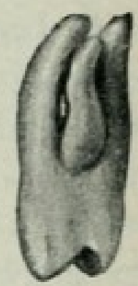


FIG. 75.—First upper bicuspid with three roots.

The roots of the molar teeth are even more frequently abnormal than those of the front teeth. A high grade divergence (Fig. 76), as well as an equally high grade convergence (Fig. 77), are not so very infrequently observed. Both conditions increase the difficulty of

FIG. 76.—Upper molar tooth with decidedly diverging roots.

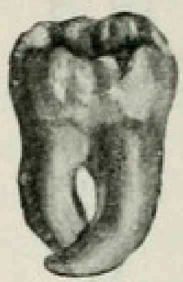


FIG. 77.—Lower molar with decidedly converging roots.

FIG. 78.—Lower incisor tooth with five tortuous roots. (All the roots are not shown in this illustration.)

sounding the roots as well as extracting teeth. Of the many abnormalities of the third molar or wisdom teeth that are met with only one is presented (Fig. 78). In this case a lower wisdom tooth possesses five bent roots.

ANOMALIES IN POSITION OF INDIVIDUAL TEETH.

Although individual teeth may occasionally stand in their normal position in the tooth row, they may be *twisted on their long axis* (Fig. 79). They may vary, however, in all possible directions from their normal position. This torsion occurs more frequently in the incisor teeth and indeed more often in the upper than in the lower. However all the remaining teeth, but most rarely the molars, are subject to this anomaly.

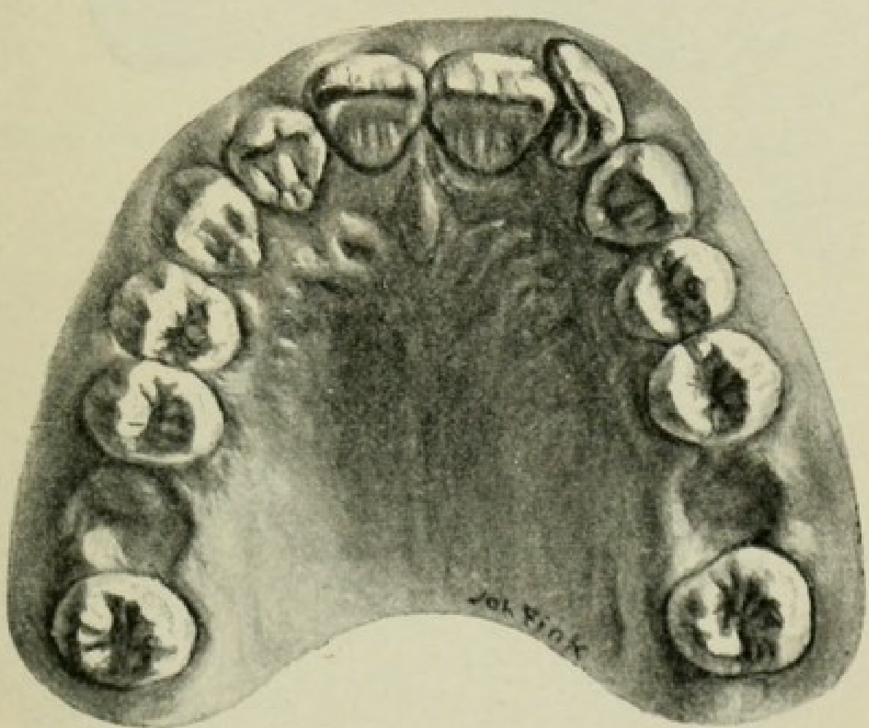


FIG. 79.—Torsion of a left upper incisor tooth.

Furthermore, a tooth may stand to the *outside* or to the *inside* of the *dental arch.* The first anomaly is very often observed in the upper cuspids, which, at the time of eruption, find the space assigned to them already occupied and therefore are forced to erupt to the outside. The lower incisor teeth may also erupt in a lingual direction and the upper incisors in a palatinal direction from the dental arch (see Figs. 80 and 81). The bicuspids are much more rarely located outside of the dental arch, and when they are, it may be nearly always assumed that the corresponding deciduous tooth was lost too soon, allowing the space to close up before the permanent teeth made their appearance.

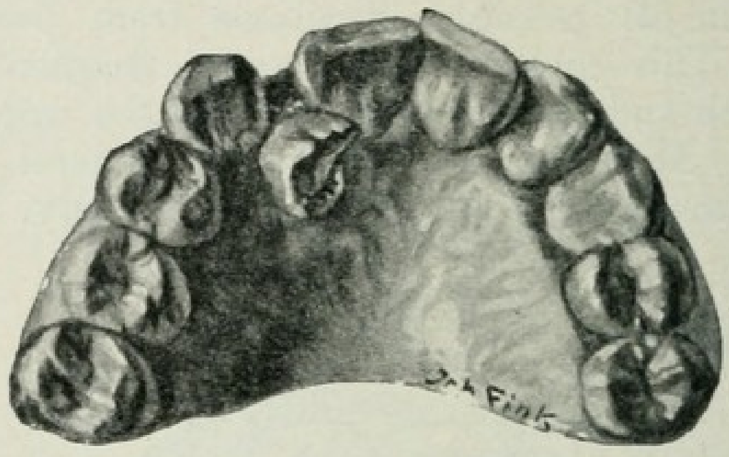


FIG. 80.—Lateral upper incisor tooth turned in a palatinal direction from the dental arch.

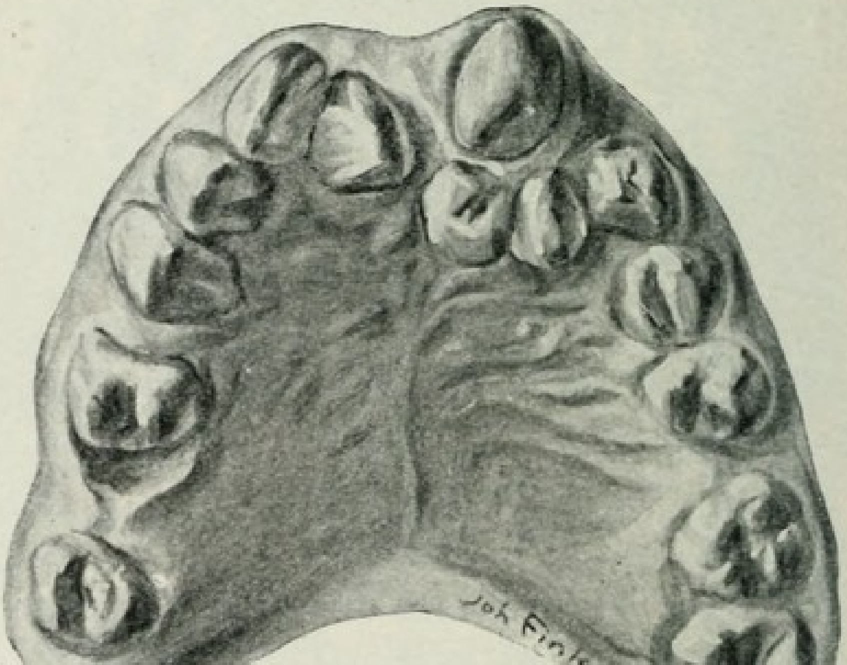


FIG. 81.—Three incisor teeth of the upper jaw which erupted to the palatinal side of the dental arch.

The condition in which two teeth exchange their positions, or in which one tooth is located in the space belonging to another, is known as *heterotopia* or in a popular sense, *transposition*. The bicuspids are the most prone to exchange their positions with the incisor teeth. Magitôt

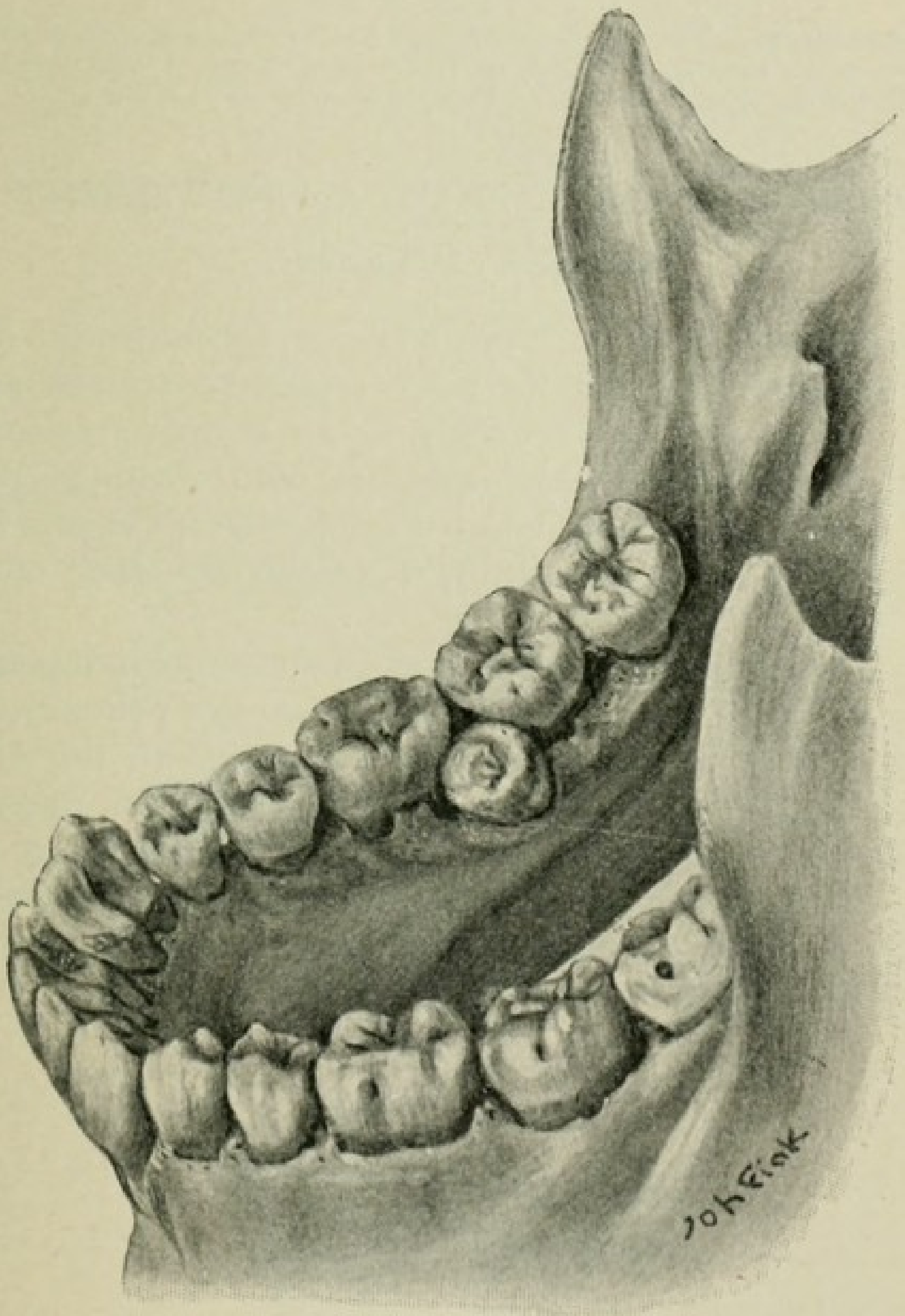


FIG. 82.—Supernumerary tooth between the first and second right lower molar.

speaks of a *heterotopia par génèse*, when teeth outside of the tooth-row erupt into the hard palate, the antrum of Highmore, and even into the orbit.

PLATE 16.

Prognathism. The upper jaw together with the base of the nose is extended forward at an extreme degree. The lower jaw is normal. From a child 16 years of age.

PLATE 17.

Prognathism. The lower jaw protrudes to such an extent that its teeth, when the mouth is closed, lie in front of those of the upper jaw. The superior maxilla is normal. From a woman 50 years of age.

SUPERNUMERARY TEETH. AN INSUFFICIENT NUMBER OF TEETH.

Supernumerary teeth show various formations. They either simulate normal teeth or represent simple cuspid teeth. They owe their origin to an overproduction of enamel germs which have sprouted and attached themselves to the connecting band between the primary tooth germ and the oral epithelium, or to the secondary enamel germ itself.

Busch considers genuine *peg-shaped teeth* as independent forms, which have been separated from the primary tooth germ by mechanical influences. Contrary to the observation of other investigators, he does not look upon the formation of these teeth as *atavistic phenomena*, a view which one would be justified in believing when the original haplodont, multi-toothed type of the mammals is taken into consideration.

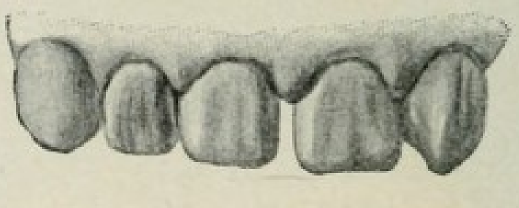


FIG. 83.—The lateral left incisor tooth failed to reach development (reduction).

Supernumerary teeth occur more frequently in the region of the incisors than in that of the molar teeth; supernumerary molar teeth are however occasionally seen. An example of this type of tooth is pictured in Fig. 82.

Tab. 16

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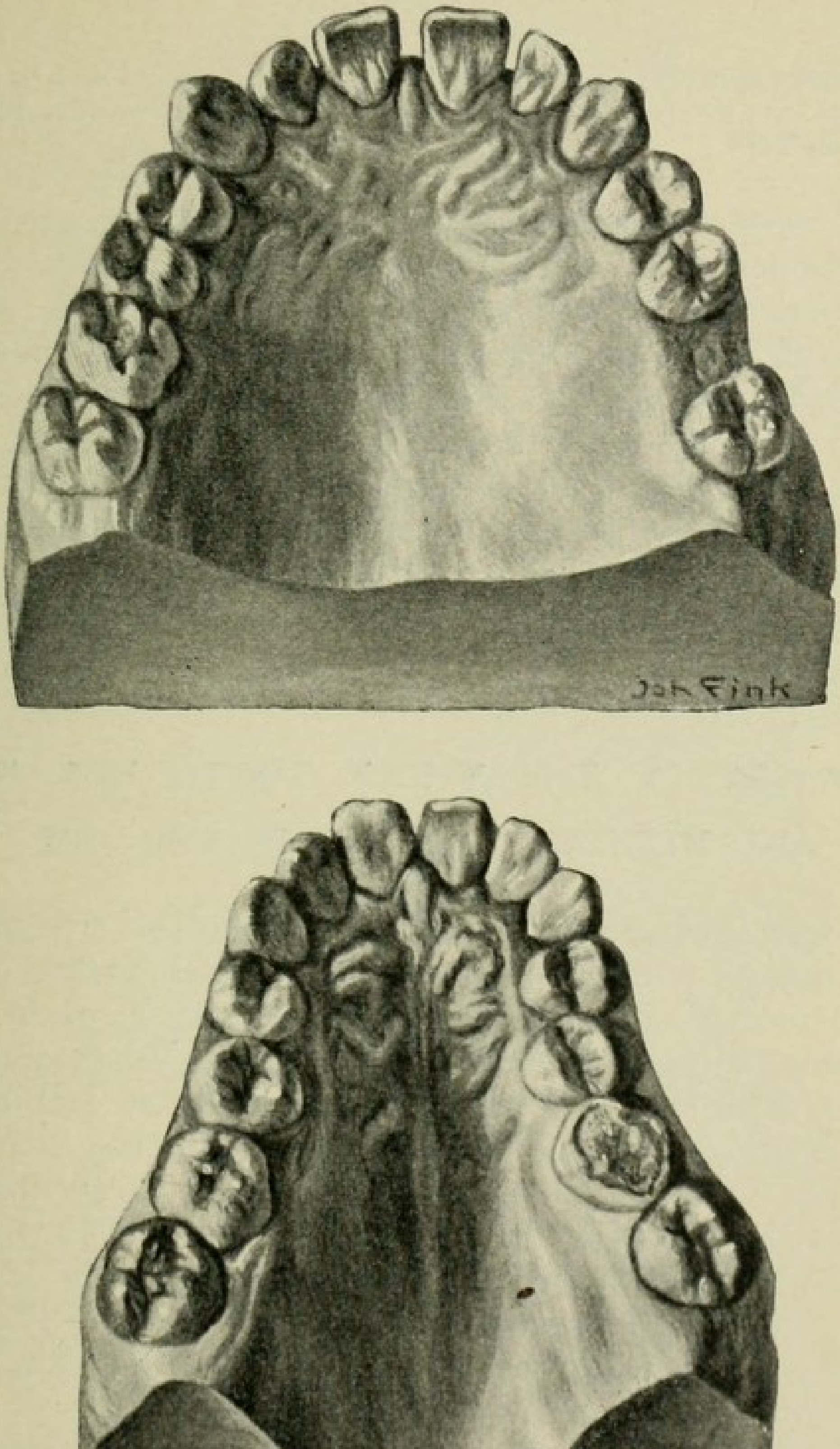


FIG. 84.—*Upper illustration.* The normal width of the palate. *Lower illustration.* A contracted palate which is retracted in the region of the bicuspid teeth.

PLATE 18.

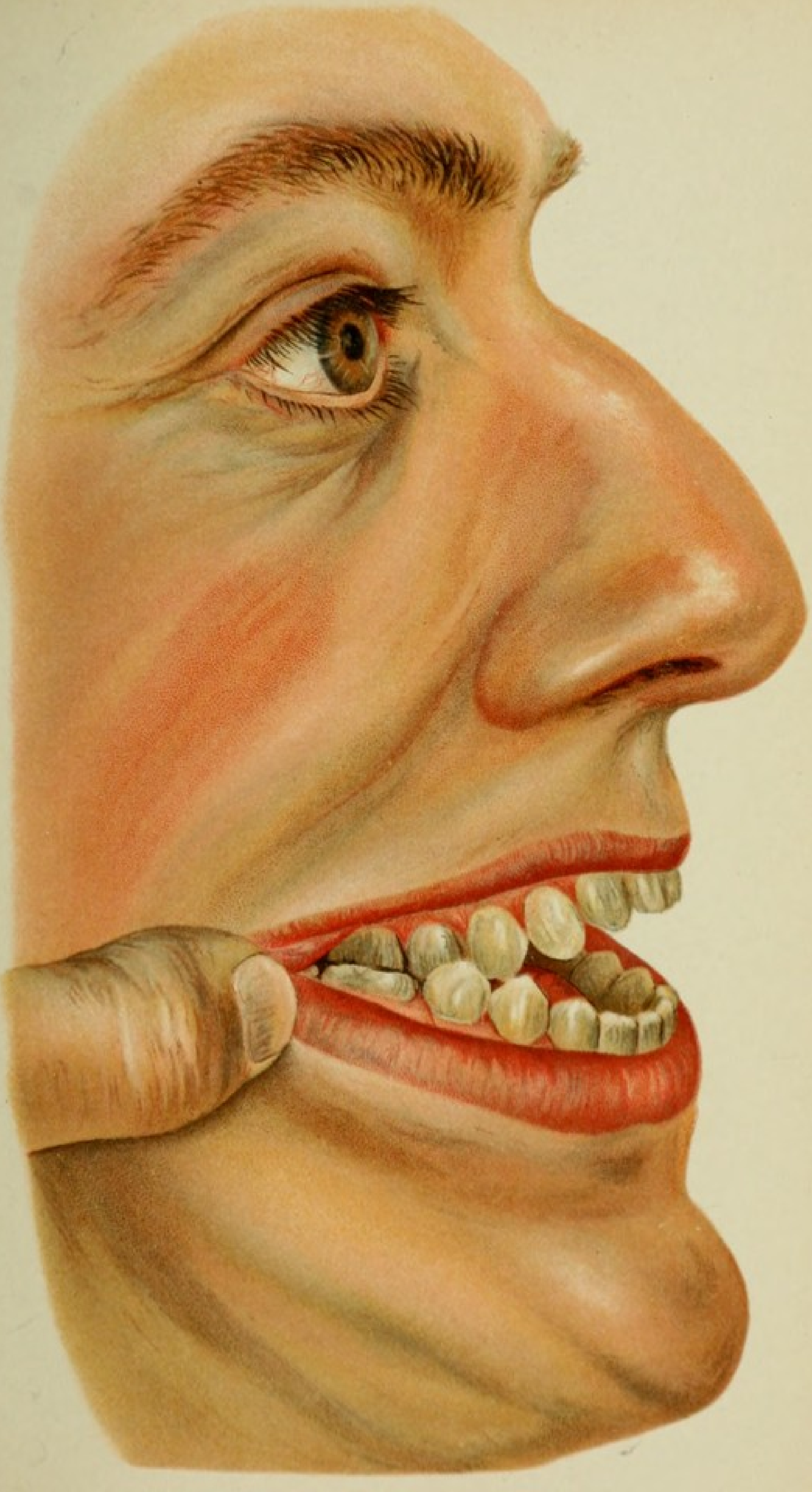
Mordex apertus. Although the molar teeth touch each other in this case, yet the patient is unable to bring the front teeth of the two jaws together.

An *insufficient number of teeth* is of less importance to the practitioner than an abnormally large number. This condition may be due to a retrogressive process of the human dental apparatus. As examples of this anomaly, to which reference has already been made, we have the wisdom and the upper lateral incisor teeth (see Fig. 83), which, according to the observations of most authorities, have undergone retrogressive changes. In explaining the failure of some teeth to appear in the tooth row, we must take into account the *retention* of tooth germs, or of fully developed teeth.

ANOMALIES OF THE WHOLE TOOTH ROW WITH AND WITHOUT CHANGES IN THE JAW.

In people of the civilized races, when the two sets of teeth occupy normal positions, the lingual surface of the upper incisors in closing the mouth should glide past the labial surface of the lower incisors. When the two sets of teeth bear this normal relationship to each other, the condition is called *orthognathism*. Should the teeth not meet in this manner the cutting edges of the incisors instead resting upon those of their opposite fellows, the result is a rapid wearing away of the incisors of both jaws; they may eventually be worn off down to the edge of the gums. In the ancient Egyptians and Celts, this condition is believed to have been physiologic.

In *prognathism* of the upper jaw (Plate 16), when the mouth is closed, the upper teeth no longer reach the lower, but stand above and in front of the lower set of teeth. This pathologic prognathism is not to be mistaken for the physiologic form as seen in negroes, in which both the upper and lower jaws protrude.



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Pathologic prognathism shows many variations ; it may consist simply in a moderate extension forward of the upper teeth which are separated from the lower teeth by only a few millimeters ; or the separation may equal a centimeter, in which case, of course, the superior maxilla has developed to an unusual size. In many cases prognathism of the upper jaw is simulated by failure of the lower jaw to develop to its normal size, while the superior maxilla is fully developed. If, on the other hand, the lower jaw protrudes, we have the condition known as *prognathism of the inferior maxilla* (Plate 17). According to Virchow, the lower jaw of the inhabitants of Friesland protrudes normally so far beyond the upper jaw, that the lingual surface of the lower incisors points to the labial surface of the upper incisor teeth. The pathologic form of prognathism of the lower jaw is not always due to excessive growth of the inferior maxilla (analagous to prognathism of the upper jaw), for on the contrary it may be normal in development, the superior maxilla having failed to reach its normal size.

Mordex apertus carabelli (Plate 18), or " malocclusion," is a rare condition in which the two rows of teeth do not meet in the neighborhood of the incisors. It occurs chiefly in children who suffer from hypertrophied tonsils or from adenoid growths of the nasopharynx, on account of which the mouth is continually kept open. As a result the alveolar portion of the jaws in the region of the molars grows abnormally large.

The *contracted jaw* (Fig. 84, lower illustration), which undergoes a saddle-like contraction in the neighborhood of the bicuspid teeth, may also occasionally cause prognathism and mordex apertus. This condition is always associated with a high palate, and is really an anomaly of the jaw in which the teeth do not assume their altered positions until the second dentition. Down found the contracted jaw with a high palate chiefly in idiots.

The so-called *V-shaped jaw* (Fig. 85) must not be mistaken for a contracted jaw. The former does not possess a dental arch, but instead the teeth form a straight line on each side, meeting at the incisor teeth to form an acute angle.

This V-shaped jaw, which is considerably below normal in size, does not occur in idiots but on the contrary is very frequently seen in intelligent and well-developed individuals. It represents probably a retrogressive process in which the jaw becomes reduced in size at the expense of the cranial portion. A high palate and prognathism of the upper jaw are also associated with the V-shaped jaw.

The *treatment* varies with the requirements of each individual case and should not be instituted until important indications arise. The treatment of anomalies in position of individual teeth is purely operative. The cause of such anomalies can usually be traced to a lack of space, and, therefore, in such cases it is necessary above all things to secure more room. This is done by spreading the arch

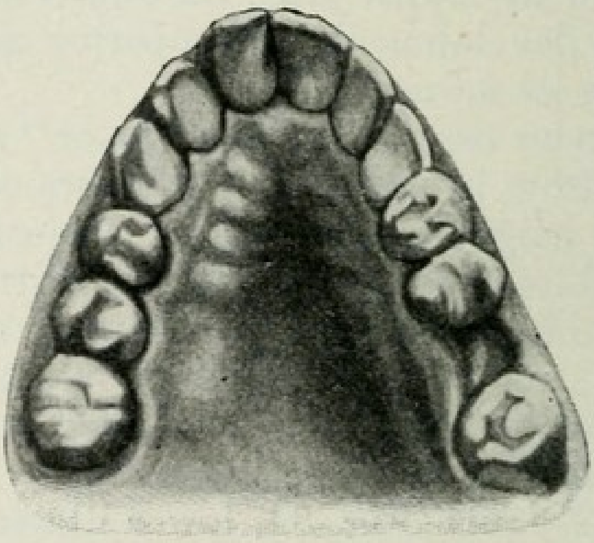

FIG. 85.—V-shaped palate in a child 15 years of age.

and thus securing the desired space; or by the extraction of a neighboring tooth, especially when it is less developed than the improperly placed tooth. The latter then moves of its own accord into its proper location. If, because it is sound and healthy, there should be any hesitancy to sacrifice it, other teeth may be extracted, as for example, the bicuspids and molars. The dental arch is then easily forced to assume its normal relations by applying a proper regulation apparatus. As we have already suggested, the most satisfactory results are obtained by expanding the whole jaw in order to obtain the requisite amount of room.

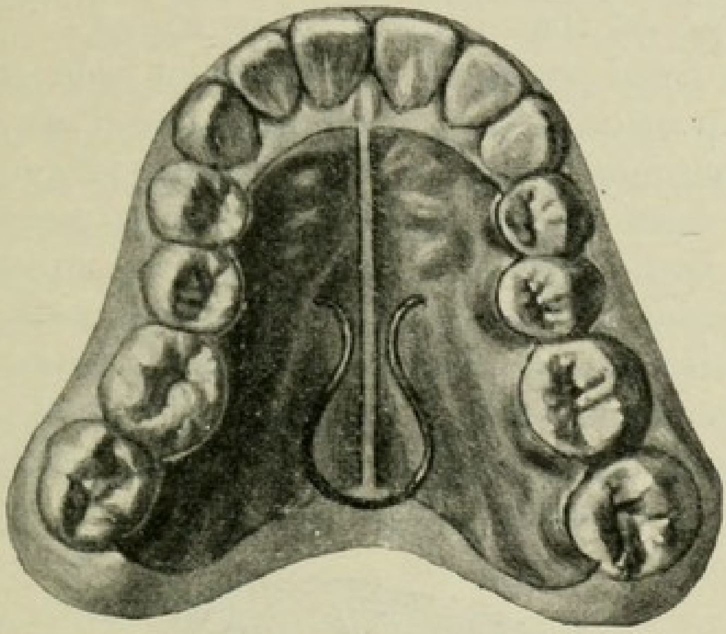

FIG. 86.—Coffin plate for expansion of a narrow palate.

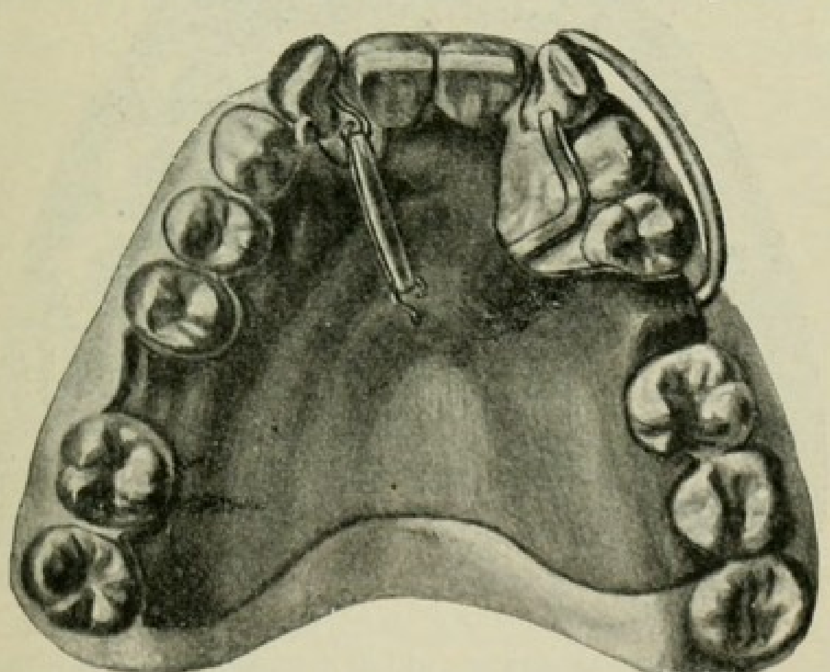

FIG. 87.—Regulating apparatus for twisted teeth when sufficient space exists. The motive-power on the left side is obtained by means of gold wire and on the right by caoutchouc.

This process, however, requires much time and is inconvenient. Coffin has invented an appliance (Fig. 86) for expansion of the jaw, which consists of a divided plate, each half of which is pressed apart by means of a spring.

Both jaws, however, must be expanded, for otherwise articulation will be interfered with.

For the correction of *torsion* (with or without sufficient space) an apparatus is employed constructed according to the principle of that illustrated in Fig. 87. It consists simply of a fixed portion (palate plate or gold crown), and a movable portion which serves as the motive-power (wire spring, caoutchouc, etc.). The motive-power will in a short time draw the tooth into its proper position. But if a dental arch lacks sufficient space, an apparatus like that illustrated in Fig. 88 gives better satisfaction. Its action consists in moving several teeth toward a space that has been secured by extraction of a tooth and thus obtaining sufficient room for a tooth that has been forced to grow in an abnormal position.

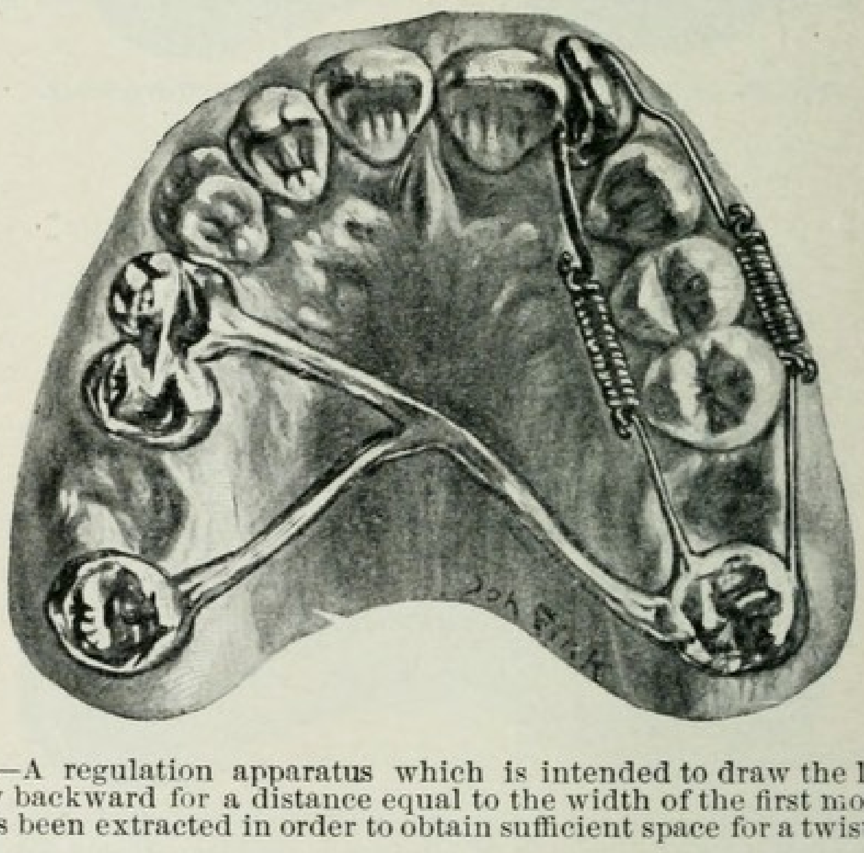

FIG. 88.—A regulation apparatus which is intended to draw the left upper tooth row backward for a distance equal to the width of the first molar tooth, which has been extracted in order to obtain sufficient space for a twisted tooth.

Supernumerary teeth should be corrected only when they actually cause harm. As they are in nearly all cases abnormally situated and formed, their removal can hardly be considered disadvantageous.

The treatment of an *insufficient number of teeth* is not altogether so unsatisfactory as is commonly supposed. An attempt should always be made by means of expansion to facilitate the eventual eruption of a retained tooth.

Such treatment is also very satisfactory in those cases in which, in spite of sufficient room, a tooth fails to erupt. When it has been determined by means of a radiograph that no tooth-germ exists, the space should be closed by employing an apparatus that will draw the back teeth forward until this space is obliterated. This procedure, however, can only be carried out satisfactorily in the front teeth, or the space may be filled by an artificial tooth.

As regards *anomalies of a whole tooth-row*, orthopedic surgery should be resorted to in the treatment of pathologic prognathism of the upper jaw, which should be combined with extraction of molar teeth. The latter is unnecessary if the teeth are far apart. If the jaw be sufficiently wide, the front teeth are simply drawn backward with a symmetrically curved metallic splint. For the purpose of fixing the traction-apparatus a plate is preferred, although gold crowns cemented to the molars are also of advantage. A high grade *opisthognathism* is corrected by applying incline planes which force the lower jaw forward; this finally causes the formation of a new maxillary joint, slightly anterior to that of the original joint. This form of correction is more satisfactory than forcing the lower front teeth forward.

In case of a *contracted* and *V-shaped jaw* expansion is as important as retraction, and one may therefore employ with advantage a retraction apparatus, together with a *Coffin plate.* This double action through one machine may be obtained by making the retraction splint from a gold wire spring. If this spring splint be fastened to a molar tooth that carries on its lingual side a strong splint attached to the remaining teeth, the retraction will be simultaneous with expansion.

Prognathism of the lower jaw is treated similarly to that of the upper one. It is advisable not to undertake to shorten the lower jaw until space has been procured by the removal of certain teeth.

After the position of a tooth has been corrected it must in each case be *fixed* for a considerable length of time, otherwise the former condition will return soon after the apparatus has been removed. The untoward effects which may develop after the use of a regulation apparatus are due to the injuries caused by clamps and splints. The injuries do not result from the sharp borders of the gold wire bringing about defects in the enamel as described by Sternfeld. It is more likely that under those circumstances destructive processes tend to develop which attack the enamel. Therefore, the smaller the size of the portions of an apparatus which comes in contact with a tooth, the less the injury which may follow its use.

DENTAL DEPOSITS.

Calcium salts, especially the phosphate and carbonate of lime, are precipitated from the saliva. If they form hard crusts, the deposits are commonly called *tártar.* This is found in large amounts in the region of the excretory ducts of the salivary glands, and therefore, on the buccal side of the upper molars and on the lingual surface of the lower incisor teeth. Tartar may, however, be deposited on all exposed surfaces (see Fig. 89). Only small amounts of tartar occur in the mouths of cleanly persons, while in persons who use a brush insufficiently a large number of teeth may show a thick layer of this accumulation.

Fig. 89. — Lower molar with thick crusts of tartar at the tooth neck.

This deposit does not, however, consist entirely of lime, but may include various elements, such as remnants of food, epithelial cells, and numerous bacteria.

On account of the organic constituents, especially when soft in consistency, putrefactive and fermentative changes take place which cause a nauseating odor. The gums and the rest of the oral mucous membrane become considerably irritated, which explains why digestion and the general health suffer. The *soft* *white deposits* are distinguished from true tartar because they include a greater amount of food remnants undergoing degeneration, as well as mucous and epithelial cells. *Green, brown*, and *black deposits*, as are shown in Plate 21, Figs. 4, 5, and 6, occur chiefly on the labial surface of the upper front teeth, and occasionally on all other surfaces of the teeth. These are usually not real deposits, for the substance penetrates, as has been demonstrated by Miller, into the substance of the outer layer of the enamel, but without affecting the enamel itself.

The nature of these deposits is not as yet thoroughly understood, excepting of course those cases in which the discoloration is due to medicaments (mercury, iron, etc.). It is also known that the smoking of tobacco causes a rusty-colored deposit to develop on the teeth.

Like the etiology, we are still in the dark as to the influence of colored deposits upon the tooth substances. Inasmuch as tartar displaces the gum with subsequent loosening of the teeth, it is necessary to remove it periodically. This is best done with especially constructed instruments. In order to avoid injuring the gums as well as the surface of the teeth, the tartar situated at the neck of the tooth should be removed with great care. This may be brought about by carefully pushing the gum far enough back with a suitable instrument to permit the prominent edge of the tartar to be grasped and loosened.

Colored deposits, especially the green, are nearly always difficult to remove, at least, by mechanical means. The best method consists in the use of a circular brush and pulverized emery. Assistance may be secured by the use of certain chemicals. Some obtain excellent results with the tincture of iodin, others with a 10 per cent. solution of hydrogen peroxid. The technic is very simple and need not here be described.

CONGENITAL DEFECTS OF THE HARD TOOTH SUBSTANCES.

Congenital defects of the enamel were formerly called *erosions.* This term gives the impression that these fossæ and other changes may follow the action of any irritant, such as acids, upon the surface of the tooth. As Berten shows, this does not take place but instead, a defective development of each individual tooth occurs. The condition is therefore a *hypoplasia*, a term which Zsigmondy applies to this phenomenon because of analagous patho-anatomic processes. The term *erosion* is reserved for certain acquired defects. The etiology of hypoplasia is already expressed in the name. It is an arrest in growth during the developmental period. Syphilis, rhachitis, and scrofula must be looked upon as the chief factors of this disturbance. These hypoplasiæ present the following forms, which however are not sharply defined but tend to pass from one into another:

1. Undulations.
2. Lacunæ.
3. Grooves.
4. Partial or complete absence of the enamel.
5. Crescentic defects.
6. Odontoporosis.

Undulations. A dentist who is a careful observer will frequently see cases in his practice in which the teeth present an undulatory surface. Inasmuch as the enamel is otherwise perfectly normal, and possesses a shiny smooth surface, this condition often escapes detection. In such cases an *enamel hyperplasia* may be suspected. Microscopic examination, however, shows that these horizontally lying undulations, which occasionally occur on all teeth, are not due to a deposit, but on the contrary are caused by superficial depressions. Accordingly the condition is a genuine hypoplasia. Walkhoff contributes an interesting case, in which not only the enamel of the crown, but also the whole surface of the root, presented this undulatory appearance. The undulations are in some cases barely visible, while in other cases they are plainly formed. The latter is especially true when the dentin is also involved.

Lacunæ. *Bowl-shaped* lacunæ are frequently observed, especially on the incisor and cuspid teeth of both the upper and the lower jaw (Plate 19, Figs. 1 and 2), which are either pale in appearance or discolored from uncleanliness. The lacunæ may be the size of minute points or larger, and they may be confluent and have irregular borders. When these lacunæ, which are in themselves striking defects, are distributed over the whole tooth surface, we may justly speak, as did the older authors, of *honey-comb teeth*.

Two or three lacunæ are the largest number usually observed, although they occur quite frequently in larger numbers, arranged in horizontal rows like a string of pearls (Plate 19, Fig. 3). A number of such pearl strings are sometimes found on one surface of the tooth. Their arrangement in stages clearly explains the nature of their origin, which may be traced to the coördinating factors of disturbances in development and the layer-like deposit of the enamel.

The *true grooves* (Plate 19, Figs. 4 and 5) are often bounded by edges containing variously-shaped notches. This condition may be accepted as evidence that the grooves were preceded by union of the lacunæ, which, as was described above, were arranged like strings of pearls.

Although cases in which there is *partial absence of the enamel covering* occur less frequently (Plate 19, Fig. 6, and Plate 20, Figs. 1, 2, 3, and 6), yet they occasionally come under observation. The chewing surface and a portion of the lateral walls of the molars as well as from a third to a half of the front teeth may show this abnormality. A clinical picture quite frequently met with, consists of a larger or smaller portion of normal enamel remaining only at the neck of the tooth, in the shape of a collar, while it has disappeared from the rest of the tooth. The hypoplasia may indeed be of so high a grade that no

PLATE 19.

Enamel hypoplasiæ.

FIGS. 1 and 2. Lacunæ.
FIG. 3. Lacunæ arranged in rows like a string of pearls.
FIGS. 4 and 5. Grooves.
FIG. 6. Partial absence of an enamel covering.

PLATE 20.

Enamel hypoplasiæ.

FIGS. 1, 2, 3 and 6. Partial and complete absence of an enamel covering.
FIGS. 4 and 5. Crescentic defects. (Hutchinson).

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enamel, or only such as is of an extremely frail texture, is deposited.

Hutchinson has called especial attention to the *crescent-formed* defects upon the central incisors (Plate 20, Figs. 4 and 5) which occur in congenital syphilis. He has been widely misunderstood and his theory has aroused a storm of wrathful opposition. His opponents are so far correct inasmuch as congenital syphilis may occur without this symptom. Hutchinson does not deny this fact, but simply contributes his observation, which is in itself correct; namely, that this sign is frequently associated with other symptoms of congenital syphilis.

Dentin may be the seat of a particular form of hypoplasia to which Baume has given the term *odontoporosis.* This process consists histologically in an abnormal substitution of the dentinal tubules by globular spaces. Dentin which has thus been altered naturally more readily undergoes disintergration.

The *therapy* of *hypoplasia* depends upon the extent and the symptoms of the condition. Sharp edges as well as shallow lacunæ which because of discoloration affect the appearance of the teeth, or predispose to caries, should be ground down and the surface polished. In the less visible regions where the hypoplasia cannot be removed by grinding, it may become necessary to fill the defects with gold, amalgam, or cement. In the visible areas it is preferable to fill with porcelain. Good service may be obtained by applying a protecting gold cap to the back teeth when they lack a very large amount of enamel. In

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Lith. Anst F. Reichhold, München.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Lith. Anst. F. Reichhold, München.

a similar condition of the front teeth large pieces of porcelain are employed, and it may indeed even become necessary to excise the tooth and replace it with a porcelain crown.

ACQUIRED DEFECTS OF THE HARD TOOTH SUBSTANCES.

Acquired defects of the hard teeth include: Physiologic wearing away of tooth tissue; wedge-shaped defects; defects on the labial (buccal) and chewing surfaces of the teeth.

PHYSIOLOGIC ABRASION OF TOOTH SUBSTANCES.

A discussion of abrasions really belongs to the realm of physiology, but as they may occasionally develop to such an extent as to require therapeutic intervention, we will for practical reasons treat of the subject in this place. The first signs of wearing away are noticed in the upper incisor teeth, in which the three notches soon disappear. Later the horizontal border, especially of the lower teeth, becomes so much worn that the dentin, and in extreme cases the pulp, becomes exposed. This is especially true in anomalies of articulation. In the course of time the points and a portion of the crowns of the cuspid teeth also wear away. However, depending upon the location of the tooth, the lingual or the buccal surfaces may wear away in preference, and often to such an extent that finally only a lamella of paper thickness remains (Fig. 90). In the normal articulation of the jaws, the upper front teeth tend to undergo abrasion on the lingual aspect, while in protrusion of the jaw they become abraded on the labial surface. Of the bicuspid and molar teeth, the cusps are worn down and the crowns sacrifice more and more of their height. The abraded areas of individual

FIG. 90.—An upper incisor tooth of an old man, which has been ground down from ordinary use.

PLATE 21.

FIG. 1.—The enamel has disappeared from the whole upper surface of a cuspid tooth. The dentine has been destroyed by chronic caries. The root shows a hypertrophy of the cement.

FIG. 2.—A molar tooth of an older man which has been worn away by mastication. The enamel is only present at the edges.

FIG. 3.—A middle incisor tooth which has been discolored dark-brown by extravasation of blood.

FIGS. 4, 5, and 6.—Brown and green tooth deposits. (Text, page 191).

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teeth, which occupy abnormal positions, present many variations, a description of which will be omitted here.

The appearance of these defects may be distinguished from other tooth affections at first sight. They are characterized by the above described localization and by a hard polished surface which is more or less pigmented (Plate 21, Fig. 2). At first, the patients are usually

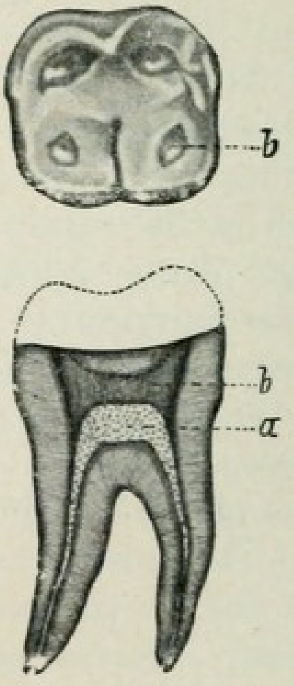


FIG. 91.—*Upper illustration :* *a*, the abraded crown of a molar tooth, seen from above; *b*, the darkly discolored substitution dentin.

Lower illustration : The same molar tooth on longitudinal section. *a*, persisting pulp; *b*, substitution dentin.

ignorant of the existence of abrasions because symptoms are absent. Not infrequently however the exposure of the dentin causes sensitiveness which occasionally results in considerable suffering. Pain also occurs when irritation of the pulp causes the development of a pulpitis. This

Fig.1.

Fig.2.

Fig.3.

Fig.4.

Fig.5.

Fig.6.

does not occur very frequently however, for normal teeth become so gradually worn away by normal use that the pulp has sufficient time to build substitution dentin (Fig. 91). On the other hand pulpitis is more likely to develop if the teeth are frail in structure, and therefore favor rapid destruction, or when they are injured by excesses.

The *therapy*, since we know the exact cause, is not a difficult one, and only becomes necessary when the defects become rapidly enlarged. If a soft tooth substance is involved, the defect is shaped for the retention of a hard filling, either gold or amalgam, according to circumstances, which is carefully placed. Such a surface is much more resistive than the dentin, and therefore checks the wearing away of the tissue. In certain cases porcelain fillings are also very servicable. When serious pulpitis already exists it is necessary to devitalize and remove the pulp, and then fill the roots. The periodical occurrence of pain in abraded bicuspids and molars, which can no longer be improved by filling, may be temporarily allayed by symptomatic treatment. This may be done by repeatedly cauterizing the chewing surface with silver nitrate.

WEDGE-SHAPED DEFECTS.

Wedge-shaped defects which are also designated as *abrasions*, *erosions*, or *denudations* develop at the exposed portion of the neck of a tooth. They owe their name to their wedge-like form, which is like the notch made by a horizontal cut in the edge of the enamel with a file (Fig. 92*a*). This condition differs essentially from carious defects by its highly polished surface which shows none or very little discoloration. Predilection is shown for the labial surface of the teeth; the lingual or the interstitial surfaces are only rarely involved.

Originally the defect is very minute, and nothing is felt when an instrument or the finger is drawn over the undulations toward the neck of the tooth excepting an insignificant but sharply defined notch. The slight touch of the finger usually causes considerable pain and it is this sensitiveness for which the patient pays the dentist an early visit. In the course of time the notches increase in depth and width, and finally lead to encroachment upon the pulp and even to the breaking off of the crown. An interesting controversy has arisen as to the development of these defects. It has been hitherto assumed that these defects were due to purely *mechanical causes,* such as the horizontal rubbing of the tooth brush together with a coarse tooth powder. This action is supposed to attack either the normal neck of a tooth or such as has been injured by acids.

Fig. 92.—Lower cuspid tooth showing a wedge-shaped defect (*a*) situated on the labial surface.

That the normal tooth structures (enamel or dentin) do not develop typical wedge-shaped defects from use of the tooth brush, has already been proved experimentally by M. Bastyr (Scheff's Handbuch), and clinical conditions show that wedge-shaped defects may

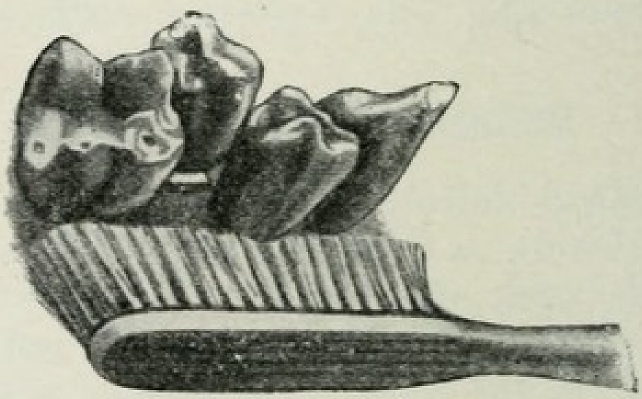


Fig. 93.—A wedge-shaped defect of a second bicuspid tooth which has grown in the lingual direction from the tooth row and which cannot therefore be reached by the tooth brush.

develop on such teeth as can not be reached by the brush (Fig. 93). Furthermore, wedge-shaped defects cannot be artificially produced by rubbing with a brush tooth-substances which have been softened with acids. This knowledge was obtained by means of the experiments of Bastyr. That investigator expresses his observations in reference to the probable genesis of this disorder as follows: "Many defects are due to mechanical influences alone, such as the use of a tooth-brush with a more or less coarse tooth powder, the friction of the lips or that of the food during mastication. More frequently, however, still other influences occur. We may exclude the theory that acids or other agents dissolve the calcium salts. It is more probable that processes are concerned which dissolve or lessen the amount of the organic ground substance of the tooth; that is, *dentoidin*. Because of this decrease in the amount of the ground substance, the lime salts become disunited and mechanically disappear."

The author agrees with the principle theory of this thesis, that is, that in the main other influences are concerned and that acids need not be taken into consideration. He also believes through careful tests, which he has reported elsewhere, that he has found the actual agent which injures the tooth substance.

In order to understand the *etiology* of such defects, we must refer to certian bacteriologic facts, of which the ferment, or better, *enzyme activity* should receive chief consideration, and especially the action of the *proteolytic* or *albumin dissolving enzyme* which until recently has not been associated with this condition. In speaking of the bacteria of the mouth, reference is frequently and incorrectly made to their *peptonizing activity*, while as a matter of fact, recent investigations show that the fluids of the mouth are alkaline in reaction and that only trypsins are present. (Pepsin acts only in an acid, and trypsin in an alkaline reaction.) Nearly all bacteria liquefy gelatin, which is an albuminous body; this leads us to wonder whether or not the albuminous ground-substance of the teeth, the *dentoidin*, is liquefied through the proteolytic enzyme of certain bacteria of the mouth, and whether through this process the tooth substance is destroyed even without previous decalcification. Through chewing and cleansing the resulting jelly-like substance is removed and a polished surface remains.

Tests have been made upon teeth placed in bacterial cultures and which were acted upon for a long time by trypsin which was obtained from the pancreas. In both tests a partial softening of the hard tooth substances was obtained and in each case the reaction was observed to be alkaline, the action of acids being thus wholly excluded. The surfaces of teeth which have become softened are naturally more prone to develop wedge-shaped defects under the influence of mechanical causes than normal teeth, and it cannot be denied that processes similar to those produced artificially occur in the mouth. In favor of this supposition is the clinical fact that wedge-shaped defects are not rare in an oral cavity with relatively good teeth where the reaction of the fluids can be demonstrated to be more strongly alkaline than when bad teeth exist. This theory is furthermore favored, even though conditionally, by the localization of the defects at the edge of the gums where the notches between the neck of the tooth and the gum offer the bacteria a safe recess for their development and propagation.

As a *prophylaxis* the patient should be advised to brush his teeth in a vertical direction. Therapeutically, *silver nitrate* is used to the greatest advantage. It acts as a most satisfactory analgesic, and at the same time lessens the susceptibility of the injured areas to the action of the above described trypsin by forming albuminous nitrate of silver, as well as chlorid of silver, etc., which are insoluble combinations and unlike the organic dental substance. If the amount of substance lost be extensive, the defect must be filled with gold, porcelain, amalgam, or guttapercha. Contrary to the observations of most authors, we find that drilling the base of a wedge-shaped defect occasions but little pain. This is remarkable considering that only a slight touch will cause severe pain.

DEFECTS OF THE LABIAL (BUCCAL) AND MASTICATING SURFACES OF THE TEETH.

Aside from the wedge-shaped defects, peculiar polished cavities are observed in other areas of the enamel. Their origin is still in the dark and therefore Baume sums them up under the title: "Abrasions from insufficiently understood causes." To this class belong the heart and egg-shaped labial defects on the front teeth which have been described by Walkhoff; and the extensive abrasions which occur on the labial surface of the whole tooth row, as was described by Baume. If such defects occur on the masticating surfaces of the bicuspid and molar teeth, they are termed by Baume *necrosis eboris.* All of these defects run a chronic course accompanied by a more or less marked hardening and polishing of the surface, and a pigmentation, which may include all the varying shades between light yellow and black.

The *therapy* differs in no way from that of the hypoplasiæ or the wedge-shaped defects.

CARIES OF THE TEETH.

Of all tooth affections caries is the most frequent and in our locality hardly more than 1 per cent. of all adults possess teeth which are absolutely free from this condition. Caries of the teeth are recognized by the fact that in certain areas of the dental tissues, depending upon the grade of the condition, a discoloration, softening and loss of substance occur. Caries does not affect all teeth alike. Attention has been called to the *frequency of caries,* depending upon the location of the teeth, by a large number of authorities, amongst them Linderer, Röse, Berten, Lippschitz, Port and others. J. Scheff has recently published a very complete table of the statistics of the frequency of caries, which is especially valuable because reference is also made to *incipient caries*; the other authorities (for example Linderer) probably resorted to their table of extractions for the source of their statistics, a fact which made them comparatively worthless.

The following figures of J. Scheff show the relative frequency of the occurrence of caries in a thousand cases :

The teeth involved.	Frequency of caries in the upper jaw.	Frequency of caries in the lower jaw.
Incisor I.	110	15
Incisor II.	95	17
Cuspid,	63	22
Bicuspid I.	87	41
Bicuspid II.	80	50
Molar I.	104	95
Molar II.	72	82
Molar III.	36	31
	647	353

Accordingly out of 1000 carious teeth which were examined, 647 occurred in the upper jaw, and 353 in the lower. This is not the place to discuss the cause of the greater frequency of caries of teeth in the upper jaw. The old theory that the saliva, which nearly always constantly bathes the teeth of the lower jaw, has an inhibiting influence on putrefactive processes no longer suffices as an explanation, since Miller has demonstrated that the saliva possesses no bactericidal agency. We are equally unable to explain the enormous differences in the frequency of caries between the individual teeth in the same jaw ; for example, in the upper jaw the first incisor shows a frequency of 110, the first molar 104, while the cuspid and the wisdom teeth show the lowest figures, their frequency being respectively 63 and 36. This may lead one to associate a causal relationship between the periods of eruption or the deposit of the tooth germ, and a susceptibility to caries. However this question has not as yet been satisfactorily solved.

Aside from these teeth which are more or less prone to undergo caries, decided *areas of predilection* occur on the individual teeth to which the diagnostician must pay special attention. The fissures in the molar and bicuspid teeth serve, especially when they are abnormally formed, that is, composed of clefts and holes, as retention areas for the putrefactive bacteria, and the food remnants which form nutritive material. The most frequent seats for the development of the carious process are not only the distal and mesial grooves and the central fossa between the cusps of the chewing surface, but also the buccal groove of the lower molars which terminates in the foramen cœcum and to a less extent, the lingual groove of the upper molars. In a similar manner the foramina cœca, which are situated on the lingual aspect of the front upper incisors, and preferably the lateral ones, are also prone to become the seat of this process. Likewise the approximal surfaces of the teeth show a predilection to become involved, because of the tendency of food to be retained in that region, which subsequently tends to undergo fermentation. On the other hand all smooth accessible surfaces which are kept clean either artificially by means of a brush, or naturally through the act of mastication and by means of the tongue, are less subject to carious changes. Herein lies the most probable explanation for the difference in the frequency of caries in the various divisions of the teeth, for as we know caries attacks most frequently the molars which possess many more depressions than the front teeth with their flat surfaces. However, this explanation does not suffice for all cases. The *etiology* really interests us the most, for without a thorough knowledge of it, all protective hygiene is illusory.

A certain group of etiologic factors are termed more or less correctly, *predisposing influences.* These consist of anomalies of the enamel, and anomalies in the position of the teeth and of articulation. There is also no doubt but that a significant influence upon the development of caries must be ascribed to heredity and race. The influence of civilization should be considered in so far as its food is poor in lime salts and because it is served in the form of a pasty soft mass, on account of which abnormal processes of fermentation arise in the mouth. It must be also considered that this soft consistency of the food is harmful because it need not be chewed and in consequence the normal nutrition of the teeth suffer from inactivity.

The frequency of caries in those who dwell in cities is of especial interest, for amongst them the poor show a much greater predisposition to caries than the wealthy. The reason for this is simply that in poor people the "mal nourris, mal logès, and mal vêtus," through disturbances of the general health especially during the first year of life,[1] cause a faulty excretion of the calcium salts, with the consequent development of poor tooth-substances. Furthermore poor patients can not afford to consult a dentist for a rational prophylactic treatment of these developmental defects and for cleansing of the oral cavity.

All of these more or less correct and known predisposing causes were already recognized, apart from the exciting causes, at the time of J. Tomes and are the influences in which we are especially interested.

With reference to the history of the etiology of caries we will only briefly refer to a small portion of the works which may be looked upon as the predecessors of the modern chemical and parasitic theory.

A primitive *parasite theory* was recognized even by the older physicians. According to it small worms were believed to bear a causal relationship to caries. In 1663, Leeuwenhoek made a more thorough investigation of this subject, the results of which were published in the "Transactions of the Royal Society." His contribution is reproduced here in his own words in order to show with what remarkable exactness he recognized, with at that time still imperfect optical methods, the wonderful microscopic conditions of the mouth.

Concerning this subject he wrote as follows : "Although I keep my teeth very clean, yet when I look at them with a magnifying glass I observe in the spaces between them a white mass which looks like moistened flour. I

[1] It is known, according to Walkhoff and other authorities, that the condition of health during the first year of life has a decided influence upon the density of the hard tooth-substance.

mixed this substance with some saliva and rain water which contained no bacteria, and observed under the microscope that this mass contained minute living organisms which only rarely showed movement. I was able to distinguish three varieties of this micro-organism. The largest were present in the smallest numbers but their movement was equally as strong and active as that of a white pike swimming in a lake. The smaller micro-organisms existed in large numbers and were characterized by a skipping movement. The third and smallest variety were partly oval and partly round in form and moved with the agility of a swarm of flies which are wildly dashing to and fro in a small enclosed space.

Aside from these forms of micro-organisms, I also noticed a number of striæ and threads of varying length yet of equal thickness, some of which were straight and others curved. They lay upon each other and seemed to possess neither motion or life."

In the same year Ficinus presented his observation that caries of the teeth was due to the action of minute organisms in the mouth which he called *infusoriæ* (*denticola*). He, therefore, accepted the old purely *parasitic theory* which reaches back to the time of Scribonius. This theory was, however, not generally adopted in spite of the fact that contributions were made to it from time to time by skilled investigators, like Klenke, who claimed a *protococcus dentalis* as the exclusive exciting cause of caries.

Then came the observation of Bahn that caries was a purely *chemical process* which consists of decalcification of the hard tooth-substances by means of acids. It was concluded from this observation that defects similar to caries could be produced by allowing certain acids to act upon extracted teeth. It was believed that the acids themselves were either introduced from without through food, or developed from fermentation processes of retained food remnants. The supposition was also expressed that the tooth-substance was destroyed by pathologically altered and acid-reacting secretion of the gums and the oral mucous membrane (Wedl), as well as through oral fluids which contain abnormal constituents (Scheff).

To this purely parasitic and purely chemical explanation of the cause of caries, is added in more modern times another, the *chemicoparasitic theory*. The name chemicoparasitic is not altogether correct for as a matter of fact the term parasitism implies the chemical processes which result from the very beginning. When we speak of bacterial diseases we never think of the physical action of the microörganisms but instead only of the chemical. The various bacteria are moreover only pathogenic when they possess the property of forming chemical substances within the organism which are in any way injurious to it. When disease follows infection with the bacillus of tetanus the diphtheritic bacillus, or any variety of pyogenic bacteria, we know with certainty that the symptoms which arise are due to specific poisons, and that the latter and the alexin or the present antitoxin which eventually develop are chemical agents. However, one would not refer to the resulting condition as chemicoparasitic, but rather as parasitic. The large number of more or less well-known bacteria in the mouth, which injure the dental tissue through any sort of process, must be absolutely considered as pathogenic according to the above statements. As soon as we recognize them to be of pathogenic nature, a smaller or greater amount of chemical action is of course understood. The process differs somewhat when acids, such as fruit acids administered in the grape cure, act upon the tooth-substance, and when the oral bacteria secondarily affect and destroy the tooth cartilage. In such a case to be sure, we have a combination of independent chemical and parasitic processes. For the sake of a clearer conception of these processes which are so easily misunderstood, the author suggests that in the future the term *chemicoparasitic*, be reserved only for such carious processes in which the decalcification of the teeth is due to other acids, than those generated in the mouth by bacteria. It is logical, therefore, to consider all ordinary carious processes, even when associated with the formation of acids by the carbohydrates in the mouth, as purely parasitic since they are due to the action of bacteria.

The majority of investigators were unknowingly adherents of the purely parasitic genesis. This is indicated by their zealous attempts in search of the specific cause of caries. Some believed caries to be due to a single species, and indeed it was formerly agreed by nearly all that the cause was the *leptothrix buccalis,* a property first attributed to this microörganism by Leber and Rottenstein, and later also by Neumann, Erdl, Schrott and others. Ad. Weil considered the process to be of a different nature. He believed that this hyphomycetes drilled through the superficial coat of the enamel and then through the enamel in order to reach the dentin. In more recent times, the theory of a specific excitant of caries has received but little attention, but the observation of Sieberth seems again to speak in its favor. He claimed to have found *streptococci* almost exclusively in the deeper layers of carious dentin. By far the greatest number of the bacterio-odontologists of the newer school accept the view promulgated by Black, Miles and Underwood in 1881. According to these observers the carious process is due to the formation of acids by a large number of microörganisms which lie between and on the teeth. Credit is due Miller, whose work on this subject is known by all, for giving it the experimental support which it needed to make it popular. When the most important of comparatively few results of special investigations, as regards the presence of multiple excitants of caries, are considered we may draw the following conclusions. Isolation of the bacteria in question was usually undertaken from the deep, comparatively intact, portion of the dentin which lies below the infected focus, in order to exclude the saprophytic and such other microörganisms as may happen to be present by chance. In this manner Galippe and Vignal found six, Jung eleven, and Goadby, as well as Miller, a number not exactly determined. By comparing, on close observation all of these exact and painstaking investigations, we became impressed with the vast divergence in the results. The conditions found seem, therefore, to prove that caries is not dependent upon one or several varieties of specific excitants, but is probably more likely to be due to the majority of the ordinary bacteria found in the oral cavity. As concerns the more minute destructive processes, the formation of acids is to be especially considered. According to Miles and Underwood, acids are excreted directly from the organic tooth-substances. We cannot agree with this observation, on the ground that bacteria never form acids from albuminous substances, to which class the organic substances of the teeth belong. The auther fully agrees with the view of K. Jung, who states "that it is hard to understand the observation made by certain writers that the bacteria generate acids by dissolving the albuminous tooth-substances through their peptonizing properties." Like in the reagent glass, acids can only be formed in the presence of carbohydrates. Bacteria cause the formation of acids as soon as carbohydrates are added to the nutritive media. We may judge of the number of acid-forming bacteria in nature from the fact, for example, that dough or similar confections when exposed to the air soon become sour. It is the same two carbohydrate elements in these substances, starch and sugar, which when introduced into the mouth as food, remain there in small or large quantities, especially in the depressions of the teeth, and soon ferment because of the favorable temperature and the presence of masses of microörganisms. One reads constantly of lactic acid being thus generated, but aside from it traces of formic, propionic, butyric and acetic acid are also found. The outer coat of the enamel is first attacked, if it is present, and eventually the enamel or the dentin is involved. The clinical observation that bakers and confectioners, in whose mouths flour and sugar dust are deposited, are subject to rapid decay of their teeth is explained by the fact that the developing acids destroy the outer cuticle of the enamel to a large extent. However it is stated in all text-books that the outer enamel coat is absolutely resistant to acids and alkalies. Since this claim is obviously a contradiction to the above clinical phenomenon, the writer decided to investigate this fundamental and highly important question. The derivation of a satisfactory explanation from the literature was excluded from the beginning, for practically nothing is known of the chemistry of the outer cuticle of the enamel.

We can only reproduce here excerpts of experiments undertaken, which were published in full in the "Oesterr-ungar, Vierteljahrschrift für Zahnheilkunde (1902, No. IV)." A large number of acids were concentrated and diluted, and their action tested both upon the outer enamel cuticle and on the enamel itself. The unequivocal results of the action of the acids were as follows: In a shorter or longer time the outer covering of the enamel became decolorized and occasionally discolored. At the same time it became swollen, formed air containing vesicles, and was finally dissolved from the enamel.

From these facts it is learned, contrary to all former hypotheses, that the enamel cuticle is strongly influenced and severely injured by acids. However, the whole membrane is not completely destroyed, but a portion remains behind in the form of more or less large flocculi that are the residue, which cannot be loosened even by the strongest mineral acids. This condition has led to the statement that it was impossible to thus destroy the whole enamel membrane. These experiments have shown that the enamel membrane can be destroyed by acids, including such as are formed in the mouth from the carbohydrates. A certain length of time and a certain degree of concentration is, however, necessary for this purpose.

It was furthermore observed on examination that *organic* as well as *inorganic acids* brought forth transverse striæ on the enamel prisms. This observation, however, did not harmonize with the perfectly correct claim that there can be "no caries without acids," for we have frequently had occasion to obtain dental caries without any traces of transverse striæ. This led to the belief that possibly still other factors are concerned in the development of caries which have not as yet been appreciated ; for instance, the enzymatic action of such bacteria as liquefy gelatin, that is, that proteolytic (albumin dissolving) action which we have already discussed in connection with the etiology of the wedge-shaped defects. Such an enzymatic activity, which is brought about by bacterial trypsin in an alkaline reaction, acts by dissolving the dental tissues. This is readily demonstrated by the action of animal trypsin upon the tooth-substances. This observation is strongly supported, as none less than Arkövy and Miller have already expressed the presumption that the development of caries in the presence of an alkaline media may occasionally be associated with other influences. Also in favor of our supposition is the fact that caries, even though in a more chronic form, occurs when the fluids of the oral cavity are alkaline in reaction. If, then, we again briefly review the points of the etiology of caries, we reach the following two conclusions :

Tooth caries depends chiefly upon purely *parasitic processes,* and as far as is known, these act in two ways. The first and more frequent consists in the formation of acids by the action of the microörganisms of the mouth upon the remnants of the carbohydrates from the food which are attached to the teeth. These acids dissolve the calcium salts of the teeth. The organic residue, as is the case in all putrefactive processes, is then destroyed by the bacteria, probably by peptonization. The second and rarest form of this process presumably leads to a more chronic form of caries which occurs in an alkaline reaction. Contrary to the former, the organic ground substance is first destroyed, and, it is highly probable that this disintegration is brought about by the bacterial trypsin. As soon as the organic connective-tissue is dissolved the calcium salts fall out secondarily. It is not impossible that in the ordinary form of caries both of these processes act alternately.

Aside from the above described injuries caused by bacteria, it is necessary to again discuss here the purely *chemical actions* upon the teeth to which reference has been previously made. This factor depends upon acids which have been introduced into the mouth from without (grape or lemon cures), or such as arise in the larger or smaller glands of the mouth on account of disease. The softening which is thus produced can hardly be called caries, and it is reported at this time simply to call attention to it.

The *objective symptoms* caused by the beginning of caries in the enamel are as follows. According to J. Tomes, two varieties are to be distinguished, concerning which he writes: "If the disease begins in a fissure on the masticating surface or in a depression in the crown of a tooth, the first sign of the presence of caries is a very dark spot. If, however, a surface is attacked which is free of indentations or fissures, the affected part loses its transparency and becomes dull and white. The white color gradually turns to an ashy gray or slate color and finally is substituted by a more or less dark brown discoloration." Since this process in the fissures is concealed by the discoloration, or complicated with dentinal caries, it is more satisfactorily studied on the flat surfaces.

Caries always begins as a white lusterless speck; this discoloration is due to the fact that bacteria penetrate the superficial enamel membrane and alter its composition. Later the superficial prismatic layer becomes split and the enamel pigmented. The enamel which is at first opaque and smooth is soon felt with the sound to be rough on account of a loss of substance. Heider called attention in "Wedl's Pathology" to the fact that these specks may be discolored dark to a varying degree, and speaks concerning this matter as follows: "The various grades of colors do not represent different stages of the process, but characterize different modifications of it. Indeed, the lighter the speck, the deeper is the destruction and the more rapid the process. The darker the color, the more limited and circumscribed is the discolored portion of the enamel and the slower the process." According to these statements, the discoloration served a diagnostic purpose in the sense that dark pigmentation indicates the presence of *caries chronica*, and specks which remain light in color, *caries acuta*. It is usually stated in the literature that this dark pigmentation really represents a retarded carious process, and, on the other hand, the light coloration a rapid progress. According to the author's observations, however, this supposition is wholly erroneous, for the pigmentation does not seem to be the cause but rather the sequel of a chronic course. This is proved by the fact that, for example, when a pale acute carious focus, situated on a proximal surface, has been changed to the chronic form by extraction of the bordering tooth, it shows a tendency after a time to become dark in color. The simple explanation of the problem is that uncleanly foreign matter of any sort in the affected focus is discharged by the rapid progression of the softening process, while it becomes fixed for a longer time when the process is slow. Therefore, the cause and affect have been mistaken for each other.

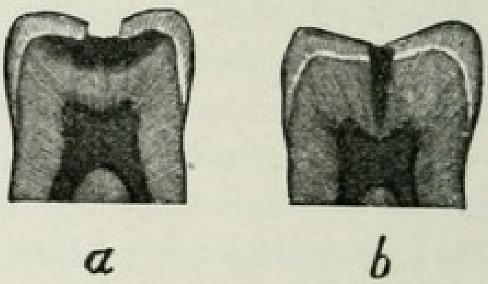


FIG. 94.—*a*, molar tooth with undermining caries, and (*b*) with penetrating caries.

Caries of the enamel is recognized microscopically by the fact that the tissue loses its transparency. It appears more or less darkly pigmented, and the enamel prisms show transverse striæ, and are destroyed in small areas. Masses of bacteria are seen in the lacunæ of the enamel. Frequently, however, none of these signs are noted, the enamel being simply diffusely discolored, and the interprismatic cement substance more swollen than is the case in the normal condition.

If the *dentin* is involved, the process often spreads underneath the enamel in a lateral direction, so that the latter partially covers the defect, Fig. 94 *a*. Miller applied the term *undermining caries* to this condition. It is especially prone to occur in the cases in which interglobular spaces are spread out in the periphery of the dentin. Sometimes caries follows directly the course of the dentinal tubules, and penetrates rapidly into the neighborhood of the pulp (Fig. 94 *b*), which is called *penetrating caries*.

The most striking symptom seen on microscopic examination (see Fig. 95) in *caries of the dentin* is the presence

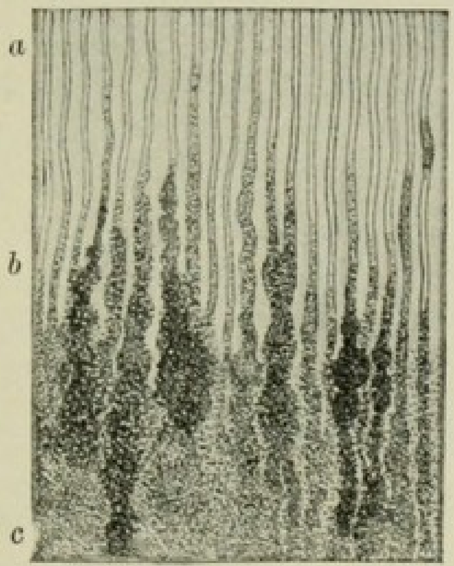


FIG. 95.—Caries of the dentin: *a*, dentinal tubules without any or only a few fungi; *b*, the tubules are here more crowded with fungi which cause them to be somewhat dilated; *c*, the normal structure of the dentin has been destroyed by a fusion of irregular spaces which are filled with bacteria. Longitudinal section.

of bacteria to a certain extent, in both the dentinal tubules and the interglobular spaces. These microörganisms include cocci, bacilli, filaments or mixed infections. Under the influence of these microörganisms the tubules become wider at the expense of the dentinal ground substance. Club-like thickenings arise in scattered areas, which becoming confluent with similar formations in the neighborhood, cause the dentin to become more and more perforated and finally destroyed. As the healthy tissue is approached the conditions become more normal, that is, the dentinal tubules are slightly or not at all increased in width and contain a less number of fungi microörganisms, and in fact in certain areas they harbor only a few fungi.

The walls of the dentinal tubules, that is, the sheaths of Neumann, which are filled with bacteria, are thickened.

They have the appearance of being swollen, which is best seen in a cross section of the tubules, like that shown in Fig. 96. At the border between the normal and carious dentin, rows of small rods and sphericles are often noted, which Miller believes consist of lime, because they are rapidly dissolved by sulphuric acid.

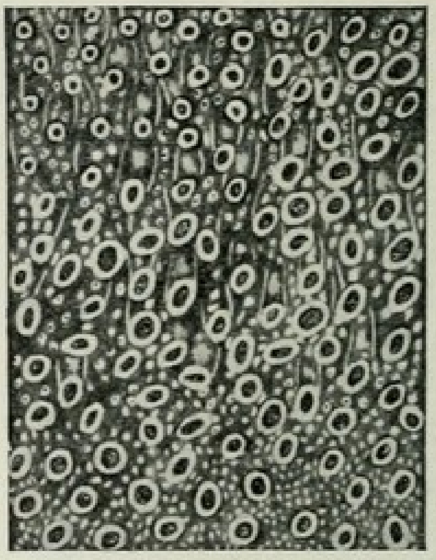


FIG. 96.—Caries of the dentin. The pale rings are the cross sections of the sheaths of Neumann, which are swollen, dilated, and filled with bacteria. Cross section.

Caries attacks the *cementum* when the roots are exposed. Caries of the roots of the teeth is distinguished from that of the other structures by less amount of pigmentation, and by the fact that the defects usually cover a larger portion of the surface, and are less likely to penetrate very deeply.

THE ZONES OF CARIES.

Four zones are discernable on longitudinal or cross section of carious teeth. They are:

Zone of transparency.
Zone of opacity.
Zone of softening.
Zone of disintegration.

A suitable incision will show a transparent dentinal layer (Plate 22 *a*.) which occurs in caries of the enamel, and follows in the form of a tapering cone the course of the dentinal tubules toward the pulp. In caries of the dentin this layer divides the healthy from the diseased tissue with a more or less wide pale area. Miller offers an explanation based upon an optical foundation which assumes that the dentin in this region has become homogeneous. It usually appears opaque because it is composed of elements of different refraction coefficients (Tomes' fibers, sheaths of Neumann, ground-substance and fibrils of the ground-substance which excrete lime). The ground-substance becomes poorer in lime, or, on the other hand, the organic become richer in lime. Thus all the constituents of the dentin possess nearly similar refraction coefficients which might explain this diaphanous condition. Chemical analysis has demonstrated that the calcium content in this zone is in fact increased, and therefore transparency results. The existence of this phenomenon is believed by Walkhoff to be due to spreading sclerosis, which consists of a contraction of the dentinal fibers, and at the same time a narrowing of the lumen of the dentinal tubules. This explanation, with which Miller agrees, is undoubtedly the best. For, as a fact, the diameters of the tubules are decidedly decreased in the transparent zone.

It must be assumed that vital processes are concerned in this connection; perhaps in the form of a protective action on the part of the pulp against the penetrating bacteria. However, we may assume that the process is vital, for Miller at no time saw the transparent zone in dead teeth. We have stained with carbol-fuchsin living as well as dead carious teeth and present on Plate 22 the picture of a living tooth in which the transparent zone remained absolutely unstained, and shows a sharp contrast between it and the highly red-stained carious dentin. In a dead tooth, however (Plate 23), the red-stain passing through the various grades of yellow coloration, and becoming paler and paler, gradually fades into the normal dentin. Plate 22 gives the distinct impression that the living tooth resists the progress of the caries, while Plate 23 shows the tooth to be absolutely passive.

The zone of opacity, contrary to the foregoing transparent zone, is colored a deep red by carbol fuchsin

Plate 22.

Carious molar tooth whose pulp is alive.

a, zone of transparency; *b*, zone of opacity; *c*, zone of softening; *d*, zone of disintegration. Longitudinal section. Picric acid. Carbolfuchsin.

Plate 23.

Carious molar tooth whose pulp is dead.

Longitudinal section. Picric acid. Carbolfuchsin.

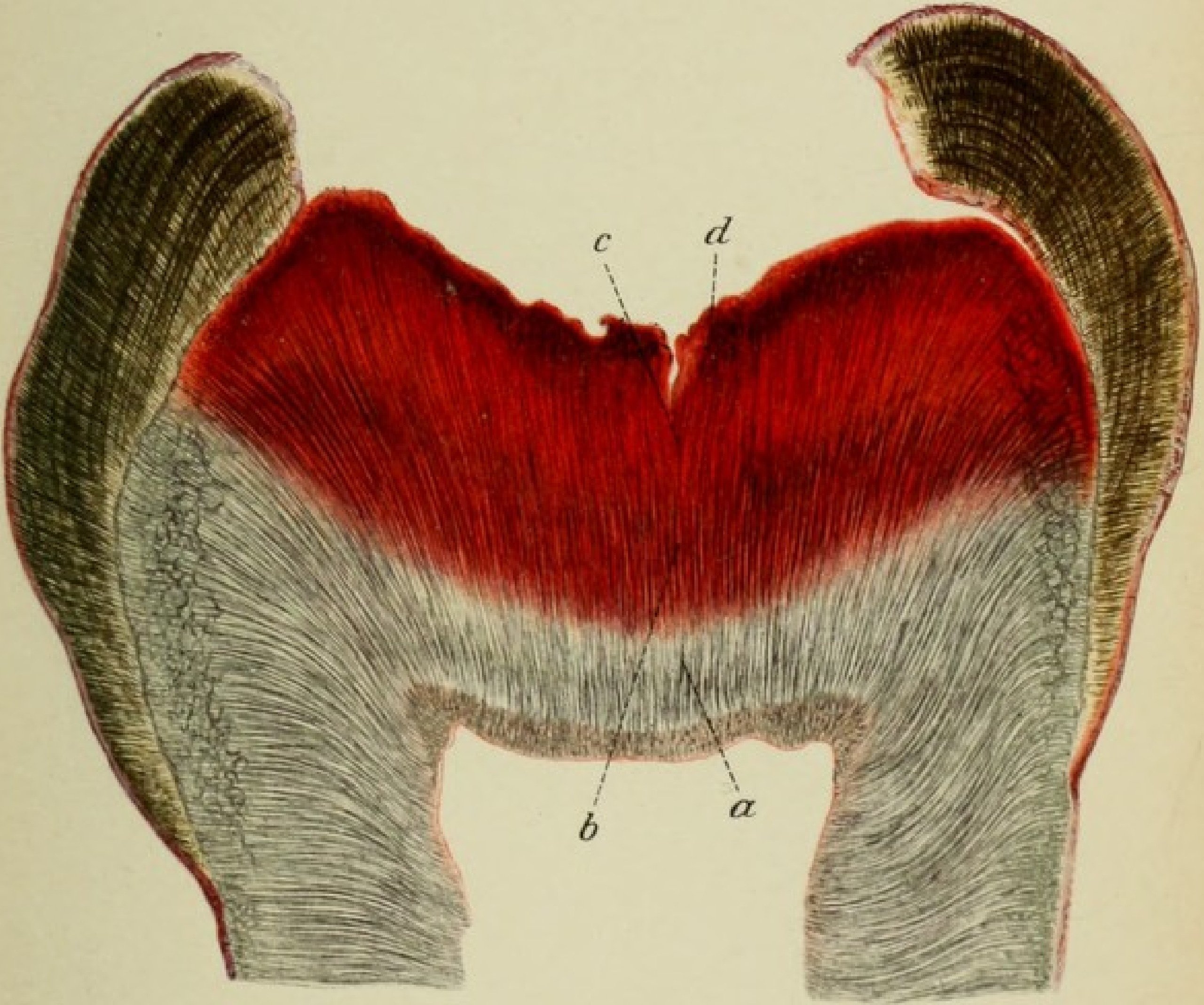
(Plate 22 *b*); a proof that marked changes have occurred in this region. Some of the dentinal tubules have already been penetrated by bacteria, and some are filled with other elements of a flaky or spherical form between which hyaline tubules, or tubules with deposits of lime may be recognized. The extreme opacity of this layer may be explained by the differences in the contents of the dentinal tubules. By gradual changes the zone of opacity passes into the zone of softening.

This is the layer in which both the dentinal tubules and their superficial branches are filled with microörganisms. Their lumina are very nearly equally dilated, and the sheaths of Neumann are swollen. Because of the uniformity of its structure, this zone is slightly transparent. (Plate 22 *c*.)

The masses of fungi which are originally enclosed in the dentinal tubules gradually become confluent to form masses of ever increasing size. The layer lying next to the surface undergoes the greatest amount of destruction; in this region the tissue is constantly undergoing destructive changes with the formation of detritus which leads to a loss of tooth substance (Plate 22 *d*).

The *treatment of caries* has been described in detail on page 217.

The *prophylaxis* should above all things be directed against the exciting causes, for the predisposing influences are less accessible. It is therefore highly important, in the first place, to thoroughly clean the oral cavity, and if possible to disinfect it. This is best done by brushing the teeth with a good tooth-powder twice a day, upon arising in the morning and just before retiring at night. It



Lith. Anst. F. Reichhold, München.

Tab.23.

Lith. Anst. F. Reichhold. München.

suffices after meals to thoroughly rinse the teeth with a mouth wash. The teeth should not only be brushed in the horizontal direction, but also in the vertical, for the former method forces the foreign material between the teeth. Ordinary prepared chalk is a very valuable preparation as it does not injure the teeth. To give it a pleasant taste, peppermint may be added, and to bestow upon it a bactericidal action, an antiseptic is added. Of the antiseptics employed in the past none has been absolutely satisfactory; chinosol, however, seems to have a retarding influence upon the carious processes. It is a deodorant and an astringent, which latter is of importance in relaxed gums. A good prescription for such a preparation is as follow:

R	Calcar. carbon. praecip.,	℥iii½	(100.0),
	Sapon. medicat.,	ʒi¼	(5.0),
	Chinosoli,	gr. ¾	(0.05),
	Ol. menth. pip,,	gtts, xv,	(1.00).

M. and Sig. For cleansing the teeth.

I also think that the addition of a 5 per cent. concentration of chinosol to the mouth wash is useful. Following is a comparatively cheap prescription for this preparation:

R	Aqua dist.	℥iii	(90.0),
	Chinosoli	ʒiiss	(10.0),
	Ol. menth. pip.	gtts.xv.	gtts xv.

M. and Sig. Mouth-wash. Add 5 drops to ½ glass water.

TREATMENT OF DEFECTS OF THE TEETH.

It is impossible for the reader to familiarize himself with the technic required in treating defects of the teeth from a description of it. Although a knowledge of this technic can only be acquired by practical work, yet we cannot afford to omit a discussion of this highly important subject. In order to present only information which is actually useful, the literature of Professors Sachs and Miller is largely drawn upon.

I. THE TREATMENT OF TOOTH DEFECTS BY FILING AND THE USE OF NITRATE OF SILVER.

The Filing of Teeth.—The early form of practice when small defects developed on the proximal surfaces was to remove them with a separating-file. That is, both teeth were filed, but not down to the edge of the gums,

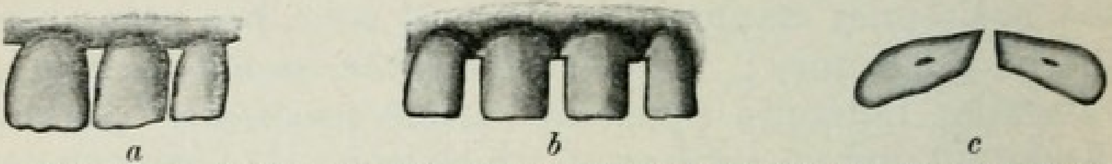


FIG. 97.—*a*, front teeth with interstitial foci of caries; *b*, the same teeth whose proximal surfaces have been ground down and the foci of caries removed. At the necks of the teeth are seen the "shoulders" of enamel which are intended to prevent the teeth from drawing together in the future; *c*, cross sections through the crowns of two upper middle incisor teeth, which show that more of the lingual than of the labial surface has been filed away.

where a small portion of the enamel was allowed to remain, which formed the so-called "shoulder." The object of this shoulder was to prevent the two teeth from drawing close together in the course of time. Thus, they stood further apart than before this treatment, and were therefore more readily kept clean. In order to facilitate the cleansing by making what was called self-cleansing spaces, more of the tooth structure was ground away on the lingual than on the labial side, and the oblique lateral surface thus formed was as carefully polished as possible.

I have never been able to observe this operation on the molar teeth, but I have seen it quite frequently on the front teeth in old individuals. In these teeth it seems to have given the most favorable results, for a return of the carious process was extremely rare even after many years.

This therapeutic agency ought to be reintroduced to-day, especially in polyclinical work.[1] It cannot be generally

[[1] The author's sentiment, as here expressed, can in no sense be subscribed to. There can be no question as to the error of this method of treating dental caries. The ideal practice is, as far as possible, to reproduce the normal physiological condition, that is, to so extend the filling as to *renew the contact point*. This to protect the approximal space from the impact of food, contrary to the antiquated practise of cutting so-called self-cleansing spaces which, outside of its mutilation of the tooth, invited its accumulation.—ED.]

resorted to, however, for many patients object to separation of their front teeth because it destroys their beauty. Fig. 97 shows the manner in which the front teeth are filed.

The Silver-nitrate Treatment.—Beginning caries, as well as wedge-shaped defects, are favorably influenced by touching the affected area with argentic nitrate. The surrounding tissue must first be covered with a varnish in order to prevent it from being acted upon by the caustic. With a little care and practice this measure may be accomplished with no ill results. Stebbins, with whom Chupein and Szábo agree, recommends the silver-nitrate treatment even for larger defects, especially in the deciduous teeth. The method of application is very simple, and consists in placing, for two minutes, a piece of silver nitrate, the size of a pin's head, into the moist cavities from which all the softened masses have been removed.

The favorable action of argentic nitrate upon the course of caries may be explained, by the insoluble combinations which it forms with organic tooth substance, and thus withdrawing the nourishment from the bacteria. We may assume that the chemical process consists in the coagulation of the albumin and the formation of the albuminate of silver oxid. Furthermore, since the animal tissues always contain sodium chlorid, a chemical change occurs in which the nitric acid of the argentic nitrate combines with the sodium, and the chlorin combines with the silver, to form the insoluble chlorid of silver. $Ag\ FO_3 + Na\ Cl = Ag\ Cl + Na\ NO_3$.

The spots which follow the application of this preparation turn black under the influence of daylight, on account of which the argentic nitrate treatment should not be employed on visible tooth surfaces.

Since the cauterized areas are worn away with time, the disease process may later begin anew. On account of the foregoing described insoluble combinations which it forms, silver nitrate penetrates but to a very slight depth. If a prolonged action is desired the diseased focus should be cauterized at regular intervals, for example, every six months.

II. THE FILLING OF TEETH.

The previously described methods are likely to prevent further extension of the caries, but in the application of the file a large amount of substance must be sacrificed while the argentic nitrate treatment must be continually repeated. The ideal method therefore consists in a restoration of the normal conditions as true to nature as possible. This is accomplished in the teeth in an almost perfect manner, by filling the defects which have developed. The results of this plastic operation depend upon the selection of the filling material and especially upon the ability of the operator.

FILLING MATERIALS.

As far as possible a filling material should possess the following properties.

It must be of such a consistency that it is flexible, or able to be kneaded, in order that it may be readily adapted to the walls of the cavity.

It must be able to withstand the influence of the oral fluids.

In areas where it is exposed to mechanical influences it must be hard as possible.

It is desirable, especially in sensitive teeth, that the material be a poor conductor of heat.

It should have a tooth-like color; this, however, needs to be considered only in the visible regions. For the exact regions indicated compare Arkövy, " Indications."

The most important requisites are numbers 2 and 3, which may be expressed by one term, *indestructibility*. Under no circumstances should a material be employed for a permanent filling which lacks these properties.

We will next study the materials which are used for filling teeth. They are gold, a union of tin and gold, amalgam, cement (zinc phosphate), combination of amalgam and cement, etc., enamel and guttapercha.

Gold.—Gold fulfils the most important requirements in an eminently satisfactory manner, for it is capable of great resistance to mechanical and chemical influences. It is only in regard to its conductivity and its shiny yellow color that it fails to fulfil the requirements of an ideal filling material. Gold in the form of foils, as placed upon the market, are usually numbered, expressing the weight of the individual sheets and also the thickness of the foils when they are of equal size. For example, if foil No. 5 weighs five *grammes* and a like-sized foil No. 30, thirty *grammes*, thickness of No. 30 is greater than that of No. 5.

Before using, the foil is cut into strips and repeatedly folded or rolled. The *gold cylinders*, however, which can be bought, are much more convenient and more satisfactory than the self-rolled foils. The gold cylinders may be obtained in any desirable size.

Another form is the *crystal gold*, which is crystallized from a gold solution.

More important than these outer forms of gold is a physical difference, namely that one preparation is *cohesive* and another *noncohesive*. As is indicated by the term, the cohesive forms of gold have the property of adhering to each other, while the noncohesive are unable to do so. Moreover the first is harder than the latter.

Combinations of Tin and Gold.—Many practitioners prefer to use in place of the pure gold a combination of chemically pure gold and tin. This tin-gold is claimed to have many advantages over pure gold. It is less difficult to fill a tooth with this preparation ; its conductivity is much less than that of gold ; and the occurrence of secondary caries is practically impossible, even in cavities which lie deeply under the surface of the tooth-gum. The only disadvantage is the dark color of such a filling. When the advantages and disadvantages are weighed, the conclusion will be reached that tin-gold is not very adaptable for complete fillings, but we must not deny it a certain value as a foundation for central and especially approximal fillings which extend below the gum line.

This preparation is made by laying a sheet or leaf of tin upon one of gold and twisting them into a loose cable. Since the tin oxidizes in the air, a large supply of this filling material cannot be prepared.

Amalgam.—The amalgams belong to the so-called *plastic filling material*; that is, they change after a time from the soft, dough-like state in which they are introduced into the cavity into a hard condition. They are preferable to gold, because they are poorer thermal conductors. Their chief disadvantages, however, consist in the fact that many amalgams later undergo a change of shape, that they are more or less easily subject to mechanical and chemical disturbances, and that they do not possess a color which is pleasing to the eye. Their employment is limited in visible teeth on account of this color, which many preparations even transmit to the tooth substances.

The amalgams are combinations of simple metals (binary amalgams), or of alloys (ternary, quaternary, etc.) with mercury. This material may be obtained as ready-prepared amalgam (copperamalgams), or the metal is not amalgamated until just before its use in the operating room.

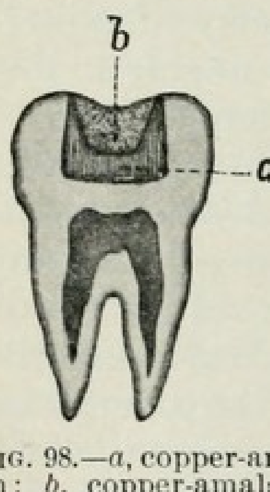


FIG. 98.—*a*, copper-amalgam; *b*, copper-amalgam with the addition of 3 per cent. pure tin (tinfoil).

The *copper-amalgam* is sold in small sheets or blocks, which are so strongly heated before being employed that minute drops of mercury exude. They are then ground in a small mortar and kneaded between the fingers until a soft mass is formed. Amalgam prepared in this manner is introduced in inaccessible cavities with difficulty, for it tends to cling to the walls. According to Miller, copper-amalgams exert an antiseptic action upon the tooth substances. This is moreover true of the few amalgams which do not contract, and are, therefore, when careful work is done in all other respects, an excellent filling material, especially for the poorer practice.

It is to be regretted that in many patients amalgam causes considerable discoloration of the teeth, and can, therefore, only be employed in the posterior teeth. There is still one other disadvantage, namely, that the surface of the filling sooner or later wears off. An amalgam filling is not only ground down by mastication and brushing, but its surfaces, especially the approximal, are discolored by the acids of the mouth. Professor Miller, however, offers a remedy which will make the copper-amalgam resistive. This consists in the addition of about 3 per cent. pure tin, which must be thoroughly incorporated in the form of a piece of tin foil into the dough-like mass. Unfortunately, however, this causes the copper-amalgam to lose its antiseptic action. It is, therefore, better to coat the walls of the cavity with ordinary (antiseptic) copper-amalgam, and complete the filling with Miller's composition as demonstrated in Fig. 98.

Most of the other amalgams are chiefly composed of tin and silver, to which are added a small percentage of zinc, copper, gold, platinum, cadmium, antimony, etc.

The amalgams, which are composed of more or less complicated alloys, unfortunately have the tendency during the hardening period, or even later, of contracting. According to Dodge this phenomenon is due to the tendency of the stiffened mass to assume a sphericle shape. Whether this is really true, or whether other factors are concerned, has not been positively decided. On the contrary, in other cases, an expansion takes place which shows itself by the rising of the amalgam above the surface of the cavity. Indeed this expansion may break off or fracture weak walls of the cavity.

Cement (Zinc Phosphate).—Commercial dental cement consists of a powder and a fluid which are mixed and kneaded together before use. The powder is a base and the fluid an acid. The powder is simply zinc oxid, to which usually other metallic oxids, as well as silicic acid and coloring matters, are added. The fluid usually employed is orthophosphoric acid, which is placed on the market in a thickly liquid form. By mixing the two constituents a mass is formed which hardens comparatively rapidly, and which is in reality nothing else than *zinc phosphate.* This material is a poor conductor; it is the only filling which adheres to the walls of the cavity, and possesses an unnoticeable color even though it is not exactly the color of a tooth. The chief disadvantage, however, which limits its employment considerably, is its tendency to undergo destruction by the various agents in the mouth. A good cement may last for five years or more if the conditions of the mouth are favorable, yet this is an exception which is by no means the rule. On the contrary, daily observations show that the cement in many mouths may be completely dissolved even in one year's time.

Cement does good service in sensitive, poor, or vain patients, whose front teeth cannot be filled with gold. There is no urgent indication for the employment of this material in the molars. It must be borne in mind, furthermore, that this material is but a provisional preserver of teeth. On the other hand the cements are particularly well suited for fastening crowns, bridges and porcelain fillings.

Mixtures of Amalgam and Cement.—It is recommended in order to prevent rapid destruction of the cement, that it be mixed with metal filings. More useful than this, however, is freshly kneaded amalgam to which one-sixth as much cement has been added. Such a filling is less suitable in color, but is more resistive at the chewing surface, as well as at the border of the gums, than are the simple cement fillings.

Enamel or Porcelain.—Enamel, glass and porcelain fillings are employed for concealing defects in visible areas. For this purpose a mass of glass or porcelain is ground into a powder and then melted in a cast or matrix of gold or platinum foil, which has been taken of the cavity to be filled. The small piece of enamel thus obtained is then fastened into place with cement. The appearance of such a filling is very pleasing, and its hardness, power of resistance, and conductive properties leave nothing to be desired. Inasmuch as these fillings are fastened with zinc phosphate, they also have in a measure the disadvantages of cement.

Guttapercha.—The guttapercha employed in dentistry is a preparation which is obtained by mixing guttapercha, softened through heat, with from four to seven parts of zinc oxid. It is useful in those locations in which it is not likely to be worn away, elsewhere it can only be regarded as a temporary filling material.

It is of especial value because of its poor conductive properties, and as a base for metallic fillings; and because of its resistance to chemical influences, it is employed with advantage in defects which reach below the gum. Many dentists prefer to fill the root canals with guttapercha, and also to fasten crowns and bridges with it.

THE TECHNIC OF FILLING OF TEETH.

EXAMINATION OF THE TEETH.

It is not an easy matter for the beginner to examine the teeth for carious areas. All of the defects are not visible, and many are often concealed, as for instance, on a proximal surface. Small defects of the enamel are also overlooked which often widen into a larger cavity in the interior of the tooth. This mistake is likely to lead to serious results, and therefore the examination of the teeth must be systemically undertaken. One should always begin the examination with the upper molars of one side, usually the left, and gradually work along to the bicuspids, the cuspid and the incisor teeth. Then examine in the same order of rotation the lower jaw of the same side, and then pass over to the other side of the mouth, observing the same order there. By conducting the examination in this manner the danger of overlooking a diseased condition is avoided.

The instruments required for examination are an oral mirror and an explorer. The latter is illustrated in Fig. 99. The mirror which is employed to illuminate the teeth is held in the left hand and the instrument in the right. The explorer must have a sharp and delicate point in order to detect minute cavities. It is impossible to locate some carious defects with an instrument, as is the case for instance in beginning superficial caries, in which a loss of substance has not as yet occurred. This

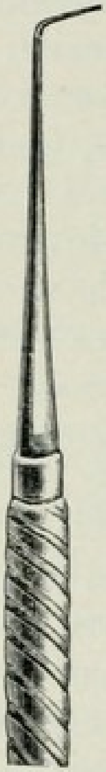


FIG. 99.—Instrument for exploring carious teeth.

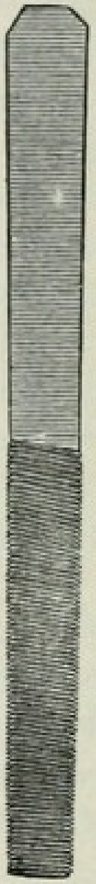


FIG. 100.—Separating file.

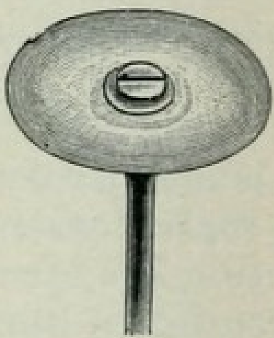


FIG. 101.—Polishing disk for the dental engine.

defect, however, may be detected by the color, which is either opaque or dark. The same holds true of cavities on the proximal surfaces, which are easily overlooked when the teeth press tightly upon each other; considerable assistance is obtained in such cases by separating the teeth either with India-rubber or a cotton wedge.

SEPARATING THE TEETH.

It is absolutely necessary to force apart such teeth as have defects in their approximal surfaces, for it is highly important in the filling of teeth that a good view of the field of operation be obtained, and that it be accessible to the instruments.

The older method of separating the molars, and it is practiced by some operators to-day, is to use the separating-file (Fig. 100) or disc (Fig. 101). In the case of the bicuspids, and especially the front teeth, it suffices to pack the space between the teeth with absorbent cotton for several days. The cotton becomes swollen from the absorption of moisture, and gradually causes the teeth to be forced apart without much inconvenience. Cotton is of little use if the teeth are located in an unyielding portion of the alveolar process, as in old people. In that case a piece of India-rubber, in the form it is sold to the trade, gives better and more satisfactory results. At least rubber may be used for the first day and then replaced by cotton. Too large a piece of rubber, however, must not be employed,

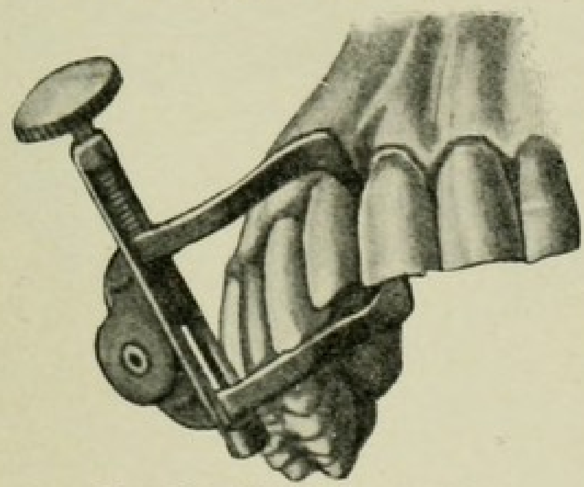


FIG. 102.—Elliott's separator.

for the pressure it causes might result in a periostitis. These separating materials must remain in place for at least two days. If it is intended to introduce a gold filling, which causes considerable strain upon the tooth, the operation should not be performed immediately after the separation, for at that time the periodontium is irritated and highly sensitive. Instead of filling the tooth immediately after separation, it is better to insert a small piece of guttapercha for several days in order (temporarily) *to fix* the teeth. After this has been done the tooth is better able to resist the malleting incident to a gold filling without ill effects. If there is need for hurry, the teeth may be separated immediately with a wedge-shaped piece of wood which is pressed between the teeth. The same effect may be obtained from a so-called mechanical separator. Such an instrument consists of two

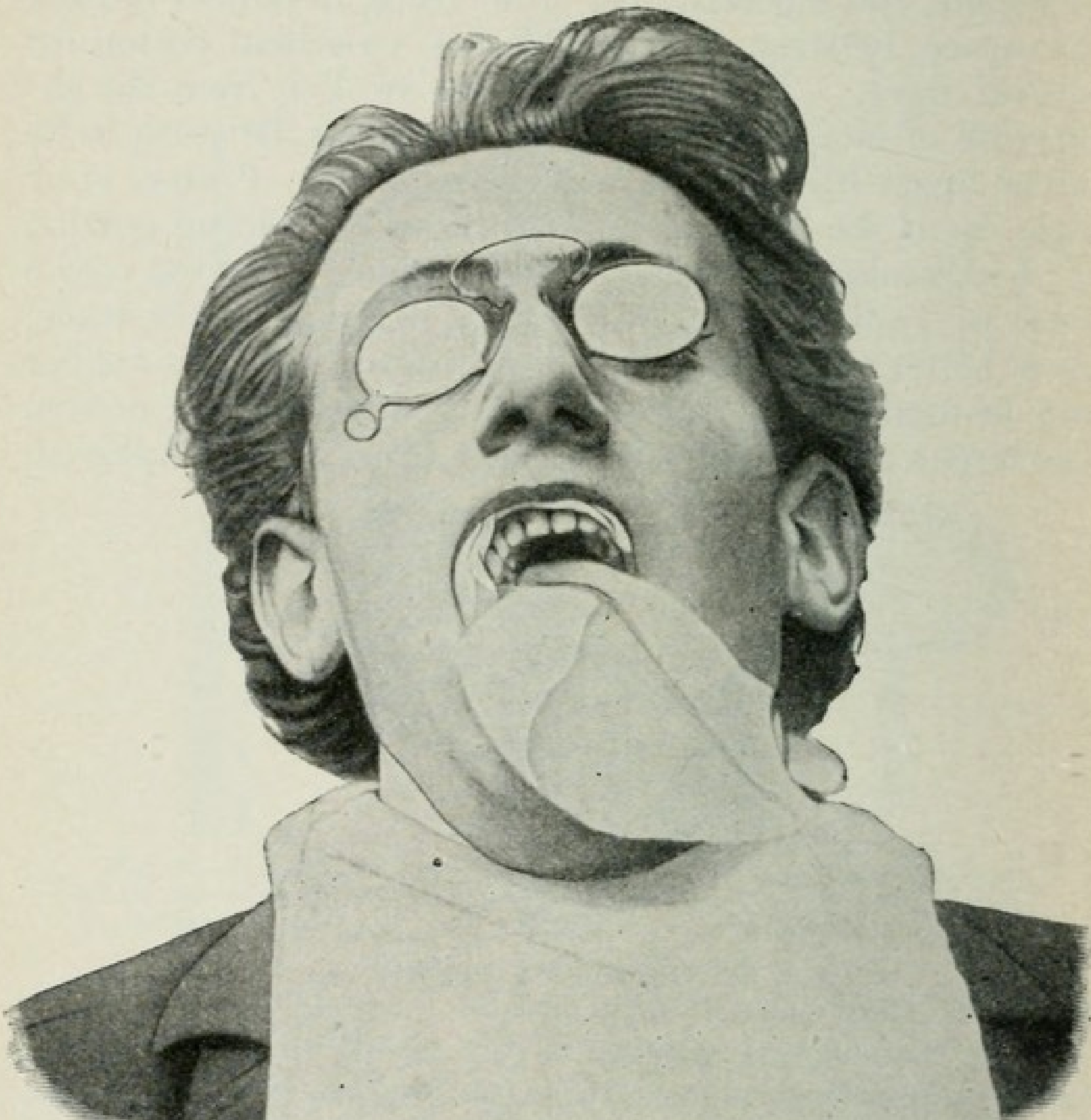


FIG. 103.—Keeping the operative field dry by means of absorbent substances: in this case a napkin is used.

metallic cones which are forced from both sides between the teeth. The most useful of the steel separators is the one devised by Elliott, which is illustrated in Fig. 102.

DRYING THE CAVITIES.

For operations which are of short duration, it is sufficient to keep the region dry by means of a small napkin, absorbent cotton, etc., in the manner shown in Fig. 103. The absorbent substance is placed, in the upper jaw, between the cheek or lips and the alveolar process ; in the lower jaw, it is applied in the same region, but it is also necessary to keep the floor of the mouth dry because of the openings of the excretory ducts of the salivary glands which are situated there.

If the field of operation is to be kept dry for a greater length of time, the *rubber dam* (*cofferdam*) introduced by S. C. Barnum should be employed.

The simplest manner of applying the cofferdam on the front teeth consists, first, in perforating it with a punch a number of times equal to the number of teeth which it is desirous to keep dry (Fig. 104). The rubber is then drawn over the teeth in such a manner that they pass through these perforations. Their isolation may be made more complete by tying a thread or waxed silk around the neck of each tooth. In order to spread the rubber sheet out smoothly, a holder is employed, which consists of two clamps joined to each other by a band.

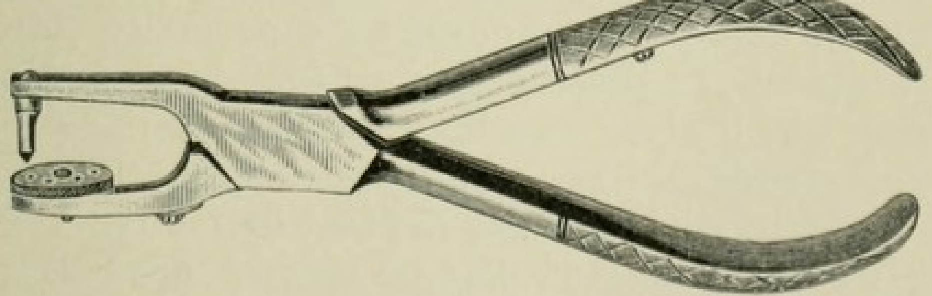


FIG. 104.—Punch for the cofferdam.

By hooking these clamps to the sides of the rubber and by placing the strap around the head, lateral tension is brought to bear upon the cofferdam (Fig. 105). A small weight may be attached at its lower edge. When operating upon approximal surfaces we must not neglect,

PLATE 24.

Application of the rubber dam and other appliances of assistance in deep caries of the front teeth.—This illustration shows us a not very infrequent condition, in which a front incisor tooth is so badly destroyed on both sides by a deep carious process, that one is tempted to remove the remainder of the crown, and to apply a porcelain crown. If, however, for any reason, it is desirous to preserve and fill the tooth, extreme care must be observed on account of the possibility of fracturing a portion of this weakened crown. For the purpose of securing a dry operative field proceed exactly as in less affected teeth. In this case the cofferdam has three holes punched into it, through which the diseased tooth as well as the two adjoining teeth have been inserted. Two weights draw the dam downward and two clamps, which are joined by a band passing around the head, spread it laterally. A German silver band (according to Herbst) acts as a matrix, and is applied to the diseased tooth in such a manner, as shown in the illustration, that it takes the place of the portion of the posterior wall of the tooth which has been destroyed. This matrix is best fixed by applying some heated Stent's material back of the tooth-row and then allowing the mouth to close.

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in spite of the above precautions, to insert a wooden wedge between the teeth, a particularly difficult case is illustrated in Plate 24, to which, with its accompanying text, the reader is referred.

Ligatures are easily applied to the front teeth and act very satisfactorily. *Clamps* are preferred for the back teeth. They not only cling more tightly to the neck of the tooth, but their lateral pieces also press the rubber sheet downward, which is an advantage not to be depreciated, considering the poor light and the lack of room in which one is often compelled to operate. Such a clamp for the molar teeth is shown in Fig. 106. As especially constructed clamps are required for abnormally built teeth, it is necessary to discuss this subject in greater detail. A clamp which gives excellent service in the filling of defects extending high up in the neighborhood of the neck of the tooth is the one devised by Hatch (Fig. 107). By means of it the gum may be pushed upward without causing any or but little pain; and is of further advantage, because it is so constructed that it is never in the way during the operation.

In applying the rubber dam it is more practical to first pass the side-pieces of the clamp through the opening in the rubber outside of the mouth, and then applying the clamp as if the cofferdam were not attached.

Tab. 24.

Lith. Anst F. Reichhold, München.

This is then followed by simply stretching the India-rubber over the lateral horizontal portions of the clamp. Fig. 109 shows the manner of applying the clamp, with the rubber wrapped about the handles of the forceps.

The cofferdam is not only of value in keeping the field of operation dry, but serves also to protect the mucous

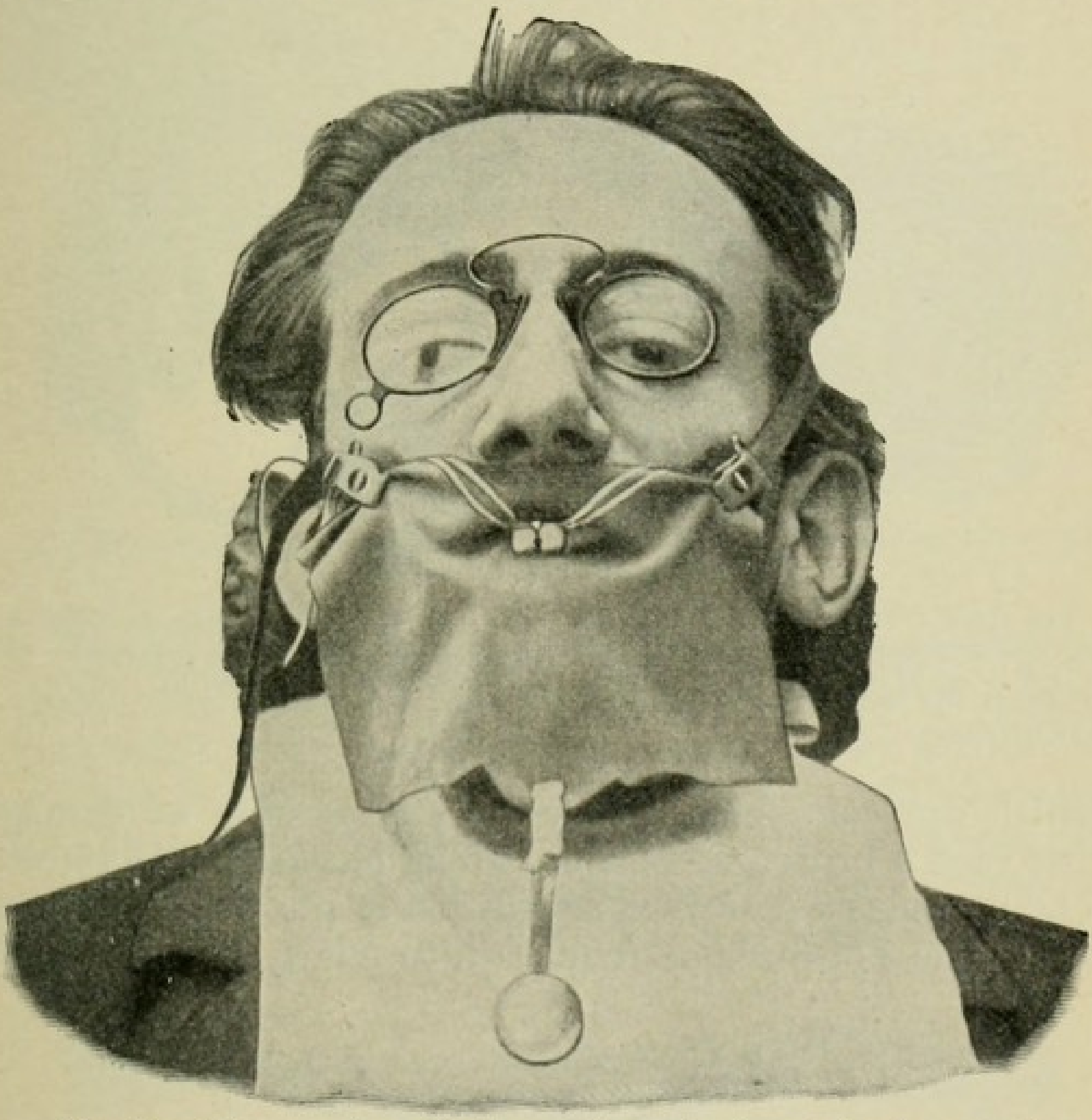


FIG. 105.—The correct application of the cofferdam to the front teeth.

membrane against toxic or irritating medications, as well as injuries from polishing disks, etc.

PREPARATION OF CAVITIES.

Before discussing the various methods of preparing cavities, it will be best to first refer to the following general considerations.

It is important in the first place to obtain a good *view of the cavity.* It is to be regretted that many practitioners pay little regard to this fundamental law and instead pass their drills into the depths of cavities, the interior of

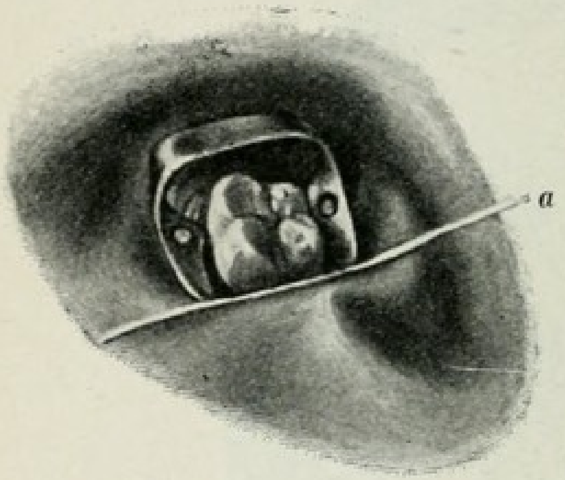


FIG. 106.—A lower molar to which the cofferdam is fixed by means of a clamp. A silk thread (*a*) is drawn between the isolated tooth and its neighbor.

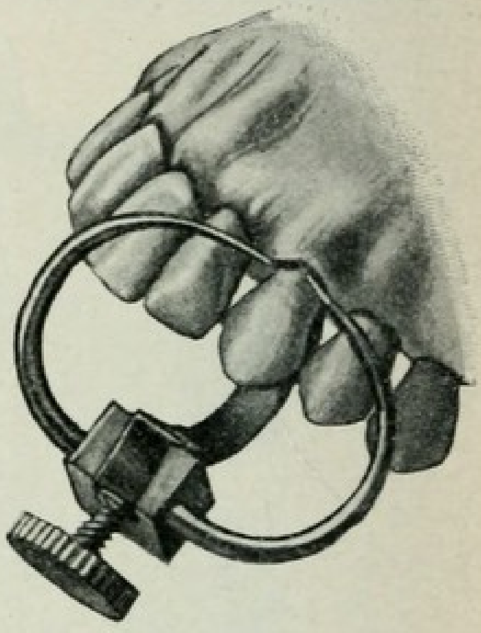


FIG. 107.—The clamp of Hatch for cervical cavities, in position. The cofferdam is not shown.

which are completely hidden. The amount of damage that such a procedure may cause can be easily understood. The previously described separation of the teeth serves to bring the approximal defects into view, but in every

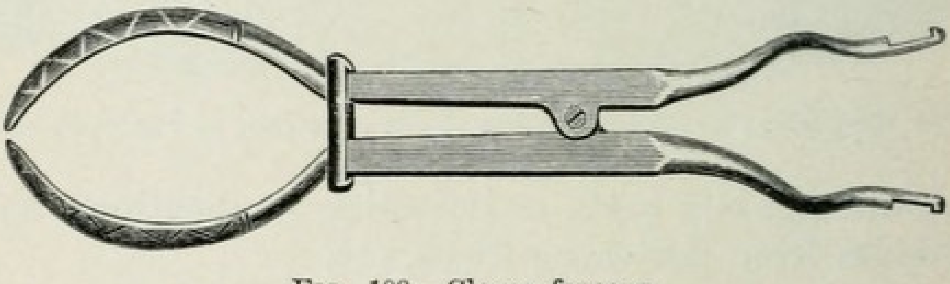


FIG. 108.—Clamp-forceps.

variety of cavity it may happen, in spite of the fact that the superficial portion of the defect is plainly seen, that a false idea is obtained as to the depth of the decay. As we know, enamel is poorer in organic matter than the dentin. Therefore caries spreads more rapidly in the dentin than in the enamel, and the latter extending over the cavity forms a covering or roof to it.

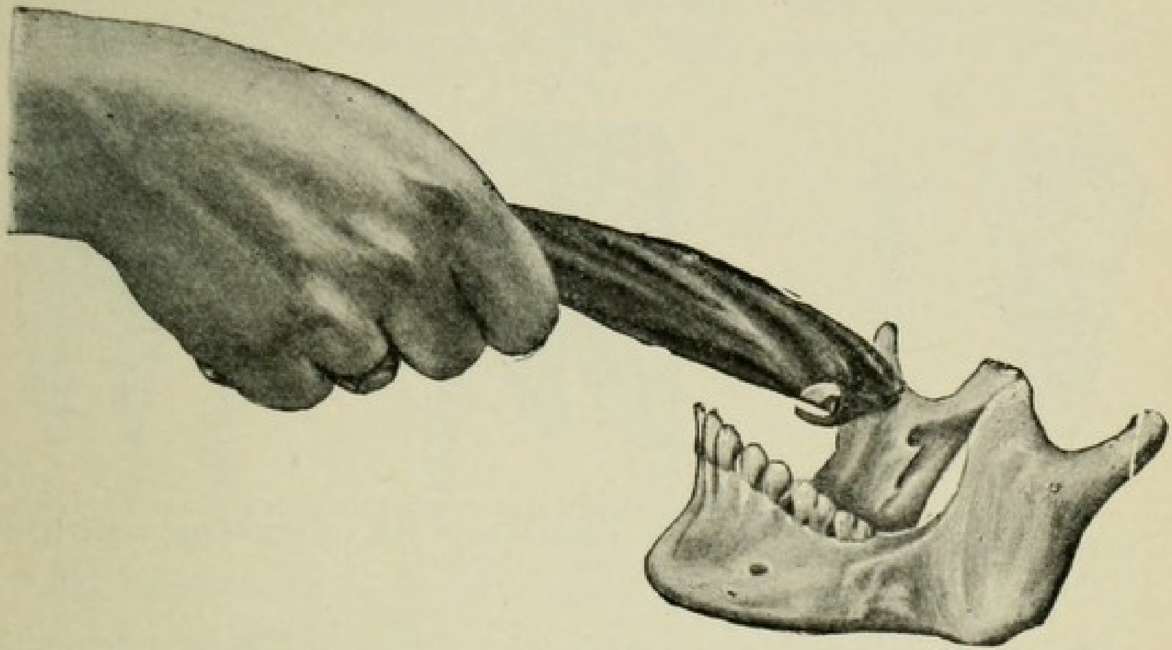


FIG. 109.—The most convenient method of applying the rubber sheet (with fixation of the clamp).

Our first object is to remove these *overhanging enamel walls.* This may be accomplished by means of a small bur or drill; the best for this purpose is the fissure bur, or what is known as a plug finishing bur. If the edges are not too strong, they may be removed with the enamel-chisel, which is useful in very many cases. But the enamel edges must nowhere extend over the dentin, for

FIG. 110.—Enamel-chisel.

they may easily become fractured in the future. They must also form a right angle as nearly as possible to the tooth surface. This also holds true for the whole border of the cavity, including both the enamel and the dentin. If in a cavity too much of the structure underneath the overhanging edges has been destroyed, as shown in Fig. 111 *a*, the weakened borders tend subsequently to break off. If, however, the enamel walls are cut down in tne shape of a funnel (Fig. 111, *b*) the filling material would form a shallow and weak layer.

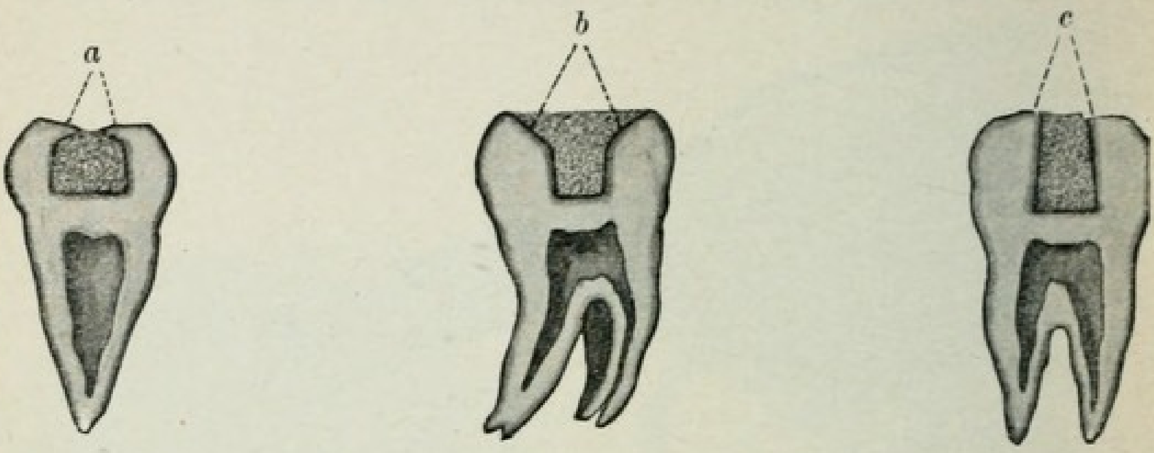


FIG. 111.—*a*, undermined borders of a cavity (tooth-edges too weak); *b*, funnel-shaped borders of a cavity (borders too weak for the filling material); *c*, cavity with nearly perpendicular edges (correct).

Since thin tooth walls and thin walls of filling material are easily fractured, the only correctly shaped borders are, therefore, those which form almost a right angle with the cavity, as is demonstrated in Fig. 111 *c*.

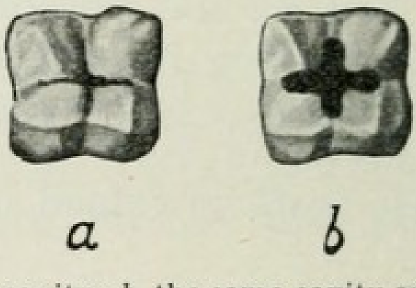


FIG. 112.—*a*, narrow cavity; *b*, the same cavity artificially enlarged.

It is much more agreeable to the patient and more rapid of execution to remove the softened dentin with an

FIG. 113.—Spoon-excavator.

excavator instead of a drill. For this purpose the spoon-excavator pictured in Fig. 113 is especially useful. It can be obtained in all sizes. The excavator must of course be as sharp as a razor. The bur should not be employed in operating upon the cavity until the softened mass of dentin has been removed. The most useful forms of burs are shown in Fig. 114. As motive power

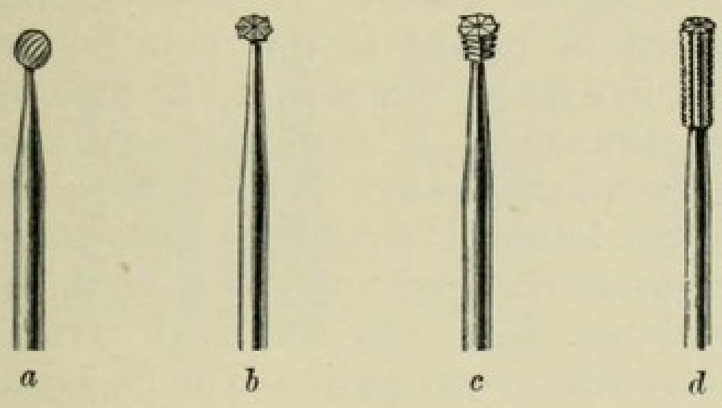


FIG. 114.—Burs for the dental engine: *a*, round bur; *b*, wheel bur; *c*, inverted cone bur; *d*, fissure bur.

the treadle dental engine is usually employed, but the electric engine acts much more uniformly, and permits the hand which guides the drill to be much steadier because the body is not shaken by the treading of the foot-power apparatus.

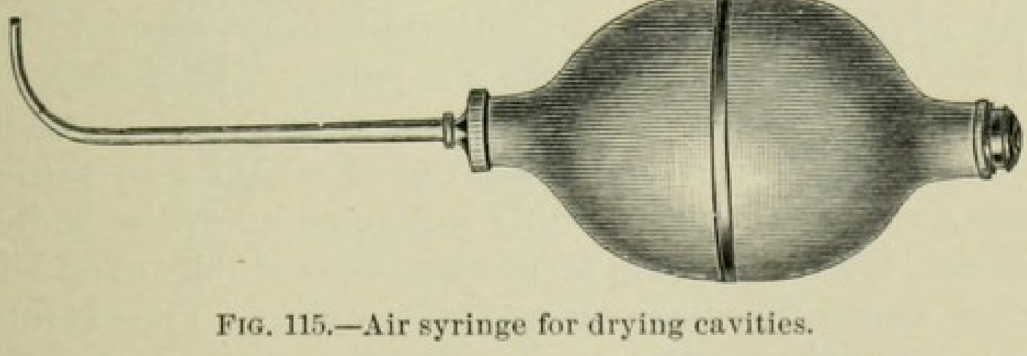


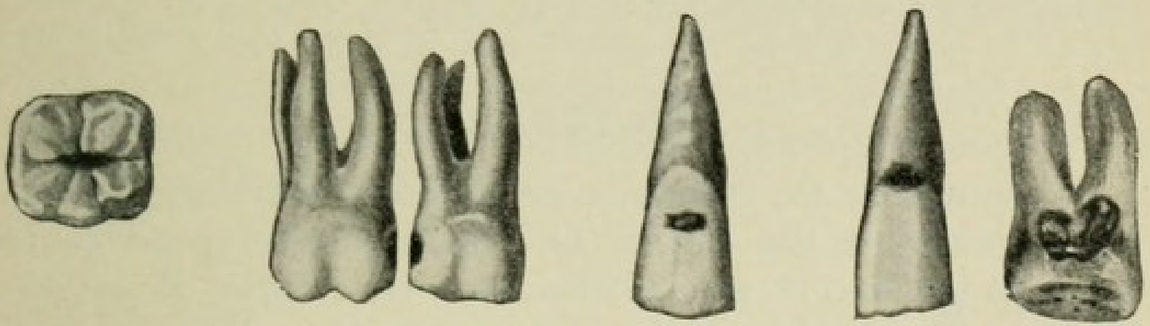
FIG. 115.—Air syringe for drying cavities.

Before inserting the filling, the cavity must be *absolutely dry*. If the tooth be protected by a cofferdam, so that even the vapor is guarded against, the cavity may be considered dry, and it is then only necessary to remove the dust which has collected, by means of the syringe shown in Fig. 115. The cavity must furthermore be thoroughly dried. This is accomplished by the use of little pledgets of cotton and moderate blasts of hot air from the chip blower or air syringe. The simple air syringe illustrated in Fig. 115, the point of which is held before using in a bright flame, gives better service than the hot air spray which is heated by electricity.

We frequently read that the cavity should be *sterilized* before introducing the filling. If, however, practitioners were questioned in regard to this point, we would find very few who live up to this law. The drilling away of the infected portions of a tooth already sterilizes the cavity in a mechanical way. If we were to carry out this rule to the letter, it would be necessary, since few micro-organisms always penetrate deeply into the dentinal canals, to excavate deep into the tooth structure which would be dangerous to the pulp. The chemical sterilization, as it is occasionally performed, consists in washing the cavity with an antiseptic, or in allowing it to remain there for a few moments. This is correct in principle, but it must not be forgotten that the short duration during which the antiseptic acts affects or destroys only the superficial vegetative bacteria. No doubt the most reliable antiseptic is formaldehyde of which a 10 per cent. to 40 per cent. solution of the commercial form may be applied to the cavity for a few minutes, the resulting pain being of no consequence. Chlorphenol is also of value and its employment causes no pain. The longer the antiseptic is allowed to act the more effective it becomes. As a rule, the hermetically sealing of a cavity by a filling seems to exert an unfavorable influence upon the bacteria of caries, for the process progresses very slowly even when carious dentin has been allowed to remain. The exclusion of air is hardly worthy of consideration, for many of these organisms are anærobic or facultative anærobic. It is more essential, in closing the cavity, that no nutritive material can reach the bacteria, for thus they are compelled to depend exclusively upon the sparse albumin of the tooth substances, which accounts for the slow progression of the carious process.

LOCALIZATION OF THE TEETH.

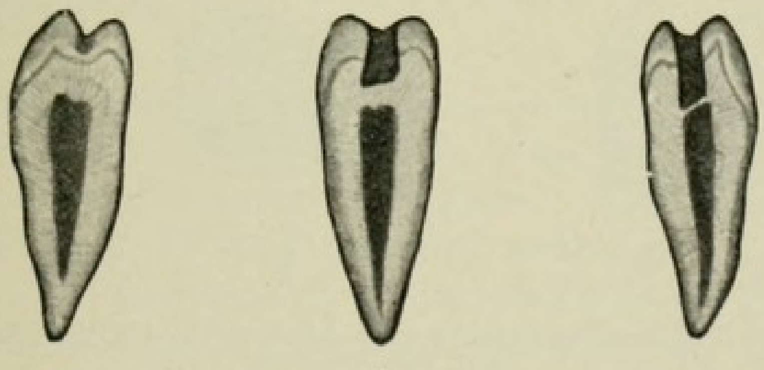
Before considering more closely the application of the individual materials, we must understand the areas of predilection of the caries.



a b c d e

FIG. 116.—Localization of caries : *a*, central ; *b*, approximal ; *c*, labial ; *d*, cervical ; *e*, subcervical.

If the defect occur on the masticating surface (Fig. 116 *a*) ; it is called *central*, if on the opposing surfaces of two teeth, *approximal* (Fig. 116 *b*) ; if on the labial surface, it is termed *labial* (Fig. 116 *c*) ; if at the neck of



a b c

FIG. 117.—*a*, caries superficialis ; *b*, caries media ; *c*, caries profunda.

the tooth, *cervical* (Fig. 116 *d*) ; and when reaching deeper than the neck of the tooth it is designated *subcervical* (Fig. 116 *e*). Of these various types all combinations occur, such as approximal-central, etc.

With reference to the depth to which the process extends, we speak of *caries superficialis* when only the enamel is involved and the dentin is not reached. In *caries media* not only the enamel but also the dentin, even though but slightly, are diseased. We speak of *caries profunda* when the carious process has extended to the neighborhood of the pulp or when the latter has been exposed in any region, or infected from the caries. These conditions are illustrated in Fig. 117 *a*, *b*, and *c*.

MATRICES.

Inasmuch as we recognize central cavities, those having all the walls, as the easiest to fill, it is good practice to attempt to convert all cavities into that form of cavity. This is accomplished through a small appliance called the matrix. In order to supply, in approximal-central cavities, the approximal wall, it has been the custom for a long time to simply press a small piece of metal (German silver or steel) between the two teeth, and between this strip of metal and the healthy tooth a metallic peg, a wooden cone, or a little guttapercha is inserted, in order to make the wall more secure (Fig. 118 *c*).

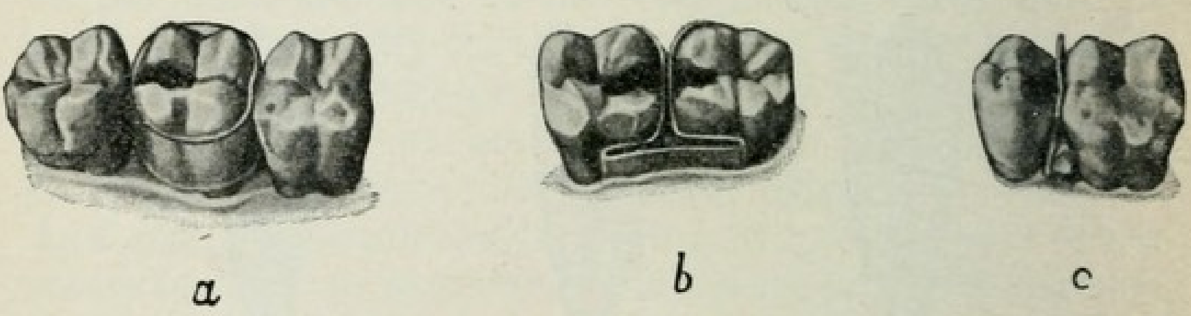


FIG. 118.— *a*, kohinoor-celluloid matrix ; *b*, matrix of Miller ; *c*, metallic strip and wooden cone.

Such German silver or steel strips are easily made and for ordinary cases are preferable to most of the matrices found upon the market. The filling however assumes on account of it, a flat, and not the true shape of the tooth. This disadvantage is overcome by the matrix devised by *Jack*, which is slightly curved outward. To be effective, this instrument must be tightly fastened into place. This requirement is satisfactorily fulfilled by the ring matrix of

Herbst. It consists of a German silver ring soldered with tin, which fits exactly to the neck of the tooth. Unfortunately however, this metallic ring has the disadvantage of darkening the field of operation. This suggested the manufacture of a ring from a transparent material, such as the *Kohinoor matrix* which is now for sale on the market (Fig. 118 *a*.). This transparent ring permits a full view of the tooth, but as it is made of celluloid, it is too soft to withstand the pressure necessary for gold filling. Its employment is therefore limited to fillings of plastic material.

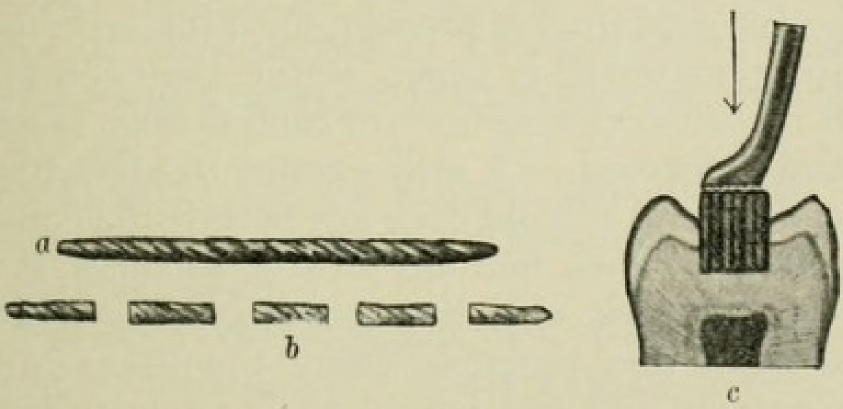


FIG. 119.—*a*, a twisted roll of non-cohesive gold-foil; *b*, the same roll cut into sections: *c*, compression of the non-cohesive cylinders of gold which have been introduced into the cavity.

An exact fitting ring consists in a metallic strip, placed around the tooth to be filled, which may be shaped into a ring by means of a screw appliance. The small apparatuses of Pinney, Brophy, Meister and others, are of this variety. If it is necessary at one sitting to fill the cavities of two neighboring approximal surfaces, the matrix of Miller is the most suitable (Fig. 118 *b*.).

This consists of two metallic strips soldered together at one end, between which, in order to fix them in place, a metallic peg or wooden cone is inserted.

A similar instrument has been devised by Herbst. The employment of matrices in gold fillings is limited. They are occasionally indispensable in filling approximal cavities in the cervical region. However, as soon as a layer of the gold has been built it is more convenient to complete the operation without a matrix, for it is very difficult to compress the gold with sufficient force at the edges without displacing the apparatus. The construction of large contours with amalgam is, however, much easier by using a matrix and it is in such fillings that it finds its true sphere of usefulness. Cement fillings may be inserted in all cases without applying a matrix. Plate 24 shows the application of a simple band-matrix to the front teeth.

FILLING WITH NON-COHESIVE GOLD.

Formerly cavities were filled much more frequently with non-cohesive gold than at present, for it has been found that such filling material is much softer than cohesive gold, and that therefore the surfaces of such fillings later become rough and deformed. A still greater disadvantage is the fact that this form of gold does not permit the construction of a contour. Yet, because of its softness it adheres closely to the walls and thus securely closes the cavity. On account of this property many practitioners use it to cover the floor and the lateral walls of a cavity. They complete the filling, however, with cohesive gold. The non-cohesive gold is more easily compressed than the cohesive and therefore such a filling is more rapidly introduced. It is especially suitable in approximal cavities, which are not sufficiently visible, for proper condensation of the cohesive gold in all places.

The soft gold, purchasable in foils, is folded into three or four angled pieces and rolled into cylinders, or as has been described in the case of tin-gold, is twisted with the fingers into a cord (Fig. 119, *b*). The latter is cut, before use, into sections, which are of such length that when inserted they extend somewhat above the upper edge of the cavity (Fig. 119, *b*).

If it is intended to fill only a small cavity with non-cohesive gold, it is best to employ a piece of the gold cord which will protrude a distance equal to one-third of the depth of the cavity. This small piece must be of sufficient thickness to just permit forcing it into the cavity. It is introduced in the manner that a cork is inserted into a bottle, so that one end rests upon the floor and the other protrudes from the cavity. Next, as thick a gold-plugger as possible is thrust in between the tooth-wall and the gold, by means of which an energetic side motion is exerted which presses the gold tightly upon the opposite wall of the cavity. If this portion remains fast, the manipulation is repeated until the walls which are still bare are covered with gold. The space which then remains in the center is also filled with a similarly shaped cylinder, the so-called "key." The portion of the metal which protrudes is then forced down with strong hand pressure and blows from the mallet. The principles of this filling, at least so far as one picture can show the different stages of a complicated process, are demonstrated in Fig. 119 *c*.

Usually at this stage the filling is still too high ; it must be dressed down with stones or finishing burs, and then burnished or polished.

The principle of this operation is the same in big cavities only it is often impossible to make a single portion of gold remain tightly in place. This difficulty is made easier by first applying several pieces of gold to a wall. These tend, then, under compression to hold each other in place. In the same manner the second portion as well as the key must be composed of several pieces of gold. It is also permissible to set pieces of gold side by side in a row along the whole wall, and when the cavity is thus lined with gold according to the established principles, the filling is continued toward the center. In the case of caries profunda, that is, in very deep cavities, the floor must be first filled with gold and in the same way as if a small cavity were being filled. Thus a shallow cavity is formed which is easily filled in the manner described above.

It is important when soft gold is used to condense it always toward the walls. At first this is done according to the above method ; after a large portion of the cavity is once filled a cone-shaped plugger is forced into the gold in order to press that metal toward the walls.

A description of the method of filling with a combination of tin and gold may be properly omitted here, as it is similar to that of non-cohesive gold.

FILLING WITH COHESIVE GOLD.

Cohesive gold has been universally adopted for filling cavities. It requires on the part of the operator perseverance and skill, and on the part of the patient, patience and repose. If any of these requirements are absent, a perfect filling cannot be made, and a poor gold

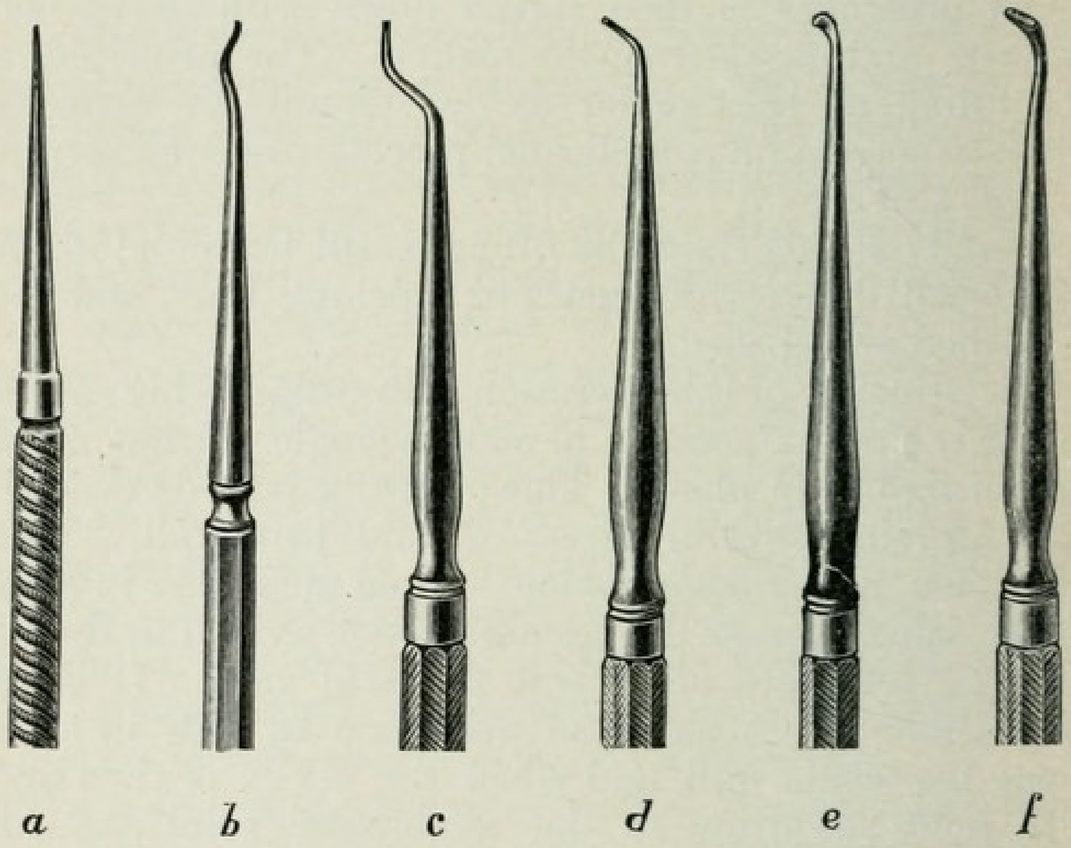


FIG. 120.—Pluggers for condensing gold.

filling is worse than a mediocre cement or amalgam filling. Aside from these requisites a number of other preliminary conditions are necessary in order to guarantee a satisfactory filling. The teeth must not be sensitive to pressure or hammering, and the tooth substance must possess a tolerable amount of mechanical resistive power. Furthermore it must be possible to make the cavity perfectly visible and absolutely dry. If one attempts to fill a cavity with gold without observing these cardinal conditions he makes a failure which will not be without untoward results.

Cohesive gold is given a cohesive property by heating. It should be heated or annealed directly before using by placing it in a sheet of mica plate, and holding this for a short time over the flame of a spirit lamp.

The instruments which are now-a-days employed for condensing cohesive gold are so constructed that they may be used both by hand or with a mallet. The beginner who attempts to select gold-pluggers from a catalogue is perplexed because of an embarrassment of riches, for in it he finds for sale all imaginable, practical and impractical, instruments. In order to save the student unnecessary expense when buying his instruments we present six hand pluggers which are sufficient for nearly all cases. 1. A broken-off excavator which tapers to a point (Fig. 120 *a*). This instrument is very useful in narrow close cavities.

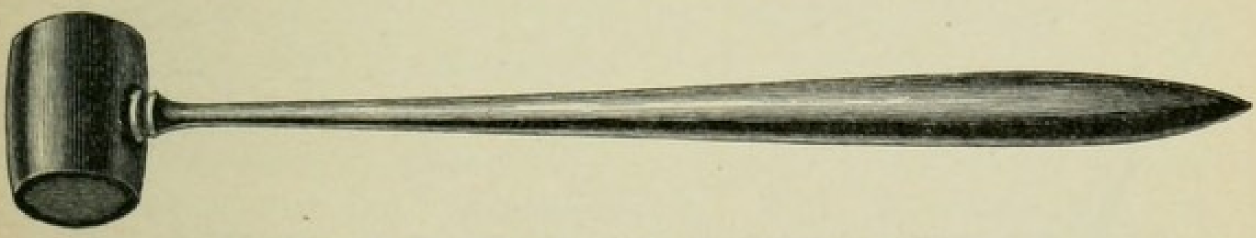


Fig. 121.—Hand mallet for condensing gold.

In anterior approximal cavities, especially in order to condense the gold against the labial wall, the screw-like plugger (*b*) is employed. For compressing the filling in areas walled off by the operator, the bayonet-formed plugger (*c*) usually gives the best service, and in areas which are already walled off, the plugger (*d*) which is bent at an obtuse angle suffices. The filling of a superficial cavity as a rule is readily condensed with the muzzle-shaped plugger (*e*), and that of a cavity at the neck of the tooth with the foot plugger (*f*).

Of all mallets the ordinary hand mallet is to be preferred, Fig. 121, for only by means of it has one the power of altering momentarily the rapidity and the strength of each blow. Many dentists manipulate the hammer themselves, yet the gold-plugger is much more easily guided when an assistant attends to it. It is claimed for the so-called *automatic* mallets that they are not only a substitute for the assistant but permit more rapid work. The *pneumatic mallet* devised by Kirby is very ingenious. It consists of a bolt, which is driven forward to strike upon the point of the plugger. A most useful instrument is constructed by supplying this hammer with the head devised by Rauhe, which makes it possible to strike blows from all conceivable angles. Its failure of general adoption is probably due to the fact that it requires an India-rubber bulb or bellows, which being operated by the foot is very fatiguing. But if in place of it, the *Kirby-Rauhe hammer* is connected with a small air pump, which is applied to the drilling machine, rapid and satisfactory blows are struck without exhausting the operator. Such a hammer is illustrated without the hand piece which belongs to it, in Fig. 122.

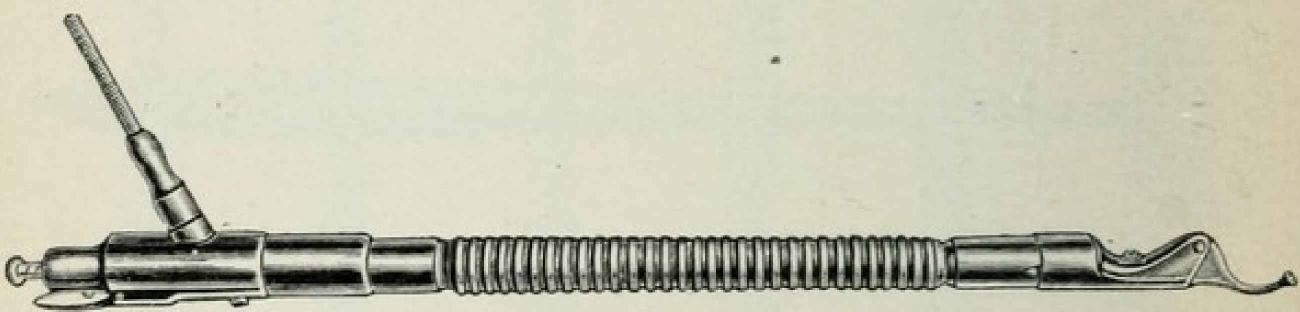


FIG. 122.—Kirby-Rauhe's automatic gold hammer for pneumatic power.

Of the other hammers which are operated by the dental engine those of Power, Buckingham, Elliot and Bonville are the most successful. The electric hammer of Bonville and Webb is preferred by some operators. The most difficult phase of the completion of a cohesive gold filling is the beginning, and nowhere can the axiom "omne principium grave" be more appropriately applied than here. It is not to be wondered, therefore, that all possible means have been resorted to in searching for assistance, and every practical dentist possesses his own trick or method for fixing the first piece of gold. Many begin the filling with soft gold, or simply with unheated cohesive cylinders, which possesses properties similar to soft gold, and after the first portion adheres, the operation is completed with cohesive gold, which clings tightly to the former. Rather wide pluggers are required to press the gold against the walls and the floor of the cavity. By that we mean pluggers with broad surfaces and fine, shallow serrations.

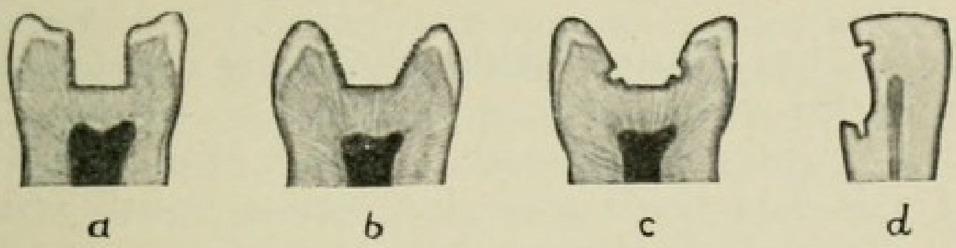


FIG. 123.—Enlargement of the cavities for the reception of cohesive gold, with or without under-cuts.

The question of securing *anchorage points, under-cuts* etc., may be settled by stating that they are only necessary in those cases in which the conditions of the cavity has not sufficient anchorage. In central cavities of all types (Fig. 123 *a* and *b*), whether they are cylindrical or funnel-shaped, it is unnecessary to make under-cuts provided the cross-cut drill is employed. This instrument forms numerous although shallow attachment grooves, as is shown in Fig. 123. If, however, the operation is done with ordinary burs, the funnel-shaped cavities must be indented with the wheel-bur (Fig. 123 *c*).

In approximal cavities the under-cuts should be made, but only in regions which are thoroughly visible, and in which the gold can be carefully condensed. Especial care is required in forming under-cuts in the front teeth, for the thinness of their crowns may easily weaken the walls of the cavity. There is also danger of drilling near to, or into the pulp, a mishap which happens quite frequently to beginners. The best fixation groove is in the cervical portion directed toward the cervix of the cavity. It is formed by penetrating with a small bur between the enamel and pulp, and parallel to the latter in such a manner that neither the enamel is weakened nor the pulp cavity encroached upon. A second retention point, provided of course that it does not cause the crown to become too weak, is made in that part of the dentin which lies between the pulp and the incisal edge of the tooth. As the tooth is very thin in this area care should be taken not to perforate the labial or lingual enamel covering, which would very much complicate the process. These two anchorage points are shown in Fig. 123*d*.

The notches selected for the purpose of attachment are usually filled with a strip or cylinder of cohesive gold, which is tightly compressed by means of a fine plugger. After this first small piece has been so tightly attached to the floor of the groove that it remains securely in position, then a second piece is placed upon the first, and a third portion of gold upon the second, and so on, until the *fixation point* or *groove* is tightly and completely filled. Each individual piece of gold must be compressed by means of a fine pointed instrument upon which very light blows are struck. When the fixation area has been filled, a slightly heated, somewhat larger cylinder of gold is brought into the cavity, and fixed with the pointed plugger to the gold in the retention and then pressed with a wider plugger against the walls of the cavity. With the completion of this procedure, the most difficult feature of the filling has been overcome, and the remainder of the operation progresses rapidly. It is of the greatest importance that each newly-introduced piece of gold should adhere tightly to that already placed within the cavity, and that, simultaneous with condensation, larger and larger surfaces of the cavity should become covered with gold. The secret of constructing a successful filling depends exclusively upon maintaining a proper relationship between these two conditions. Introducing too large masses of gold upon the fixation area gives the filling a spherical form, Fig. 124*a*. In this case it is almost impossible to subsequently establish an air-tight union with the tooth-wall, for the small piece of gold, which is later introduced between the condensed gold and the cavity wall, rapidly becomes stiff and cannot, therefore, properly adapt itself to the narrow groove.

If, on the contrary, the gold in the under-cut has not been properly condensed and a large portion of the cavity immediately covered with a thin layer of gold, the latter tends to become loosened from the walls of the cavity, while the rest of the filling is being constructed (Fig. 124*b*). The failures which are experienced soon teach one how much gold may be condensed against the fixation groove, and how much against the walls. An attempt is made in Fig. 124*c* to show the correct conditions, that is, the principles which must be considered in this procedure. Indeed these requirements are also applicable in filling central as well as approximal and labial cavities.

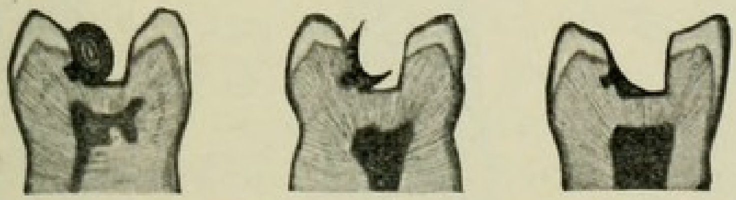


FIG. 124.—*a*, the condensing of the gold has been limited too much to the under-cut (fixation groove), and it has, therefore, become rolled into a ball; *b*, in this case, on the contrary, the gold in the under-cut has not been sufficiently condensed, and the building up of the walls was begun too soon, with the result that the gold layer became contracted and drawn away from the walls; *c*, here the proper conditions have been observed and a satisfactory result obtained.

The filling of very large cavities is rather complicated, and the process is demonstrated in Fig. 125. At first the fixation point and its neighborhood is filled, and then the gold is deposited between this layer and the opposite wall, (*b*). Finally the gold is spread in layers over this in such a manner that it will join the two portions which were first introduced. This is repeated until the cavity is completely filled.

Unfortunately the size of this work does not permit a discussion in greater detail of this very important subject.

The author's own method of *inserting a gold filling* is shown in Fig. 127, which represents, somewhat enlarged, an incisor tooth crown with an approximal filling. Two under-cuts are made. The steps of the process are as follows: At first a small piece of crystal-gold is laid on the floor of the upper under-cut and then condensed into a firmly-attached plug by means of light blows. A broad plugger is employed to spread the crystal-gold in front of the fixation notch, and by means of a pointed plugger, it is condensed into the notch. We cannot be too emphatic in recommending the filling of the fixation grooves partially or completely with crystal-gold. For it attaches itself almost immediately and prevents the struggle between the operator and the first portion of gold, as one often sees even with the experienced dentist, to the detriment

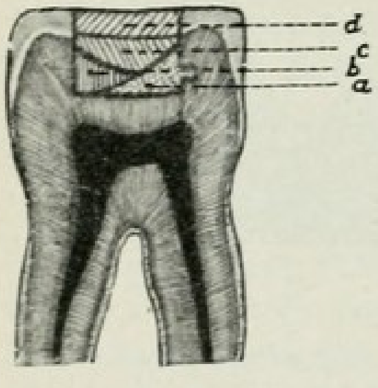


FIG. 125.—The various stages in the filling of a large central cavity with gold. *a*, first; *b*, second; *c*, third; *d*, fourth layer of gold.

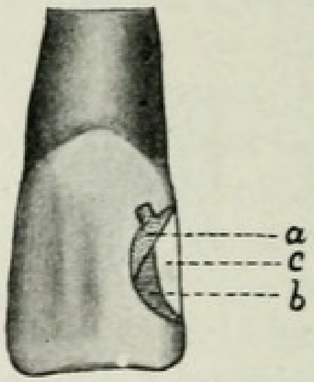


FIG. 126.—The various stages in filling with gold an incisor approximal cavity which is not too large; *a*, first; *b*, second; *c*, third layer of gold.

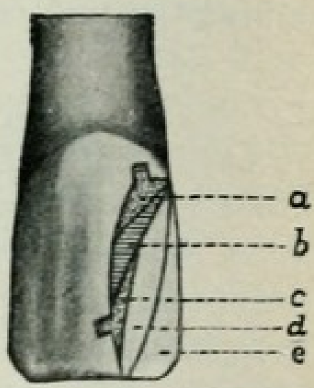


FIG. 127.—The various steps taken in filling with cohesive gold a large approximal cavity of an incisor tooth: *a*, crystal-gold and small gold cylinder; *b*, larger gold cylinder; *c*, crystal-gold and small gold cylinder; *d*, large gold cylinder (slightly heated); *e*, gold foil No. 40, (strongly heated).

of the filling. Letter *a*, in Fig. 127, indicates the position of the crystal-gold upon which at first small cylinders of gold about the diameter of the under-cut are hammered. These cylinders are but slightly heated, and must not be made too firm. Next larger cylinders (*b*) are placed upon the upper under-cut, which is now filled with gold. These cylinders are successively compressed from the point of attachment to the lingual wall of the cavity. The rule holds good here, as it does in working with non-cohesive gold, that the visible portion should be covered first. If, on the contrary, the labial wall were first covered with gold, aside from the development of other inconveniences, the entrance of the light would be cut off. As soon as the work has progressed so far that the gold reaches the neighborhood of the lower under-cut, it becomes necessary to fill this with crystal and cylindrical gold in the same manner as in the upper notch. This is demonstrated in Fig. 127 *c*. Thus the upper is finally closely united with the lower under-cut, after which the further upbuilding of the filling presents no difficulties. The area, at *d*, is filled with larger cylinders, but it must be remembered that each cylinder must be carefully condensed by itself before a second is introduced.

After the cavity has been filled with larger cylinders until a certain level (*d*) is reached, the operation should be completed, in order to secure a fairly uniform surface, by constructing the contour with thicker foil, No. 40. This foil being folded into three or four angled pieces, which are approximately the size of the surface of the cavity. Up to this stage the gold has been condensed with the ordinary mallet or with hand pressure, during which the handle of the hand plugger must be moved to and fro while the point remains stationary. By means of this motion it is alone possible to obtain a uniform condensation, for it permits not only the edge of the plugger but also its whole surface to act upon the gold. The last foil used should be strongly heated in order to increase the hardness of the contour. The automatic, or hand mallet, gives better service here than hand pressure in securing a rapid and uniform condensation of the refined gold which lies on the surface.

Herbst has suggested a method of condensation of the gold by means of *rotation*. According to his method, the gold is burnished within the cavity by means of a smooth instrument, driven by the dental engine. This rotary movement requires an assistant, but saves much time and is decidedly more agreeable to the patient.

THE FINISHING OF A GOLD FILLING.

The careful finishing of a gold filling is fully as important as any other part of the operation. Fillings which have not been properly finished have a very unsightly appearance, and what is more harmful, permit remnants of food to cling to the uneven surface and to the edges which project over the enamel. The oral bacteria soon cause the food to undergo degeneration, whereby products are formed which have an injurious action upon the teeth. As a result, a recurrence of caries arises in the course of time at the edges of such poorly finished teeth.

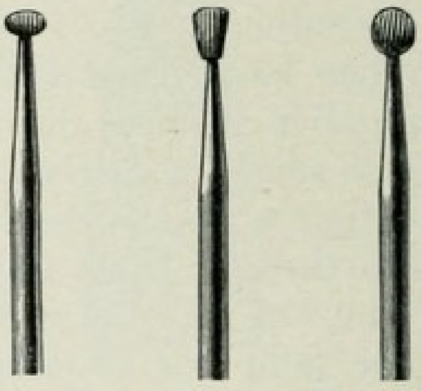


FIG. 128.—Plug finishing burs which are employed in working upon the occlusal surface of a gold filling.

In order to give a tooth its original appearance as nearly as possible, the masticating surface of central cavities must be given a *concave form*. Such cavities are usually filled too high, and must therefore, according to the foregoing law, be cut down. In order to detect the longest articulating point, a small piece of carbon paper is placed between the teeth and the patient is requested to bite. That portion of the surface of the gold which shows a black point indicates the area which must be ground down. For this purpose the steel-finishers shown in Fig. 128 are employed. Mandrels carrying emery, corundum and carborundum points are also resorted to for reducing the filling to the proper occlusion. All of these grinding substances when applied in the dry state produce heating of the tooth; it is therefore advisable to keep the stone wet.

This is easily accomplished by an ordinary water syringe (Fig. 129) held by an assistant. In the application of these grinding materials, the first object is to cause the surface of the gold to pass smoothly into that of the enamel, and shape it so that the antagonist will no longer strike it too forcibly. The filling must moreover be as smooth as a mirror, and this can only be accomplished by means of steel polishers. It is also useful to employ small points and wheels of wood, leather, felt, etc. which are covered with some polishing substance such as pulverized emery, prepared chalk, etc.

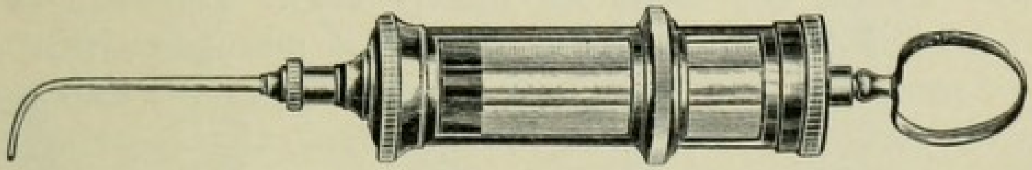


Fig. 129.—Water syringe.

Labial and especially approximal fillings must be given a convex form. Where space permits the application of fine paper disks, the operation is performed in exactly the same manner as in the case of fillings of the masticating surface, that is, the filling is first cut down to the level of the enamel at the edges and then given a high polish. This is carried out with greater difficulty at the neck of the tooth, both because the sensitive gum stands in the way and because the tooth is contracted in this region, which interferes in reaching the neck of the tooth with the finishing material. Many dentists remove the excess of gold at this point with thin bladed, curved gold trimmers, but better than these, when the surface can be readily reached, are strips of emery paper or cuttlefish-cloth strips.

AMALGAM FILLINGS.

It is a simple task to introduce amalgam fillings for the substance employed is a plastic material, that is, it is in a soft dough-like state. The ease with which this filling is made, has unfortunately caused much bungling and has therefore resulted in a loss of confidence of the laity. To obtain a properly fitting amalgam filling, the cavity must be as thoroughly prepared as for a gold filling, only the fixation grooves may be omitted provided the cavity possesses a form which will retain the filling. The instruments include old gold pluggers, polishers, etc. A good set of instruments is shown in Fig. 130. It consists of six instruments. They are, (*a*) which is a double-ended instrument with broad coarse points which are bent at nearly right angles. It is very useful for introducing pieces of amalgam into the upper molars. For the purpose of pressing the amalgam into the cavity and rubbing it to place, the instruments (*b*), (*c*) and (*d*) are employed. The instrument (*e*) is very useful; the rounded end for pressing the amalgam into the cavity, and the wing-like process for making the surface of approximal fillings smooth. The spatula (*f*) is indispensable for approximal fillings.

A description of these instruments really explains the technic of the filling. The thoroughly kneaded amalgam is formed into little pieces which must be decidedly smaller than the cavity itself. Of these at first one is introduced into the cavity and rubbed tightly against the walls. This first piece is followed by a second, then a third, and so on until the cavity is filled.

Usually the amalgam is mixed with too much mercury which gives it too soft a consistency. This evil may be met by condensing the amalgam with small pieces of bibulous paper instead of steel instruments. This causes the excess of mercury to appear on the surface in the form of small globules. The same object may be attained by absorbing the surplus mercury with tin, or gold foil, or it may be wiped off with small pledgets of cotton. The finishing of an amalgam filling is performed in the same manner as for gold, only the mass must first become thoroughly hardened, which requires several days.

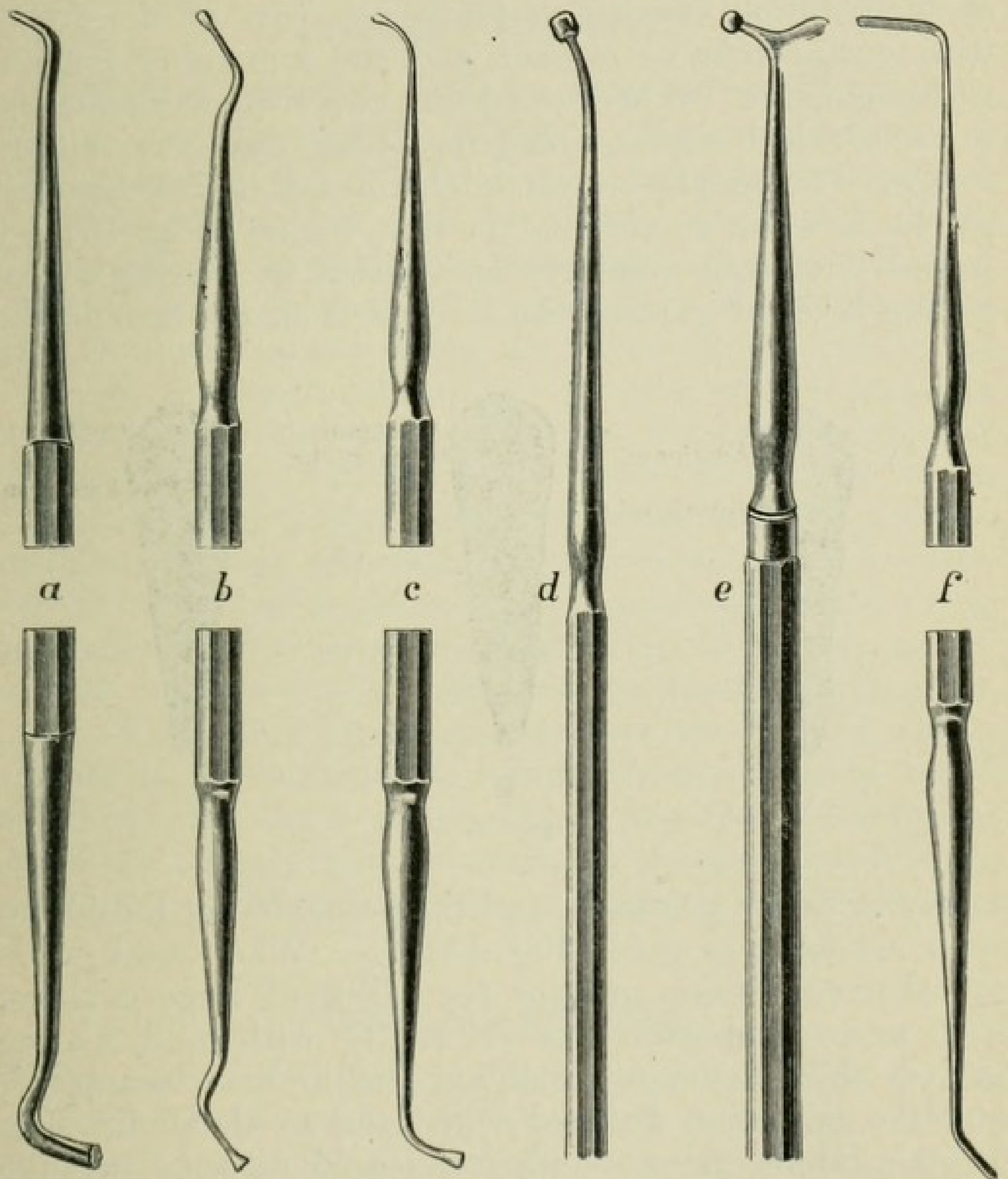


FIG. 130.

Aside from the pure form, amalgam is employed in several *combinations*. They consist (1) of a mixture with some other material in order to combine the properties of both. A satisfactory filling material of this sort consists of a mixture of zinc phosphate, cement, and amalgam. It clings to the walls of the cavity like cement, is a poor conductor of heat, and is about as resistive as amalgam fillings. This filling material is introduced according to the same principles as amalgam. (2) Another variety of combination consists in filling one part of the cavity with guttapercha or cement, and the remaining portion with amalgam. Where the gums cover the teeth that is, in the cervical region, amalgam fillings are very rapidly destroyed (especially copper amalgam) and therefore guttapercha is more serviceable in that region (Fig. 131 *a*). An advantageous combination consists in placing a protecting layer of guttapercha or cement on the floor of the

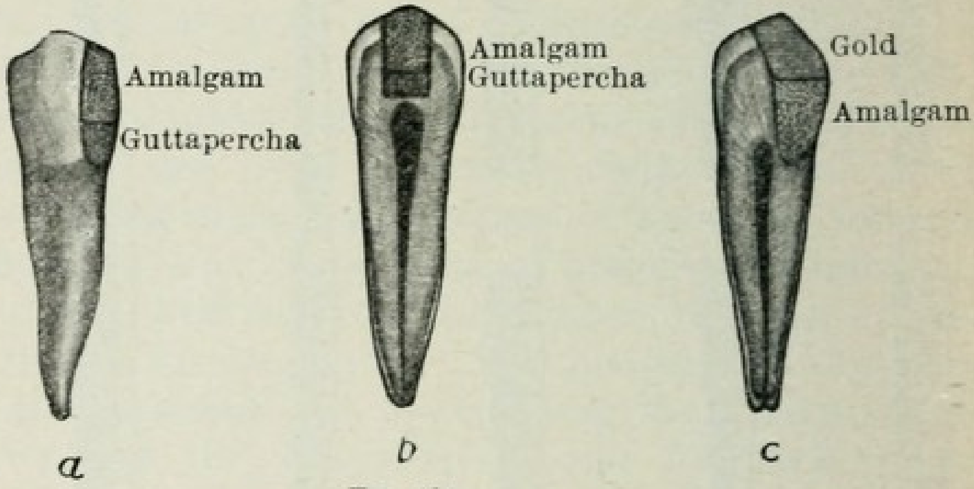


FIG. 131.

cavity in caries profunda, and then completing the filling with amalgam or gold (Fig. 131 *b*). When weak walls or other conditions prevent the filling of large cavities, such as an approximal-central cavity with gold, a more or less thick layer of amalgam should first be applied, and the operation finished with gold as shown in Fig. 131 *c*. Some operators place the gold directly into the amalgam when still soft, with the idea that the first layers should become amalgamated, and that later it is possible to complete the filling as if it were composed wholly of gold. This method, however, lacks the firm foundation which is necessary for the correct construction of a gold filling. It seems much wiser to permit the lower layer of amalgam to harden for several days, and at the expiration of that time to hammer the gold upon it. A good cement as the foundation is preferable even to the hardened amalgam in most instances.

CEMENT FILLINGS.

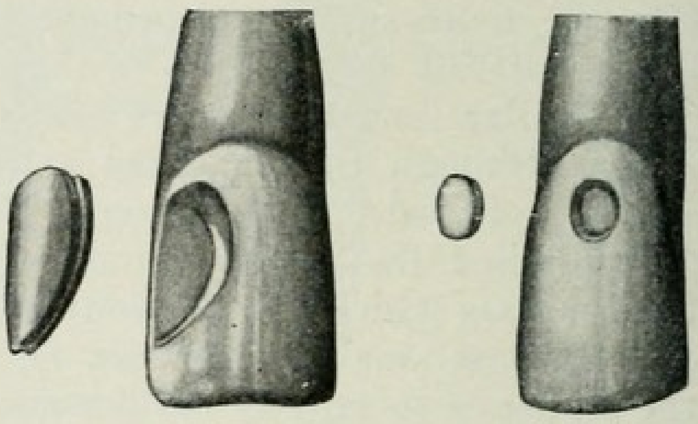
The same principles must be observed in the preparation of the cavity for the reception of a cement filling as for amalgam. All carious dentin must be removed as carefully as possible and the cavity thoroughly dried. Under-cuts are not always necessary; at any rate they need not be as deep as for the retention of gold or amalgam, because cement being an adhesive material sticks firmly to the tooth-substance. Because of this property of adhering to the tooth-substance, cement is probably the best filling material for cavities with weak walls.

The same, or similar instruments are employed as for amalgam fillings, although the spherical and the spade-shaped tools are preferred. This material is most conveniently applied when the liquid has absorbed enough powder to form a mass which can be moulded like amalgam. From this mass small pellets are formed which, because of the tendency to rapidly harden must be introduced into the cavity as quickly as possible. The finishing of the filling is similar to that of the amalgam fillings, but is not performed until the cement has become hard.

PORCELAIN FILLINGS.

The search for an ideal filling material led to the employment of enamel, glass, and porcelain. With reference to their appearance, properly prepared porcelain fillings are practically ideal, and are therefore mainly used in visible regions. Of those who advocate the use of this form of filling, some prefer to employ already prepared pieces of porcelain, while others first melt this substance in a mould, or matrix, which has been adapted to the form of the cavity.

A useful filling may be obtained by grinding a piece of the right size out of an artificial tooth. It must be borne in mind, however, that such a piece of enamel must fit as exactly into the cavity as possible. Cavities which are almost round may be given circular form, then a piece of porcelain, which fits the cavity exactly, is introduced and fastened in place by means of cement. Those who do not possess sufficient practice and patience for this purpose, may obtain already prepared enamel, out of which disks of the required size may be easily ground. Dall has manufactured enamel rods of various forms, round, oval, crescentic, etc. These are very useful, and are suitable for nearly all varieties of labial defects. If a whole corner of a tooth is to be replaced, it is preferable to employ a fragment



a b

FIG. 132.—*a*, approximal cavity prepared for the reception of an enamel filling; beside it is the filling material of melted enamel supplied with a retentive under-cut; *b*, labial defect, which has been drilled into the circular form for the reception of an enamel disk; the latter is also shown.

from an artificial tooth, to which a platinum pin has been attached. This is introduced into the cavity in such a manner that it may be tightly anchored into the cement. Various forms of such tooth corners supplied with long platinum pins are now sold to the trade. If a sufficiently deep cavity is cut into the tooth in which the peg may be fastened, the filling obtains a much more secure hold than if the pin is only inserted in the cement. Of course if the pulp has been devitalized, much larger and thicker pins may be employed, reaching into the root canal.

At the present day, however, *fusible glass* and *porcelain* are more frequently employed than the above described pieces of enamel. To fill a defect with this material the cavity is prepared as for any other filling, with the exception that it should be given a trough-like form, without under-cuts, in order to permit the securing of a matrix. The mold is obtained with a piece of gold or platinum-gold foil, No. 60, a small piece of which is pressed into the cavity by means of a small piece of spunk or cotton. While a small pledget of cotton is being pressed into the cavity with one hand in such a manner that the foil cannot be displaced, a steel polisher is used with the other hand to press it on all sides against the walls of the cavity. If by means of this manipulation an exact mold of the cavity is reproduced, and it sets so tightly in place that it cannot be shaken, it may then be carefully lifted out by means of a pair of plyers. As much porcelain powder, which has been made into a thick paste with distilled water, is then introduced into this cup-like impression by means of a small spatula, as is necessary to obtain the required height of the filling. The whole mass is then carefully and slowly heated over a white flame or in an electric furnace until it melts, after which it is allowed to slowly cool. If sufficient of this substance has been added the desired height as well as the form of the edge are obtained. Should this not be the case a fresh mass should be added and the filling again fused. Various methods have been proposed for roughening this mass of enamel on that side which is turned to the walls of the cavity, in order to make it more secure in the cement. In the majority of cases it suffices to slightly nick the filling with a diamond disk.

A rough surface may also be obtained by dusting a little gypsum on the floor of the matrix before introducing the porcelain.

Experience has taught us that glass fillings discolor in the course of time, which is attributed to the cement substance which is employed ; but since this phenomenon occurs also when perfectly colorless cement is used, it is more probable that the coloring matter in the filling itself becomes altered. The porcelain bodies which are melted with difficulty—that is, require a high degree of heat to fuse them—are believed to be the most resistive to color changes.

GUTTAPERCHA FILLINGS.

To obtain a durable filling with guttapercha, it must only be employed in places suitable for a comparatively soft material and where no pressure needs to be resisted. The cavity must be prepared with as much care as for other fillings. Before inserting the guttapercha no trace of dampness should exist, for otherwise the filling will not adhere to the walls of the cavity. The guttapercha is introduced into the cavity in little separate pieces, which are softened by holding it over the spirit lamp for a minute. By means of a ball burnisher plugger sufficient material is then successively added and pressed lightly into place until the cavity is filled. The excess which finally remains is then removed by a thin knife-like instrument which has been heated. In doing so the instrument should be directed toward the edge in order to elevate the marginal closure. Many paint the surface with chloroform in order to obtain greater smoothness; this procedure, however, causes the surface to become rougher and more easily destroyed. Such fillings, too, are likely to be applied without proper care, and therefore it is not surprising that in a short time the tooth tissues which underlie the filling undergo destruction to a larger extent. We cannot, therefore, be too emphatic in warning against the careless employment of this substance as a filling material.

In our experience, guttapercha is best suited for cavities which extend below the gum. In these cases temporary guttapercha under comparatively strong pressure is introduced, and allowed to remain for from two to three weeks. It exerts a constant pressure upon the soft parts and leads to an obliteration of the blood-vessels. If after the lapse of this time the filling is removed, it will be found that the gum stands off, and that the neighborhood of the cavity, as well as the cavity itself, can be dried much more easily than previously, and that it will then be possible to introduce with considerable prospect of success, a guttapercha filling even into a cavity which reaches far below the surface of the gums.

It is important not to heat the guttapercha either more or less than is necessary for its adaptability.

DISEASES OF THE PULP.

Of special merit in connection with the diseases of the pulp is the work of Arkövy ("Diagnostik der Zahnkrankheiten") in which he studied and classified the important forms of lesions of this organ. Diseases of the pulp usually develop as a sequel to caries, although they have been observed on rare occasions to follow traumatic influences, as for instance, the fracture of a tooth-crown or injury to the pulp caused by a dental instrument. The extent to which caries, even of the superficial type, acts upon the pulp is shown by the development of *secondary dentin*, which is shown in Fig. 133. Although most authors believe that secondary dentin is a physiologic function of the pulp, yet it is also undoubtedly the result of pathologic processes. It is for this reason that we feel justified in calling attention to it in this place. Wedge-shaped defects and abrasions may also lead to secondary formation of dentin and indeed to pulpitis. Pulpitis develops when secondary formation of dentin proceeds comparatively slowly and does not tend to halt the further progression of the defect. Concretions in otherwise intact teeth, which are known to frequently occur in the pulp, cause remarkably few symptoms; here and there however they cause circulatory disturbances which are likely to injure the pulp. Atrophia præcox and pyorrhœa alveolaris lead to exposure of the roots through which the characteristic so-called "ascending" pulpitis develops. Aside from these diseases of the pulp which arise in consequence of local causes, other forms occur, the

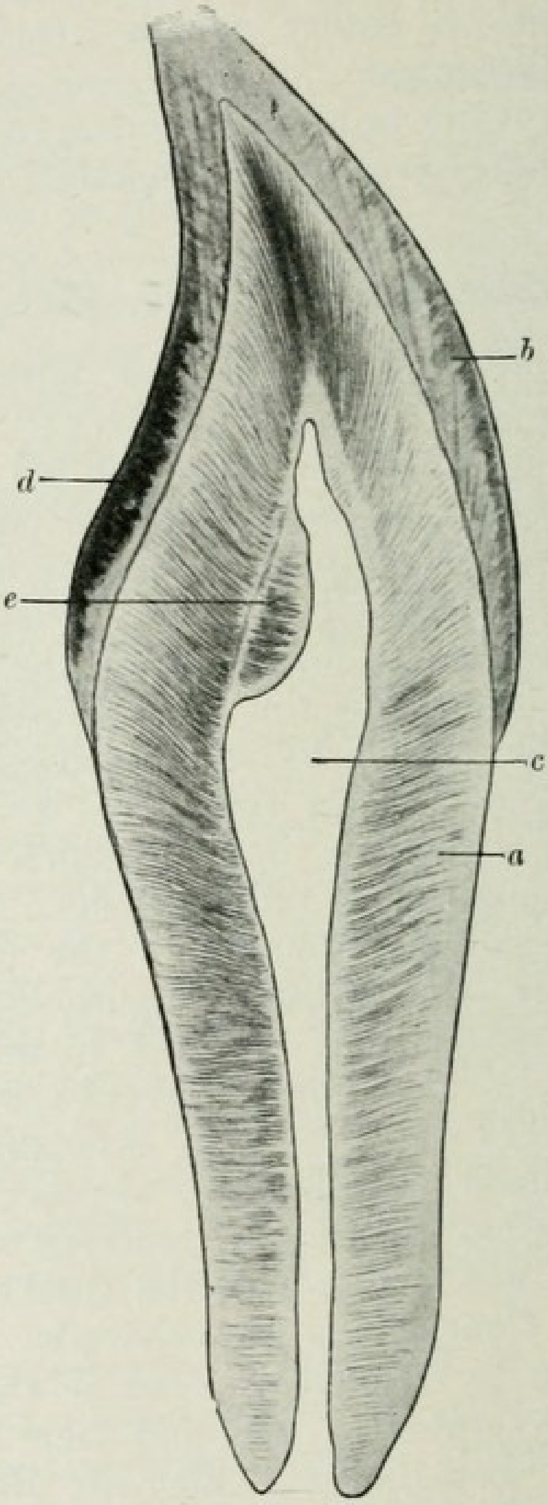


FIG. 133.—Development of secondary dentin. *a*, dentin; *b*, enamel; *c*, pulp cavity; *d*, superficial caries of enamel; *e*, secondary dentin.

etiology of which may be traced back to constitutional diseases (nervous disturbances, gout, rheumatism, etc.).

The subjective symptoms of a pulpitis demonstrate themselves at the beginning by an abnormal sensitiveness to changes in temperature, especially cold and hot drinks, which call forth attacks of pain, as well as sour and sweet foods, that is irritating chemical substances. Pain is furthermore caused by the mechanical action of certain substances, as for example the presence of coarse foods in the cavity, or when the tooth is touched with an instrument. The diseased tooth is usually, however, not sensitive to tapping, a fact which is of value in distinguishing diseases of the pulp from those of the periosteum.

The pain, which originally lasts but a few moments, finally continues for hours and even days. It may spread to the neighboring regions to such an extent that the patient no longer feels it as originally in any one tooth, but in the whole tooth row of the involved jaw and even in the opposing teeth.

The most important of the forms of diseases of the pulp, classified by Arkövy and Rothmann on a patho-histological basis, are as follows :—

1. Hyperemia of the pulp.	Acute forms.
2. Acute superficial pulpitis.	
3. Acute partial pulpitis.	
4. Acute total pulpitis.	
5. Acute partial purulent pulpitis.	
6. Acute traumatic pulpitis.	
7. Chronic parenchymatous pulpitis.	Chronic forms.
8. Chronic total purulent pulpitis.	
9. Chronic hypertrophic granulomatous pulpitis.	
10. Chronic hypertrophic sarcomatous pulpitis.	
11. Gangrene of the pulp.	
12. Idiopathic or concretional pulpitis.	

HYPEREMIA OF THE PULP.

In this disease the normal sensitiveness of the tooth is increased ; that is, hot and cold call forth a slight and rapidly disappearing pain. Hyperemia occurs mostly in carious or worn down teeth, and is due to thermic irritants which act upon the insufficiently covered pulp, or (in caries) to injurious bacterial products. Such a pulp removed from an extracted tooth shows under slight magnification dilatation of the whole vascular system, including both the afferent as well as the efferent vessels. As long as circulation continues in spite of this dilatation no further disturbances arise, but as soon as it ceases inflammatory signs appear.

The treatment is always conservative, that is, the pulp should be encouraged to heal. This is accomplished by removal of the causal factors. Exposed, abraded dentin must be protected by a non-conducting filling material, and in order to stop the action of the carious products as much of the softened dentin must be removed as possible, and the cavity closed. The latter is carried out in the same manner as in the case of caries profunda, being sure to introduce a non-irritant and non-conductive material like guttapercha between the floor of the cavity and the filling.

ACUTE SUPERFICIAL PULPITIS.

The superficial form of pulpitis, which has also been called *septic inflammation of the pulp* by Arkövy, is most frequently seen in the first molars of young patients, in which the larger portion of the crown has been destroyed by caries without however exposing the pulp cavity, Plate 25, Fig. 2. In this type of pulpitis an unpleasant sensation arises spontaneously which sensitive patients call pain. It disappears rapidly but recurs after short intervals. The use of the excavator as well as irrigation with cold water cause little or no pain.

On microscopic examination, we find, as described by Rothmann, deposits of micro-organisms " like finely scattered sand " in the superficial portion of the pulp. The pulp tissue itself has as yet suffered no alterations whatever. As to the question why such bacterial invasions do not occur in other carious processes, it must be remembered that in young teeth the dentinal tubules are very wide and easily traversed by bacteria. Furthermore, such poorly constructed first molars possess as a rule insufficient vital energy to build a protecting transparent zone, which would prevent the penetration of the bacteria.

The *therapy* is satisfactory, for this is the only curable form of pulpitis. In my experience, the best results are obtained by introducing, for from five to ten minutes, in the cavity which has previously been thoroughly cleaned, a 5 per cent. solution of formaldehyde (that is 5 per cent. of 40 per cent. watery solution) or a crystal of pure chlorphenol. After a number of the bacteria have thus been destroyed, a procedure which does not cause the pulp the slightest injury, a permanent antiseptic is placed on the floor of the cavity before introducing the filling. For this purpose a mixture of iodoform and creosote is used which is covered with an asbestos cap.

ACUTE PARTIAL, TOTAL, AND TRAUMATIC PULPITIS.

If any portion of the pulp is exposed in consequence of a carious process, or through an injury (Plate 25, Fig. 6) all the symptoms of an inflammatory process soon develop. The reddening becomes especially noticeable, and von Metnitz has even observed a swelling of the pulp in the region of the perforation.

The attacks of pain in *partial pulpitis* vary from a light to a severe degree, occur at frequent intervals, and may arise spontaneously, or after irritation from taking food or cold drinks. The patient is perfectly able to indicate the tooth involved, for at this period no radiation pains have set in. Tapping the tooth does not call forth pain, for periosteal involvement is absent.

After a short time the inflammatory process spreads to the remaining pulp tissue so that an *acute total pulpitis* develops from the above described form. It is diagnosticated by the following subjective and objective symptoms. The pains become more severe, and radiate to the neighborhood to such an extent that they can no longer be traced to the affected tooth, for they now extend throughout

PLATE 25.

FIG. 1.—Bicuspid tooth with normal healthy pulp.

FIG. 2.—Molar with acute superficial pulpitis. Although the pulp cavity has not been penetrated, yet the surface of the pulp which lies nearest to the focus of caries is reddened.

FIG. 3.—Incisor tooth with acute partial pulpitis. At the seat of perforation of the pulp cavity the pulp shows circumscribed redness.

FIG. 4.—Molar tooth with acute total pulpitis. The whole pulp is reddened.

FIG. 5.—Bicuspid tooth with partial purulent pulpitis. The crown of the pulp is partially ulcerated, and is therefore yellow in color.

FIG. 6.—Molar tooth with traumatic pulpitis. A fracture of the crown exposed the pulp, which is considerably reddened.

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the jaw and even to its opposite fellow. Spraying of cold and hot water cause excruciating pain, and a similar effect follows even the slightest touch of the pulp. A secondary periostitis usually develops, so that tapping the tooth or closing the mouth causes pain.

Partial inflammation of the pulp shows, patho-anatomically, a circumscribed reddening which extends toward the perforated area (Plate 25, Fig. 3). On account of the associated circulatory disturbances, the afferent vessels which penetrate the root canals also become dilated, and therefore cause a reddening in that region. The remaining pulp tissue remains practically normal. The pulp tissue is strongly infiltrated; larger and larger masses of mononuclear and poly-nuclear cells arise at the seat of the pulp-cells, and in the region of the nerves and blood-vessels. These infiltrated masses unite and form an abscess of the pulp. The blood-vessels are dilated, stasis has already developed in some areas, and even circumscribed foci of necrosis are seen (Plate 28). *Acute total pulpitis* (Plate 25, Fig. 4) shows the same picture, only it spreads over the whole pulp.

In connection with the *treatment* we must bear in mind that the pulp can no longer be saved, and should, therefore, be devitalized and extirpated.

Fig. 1.

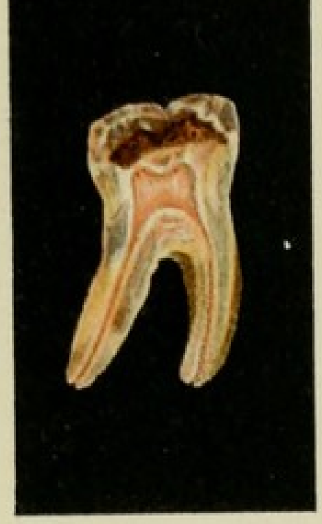

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

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ACUTE PARTIAL PURULENT PULPITIS AND CHRONIC TOTAL PURULENT PULPITIS.

(Plate 25, Fig. 5 and Plate 26, Fig. 4.)

A suppurating inflammation of the pulp may follow an ordinary acute partial pulpitis, or it may be due to localized exposure of the pulp. The process leads immediately to a loss of substance, and should, therefore, be termed *acute ulcerative pulpitis.* In the course of time, that is, when the process becomes chronic, the suppuration involves a greater amount of the pulp tissue and forms a *chronic total purulent pulpitis.* The true suppurative form is more likely to occur when the pulp cavity is not exposed, and especially when large metallic fillings exist (see Plate 27, Fig. 2). The pressure and erosion due to the pus causes a character of pain in such teeth which is altogether different from that experienced in non-suppurative inflammations. The pains do not arise suddenly, but are very slight at the beginning and increase in severity gradually.

They are characterized usually by a dull gnawing or throbbing sensation. Cold water causes pain only in the early stages, later it is only caused by hot water. Careful opening of the pulp cavity during which some of the pus is discharged, is not necessarily painful at first, but after a few seconds the patient complains that the pain has again returned to the diseased tooth.

The *treatment* is the same as in the case of the ordinary partial and total pulpitis. The only difference being that the surface of the pulp must be freed of pus before introducing the arsenic, for otherwise the pulp will be devitalized much less rapidly and accompanied by greater pain.

CHRONIC PARENCHYMATOUS PULPITIS.

(Plate 26, Fig. 6.)

This form of pulpitis is described by Arkövy as follows: "The microscopic findings show that the pulp is succulent, swollen, grayish and covered, provided the

PLATE 26.

FIG. 1.—Bicuspid with gangrene of the pulp.

FIG. 2.—Molar with chronic hypertrophic sarcomatous pulpitis.

FIG. 3.—Incisor with chronic hypertrophic granulomatous pulpitis.

FIG. 4. Incisor with chronic total purulent pulpitis. The yellow spots indicate the abscess cavities in the destroyed parenchyma.

FIG. 5.—Bicuspid with ascending pulpitis. Pyorrhea alveolaris caused the root to become exposed and as a result the pulp lying at the apical foramen became infected.

FIG. 6.—Wisdom tooth with chronic parenchymatous pulpitis.

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whole pulp is not yet involved, with snow-white specks or stripes, while in other cases it is grayish throughout and very transparent. This is as true of the crown as of the root pulp. The exposed coronal portion of the pulp shows a circumscribed area of injection, of which no traces can be detected in the neighboring portions of the pulp." The patient experiences no sudden spasms of pain, but instead a continuous discomfort exists which may pass into a tense drawing sensation. Cold water causes a painful sensation only after a time. Touching the tooth with an instrument is also not very painful. Injuries to the pulp, on account of general dilatation of the blood-vessels, lead to profuse hemorrhages.

Microscopically, it will be observed that the pulp cells have multiplied (hyperplasia) and that the blood-vessels are congested (hyperemia). This form of pulpitis is distinguished from chronic total pulpitis by the smaller amount of leukocytic infiltration. The pressure caused by the hyperplasia and hyperemia upon the elements of the pulp for weeks and months finally results in *atrophy*, (Plate 27, Fig. 1). Rothmann writes concerning this condition as follows: "The originally fibrous adenoid tissue of the pulp, which is partially composed of fine meshes, is completely converted into a widely meshed *adenoid connective tissue*, on account of the cell proliferation following the hyperemia." The writer cannot agree with this view, on the ground that the full grown pulp possesses no adenoid connective tissue; that is, reticular tissue, filled with leukocytes.

In the rare instances in which a periostitis develops, the *treatment* consists in thorough removal of the pulp tissue.

Fig.1.

Fig.2.

Fig.3.

Fig.4.

Fig.5.

Fig.6.

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CHRONIC HYPERTROPHIC GRANULOMATOUS AND SARCOMATOUS PULPITIS.

We have illustrated both forms on Plate 26, Figs. 2 and 3. They differ from all of the previously described varieties of pulpitis by the presence of true growths. According to Arkövy, some are simply *granulations* (homoplasia), while others are developed from degenerated pulp elements (heteroplasia), and are *sarcomata*.

Chronic hypertrophic granulomatous pulpitis, that is, polyp of the pulp arising from granulation tissue (Plate 26, Fig. 3), represents a minimum amount of new growth which rarely exceeds the size of a pea. This polyp does not cover the whole surface of the pulp, but, at the most, only one or two tips of that structure. The consistency is soft, on account of which touching it with an instrument may very easily cause an injury, which is always accompanied by a rather severe hemorrhage.

The patients usually suffer no pain; only mechanical insults call forth a sensation similar to that which occurs when an inflamed gum is irritated.

Arkövy classifies under the head of *chronic hypertrophic sarcomatous pulpitis* all those neoplasms of the pulp which are clearly outlined, which have a smooth or lobulated surface, and which are accompanied by but little hemorrhage. They do not involve one or two tips of the pulp, but occupy its whole crown, and fill a more or less large portion of the carious tooth cavity (see Plate 26, Fig. 2). The subjective symptoms are similar to those of the granulomatous form.

The *differential diagnosis* consists in distinguishing it from hypertrophies of the gum, and eventually from tumorous masses which grow upward from the depths of the alveoli. In the first case the growth may be pressed out of the carious cavity by means of guttapercha or cotton, and in case of periosteal tumors, the root canal is demonstrably increased in size, a condition which is less likely to be seen in the presence of pulp polyps. Such polyps are removed by means of the thermocautery or

PLATE 27.

FIG. 1.—Incisor tooth with atrophy of the pulp. It is probable that a chronic parenchymatous pulpitis formerly existed for it may occasionally lead to an atrophy.

FIG. 2.—Bicuspid tooth with a chronic total purulent pulpitis which developed underneath a large metallic filling.

FIG. 3.—Incisor tooth with idiopathic or concretional pulpitis. The pale concretions are seen as points in the somewhat reddened pulp.

FIG. 4.—Molar tooth with ascending gangrene of the pulp.

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the lancet, and the remaining pulp tissue destroyed and extirpated.

GANGRENE OF THE PULP.

(Plate 26, Fig. 1.)

Gangrene of the pulp may follow as a sequel to most of the previously described acute and chronic inflammations of the pulp, or this structure may undergo gangrenous degeneration without having been preceded by any symptoms of disease. It occurs most frequently in teeth which have been badly necrosed. The reason why gangrene should develop instead of suppuration, is probably explained by the presence of different microörganisms. Thus in purulent pulpitis pyogenic bacteria predominate, and in gangrenous pulpitis true excitants of putrefaction exist. Arkövy obtained such a microörganism in pure culture from a large number of gangrenous pulps, and the writer has also isolated it. That this organism, called the *bacillus gangrenæ pulpæ*, is really able to cause a typical gangrene of the pulp has been determined by Arkövy, through inoculation of healthy teeth.

The development of gangrene destroys the pulp not only when the pulp cavity has been opened, but also rarely in intact teeth, and more frequently in teeth supplied with large fillings. In very rare cases on opening of the tips of the roots, an ascending form of gangrene, may be observed following pyorrhea, Plate 27, Fig. 4. This condition is easily explained, for injurious bacteria enter the pulp through the apical foramen, while gangrene of intact teeth is explained by the fact that microörganisms

Fig.1.

Fig.2.

Fig.3.

Fig.4.

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circulate in the healthy pulp as they do in healthy tissues in other portions of the body.

When a tooth which is diseased in this manner is opened, the foul odor is the first characteristic noted. A pledget of cotton inserted into the cavity will bring forth a dirty colored discharge, instead of the red discharge seen in most forms of pulpitis, or the yellow discharge of the suppurative form. In the early stages, sounding the deeper portions with an explorer still causes pain. Later all sensitiveness ceases and the whole root canal is filled with this foul mass. In this stage the whole tooth assumes a dark color.

The pains are considerable and occur in paroxysmal attacks, and at the beginning are easily mistaken for those of acute partial and total pulpitis. They differ, however, from these inasmuch as they react less promptly to mechanical irritants, and are also not as prompt in reacting to heat and cold. In the case of unopened pulp cavities, on the contrary, and when the pulp tissue has already undergone extensive destruction, considerable pain is caused by the action of warm water. The explanation of this is that the gas evolved from the putrefactive changes is locked in the pulp cavity, and, expanding on account of the higher temperature, exerts pressure upon the surviving nerve elements, or upon the periosteum. The periosteum becomes rapidly involved, and as a result the tooth is highly sensitive whenever an attempt is made to masticate, or whenever the tooth suffers any external disturbance.

The *treatment* requires especial discussion and will therefore be considered in the next chapter.

IDIOPATHIC OR CONCRETIONAL PULPITIS.

(Plate 27, Fig. 3).

The development of dentinal tumors in the body of the pulp, or the deposition of concretions of lime, may cause such severe pain as to compel the patient to consult us. Perfectly healthy teeth may develop this condition, but

PLATE 28.

Acute partial pulpitis.

a. Normal pulp tissue.
b. Dilated blood-vessels.
c. Blood-vessels filled with coagulated blood.
d. Round cell infiltration.
e. A necrotic and caseous focus.
Longitudinal section. Hematoxyl.—Eosin.

PLATE 29.

Chronic pulpitis.

a. Normal pulp tissue.
b. Dilated blood-vessels.
c. Leukocytic infiltration.
Longitudinal section. Hematoxyl.—Eosin.

PLATE 30.

Abscess of the Pulp.

a. Normal tissue.
b. Odontoblastic layer.
c. Abscess cavity.
Longitudinal section. Carmin.

PLATE 31.

Fatty degeneration.

a. Normal pulp tissue.
b. Blood-vessel cut transversely, filled with red blood corpuscles.
c. Fat cells; the nuclei are compressed against the surrounding capsule.
Longitudinal section. High magnification. Picrin-Formol. Hematoxyl-Eosin.

PLATE 32.

Reticular atrophy caused by hydremic degeneration of the pulp elements.

a. Normal pulp tissue.
b. Odontoblastic layer.
c. Cells which have undergone hydremic degeneration still showing some of the nuclei at the walls.

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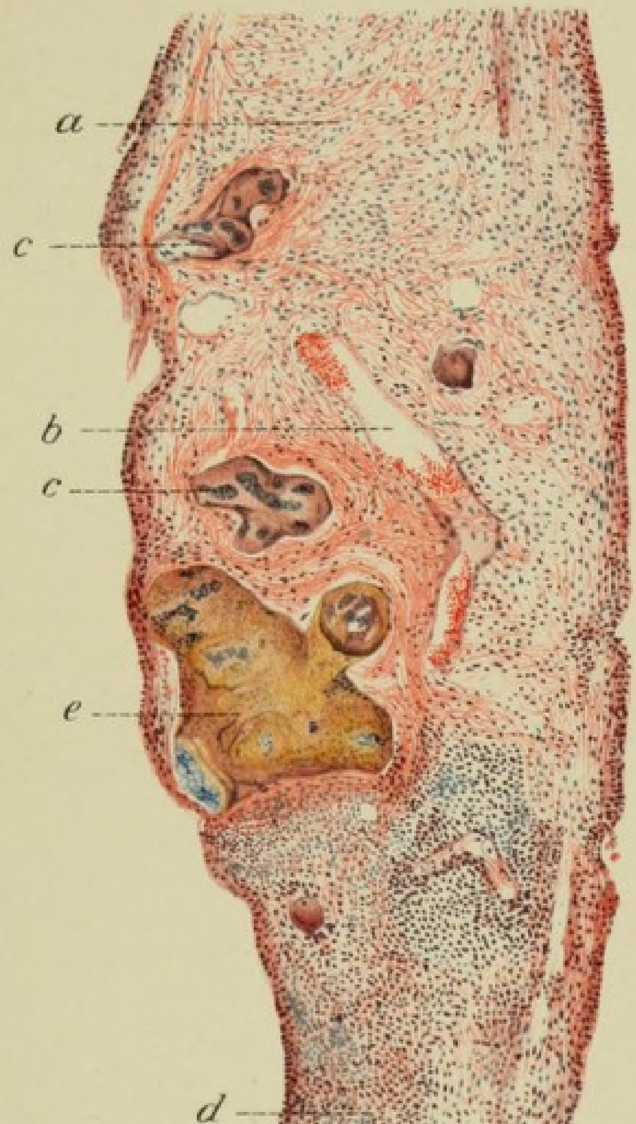
it occurs more often when a considerable portion of the crown has been worn down.

The pains are usually *neuralgic* in character, and the condition may, therefore, be easily mistaken for trigeminal neuralgia. Inasmuch as the patient cannot always tell which tooth is affected, and as the objective diagnosis is not always possible, it may be necessary to sacrifice several teeth before the diseased one is located. *Extraction* is of course of value, yet it is not the only therapeutic remedy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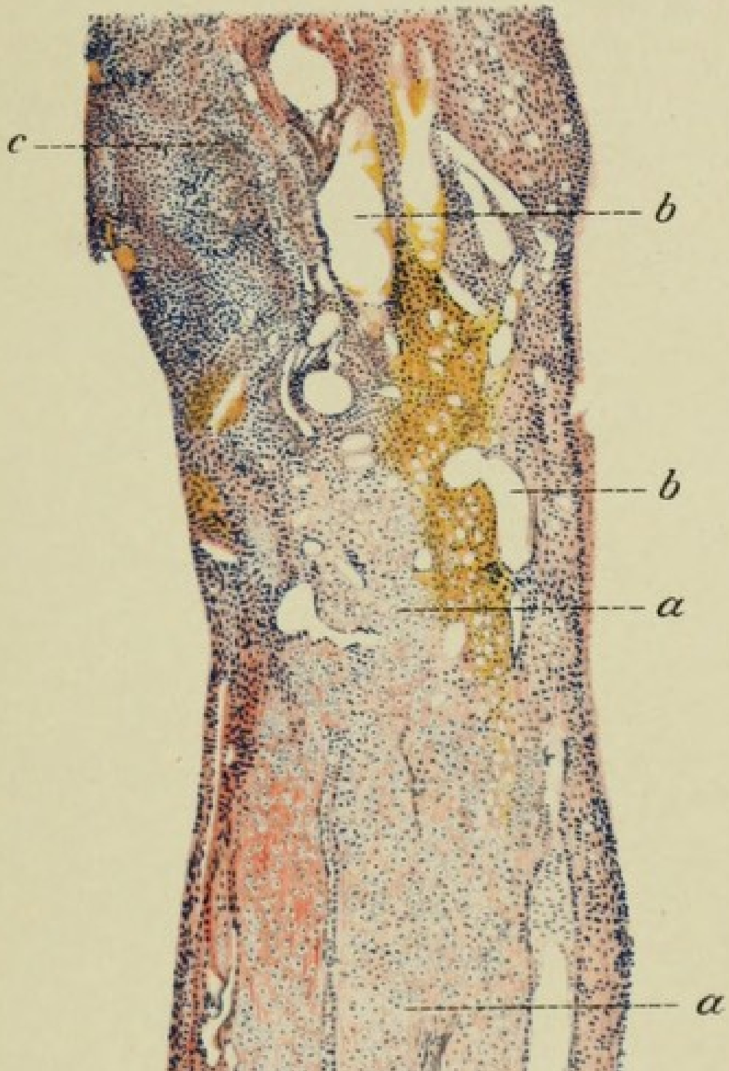
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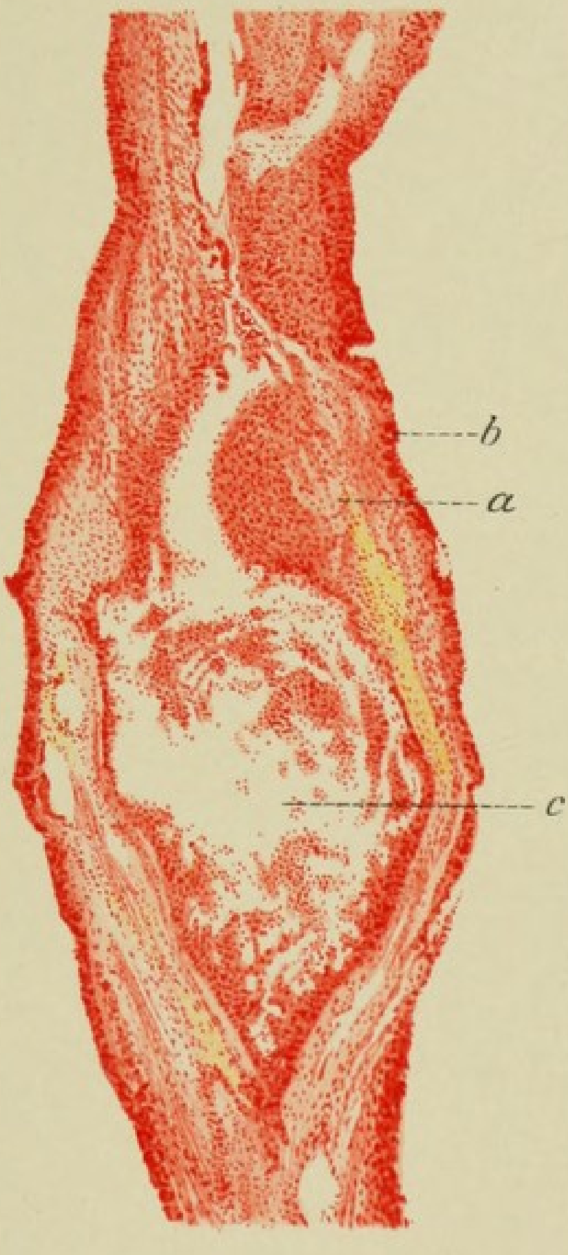
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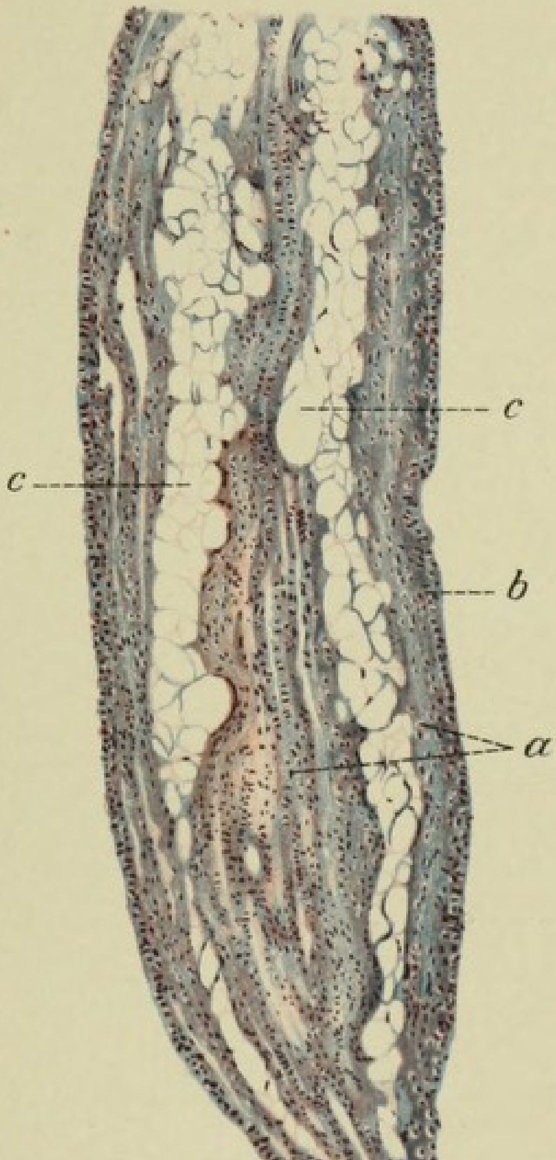
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in this condition. The same object may be obtained by extirpation of the pulp, provided this is not made impossible by too extensive involvement with concretional deposits. This should always be attempted before extraction is resorted to.

PATHOLOGIC AND ANATOMIC REMARKS CONCERNING DISEASES OF THE PULP.

Pulp tissue differs considerably, pathologically, from other similar tissues of the animal organism. This difference manifests itself chiefly by the astonishing lack of resistive power to disease. A restitution of healthy tissue in place of that which has been destroyed has not as yet been observed, even though the only case in the literature (by Gysi) seems to contradict that statement. The author has also failed, in the microscopic examination of many hundred pulps, to observe any but a very slight tendency to the development of *scar tissue.*

In our opinion, the reason for this poor healing capacity of the pulp can be traced to the narrow afferent and efferent vessels, together with the poor supply of lymph spaces. Even a circumscribed disease of the pulp leads to local circulatory disturbances, which are naturally shared by the vessels enclosed within the root canal. In that case, the blood-vessels of the root pulp are also congested, and show a highly red color. The increased pressure thus formed interferes with the outflow of the blood, as well as its circulation throughout the plexus within the pulp. Such a disturbance occurs also in other organs, but is more or less completely compensated for by collateral circulation. The insufficient anastomosis of the blood vessels, which is necessary because of the narrow canal with rigid walls in which they are enclosed, explains perfectly the astonishing lack of resistance of the pulp.

Aside from the few cases of tumor formation, practically only *degenerative processes* occur, which because of their pathologic anatomy are termed *regressive disturbances in nutrition.* As demonstrating these changes the following specimens are shown. On Plate 28 is seen a longitudinal section of a chronically inflamed pulp, stained with hematoxylin-eosin, in which one may study the picture of a circumscribed necrosis. Some areas show infiltration of round cells; the blood-vessels are dilated and their lumina are partially occluded with blood clot. The necrotic area is soft in consistency, and, because of its nucleated character, is similar to the caseating focus which tends to develop in richly cellular tissue as a result of tuberculous disease. Accordingly, this is a case of beginning *caseation*, which would probably have proceded to necrosis of the whole pulp tissue, provided the pulp had not been extirpated.

Plate 29 shows a chronically inflamed pulp with enormous dilatation of the blood-vessels. This dilatation of the arteries and veins brings many cross-sections of vessels into view which were previously invisible, and thus gives the impression that a large number of new vessels have been formed. The tissue in the neighborhood of these dilated vessels is considerably infiltrated. The fact that individual vessels, situated in normal areas, are also dilated may be accepted as an indication of the manner in which local circulatory disturbances may interfere with the circulation of the blood throughout the whole pulp.

Plate 30 shows an *abscess* following a total purulent pulpitis. The true abscess cavities, which are still partially filled with pus, possess no distinct boundary, but pass into spaces which developed from total destruction of certain portions of the pulp. This destructive process tends to spread in the walls of the cavities, as may be seen by the cellular disintegration of the same.

Plate 31 shows, under high magnification, a section fixed with picrin-formol, and stained with hematoxylin-eosin. The pulp tissue is normal, excepting for the presence of swollen yellow cells with nuclei situated at the walls. Eventually a *fatty degeneration* may develop, for the cells appear exactly like fat cells of a fatty heart. The preparation is from a young individual. The pulp was not inflamed, but was removed from the tooth for other reasons, and the discovery was therefore accidental.

Plate 32 shows the pretty picture of a *reticular atrophy* which developed from a *hydremic degeneration* of the pulp tissue. In certain areas one may still see cells filled with fluid, the membranes of which are distended like bladders, and whose nuclei are pressed against the walls. In other areas these cells form vacuoles by fusion. This hydremic degeneration spreads to the root portion of the pulp, and gives it a spongy appearance. The crown portion, which is not shown here, has been altered by inflammation.

Plate 33 shows two large free *lime concretions* which have almost completely compressed the pulp tissue. These oval lime-bodies, the layers of which are concentrically arranged, caused an idiopathic pulpitis and led to the extraction of the involved tooth.

Plate 34 shows another variety of lime-bodies, which are found in a pulp associated with a partial pulpitis. The preparation shows an area of normal pulp tissue in which are seen a considerable number of comparatively small lime-bodies which are arranged in layers. The dark color of these bodies which is obtained on staining hematoxylon indicates that deposits are concerned which are at present undergoing calcification, for, as a rule, old concretions do not color so intensely.

Plate 35 shows *calcium granules.* These are more likely to develop in the connective tissue around the blood-vessels, which has undergone hyaline changes. In fact this picture shows a calcium granule which rests upon a blood-vessel, and which seems to compress it to one side.

Plate 36 shows, with high power, a chronic inflammatory process, which has degenerated the pulp to such an extent that it does not look unlike a psammoma of the dura mater. The whole tissue consists only of fibrous strands with a few normal pulp cells. All the remaining pulp cells, and, as far as can be seen, the majority of the vessels have undergone hyaline degeneration. These tissues have been changed into round or polygonal hyaline bodies, whose

PLATE 33.

Large concretions of lime which have a layer formation like that of an onion.

a. Normal pulpitis.
b. Lime granules.
Longitudinal section. Hematoxyl.-Eosin.

PLATE 34.

Small Concretions of Lime.

a. Normal pulp tissue.
b. Blood-vessels.
c. Small concretion of lime which is also arranged in concentric layers like an onion.
Longitudinal section. Hematoxyl.-Eosin.

PLATE 35.

Deposits of Lime.

a, Normal pulp tissue.
b. Blood-vessel (longitudinal section).
c. Blood-vessel (cross section).
d. Deposits of lime, of which the upper one rests upon a blood-vessel.
Longitudinal section. Hematoxyl.-Eosin.

PLATE 36.

Hyaline Degeneration of the Pulp.

a. Fibrillary connective tissue.
b. Blood-vessels.
c. Hyaline flakes within which beginning calcification is shown.
Longitudinal section. Hematoxyl.-Eosin. High magnification.

PLATE 37.

A senile sclerotic pulp.

a. Fibrillary connective tissue poor in nuclei.
b. A longitudinal section of a blood-vessel.

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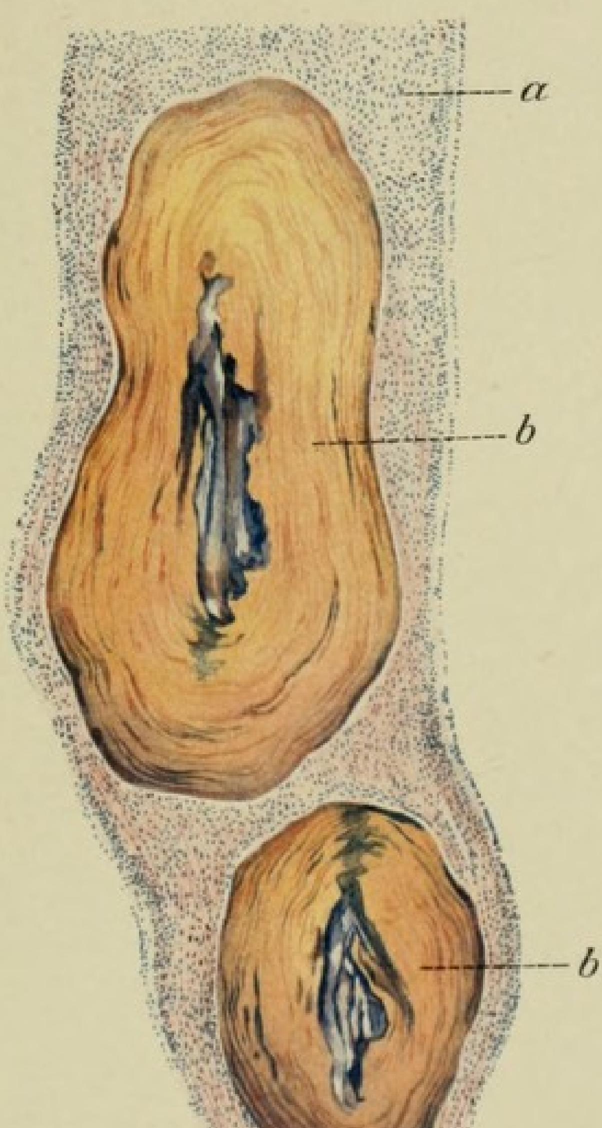
centers are calcified, and therefore stain blue with hematoxylin. The periphery of each body, however, appears as a transparent, pale, and colorless hyaline halo.

All of the pulps thus far described were obtained from young persons in order to exclude senile changes.

Plate 37 shows a senile pulp in which the usually soft, richly cellular pulp tissue is substituted by a firm, fibrous connective tissue which has but few nuclei. The change is therefore a *sclerosis.* The long extent of the course of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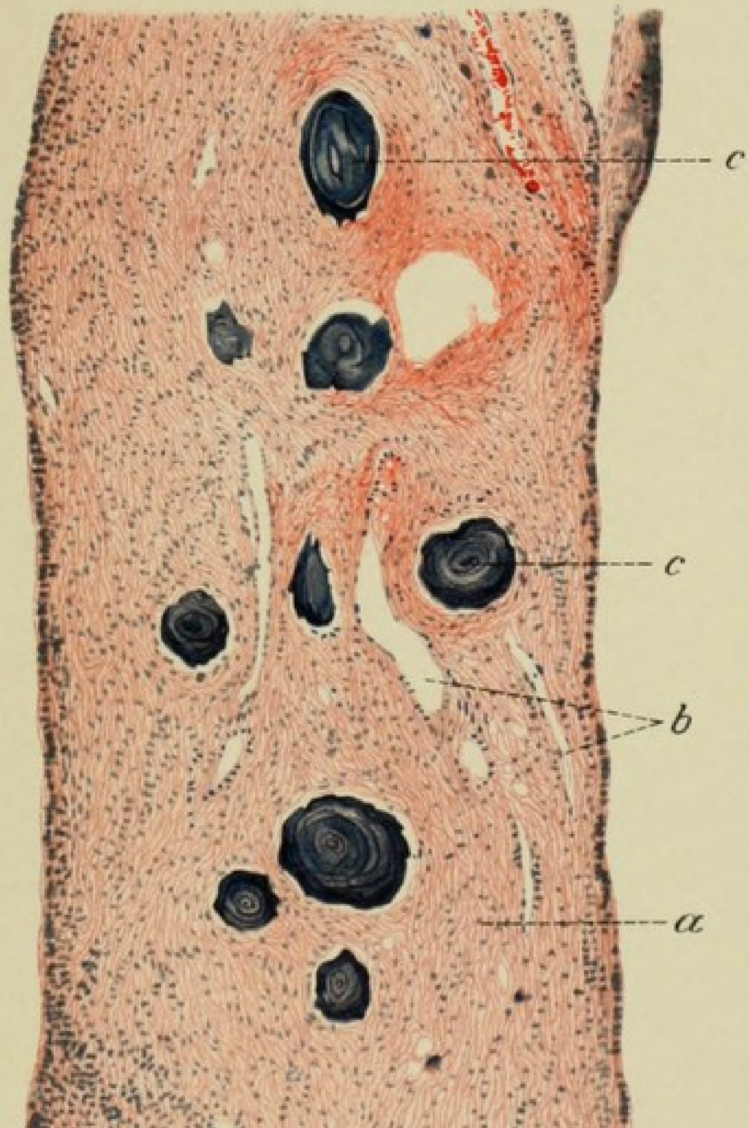
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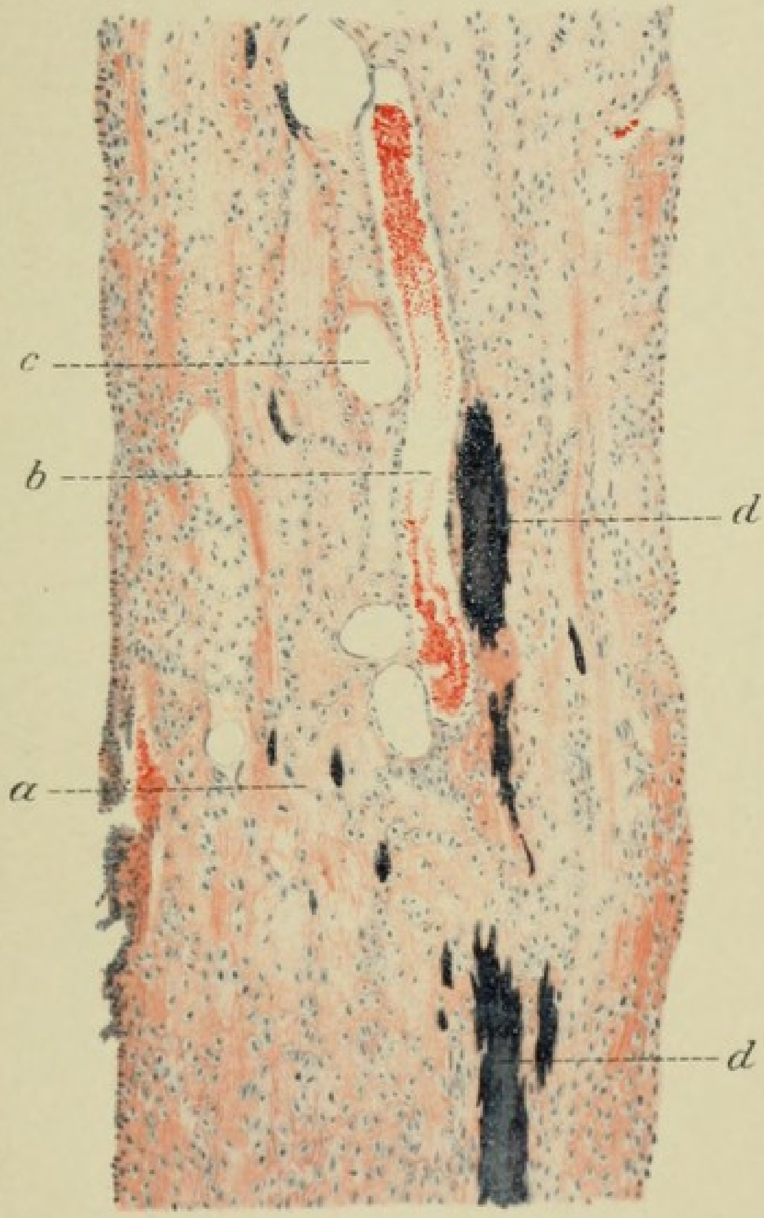
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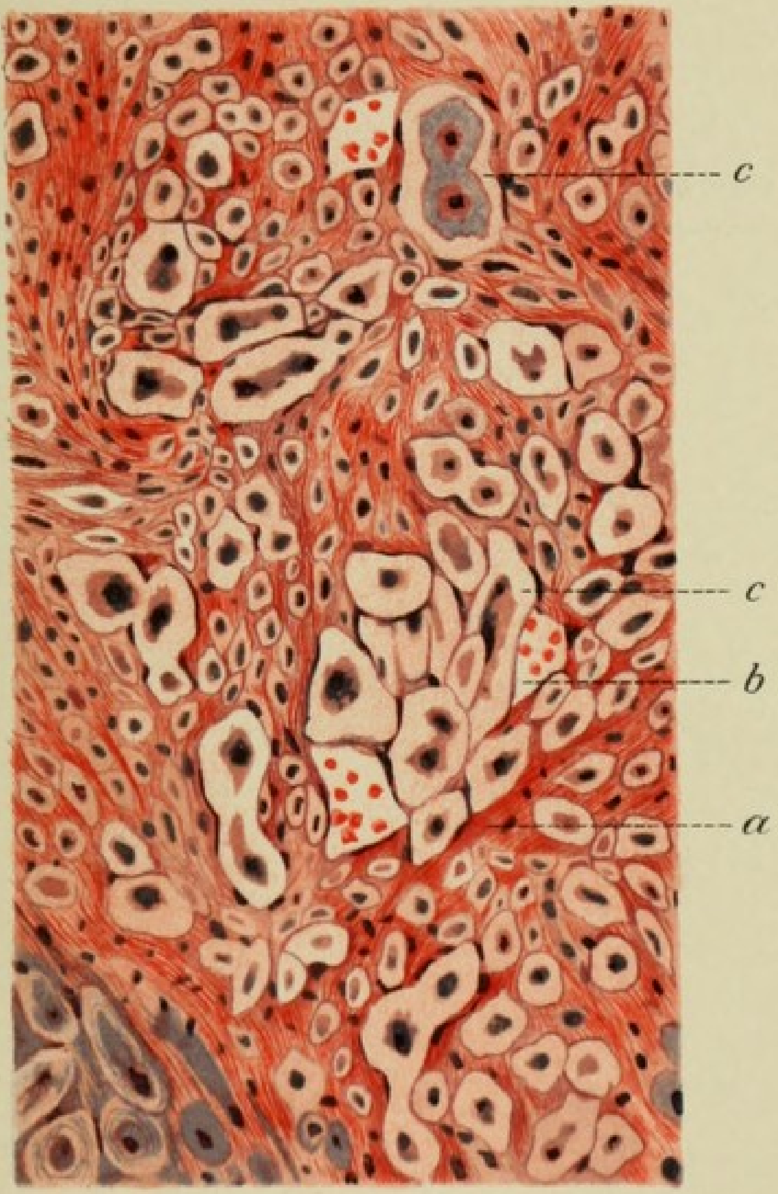
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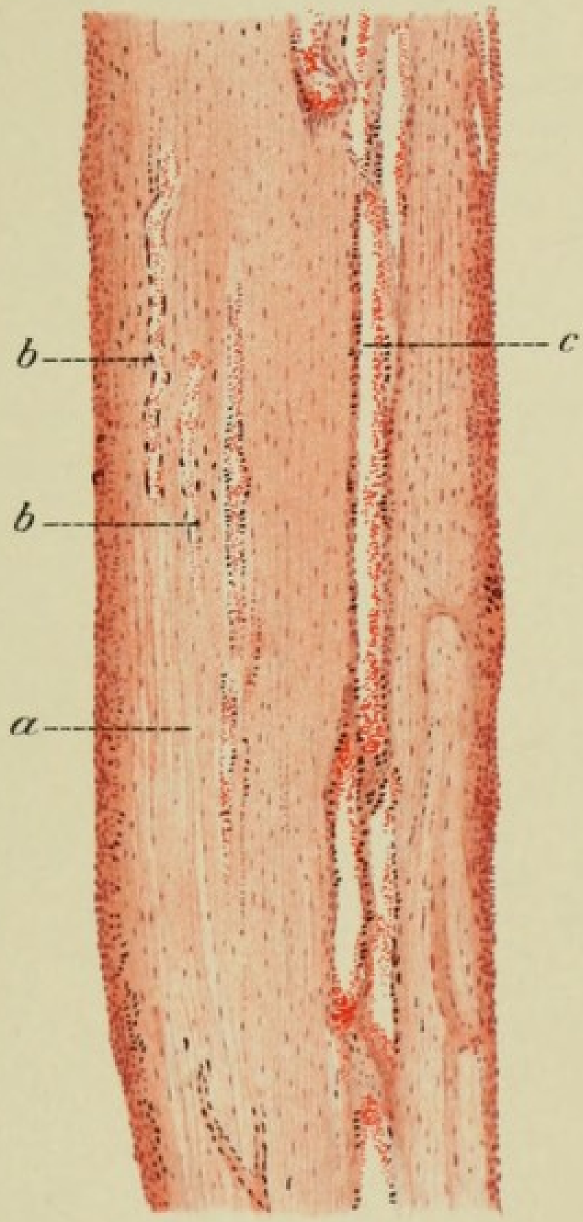
b
b
a
c

these fibrillæ of the connective tissue is remarkable, as well as the long course of the blood-vessels, which is due to the former condition.

These pathohistological examples are presented in order to demonstrate the *course* of the diseases of the pulp.

DIAGNOSIS OF PULP DISEASES.

Arkövy has attempted, in an exhaustive and classical work, to establish the diagnosis from the objective examination as well as from the anamnesis. Even though his advice is closely followed it is not always possible to obtain a correct impression of the existing disease of the pulp. This is accounted for by the fact that patients, as well as the sensitiveness of pulps, vary considerably. Furthermore the symptom-complex may alter in a very short time, and with it the reactions. The *thermometer of Walkhoff* is recommended when it is only desired to determine the presence of pulpitis, without deciding its exact nature, which is frequently sufficient for clinical purposes. Walkhoff has called attention to the fact that water at 37° C. never causes the teeth any pain, but that changes of a slight degree in temperature either above or below 37° C. causes pain when the dentin is sensitive, and more intense pain when pulpitis exists. That investigator constructed a syringe, which is so arranged that the temperature of the water may be read off directly from a thermometer inserted in its piston. Thus, if a tooth becomes painful when it is sprayed with either cold or hot water, a conclusion may be formed as to the condition of the pulp; but here, too, we must not disregard the fact that the varying sensitiveness of patients makes the diagnosis difficult. As a rule, then, the *diagnosis* of pulpitis may be made when either cold or warm water gives the tooth pain. If pain is caused only by warm water, and not by cold water, it may be safely assumed that a considerable lesion of the tissue already exists; that is, the pulp has been partially or wholly destroyed by a suppurative or gangrenous process.

The writer has observed that *indolent pulps* fail to react to thermic stimuli, and has, therefore, sought for another method, in the employment of a *chemical irritant*. This consists in removing as carefully as possible the carious mass, and then applying for several minutes a 5 per cent. (of the 40 per cent. strength) solution of formaldehyd to the cavity which has been protected against moisture. Usually a slight drawing pain develops, which disappears after a short time. If, on the contrary, the pain under these circumstances continually increases in severity, it may be safely concluded that an inflammation of the pulp exists, which has been aroused through the influence of the irritation caused by the formaldehyd.

Our attempts to find a wholly satisfactory explanation of the formaldehyd reaction have as yet been in vain. Until more positive information can be offered it suffices to assume that this irritating agent passes more rapidly to the pulp because the odontoblastic processes (Tomes' fibers) are either altered or have disappeared from the dentinal canals. When the pulp is perfectly intact the contents of the dentinal canals are also intact, and there develops in them through the action of the formaldehyd a peculiar *coagulum*, which prevents the formaldehyd from penetrating further.

TREATMENT OF DISEASES OF THE PULP.

THE APPLICATION OF A CAP TO THE PULP.

When the pulp has been exposed by any process, and is not inflamed, it may be bridged over with some non-irritating material. Care must be taken to select a protecting material which is easily sterilized. It must also be chemically indifferent and be a poor conductor of heat. A cap made of asbestos which can be heated probably fulfils these requirements the best. This cap is placed over the pulp in such a manner that the latter will not be touched, and is then covered with a thin layer of cement, but without exerting any pressure.

A pulp covered in this manner is believed to protect itself from foreign bodies by developing secondary dentin, and thus reëstablishing normal conditions. In spite of this treatment, although we do not understand the exact cause, the pulp occasionally becomes inflamed in the course of time. Therefore, it is advisable not to permanently fill the over-capped tooth immediately, but to wait several weeks or months.

If the exposed pulp should bleed, Walkhoff advises that it be touched with a concentrated solution of chlorphenol, and then apply an iodoform paste. The writer has made tests with small amounts of *formaldehyd-gelatin*, and found that it has a good effect upon the pulp. It is probable that portions of the remaining living pulp tissue absorb this material, and the formaldehyd being set free exerts a strong disinfectant action. We cannot explain why this antiseptic, usually so strongly irritating, is non-irritant in the form of formaldehyd-gelatin; it may be due to the fact that in the latter form only minute amounts are liberated.

THE DESTRUCTION AND EXTIRPATION OF THE PULP.

If it is decided to remove an inflamed pulp partially or completely, which is frequently the only possible treatment, a certain amount of preparation is necessary, for without it this operation would be too painful. Therefore it must be previously cauterized. This is accomplished with *arsenic* or with *arsenious acid*, which was introduced by Spooner in 1836. In more recent times Dalma recommended an alkaloid, *nervocidin*, which will probably play an important role in dental therapy, even though in our experience it has been less reliable than arsenic. Arkövy, Detzner, and others claim that arsenic causes at first a hyperemia of the blood-vessels, which is followed by circulatory disturbances with capillary stasis. After a few hours the nerves lose their physiologic function. This is not, however, accompanied by coagulation of the pulp tissue; on the contrary, this tissue remains soft and capable of absorbing substances. The arsenic is so rapidly absorbed that, as personal tests have shown, in the pulp which has been cauterized but a short time previously no trace of the arsenious acid can be detected.

Arsenic is best employed in the form of a paste, of which a quantity the size of the head of a pin is placed into the cavity, from which the softened mass has been removed without exerting pressure upon the pulp. In order to prevent cauterization of the oral mucous membrane, the cavity must be well closed by means of a guttapercha or cement filling. Of a number of remedies employed to counteract the painful hyperemia, which develops at the beginning of the cauterization, tannin is probably the best. This is true not only because it has an astringent action and is therefore pain alleviating, but also because it gives the pulp a firm consistency which makes the extirpation much less difficult. The following mixture is most useful :

Acidi arsenicos,		
Creosoti,	*āā*	ʒj½ (5.0).

To a pledget of cotton moistened with this fluid a little *tannic acid* is added, and the whole is then introduced into the cavity in such a manner, that the tannin lies directly over the pulp.

In very desperate cases, the method recommended by Walkhoff is of service. He applies, depending upon the severity of the case, either for a few minutes or from one to two days, a concentrated solution of *chlorphenol* ; after this procedure, the introduction of arsenic never causes pain. The majority of authorities permit the arsenic to remain in the tooth only from one to two days, after which period of time, however, the pulp can only rarely be removed without causing some pain. If the arsenic is removed, say in forty-eight hours, and the tooth temporarily closed and allowed to rest for three or four days, the pulp commences to slough, when it is possible to extract even the root-portion without causing any pain.

For the removal of the pulp in the root-canals, a finely-barbed brooch (Fig. 134) is introduced, turned around on its longitudinal axis, and then drawn out. The whole pulp will cling in the form of brownish-red, tough fibres, to the instrument, provided the pulp tissue has not undergone decomposition, and if the tannin had sufficient time to act thoroughly.

In that case—that is, when the pulp is not destroyed—it may be assumed, since the instrument employed had been sterilized, that the root canal is not septic, and it may, therefore, be immediately filled without further preliminary treatment.

The *material for filling a root canal* requires no antiseptic action, and can therefore be selected according to preference. Guttapercha, which is preferred, is forced into the canal in the form of fine points, or it is pumped into that part of the tooth in a liquid state (chloroform solution). Many operators introduce fine *metallic points coated with cement*, which are so inserted into the canal that a short end rises up into the pulp cavity. Metallic pins are to be preferred to other materials, because they can be heated and thus sterilized, and because they can be easily passed to the tip of the canal. A metallic pin is furthermore of advantage, when eventually a recurring periostitis develops, because it can be grasped by its protruding end and easily worked loose from the root.

FIG. 134.—Brooch for cleansing a root canal.

It is understood, of course, that before introducing a root filling, the canal must be absolutely clean and dry. In order to thoroughly cleanse a *root canal*, it suffices to wipe it repeatedly with an instrument wrapped with cotton which has been immersed in ether or chloroform. Such an instrument is illustrated in Fig. 134. After this procedure, the canal is thoroughly dried with warm air.

If the pulp has been destroyed by extensive *gangrenous or putrefactive processes* and no longer hangs together, its extraction will be much more difficult, because only

PLATE 38.

Demonstration of the amputation of the pulp on a longitudinally cut molar.

FIG. 1.—Focus of caries reaching to the pulp. The latter is partially inflamed and was cauterized with arsenic.

FIG. 2.—The carious cavity is prepared for the reception of a filling, and the crown pulp has been drilled away.

FIG. 3.—A cotton swab soaked in creosote lies at (*a*) in the pulp cavity, which at (*b*) is protected and supported by collodium and cotton.

FIG. 4.—An antiseptic lies at (*a*) over the stump of the pulp; at (*b*) is a pellet of tinfoil; and at (*c*) the completed metallic filling.

single shreds can be removed with the brooch at one time. During this manipulation, great care must be exercised lest septic portions of the pulp be forced out of the apical foramen, for in that manner a severe type of *periostitis* may be caused. The work must, therefore, be careful and gentle.

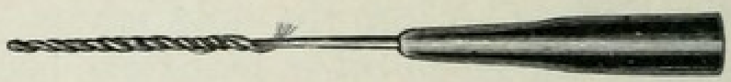

FIG. 135.—Brooch wrapped with cotton for sterilization and desiccation of the root canals.

If the brooch meets an obstruction, an *atresia* of the root canal exists, which may sometimes be of so great a degree that the lumen is completely locked or displaced because of concretions of lime. This condition may also be caused by curvature of the roots. In such cases an increase in the caliber of the canal should be made with a drill. Since, however, the drill driven by the machine does not always follow the canal, but, on the contrary, tends to establish a false course, especially when the root is crooked, it may perforate the side of the root. Furthermore, since the drill frequently breaks off and remains fast in the root, we should explore frequently ahead of the drill, and, in doubtful cases, we should resort to other means of increasing the size of the canal. This consists in the employment of acids (*sulphuric acid*, Callahan; *nitro-hydrochloric acid*, Boennecken), by means of which a superficial decalcification of the canal walls, and, therefore, a dilation of the lumen is obtained. In order to prevent

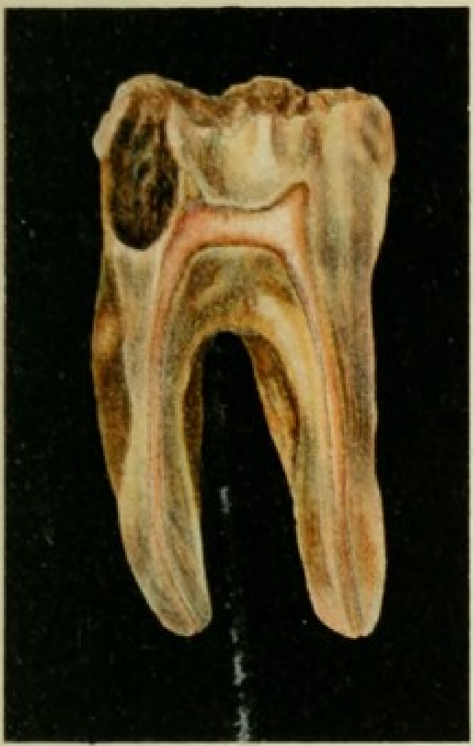

Fig. 1.

Fig. 2.

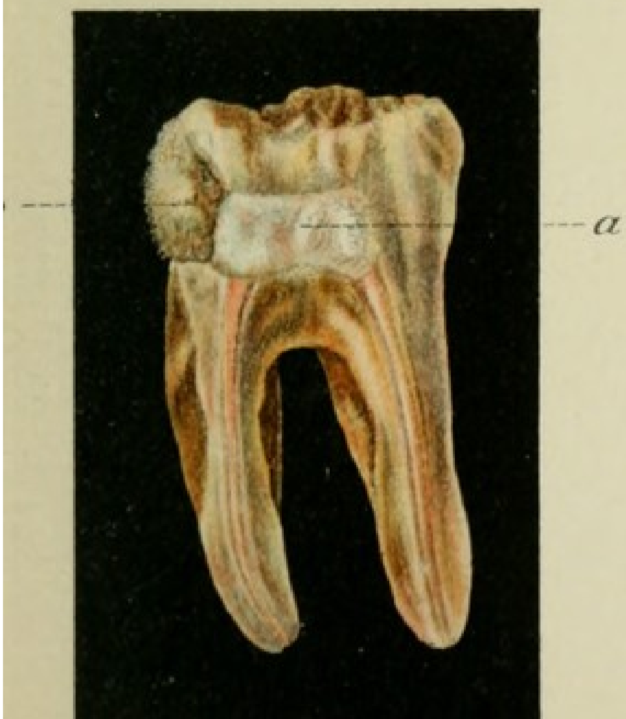

Fig. 3.

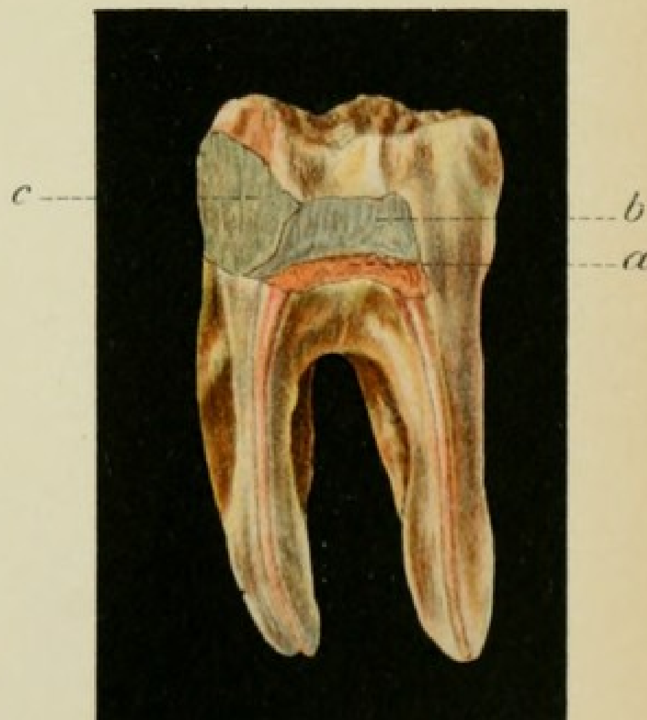

Fig. 4.

too extensive destruction of the tissue, the concentrated solutions should be allowed to act but a few minutes, after which it should be neutralized with sodium bicarbonate.

The application of acids does not only assure an increase in the size of the canal, but a *sterilization* at the same time. This, however, does not suffice for the immediate filling of the root canal, for it is still necessary to introduce an antiseptic dressing into the root before filling. These antiseptic applications must be continued for a longer or shorter period of time, depending upon the degree of destruction of the pulp and upon the presence or absence of periostitis.

When the pulp has been destroyed, a filling material, which has an antiseptic action, should be used for the root canals. There is nothing better for this purpose than a paste of *iodoform and creosote*, but as cotton is rapidly destroyed, fine silk fibers is better as a vehicle for this antiseptic. Silk slides much better into the canal than cotton, and when necessary is easily withdrawn.

AMPUTATION OF THE PULP.

All pulp tissue cannot be removed from certain teeth, especially from teeth possessing a multiple number of roots, as is explained in connection with metallic corrosions on pages 38 and 39.

In order to avoid the cleansing of inaccessible canals, Witzel devised a method which he called *amputation of the pulp.* It consists in drilling away the previously devitalized crown pulp and placing a permanent antiseptic upon the stumps of the root pulps in order to make them reactionless.

This procedure is divided into three parts:

Cauterization of the pulp.

Excision of the crown-pulp.

Introduction of a medicament over which the final filling may be placed.

In order to obtain satisfactory results from the very valuable procedure of pulp-amputation, it is desirable to be as antiseptic as possible, and this is obtained only by following a certain strict *technic* as follows :

After one or two days of application of arsenic (arsenic with creosote and some tannin), the cavity is scrupulously freed of all carious tooth tissue and without disturbing the pulp, is prepared for the reception of the filling.

The cavity is then bathed in a strong antiseptic. Next a drill, which has been previously sterilized and drawn through creosote, is pushed through the tissue of the pulp cavity, and the crown pulp cut out.

The cavity is then well washed with sterilized warm water, and a pledget of cotton saturated with an antiseptic, such as a 10 per cent. solution of formaldehyd or creosote, is then introduced into the now clean and empty pulp chamber. This pledget of cotton is then temporarily protected from the saliva by means of collodium and cotton.

While these remedies are acting, a pellet is prepared by wrapping the selected medicament in sterilized tinfoil, and shaping it into the form and size of a large wheat kernel. As this pill has been handled by the fingers it should be immediately immersed in a small dish containing creosote.

Baume has recommended borax as an antiseptic; as this diffuses so rapidly, we mix it with eugenol to form a paste. This *borax-eugenol* paste causes an *aseptic colliquation necrosis* of the root-pulp. The latter becomes so liquefied that after about one year's time the canals are found completely empty. Another paste, consisting of *tannin and creosote*, leads to complete destruction, and is especially valuable when suppuration of the pulp exists.

After the diseased tooth is made thoroughly dry, the collodium and cotton plug as well as the antiseptic cotton in the cavity are removed. The pill is passed directly from the dish of creosote into the pulp chamber, in which it is compressed by means of a sterilized plugger.

The pill is of the proper size, and completely fills the pulp chamber. If it be too small, all the root pulps will not be covered, and if it be too large, it cannot be properly applied to the walls of the cavity.

The cavity above the pill-plug is then well bathed with ether, dried out with hot air, and filled with any suitable filling material. It must be remembered that cement cannot be employed with borax-eugenol, for the borax prevents it from becoming hard. Plate 38 demonstrates the process of amputation.

DISEASES OF THE ROOT-MEMBRANE (PERIODONTITIS.)

As the name *periodontitis* implies, inflammation of the root membrane is not only a process localized in the periosteum, but, as a rule, includes the surrounding structure of the tooth. At first the root membrane is alone involved (*periostitis*), while later the substance of the bone (*osteitis*) and the bone-marrow (*osteomyelitis*) are affected.

Periodontitis usually follows disease of the pulp, the septic products of which are generally the immediate cause. They pass through the apical foramen to the periosteum and there set up an irritation. Aside from the secondary cases of periostitis, primary cases occur which are caused by trauma. Any heavy blow or pressure upon the teeth or periosteum may lead to direct inflammation. To this class also belong cases in which the teeth were separated too rapidly with rubber, or from too severe malleting when filling with gold. A host of other conditions, are capable of irritating these tissues. Of chemical irritants we may mention *mercury*, which, after prolonged use, leads to an unlimited destruction of the periodontium. The careless application of *arsenic*, even though locally, also calls forth lesions of these tissues. Plate 44, Fig. 1, shows the destructive effect of arsenic.

Patients suffering from periodontitis experience pains altogether different from those of pulp disease. They are less likely to occur in spells, but are more constant, and are described as being dull. There is a feeling of weight in the affected tooth, and this sensation is considerably

PLATE 39.

FIG. 1.—Acute marginal periodontitis.
FIG. 2.—Acute apical periodontitis.
FIG. 3.—Acute circumscribed periodontitis.
FIG. 4.—Acute unilateral periodontitis.
FIG. 5.—Acute unilateral periodontitis.
FIG. 6.—Chronic diffuse purulent periodontitis.

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increased when the patient assumes a horizontal position, so that sleep if it be at all possible, will be disturbed. The general health is more influenced than in pulpitis; the patient feels ill, and especially so when fever sets in, which often occurs in severe cases.

Aside from the above described symptoms, the sensitiveness of the tooth on pressure is of diagnostic significance. At the beginning this sign is not very pronounced, but it increases more and more, and is accompanied by elongation and loosening of the teeth. The elongation is due to the swelling of the root membrane, and the looseness is a sign that the surrounding tissues of the tooth are either partially replaced by soft granulation tissue, or that they have been partially destroyed by the action of the pus. Cold water is well borne, while, on the contrary, warm water may cause pain.

According to the course and location of the periodontitis, Arkövy has made the following *classification*:

ACUTE PERIODONTITIS.

1. Acute marginal periodontitis.
2. Acute apical periodontitis.
3. Acute circumscribed periodontitis.
4. Acute diffuse periodontitis.
5. Acute purulent periodontitis.
6. Apical abscess.
7. Toxic periodontitis.

CHRONIC PERIODONTITIS.

1. Chronic apical periodontitis.
2. Chronic diffuse periodontitis.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Lith. Anst. F. Reichhold, München.

3. Chronic purulent periodontitis.
4. Chronic granulomatous periodontitis.
5. Apical necrosis.
6. Total necrosis.

ACUTE PERIODONTITIS.

Acute marginal periodontitis (acute inflammation of the root membrane) (Plate 39, Fig. 1) is caused by mechanical influences, such as tartar, and protruding or overlapping fillings. It may also possibly arise from chemical causes, such as stagnating remnants of food which have settled at the neck of the tooth and there undergone fermentation. This chemical origin is probably the most frequent. It occurs mainly between two teeth, and leads the patient to believe that their pain is located between the teeth. The interdental papilla is also involved in the process and is reddened and painful.

Acute apical periodontitis (acute inflammation of the tips of the roots Plate 39, Fig. 2) may be caused by a large number of pulp diseases, and occurs either at the termination of such diseases or sets in simultaneously with total inflammation of the pulp. Inasmuch as any vertical pressure is keenly felt, biting is impossible.

Acute circumscribed periodontitis (acute circumscribed inflammation of the root-membrane) (Plate 39, Fig. 3) originates either in trauma or total inflammation of the pulp; in such cases it is *secondary*. It may also have an *idiopathic* origin, as, for instance, when the whole organism is in a weakened condition because of some foregoing sickness. The symptoms are not very decided. The patient experiences a discomfort rather than a pain; the latter occurs only when pressure is directed toward the diseased area, *acute unilateral periodontitis*, which is illustrated on Plate 39, Figs. 4 and 5 also belong to this class.

Acute diffuse periodontitis (acute extensive inflammation of the root-membrane) is usually secondary to the apical or unilateral form, and represents a complication of

PLATE 40.

FIG. 1.—Acute purulent periodontitis.
FIG. 2.—Hypertrophic periodontitis, (or chronic diffuse).
FIG. 3.—Apical necrosis.
FIG. 4.—Total necrosis.
FIG. 5.—Interradicular abscess.
FIG. 6.—Interradicular abscess.

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a prolonged destructive process of the pulp. Edema of the surrounding soft parts is often accompanied by fever.

Acute purulent periodontitis (acute suppurative inflammation of the root-membrane) (Plate 40, Fig. 1) is particularly likely to develop in conjunction with suppurative inflammations of the pulp, but has also been observed to follow gangrene of the pulp, and to occur in dead, senile roots, through the canals of which some form of infection found its way. The process is either circumscribed or diffuse. The disease is very severe, and occasions alarming symptoms such as chills and edema.

Apical abscess (abscesses of the apical region of the roots) represents a small, soft, red or yellow swelling, which is attached to the tip of a root. An incision shows that it is a very thin sack filled with pus. In the author's opinion, it is questionable whether this condition is not really a granuloma of the root which has undergone purulent degeneration.

This condition is usually associated with gangrene of the pulp. Next to the tips of the roots and their neighborhood, the area of predilection is situated at the point of division of the roots in those teeth having multiple roots, (*interradicular abscess*) (Plate 40, Figs. 5 and 6).

Toxic periodontitis is chiefly caused by mercurial poisoning in the diffuse form, or by the action of arsenic, in which case the periosteum is inflamed and mortified to a more or less large extent. This may lead, in fact, as is shown on Plate 44, Fig. 1, to partial necrosis of the bone. For this reason arsenic applications must be well protected.

Fig.1.

Fig.2.

Fig.3.

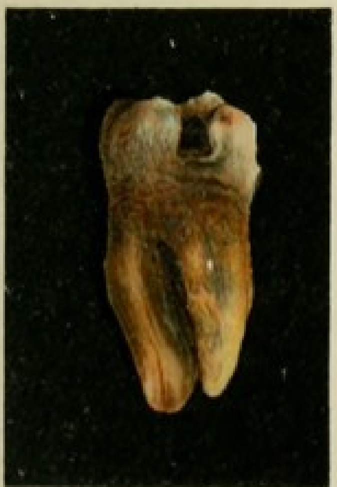

Fig.4.

Fig.5.

Fig.6.

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CHRONIC PERIODONTITIS.

Chronic apical periodontitis (chronic inflammation of the tips of the roots) is caused by chronic diseases of the pulp. It is manifested by a thickening of the periosteum in the fundus of the alveolus. If this condition becomes more extensive, we speak of chronic diffuse periodontitis.

Chronic diffuse periodontitis (chronic diffuse inflammation of the root-membrane). In this disease the root-membrane is considerably hypertrophied, and may lead to such a pronounced form as that illustrated on Plate 40, Fig. 2.

Chronic purulent periodontitis (chronic suppurative inflammation of the root-membrane) is a diseased condition into which the root-membrane passes after a long standing acute suppurative inflammation. Such teeth suffer but little pain, the gums lie loosely about them, and, when the tooth is pressed, a considerable amount of pus is forced out. (Plate 39, Fig. 6.)

Chronic Granulomatous Periodontitis.—A granuloma of the root, which term, strictly speaking, should include all hyperplasiæ of the root-membrane, consists, as the name implies, chiefly of granulation tissue. Since the latter is supplied more or less abundantly with epithelium, its consistency varies considerably. As these little growths have the tendency after a long period of time to form root-cysts, which require surgical interference, it has been discussed elsewhere under cysts. (Page 122).

Necrosis of the apex and total necrosis (Plate 40, Figs. 3 and 4) do not really belong to the diseases of the root-membrane for they are a sequel to them. The process concerned consists in the death of the cement cells, either on account of long standing suppurative inflammation of the root-membrane, or as a result of senile changes. The disease is recognized in extracted teeth by the fact that the roots show a light-gray to a black discoloration. In the early stage the surface is still smooth, later, however, it becomes rough, partly because of typical resorptive processes, and partly because of erosions due to the pus.

PLATE 41.

FIG. 1.—Fistula.

FIG. 2.—Alveolar pyorrhea. The gum is loose, and in the resulting pockets yellowish pus may be seen. Dark crusts are attached to the roots and the surrounding bone is undergoing destruction.

Teeth showing symptoms of necrosis of the roots are difficult to cure, for the organism acts upon the dead cement substance, as upon foreign bodies, and attempts to discharge it.

THE COURSE OF INFLAMMATIONS OF THE ROOT-MEMBRANE.

Since inflammations of the root-membrane are usually due to some septic irritant, they exist so long as this irritant is present, and spontaneous healing is therefore impossible. The subjective symptoms may indeed become less severe, yet this usually indicates that the acute has passed into the chronic stage.

As a rule, the bone becomes swollen in the neighborhood of the diseased area; this indicates that the bone marrow and the bone are sharing the inflammation. Aside from these strictly local symptoms, the nearby soft parts, like the lips and cheeks, also become swollen. Indeed, in some rare cases the inflammation may become so extensive, and so much edema develop, that the patient's life is in danger. The regional lymph glands of the lower jaw and the neck are also involved.

The chief event, however, is the formation of pus which seeks an exit in every direction. Since there exists in the region of the neck of the tooth no marginal opening (Plate 43, Fig. 2 *a*), the pus passes through the bone, and appears first underneath the periosteum, which is thus caused to bulge out. This swelling, because of its limited rounded form and hard consistency, is not rarely mistaken for a bony growth. (See Plate 42, Fig. 1, subperiosteal abscess.) The pus breaks through the periosteum after a time and reaches underneath the gum (periosteal abscess, Plate 43, Fig. 1), from where it travels rapidly through the surrounding soft tissues. As a result, the general swelling

Fig. 1.

Fig. 2.

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increases, but, as now the tension of the bone, and of the periosteum has been lessened, the pains disappear.

All *swellings* of the jaw caused by pus, whether they are situated deeply in the bone or on the surface, are designated as *parulis*. Since the pus usually penetrates toward the labial side, the parulis is most often found on the side toward the lips or cheeks. When the parulis is sufficiently filled, it ruptures spontaneously, and the pus is discharged into the mouth. Later the parulis fills itself repeatedly, but empties itself continually, for the mucous membrane after it has once been weakened easily ruptures, and allows the escape of the pus before it expands to a large size. Finally, it no longer becomes swollen, but the pus formed in the neighborhood of the tooth continually discharges itself outwardly ; that is, a *fistula of the gum* has been created. Not only is the gum ruptured, but the spongiosa, and even the compacta, may become partially necrotic and destroyed. Plate 44, Fig. 2, shows a beginning necrosis. In chronic cases so-called *blind abscesses* may be formed, such as illustrated on Plate 42, Fig. 2. These usually remain small and cause the patient little or no pain.

The pus penetrates the upper jaw toward the hard palate less frequently, because in that direction the bone possesses considerable thickness. It collects at first underneath the periosteum and causes it to puff out, under which circumstances the swelling feels hard. Next the pus reaches below the gum where the palpating finger can plainly detect fluctuation. This swelling interferes decidedly with speaking and masticating, Fig. 56 *b*, upper illustration, presents the rare case of *double-sided, subperiosteal abscess*. In the upper jaw the pus may travel in other directions, for example, toward the nasal cavity and toward the antrum of Highmore. In the last case an empyema may be simulated, or when the pus stagnates an empyema may be induced.

One of the rarest of occurrences is an *abscess formation on the lingual side* in the region of the lower molars. The pus does not collect here, because the plate of bone

PLATE 42.

FIG. 1.—**Subperiosteal abscess.**
a. Collection of pus.
b. Periosteum.
c. Mucous membrane.
FIG. 2.—**Blind abscess.**

PLATE 43.

FIG. 1.—**Periosteal abscess.**
a. Collection of pus.
b. Periosteum.
c. Mucous membrane.
FIG. 2.—**Periosteal abscess.**
a. Marginal opening of the same.

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is quite thin near the points of the roots. This plate, therefore, does not bulge out, but is rapidly ruptured to permit the pus to flow into the submaxillary tissues which become swollen.

The laity fears the most the exit of the pus through the *outer skin*, because it always results in the formation of a scar. In fact, a fistula may be established through the cheek, but as a rule the pus penetrates the outer skin at the lower jaw and occasionally at the neck.

The attempt is usually made to seek the diseased tooth in the neighborhood of the swelling or of the fistula. This is, as a rule, a proper procedure, but one must not disregard the fact that a burrowing abscess may exist which runs a hidden course. For instance, it may be observed that an abscess appears in the region of the incisor teeth of the lower jaw, whose origin is in the second molar, or a fistula may appear in the palatal tissue in the region of the molar teeth, with the source in a central incisor.

TREATMENT OF INFLAMMATION OF THE ROOT-MEMBRANE.

If the periodontitis is found in its beginning stages, the formation of pus should be actively counteracted, and for that purpose it is necessary to determine the causal factor. As this is usually due to partially or completely destroyed remnants of the pulp, they must be carefully

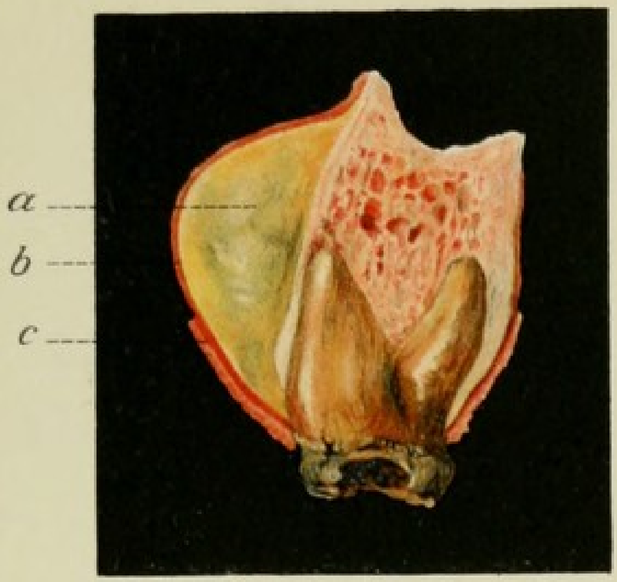

Fig. 1.

Fig. 2.

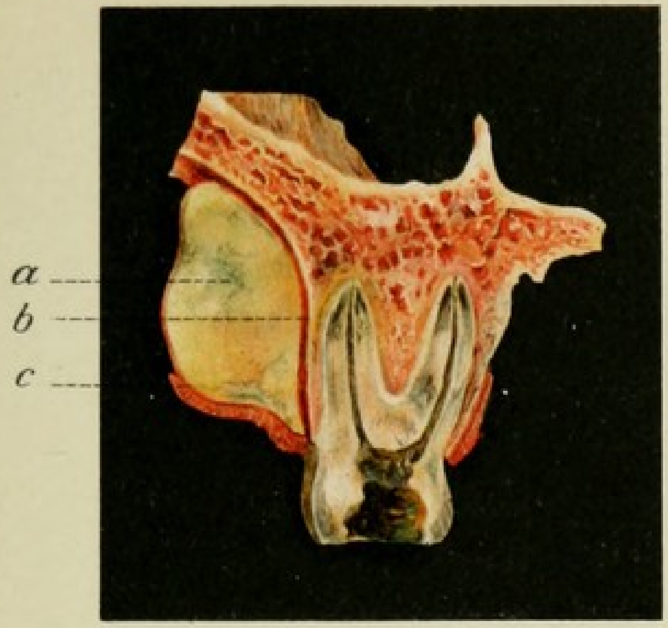

Fig. 1.

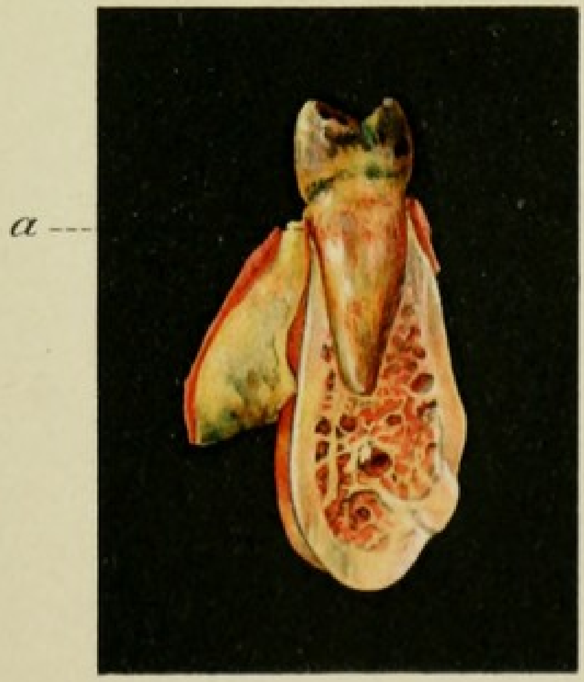

Fig. 2.

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removed and the *root canal sterilized,* exactly as in the case of gangrene of the pulp, as described on page 280. If pus has already formed, the most satisfactory results are obtained in treating the root; that is, opening the latter so that the pus may be discharged through the root canal. This means the formation of a blind abscess,

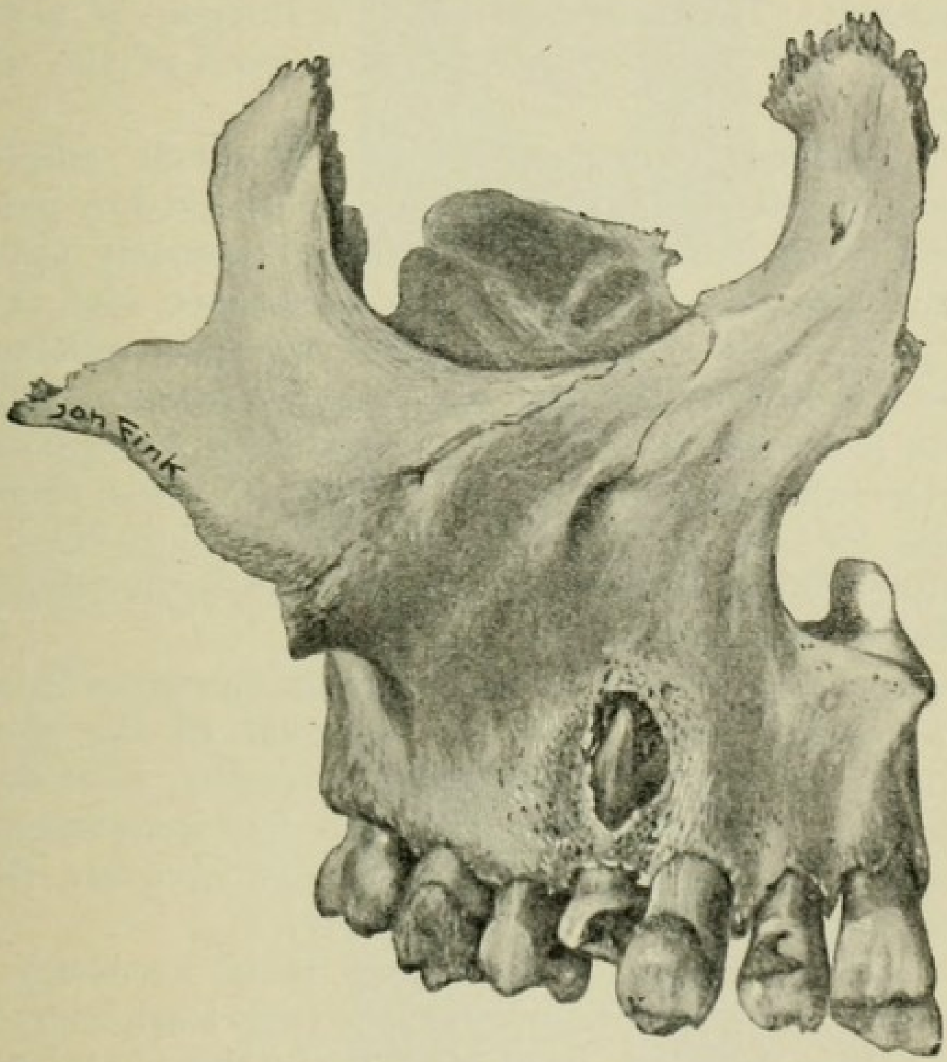

FIG. 136.—A macerated upper jaw in which an oval section of the facial alveolar wall was destroyed by the formation of pus following a periostitis of the first bicuspid tooth.

as is demonstrated on Plate 42, Fig. 2. In such cases, it is not advisable to introduce antiseptic fillings into the root at once, it being wiser to allow the tooth to remain open for several days. The further treatment is like that of a gangrenous pulp. A parulis should be incised, but the knife must be forced deeply into

PLATE 44.

FIG. 1.—Toxic periodontitis (due to arsenic). A protruding deposit of arsenic caused destruction at (*a*), not only of the gum, but to a certain extent of the periosteum and the bone.

FIG. 2.—Beginning necrosis of the bone. The continuous formation of pus has caused necrosis of the substance of the bone at (*a*).

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the mucous membrane, which is often very thick, in order that the occasionally excessive amount of pus can be discharged. The introduction of a *tampon of iodoform gauze* will prevent the premature closure of the wound edges.

Of external remedies, *warmth* is much employed. Occasionally the inflammation may be lessened by painting the part with *iodin* and *aconite* (simultaneously applied). Formerly, *leeches* were given the preference, and, indeed, with good results. Since the effects are most satisfactory, and as infection of the oral cavity by the leech is unheard of, this procedure is to be recommended in certain cases.

If the inflammation respond to none of these remedies, *excision of the diseased tip of the root*, as has been recommended in recent times by Weiser, is indicated, and eventually *replantation* may be done.

Replantation or *reimplantation* is an operation in which an extracted tooth, after the removal of the diseased portion of the root, is returned to its socket, in order that it may again heal into place. In *transplantation*, the extracted tooth is inserted in a foreign alveolus, that is, in one it had not occupied previously.

In performing this operation, it is necessary that the tooth, which is to be inserted, be in as fresh a condition as possible, because its union with the alveolar wall occurs much sooner, when the periosteal cells on the roots, as well as the cement cells, are still living. For this reason, none of the tissues should be subjected to injurious disinfectants, but, instead, the tooth, as well as the alveolus, are only treated with a physiological salt solution; by following this advice many failures may be avoided.

If the roots fit the alveoli, nothing needs to be done excepting to fill the root canal and all existing defects,

Fig. 1.

Fig. 2.

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inserting the tooth into place and applying a fixation band (ligature, splint, etc.). In favorable cases the tooth heals tightly into place, so that it may again become useful. If, however, no alveolus exists, or it does not permit the entrance of the root, it is necessary to drill an opening in the alveolar process by means of suitable bone-burs, etc.

Such implanted teeth sometimes grow tightly in place by means of a connective-tissue union (pseudoarthrosis) and functionate for many years. However, these teeth are constantly attacked by absorption processes, which, after a shorter or longer time lead to their loss.

It has been attempted to prevent these resorption processes by forming roots from porcelain or metal, but no good results have thus far been achieved.

We find ourselves, therefore, in a difficult dilemma as concerns replantation, from which we cannot hope to soon escape. If we select a natural root-material, the root becomes absorbed (and with it some of the alveolus or surrounding tissue), and if we select an artificial insoluble root-material, the structures surrounding the root are absorbed. As various as are the methods of this operation, equally so are the results, and after a shorter or longer time the teeth become loose and are lost. In spite of many failures, success occasionally is met with, and, therefore, we are always inclined to resort to replantation time and again. If none of the mentioned forms of treatment succeed, necrotic roots when found should be *extracted*.

EXTRACTION OF TEETH.

INDICATIONS.

Since the enormous value of the teeth to the economy has been discovered, it is one's duty to determine before each extraction whether such a procedure is justified. For that reason we will consider the individual causes which would absolutely warrant the removal of a tooth.

Loose teeth, which in spite of all therapy cannot be fastened, often cause discomfort and pain, on account of which their removal is necessary. The loosening is usually due to disappearance of the alveolar borders in consequence of senile atrophy, atrophia præcox, alveolar pyorrhea, or chronic suppurative inflammation of the root-membrane.

Carious teeth are rarely extracted in modern times by scientific dentists. Even when the crown has been destroyed to a considerable depth, the tooth may still, by suitable treatment, be made functionating or at least reactionless. Only in those cases in which this can no longer be achieved, or when from disease the tooth prevents the insertion of a substitute tooth, is extraction justified.

It occurs also that a *sound tooth* must be sacrificed in applying artificial teeth, when, for example, only a single elongated cuspid tooth remaining in the jaw prevents an æsthetic treatment of the mouth. Occasionally supernumerary or regular teeth have grown so far out of the tooth-row that correction is better attained by extraction than by pressing them back into position.

Sometimes a patient calls after a night of much pain, and begs one to extract a tooth, which has been attacked by an acute inflammation of the root-membrane. If the patient is weak and nervous, and cannot bear a prolonged treatment, or if this process has repeatedly returned, we need not hesitate to comply with his request.

Diseases of the jaw-bone, like osteitis, necrosis, gangrene (noma), abscess or fistula formation, demand extraction of the suspected teeth. In nearly all these cases it is usually possible to diagnosticate necrosis of the cement or roots. This necrosis is either the result or more frequently the cause of disease of the bone. Dead teeth which have become necrotic should be extracted as soon as they cause any symptoms, for they irritate the surrounding tissue and their roots become absorbed.

If teeth cause serious *neuralgia* they must be extracted in certain cases; in the different forms of pulpitis conservative treatment should be first instituted. This treatment, however, does not suffice in the case of thickening

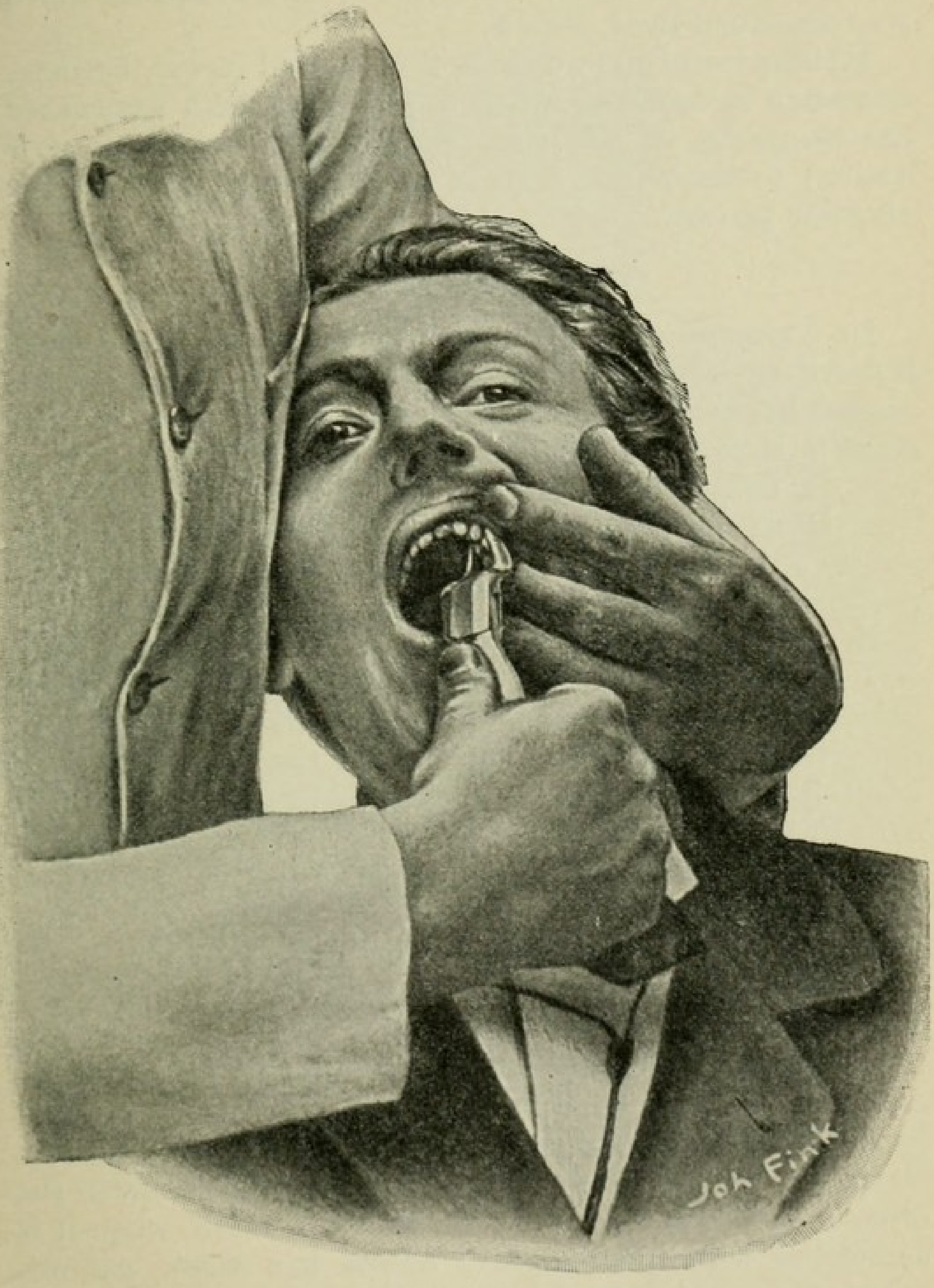

FIG. 137.—Position in extracting a tooth from the left upper jaw.

of the root-cement (exostoses), and occasionally when there is an odontoma of the inner walls, a condition which was described by J. Scheff.

Extraction of the upper first or second molar, becomes necessary in *empyema*, when one of these teeth has caused the empyema, or when in the course of treatment it is desired to drain the antrum of Highmore, through the alveolar process.

CONTRAINDICATIONS.

In *hemophilia* we must not fail to realize that a fatal hemorrhage may follow an extraction. If in spite of this disease the operation must be performed, we must not feel content if the blood ceases to flow soon after the extraction, for frequently a fatal outflow of blood develops some time later, as in the night for instance. Severe hemorrhages are especially to be dreaded in nephritis, scorbutus, purpura hemorrhagica, and leukemia.

In certain cases of *pregnancy*, when the woman is weak and exhausted, or when it is known that considerable pain will be caused by the operation, extraction is contra-indicated. If, however, palliative treatment gives no relief it is wiser to inflict a short pain upon the patient than to let her suffer for a long time. The same regulations hold true for women during lactation and menstruation.

Opinion varies as to the propriety of extraction in the presence of *edema* or *maxillary abscess*. Some claim there is danger of pyemia and septicemia, whereas others have not observed such results. The author, however, is acquainted with two cases in which extraction was followed by phlegmonous degeneration and death. In one case the cheek was swollen before the operation, but not so in the other. It is not advisable to extract a tooth when it is associated with inflammatory edema in a weak patient, who is worn out from disease, for in that case serious consequences may easily result.

FIG. 138.—Position in extracting a tooth from the right upper jaw.

THE TECHNIC OF EXTRACTION.

Before beginning an extraction the instrument must be absolutely clean and if possible, sterile, for there is danger of transmitting disease through them. The teeth and the gums of the side concerned should likewise be thor-

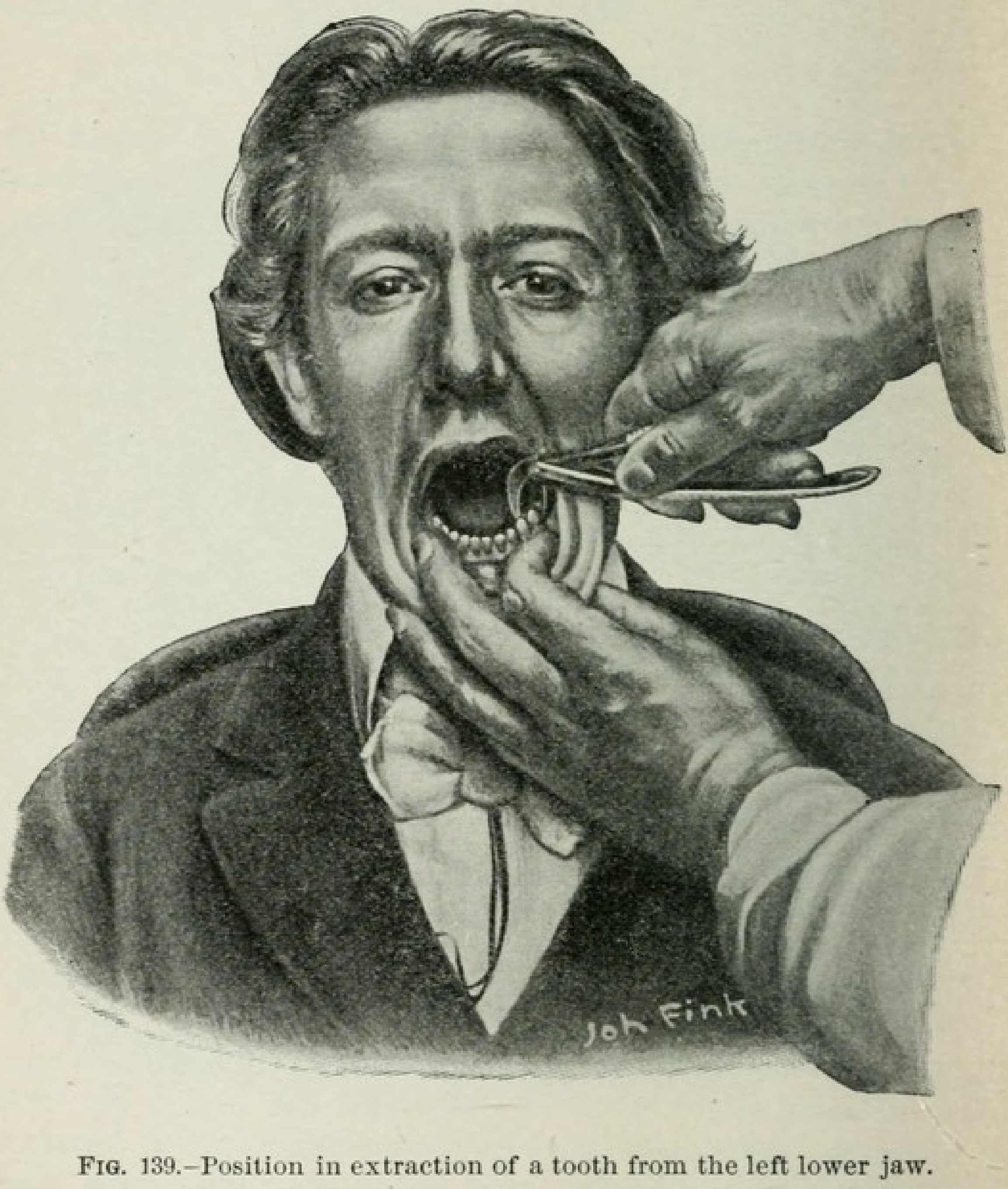

FIG. 139.–Position in extraction of a tooth from the left lower jaw.

oughly cleaned, in order that the attached deposits be not inoculated. The writer insists, both in private practice and in the clinics, that each tooth be washed with ether before the extraction. Rubbing them with ether does not only free the teeth and gums of unclean material, but also causes a slight amount of anesthesia.

It is perhaps of value to the beginner to become acquainted with the following fundamental principles which bear upon the manipulation of the forceps:

The forceps must be passed up along the neck of the tooth as far as possible. They must not be pressed together more tightly than is necessary for a firm hold, otherwise there is a risk, especially in deep caries and brittle teeth, of breaking the tooth off even in simply applying the instrument.

Attempt at first through *slow* "*working*" to loosen the tooth, and gradually apply more and more force to the movements. Instead of loosening the tooth from its attachment, if it is forcibly luxated from the very beginning, the crown or a portion of the alveolar process may be broken off. Inasmuch as the external bony plate of the alveoli is thinner than the internal, and the spongiosa so formed that the roots can grow longer in a lingual direction, more strength should be employed in "working" outwardly than inwardly.

Aside from the movement for loosening, it must not be forgotten to give one tug forcibly downward or upward. Care must be exercised not to strike and thus injure the neighboring teeth with the forceps.

EXTRACTION OF THE UPPER TEETH.

In extraction of the upper teeth, the patient must sit on an elevated seat with the head inclined backward. The dentist fixes the patient's head with his left hand, and employs that hand at the same time to draw the lips away, in order to obtain a good view of the mouth.

The position of the operator in extracting upper teeth is always to the right of the patient. If the left upper jaw is to be operated upon the operator must bend somewhat forward, but in case of the right upper jaw he should stand at the right shoulder of the patient (see Figs. 137 and 138).

FIG. 140.—Position for extracting a tooth from the right lower jaw.

EXTRACTION OF THE LOWER TEETH.

When the lower teeth are to be extracted the patient should be seated upon a low seat, and the head should be so fixed that it is bent slightly forward.

The operator should stand back of the right shoulder when removing teeth from the right half of the lower jaw. With his left hand passed around the left side of the patient's head, he grasps the lower jaw in such a manner that the thumb rests upon the teeth and the fingers around the jaw (see Fig. 140).

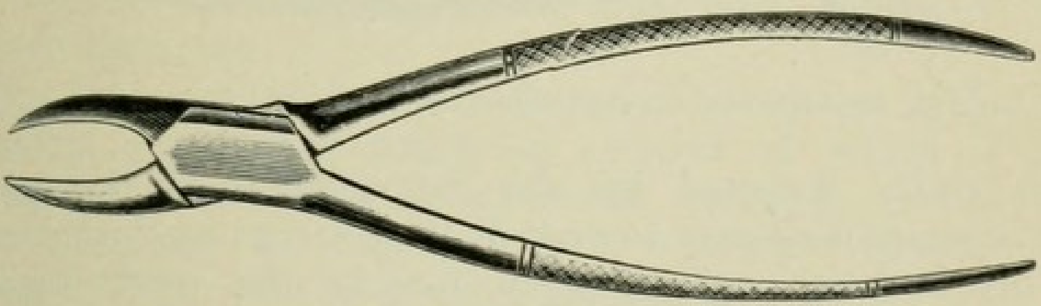

FIG. 141.—Forceps for upper incisor and cuspid teeth.

In extraction of teeth from the left lower jaw the operator stands likewise at the right side and a little in front of the patient. But as this position interferes somewhat with the light, it is better to stand wholly on the left side. Naturally in this position it is impossible to clasp the hand around the head of the patient, and therefore the opposite side of the jaw should be simply grasped with the left hand (see Fig. 139).

THE EXTRACTION OF UPPER INCISOR AND CUSPID TEETH.

The same pair of forceps is usually employed for extraction of the upper incisor and cuspid teeth. Its jaws are a direct continuation of the handles (Fig. 141). One may, however, select one of a large number of models, so long as the jaws are formed to exactly fit the oval shape of the roots. The groove of the labial jaw should really be wider than that of the lingual, because the roots are thicker in front than behind.

With such a pair of forceps, the tooth is grasped as high up on the neck as possible, and *rotated* on its long axis. This manipulation is usually sufficient to loosen the *central incisors*, for their roots are rounded. But if unexpected curvatures or abnormalities in the thickness and length, etc., of the roots exist, which

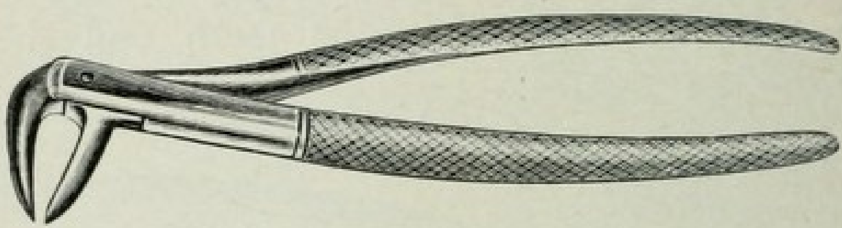

FIG. 142.—Forceps for lower incisors, cuspids and bicuspids.

are easily detected by the enlargement of the parts, it becomes necessary to precede the rotation by "*working*." This is best performed by forcing the tooth rapidly in a labiolingual direction to and fro, and, at the same time, exerting considerable traction in a labial and downward direction.

This manipulation is similar for the *lateral incisor teeth*, but, as their roots are more tightly pressed together in a lateral direction, not much assistance is obtained through rotation. Better results, in that case, follow working, which, however, must be carefully performed in order to prevent a fracture of the roots.

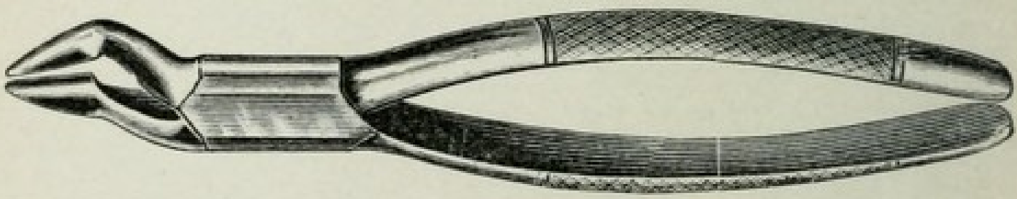

FIG. 143.—Forceps for upper bicuspids and for certain roots of the upper jaw.

The *upper cuspid teeth* are known to have the largest and strongest roots, which are set in much stronger alveoli than the incisor teeth. They must, therefore, be grasped at as high a point as possible, and it is often necessary to exert considerable strength in order to loosen them, through rotation and luxation.

THE EXTRACTION OF LOWER INCISOR AND CUSPID TEETH.

For the extraction of these teeth, a pair of forceps is necessary, whose jaws stands at right angles to the handles (see Fig. 142). The *lower incisors* have small, laterally compressed roots, on account of which it is impossible to remove them by a twisting motion, but, instead, they should be forced toward the lips; this one movement of luxation is sometimes sufficient to remove the tooth.

The *lower cuspid teeth* are fastened by means of long, laterally compressed roots, on account of which it is necessary to employ considerable strength; usually, it is necessary to resort to the "working" movement repeatedly, in order to remove the tooth.

THE EXTRACTION OF THE UPPER BICUSPIDS AND MOLARS.

The roots of the *first upper bicuspids* are pressed tightly against each other, and are often divided into two parts.

The *second upper bicuspids*, as a rule, possess only one root. For the extraction of this tooth, it is best to employ the bayonet-shaped forceps shown in Fig. 143. Since these roots are often very tender and brittle, they must be grasped at a high position, and loosened from their surroundings by slow and careful luxation.

As we know, the *upper molars* possess three roots, two of which are located on the buccal side, and one on the palatine side. On account of this arrangement, the jaws of the forceps must have two notches on the buccal side, and one on the palatinal. In order that the molars may be conveniently grasped, the jaws of the forceps should form an obtuse angle with the handles. It is, therefore, necessary to have a separate pair of forceps for each side. (See Figs. 144 and 145.)

Naturally, the upper molars cling, as a rule, very tightly to their alveoli, but, by means of a careful to and fro movement, it is usually possible to withdraw all three of the roots simultaneously. During this procedure, the pressure should be mostly exerted in the buccal direction, because of the thinness of the outer

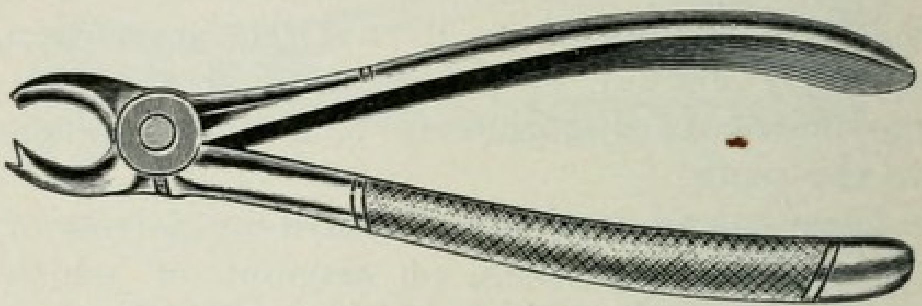

FIG. 144.—Forceps for left upper molar teeth.

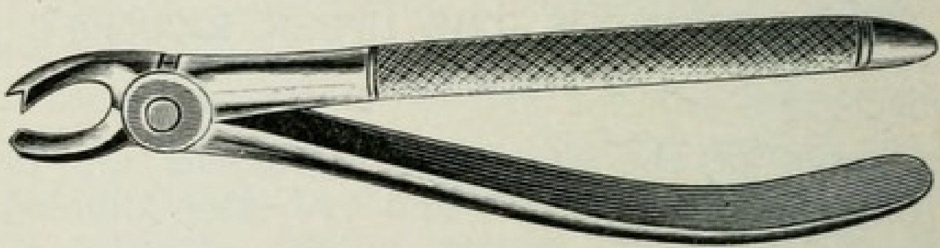

FIG. 145.—Forceps for right upper molar teeth.

plate of bone. If the crown is already so deeply destroyed that it is no longer properly connected with the roots, it is wiser to remove them one by one with the bayonet forceps. The same forceps are employed for the *third molar* or so-called *wisdom teeth*, especially when they are abnormally small.

THE EXTRACTION OF THE LOWER BICUSPIDS AND MOLARS.

Each of the *lower bicuspids*, the first as well as the second, possesses one root, which appears round or oval on cross section. Similar forceps are employed in their extraction as for the lower incisor teeth (Fig. 142), and they are extracted in exactly the same manner. They adhere somewhat more tightly to the jaw, but, even so, they too, sometimes drop out of the alveolus after the first outward movement.

The *lower molars* have two roots, a strong mesial and a weaker distal root, which is twisted backward. There is but one form of forceps which acts satisfactorily in extracting these teeth, the crow-billed forceps pictured in Fig. 146. It is constructed after the same principle as is the pair of forceps used for lower incisor teeth; that is, the jaws form a right angle with the handles, but possess on both sides two notches, into which the roots fit.

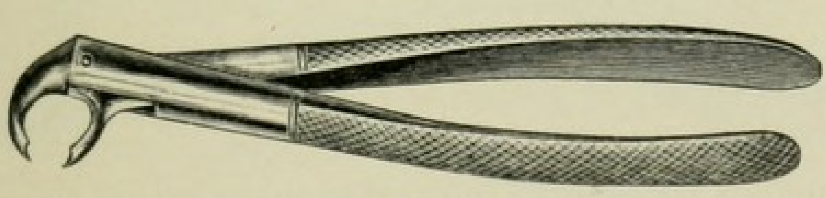

FIG. 146.—Forceps for lower molars.

The forceps must be very strong, since the lower molars set exceptionally tight in their sockets. The roots of the *first lower molars* diverge considerably, on account of which they are held strongly in place. It is necessary, therefore, in order to remove them simultaneously with the crown, to combine strength with precaution; that is, they must be deeply grasped, slowly but energetically luxated, and finally turned outward. The roots of the *two lower molars* diverge much less or not at all, but they are inserted in the portion of the inferior maxilla which is thickened on the outer side by the oblique line, and on the inner side by the mylohyoid line, which enhances the difficulty of their extraction. The same forceps are employed for the wisdom teeth as for the remaining lower molars. When their roots are poorly developed, the *wisdom teeth* are easily removed; sometimes, however, they are hooked into the jaw with crooked roots. Such a third molar, which possesses five hook-like curved roots, is shown in Fig. 78; even in this case the crow-billed forceps sufficed for the removal.

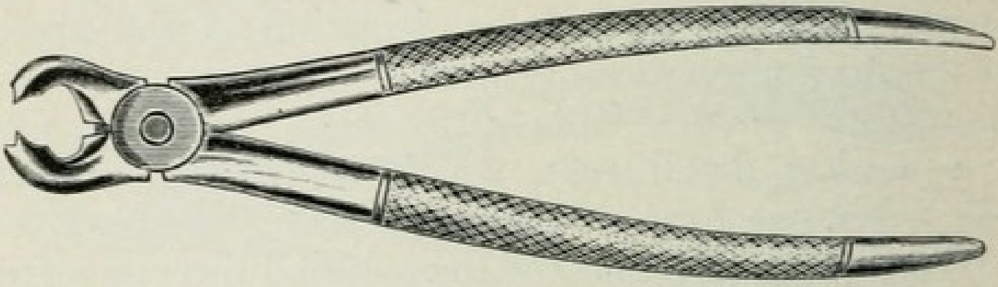

FIG. 147.—Forceps for lower molars.

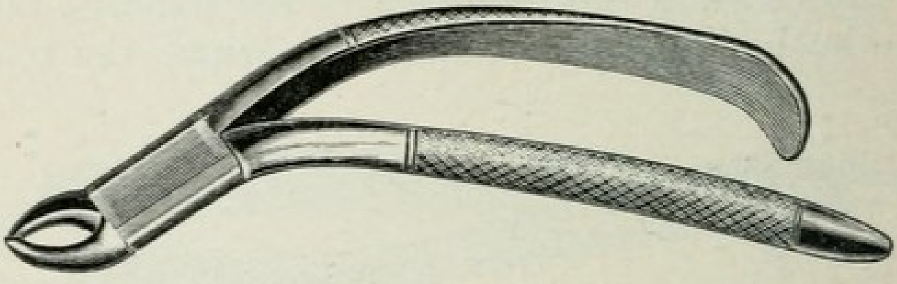

FIG. 148.—The universal forceps of Rauhe.

Fig. 147 shows another form of forceps for lower molars, which is also recommended by various practitioners.

Universal forceps may only be looked upon as instruments which give assistance in certain cases, for they cannot be properly applied to teeth in all localities. The best are those of Rauhe, which are shown in Fig. 148.

EXTRACTION OF ROOTS.

Roots are, as a rule, more difficult to extract than teeth, and when they remain behind after an unsuccessful tooth extraction their removal may at that time be impossible. If, therefore, a root is broken off in such a manner that it lies deeply imbedded in the jaw-bone, it is wiser to postpone action and see whether any ill effects develop. There are many dentists who believe that every fractured root must be immediately removed. But as this is accompanied by considerable pain, it can but imbue the patient with great fear for all future extractions. It is, therefore, better to wait until the root has risen slightly above the alveolus, which will surely occur in time. It may then be removed without injury to the surrounding tissue.

Roots remaining after the crown has been worn off are more easily extracted than those of fractured teeth. This is due to the fact that the circular ligament, which has usually been destroyed in these cases, no longer resists the action of the forceps, and also because the walls of the alveoli are usually atrophied. Complications which are specially difficult arise when the gum grows as a tense covering over the root, or when the latter is broken off at a point high up in the alveolus. In the first case, the gum bridge is removed by means of a knife or a pair of scissors ; in the last case, a pair of forceps with a cutting jaw (resection forceps) are required. The *bayonet-shaped forceps* shown in Fig. 143 are useful in the extraction of all roots of the upper jaw. The forceps constructed by J. Scheff, which have long, slender jaws, are highly praised by some practitioners, because they can be passed high up between the gums and the bone.

If a root is broken off so high up that it cannot be reached with the above described forceps, the object is sometimes best attained by means of the root-screw. A large number of screws of various thickness exist, but one which corresponds in diameter to that of all root canals is sufficient for most cases. It is screwed to the accompanying handle, and is then inserted into the root canal, which is usually enlarged. A lateral and outward movement is usually sufficient to remove the roots. If, however, the root on the lingual side is deeply destroyed, while the labial side rises beyond the alveolar border, a Langenbeck's periosteal elevator should be resorted to. The application of this instrument is shown in Fig. 149.

It is a very simple tool, the end of which is concave and forms an obtuse angle with the handle, which is thick and made of wood. This handle is tightly grasped by the whole hand, the concave point is forced along the neck of the tooth until the alveolus is reached, and the root is then forced with considerable pressure toward the oral cavity. What was said of the upper roots is also true of the lower.

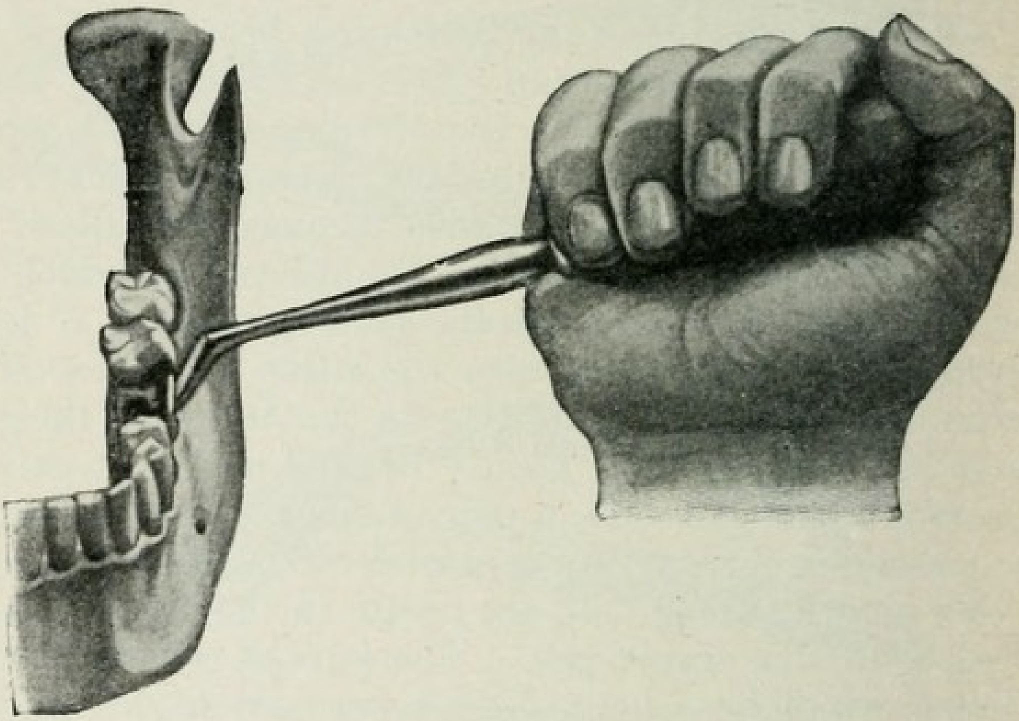

FIG. 149.—The application of the Langenbeck periosteal elevator.

The same forceps are employed in uncomplicated cases as for the *lower incisor teeth*. They may even be used to extract molar roots which are united. The root which extends above the alveolus is the one to be grasped, for then we often have the satisfaction of seeing the others coming with it. The resection forceps are not of much service in the posterior and thicker portions of the jaw. Therefore, it is better in hopeless cases, to cut through the alveolar process from both sides above the affected part with the alveolar forceps. It must not be forgotten when the Langenbeck periosteal elevator is employed, that the lower jaw must be steadied with the hand so that it will not slip or become dislocated.

EXTRACTION OF DECIDUOUS TEETH.

The primary teeth are very rarely extracted in a well regulated practice. Premature extraction causes the alveolus to atrophy, so that the permanent teeth fail to find sufficient space ; and, furthermore, the teeth of second dentition require for their healthy development, the pressure stimulus which mastication exerts upon the first teeth. On these grounds the deciduous teeth should be fostered as carefully as the permanent. Therefore, only such teeth are usually extracted whose roots are undergoing absorption, and whose sharp edges and points irritate the surrounding tissues. As most of such teeth are loose, they may be removed without difficulty. Similar forceps are employed as for the permanent teeth, only smaller in size. If it is necessary to extract deciduous teeth which are not loose, it must not be forgotten that they are set in a very flexible jaw and possess comparatively weak roots ; there is, therefore, no need of applying the forceps with great strength and to luxate as energetically as in the case of the permanent teeth. However, the operation must not be looked upon as being too easy, for when the crown instead of the neck of the tooth is grasped, a fracture may result, an accident which will not tend to give confidence to the already frightened children.

In conclusion the writer wishes to call attention to a moral point which is often sinned against ; namely, that in case it is intended to remove the tooth of a child, quietly to make your intention known, and never to deceive the patient. Often even the parents implore us not to tell the child the truth ; if we were to accede to these requests, it would be but our just reward if future clients were to show a lack of confidence and respect.

COMPLICATIONS DURING AND AFTER EXTRACTION.

An extraction is not always performed without ill results, for unpleasant *accidents* may occur which involve either the tooth itself or the surrounding structures.

The most frequent accident is *fracture of the tooth* to be extracted. The awkwardness of the operator is often the cause. He either selects poorly fitting forceps or he applies them improperly. Frequently the tooth is too forcibly luxated, or it is grasped too tightly. In the majority of cases, however, the dentist cannot be blamed for the accident. This is especially true of those cases in which the patient behaves unreasonably, draws the head to one side, and strikes at the forceps. Sometimes, however, teeth break off most unexpectedly without the dentist or patient being at fault, as when the alveolus is exceptionally hard and non-yielding, and when the teeth are as brittle as glass. Also, other factors occur, such as anomalies in construction, and in the course of the roots, and the like.

If the tooth to be extracted is not properly grasped, the forceps may act upon a neighboring tooth and thus *loosen* it or it may even be fractured or knocked out. Such loosened teeth should be left alone or at the most be fastened with a ligature, and in about fourteen days they again grow fast. Aside from the neighboring teeth the antagonistic teeth also run a certain risk of being fractured. This happens when the tooth leaves its alveolus with unexpected ease, on account of which the forceps easily strike the teeth of the opposite row.

Not unfrequently a fine long bony plate is attached to the roots of the extracted tooth, especially when the upper molars are removed. This is of no significance, but if longer portions of the alveolar process break off the condition may be considered a complication. The *tooth-cell portion* of the alveolar process of the lower jaw, especially in the region of the molars, is most likely to become fractured, because it is brittle and unyielding in that neighborhood. Formerly, when the dental key was employed, this complication occurred much more frequently. *Fractures in the upper jaw* near the molars may expose the antrum of Highmore. They usually heal of their own accord when proper cleanliness of the oral cavity is maintained. Sometimes, however, it may lead to suppuration, and finally to the formation of the empyema, which eventually becomes chronic.

A very unpleasant complication consists in *bruising* and *tearing* of the surrounding soft parts, such as the gums, the lips and the tongue.

An extensive tearing of the gums occurs at times and may require a suture. Much more serious are bruises of the periosteum, which lead to necrosis of the bones.

Intense *wound pains* frequently follow extraction, although they occur rarely after other operations. They either represent the continuation of the extraction pain, which may continue for hours or even days, or they are intermittent and equally as severe, but set in only after the elapse of some time. Sometimes the pain is localized in the tooth-socket, but more often it spreads over an extensive area of the face. It exists largely in the region of the branches of the trigeminal nerve, and therefore simulates neuralgia.

The *cause* may sometimes be looked for in the tearing and twisting of the nerves which lead to the pulp; but devitalized teeth also give rise to such symptoms, and, in such cases, it is more likely that the cause is the tearing of the nerves of the periosteum. Pain in the tooth-sockets occurs more often in the lower than in the upper teeth, which is accounted for by the fact that the mandibular nerve, which is imbedded in the spongiosa, directly underneath the roots of the molars, becomes bruised during luxation by destruction of the bony trabeculæ. Secondly, *infectious processes* are more prone to develop in the lower jaw for mechanical reasons, than they do in the upper jaw. When the pains do not appear until much later, we should take into consideration the factor described by Sauer, according to which the periosteum and the gums, because of scar formation, lie over sharp edges, which cut into the soft tissue.

Wound pains should be treated energetically, for, as may be observed, the after-pain, from extracting, is very severe. In light cases, washing with chamomilla tea suffices. Frequently, on the contrary, the cold application is much more efficient, and is done by simply spraying cold water into the part. Internally, antipyrin (15 gr. to $1\frac{1}{4}$ʒ a day), or phenacetin (15-45 gr.) are administered. Chloral hydrate (15 gr.-45 gr.) is employed as a hypnotic, and, locally, a tampon is inserted into the alveolus. This tampon, which is composed of clean cotton, is previously immersed in a 5 per cent. solution each of cocain and iodoform. This application must be repeated until all pain disappears. If all of these remedies fail, we may resort to morphin, of which a solution, containing $\frac{1}{8}$ gr., is injected into the gum of the affected side.

A serious complication, at times, is the development of *hemorrhages* after extraction. This is not only observed in hemophilia, for large hemorrhages occur in certain diseased conditions, but without any known cause.

Such hemorrhages are most successfully combated with the ordinary styptics, such as alum and sesquichlorate of iron, by means of hot water (according to J. Scheff) or adrenalin chlorid. If the hemorrhage cannot be stopped by such means, we must resort to mechanical closure of the alveolus. We must realize in this connection that an uncontrollable hemorrhage may follow, not only from the blood vessels in the fundus, but also from many points in the alveolus. Therefore, the plug must be so formed that the whole alveolus is tightly closed to its very summit. For this purpose, cotton serves as an excellent plugging material. It should be first immersed in chlorid of iron, and then dried. The cotton should be tightly plugged into the alveolus, and be allowed to remain there until it falls out of its own accord.

In obstinate cases, plugging the alveolus with a very hard substance is more effectual ; for example, Stent's material or guttapercha, which are introduced into the alveolus in a softened state, and there allowed to harden. Plaster of Paris is also useful, but we must be careful that this substance fills the whole alveolus. Another method is to cut a cork into the shape of the alveolus, and insert it into place, so that it stands far enough above the teeth to permit the antagonizing teeth to bite upon, and force it deeply into the alveolus. Patients treated in this way must not, however, open the mouth, for otherwise the hemorrhage will begin anew.

Niemeyer has constructed an apparatus for this complication, consisting of a metallic plate which fits exactly over the alveolus, and which is fixed with two clamps to the neighboring teeth. In that manner, the alveolus is tightly closed with a covering, which prevents the escape of blood, and which does not interfere with opening of the mouth. Since neglect of these post-operative hemorrhages leads to considerable loss of strength, and even death, the patient should not be discharged until the blood has ceased to flow, and he should be advised to seek our assistance if hemorrhage reappears later.

ANESTHESIA.

Dental operations, especially extraction of teeth, are frequently very painful, and, therefore, we are compelled, in nervous and sensitive patients, to resort to pain-alleviating or pain-destroying remedies.

The action of such anesthetics is limited, either to the part being operated upon (local anesthesia), or to the whole body (narcosis).

Local anesthesia may be produced by thermic action (cold), mechanical action (swelling of the nerve fibers and pressure upon the same), and by chemical action.

Anesthesia by means of cold is best obtained with evaporating substances, such as ethyl chlorid (chlorethyl), which finds its greatest field of usefulness in dentistry. Before applying ethyl chlorid, the neighborhood of the tooth to be extracted should be protected, so that it will not be affected by this liquid. This is done by covering the neighboring teeth with a layer of softened wax, cotton rolls, or a napkin. The commercial ethyl chlorid, which is obtained in tubes, is then directed both upon the labial and lingual side of the alveolus of the tooth to be extracted. Since ethyl chlorid boils at 11° C., the tube may be held quite some distance from the field of operation, for the heat of the hand is sufficient to cause the expansion of this preparation, and to force a strong stream to be sprayed forth. After the spray has been allowed to act upon the gum for from ten to fifteen seconds, a shiny white coating of frost is formed, which indicates that the operation may be begun. The latter is thus made decidedly more bearable, and, especially so, if in association with the local action of cold, a light general anesthesia is produced by inhalation of gas. Ethyl chlorid is also recommended for minor operations upon the mouth, such as removals of growths, etc. It is sometimes also of good service in the extraction of a living pulp, in which case the spray is directed, not upon the gum, but upon the pulp. It must be remembered in this connection, on account of the highly inflammable nature of this substance, that it be not followed by the application of the thermo-cautery. The consequences of such a mistake are illustrated by the following case: "When this method was still new, the writer wished to burn away an epulis frozen in the above manner. As the oral cavity was approached with the red-hot cautery, a flame blazed forth from it. Luckily, no burn-wounds developed, and, aside from the shock, there were no ill effects."

Anesthesia is obtained by *mechanical action* through the injection into the tissue, under high pressure, of a very dilute solution of a medicament or *physiologic salt solution*. This is supposed to cause a swelling of the nerve fibres. Such fluids must be injected in large quantities, and as strong pressure is preferable, a powerful syringe should be employed. The injections should be made in two or three different areas, on both the lingual and labial side, until the gum swells like a blister. Attempt, also, to inject some of the fluid between the root of the tooth and the alveolus. Many of these agents, which may be had on the market, have a purely mechanical action. This method is not universally employed, for at times sensation is only partially obtunded, and the multiple deep injections are painful.

Of chemicals having anesthetic influence, *cocain* occupies the first position. Whenever it comes in contact with a nerve it destroys its power of sensation for a short time. For operations upon the gum, which absorbs this medicament well, it suffices to paint the part with a from 5 to 20 per cent. solution, and allowing it to act from two to four minutes. As this analgesia remains local, and does not penetrate deeply, it suffices for small incisions into the gums but not for extraction of the teeth; in the latter case the solution should be injected beneath the gum. Too strongly concentrated solutions should be interdicted for they may cause a number of toxic symptoms. For that reason the 20 per cent. solution of cocain recommended formerly by Ad. Witzel for subgingival application is no longer employed and is now substituted by much weaker solutions. *Schleich's solution* which contains but a small percentage of cocain is a favorite preparation of many dentists. Thiesing states that the 1 per cent. solution should not be exceeded and that not more than 2g (0.02 cocain) be given to a single dose unless absolutely necessary. Especial care must be exercised in administering it to children. Braun recommends the following solution:

℞

Cocain hydrochlorate,		gr. 15	(1.0),
Sodium chlorate,		gr. 12	(0.8),
Aq. distill.	qs. ad	℥iii⅓	(100.0).

M. D. S. 1 per cent. cocain solution.

Following is the *technic* of its application: If the operative field should be anesthetized for the purpose of extracting a tooth, a 20 per cent. solution of cocain is at first painted upon the gum, which has been previously well dried and washed off, either with ether or hydrogen peroxid. Next the gum, which has been made less sensitive, is pierced by the Pravaz syringe, which is filled with a 1 per cent. solution, and which, of course, has been thoroughly sterilized. The needle of the syringe should penetrate deeply enough to prevent the fluid from again oozing out of the point of entrance.

A labial and a lingual injection should be made, and ½ gram of solution in the syringe is emptied on each side. The extraction may be begun after three minutes, and usually may be performed without any pain whatever. Only in the case of periostitis is it impossible to obtain complete anesthesia.

As has already been stated, such injections are not altogether harmless, and therefore a number of substitutes have been offered in place of the cocain.

Beta-eucain, which has been strongly recommended in recent years by Thiesing, has probably been used the most extensively. According to that authority, it has the same action as cocain without being poisonous. As a further advantage over cocain, this remedy can be sterilized by boiling without losing any of its properties. Depending upon the nature of the operation (incision, extraction of loose or firm teeth) from a 2 to a 3 per cent. solution is employed. Following is the prescription :

℞

Beta-eucain,		gr. 30.00	(2.0),
Sodium chlorate,		gr. 9.00	(0.6),
Aq. distill.	qs. ad.	f℥iii⅓	(100.0).

M. D. S. 2 per cent. solution of eucain.

The quantity of the fluid should, of course, be measured according to the severity of the operation. In light cases one-half of a Pravaz syringeful is sufficient, but in case of necessity the dose may be increased to two such syringefuls.

In order to obtain good results with beta-eucain two subperiosteal injections, one on the labial and the other on the lingual side, should be made for the extraction of teeth possessing but a single root. In the case of the upper molars, corresponding to the three roots, two buccal and one lingual injections are made. Since they are imbedded in a thick bony mass, the lower molars require the largest quantity of fluid and the greatest number of injections. The solution is best introduced into the jaw-bone in this case by means of four injections, of which two are made along the buccal root border and two along the lingual. In well-developed jaws an attempt may be made to pass the needle between the roots and the alveoli, in order to introduce the anesthetic into the interior of

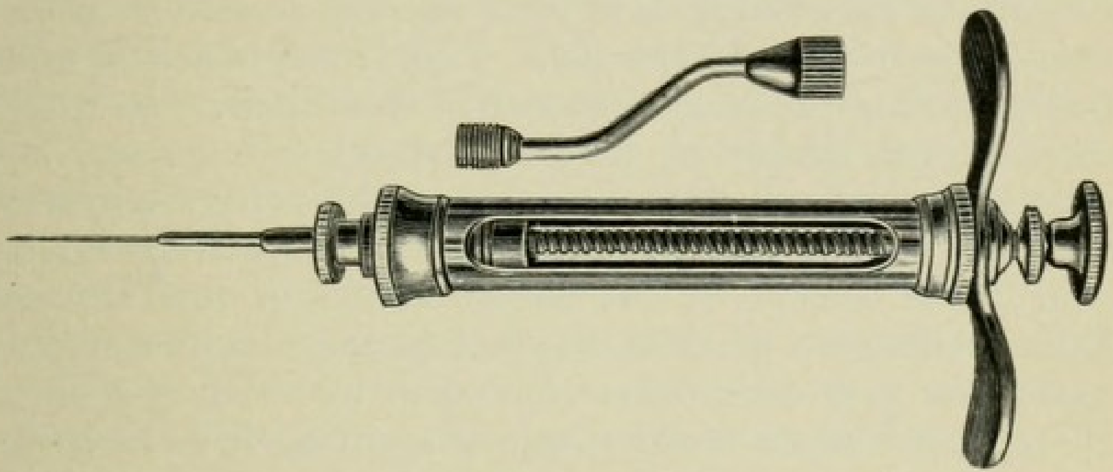

FIG. 150.—Pravaz syringe.

the bone. For this purpose, however, the needle must not be forced deeply into the alveolar periosteum at once, for thus too much pain is occasioned, but instead, the needle should be passed slowly, and accompanied at intervals by the forcing out of a little of the fluid. The needle is then gradually forced through the successively anesthetized tissue.

DENTIN ANESTHESIA.

One of the most important problems is that of anesthetizing the dentin. We need not, therefore, be surprised at the fact that new remedies and methods are continually being brought forth, which are claimed to destroy more or less completely the pain accompanying the preparation of carious tooth cavities.

Unfortunately, none of these remedies have been worth adoption, while the ordinary local anesthetics are particularly ineffectual for this purpose, probably because in place of nerves, the dentin has the Tomes' fibres, which assume the function of a nerve apparatus. Furthermore, we unfortunately know but little about the Tomes' fibres, and that is probably the reason of our inability to influence them.

The majority of these remedies are either useless, or if they are really successful in making the dentin non-sensitive, they injure the pulp.

The sensitiveness may be overcome by inserting into the cavity for several days *zinc chlorid, creosote, carbolic acid, or paramonochlorphenol.* The latter, which is especially useful, was recommended by Walkhoff. Its application is as simple as that of the other remedies, and consists in introducing into the tooth cavity a pin-head sized amount of the crystallized fluid. The cavity is then well closed because of the caustic action of this remedy. Römer obtains a marked decrease in the amount of pain associated with excavation of a tooth by rubbing a bit of chlorphenol into a powder, and permitting it to lie in the cavity for from two to three minutes.

A tooth may be excavated with but little pain by means of *kataphoresis,* which consists in conducting low tension electric currents through the tooth. This procedure is, however, not only very inconvenient and time consuming, but what is much worse, it injures the pulp. It has been repeatedly noticed that teeth treated by means of kataphoresis lose their vitality either immediately or it may be some months later.

Momentary action is probably most frequently produced by means of *carbonic acid,* which owes this property to its action upon the nervous apparatus, which becomes fatigued and loses its conductivity. This action is especially marked during the nascent state. Credit is due to Walkhoff for the addition of this remedy to our armamentarium. By means of an apparatus invented by Bauchwitz it is possible to obtain the action of carbonic acid upon the dentin in a simple manner. Whether this remedy will continue to be as promising in the future, can only be determined after the experiences of various practitioners have been compared.

By observing a physical law, patients may be spared much pain ; namely, that just as dull instruments in operations upon the soft parts cause severer pain than sharp instruments, so do dull drills act upon the sensitive dentin. Therefore, we should employ only first class and absolutely sharp instruments, and the cavity must be kept dry in order to prevent the instrument from slipping against the walls.

The surest action is obtained by *submucous* or *subperiosteal injections* of a 5–2 per cent. of *cocain* or *beta-eucain* solution, in the same manner as for extraction of teeth. The operator must, however, begin work immediately, for the anesthesia which is sometimes complete, lasts only five to ten minutes ; that is, about from five to fifteen minutes after injection.

This method is sometimes rewarded by most satisfactory results, for if care is taken to anesthetize the gums before making the injections, the patient feels no pain during the whole operation.

GENERAL ANESTHESIA.

By general anesthesia is meant that condition in which the sensory nerve centers cease to functionate, as contrasted with local anesthesia, in which only the peripheral sensory nerves have ceased to act. To obtain unconsciousness, volatile substances are employed which are rapidly absorbed by the blood and again rapidly discharged. Such substances are *nitrous oxid*, *ethyl bromid*, *chloroform*, and *ether*.

Nitrous oxid, or laughing gas, is probably most frequently used in dental operations. It is a colorless gas of a sweetish odor, and is obtained from ammonium nitrate. Before using it, from fifteen to twenty litres of this gas, which is the quantity required for a short operation, are allowed to flow into a gasometer, the receiver of which is immersed in water. The patient inhales the gas by means of a mask, which is joined to the gasometer by a rubber tube. This mask is supplied with a valve through which the expired air escapes.

Complete unconsciousness results in about one to two minutes; the subject awakens, without any untoward effect, of his own accord, and usually refers to the procedure as very agreeable. Of the large number of patients who have been anesthetized by nitrous oxid only very few are known to have died from its effects. We may conclude, therefore, that this form of narcosis is one of the safest. It is, however, only indicated for operations of short duration, like extraction of one or more teeth.

In more recent times, in spite of these advantages of nitrous oxid, it has fallen more and more into disuse. The reasons, no doubt, are simply convenience and economy. The modern remedies do not require such complicated apparatus.

Ethyl bromid is more convenient in application, because it can be inhaled from the ordinary chloroform mask. In case of necessity a piece of cloth sprinkled with ethyl bromid serves the same purpose.

Since ethyl bromid is rapidly decomposed by the air, it is advisable to set the mask tightly upon the face, and to cover it with a rubber sheet.

The amount to be used is from ten to thirty grams, which is best poured upon the mask at one time. Narcosis develops in a few minutes and lasts only a short time, but, by adding more of the anesthetic, the narcosis may be prolonged for from ten to fifteen minutes. Narcosis for a longer period of time is unsafe.

As the corneal reflex is not obliterated, we determine by another sign whether unconsciousness has set in; this consists in the fact that the raised arm falls powerless when narcosis has developed. Some prefer to have the patient count aloud; this is, however, not very satisfactory, for it is interfered with by the speculum which is placed into the mouth before narcosis.

During the narcosis the patient is wholly unconscious, notwithstanding that the muscles still respond to stimuli, and in spite of the fact that at the moment of extraction the patient cries out loudly.

The awakening is usually abrupt and like that following healthy sleep. Nausea occurs only in very rare cases. The patient describes the process of narcotization as a disturbed dream, in which he continually hears the telephone ringing, or the noise of the tram car, or may imagine he is taking a ride in a railway train.

At the commencement of the narcosis the respiration is often irregular, and the patients should therefore, be advised to take deep and slow respirations. Later, however, the respiration again becomes normal, and in deep narcosis snoring is often heard. Blood pressure and pulse rate remain normal. During the excitement at the beginning of the narcosis the frequency of the pulse increases (it may rise to one hundred and fifty beats a minute), but when the stage of unconsciousness sets in the heart action returns to normal.

Ethyl bromid is excreted chiefly through the lungs, and small amounts through the urine. The breath has an unpleasant garlic-like odor for from two to three days after the anesthetization.

Schneider, by means of animal experimentation, proved that ethyl bromid is no cardiac poison. The blood-pressure fall was barely preceptible after the largest dose, and the animals died in every case from asphyxia and never from syncope. For prolonged narcosis *ether* or *chloroform* are more suitable.

The latter is especially serviceable in dental practice, because the narcosis continues for some time after removal of the mask. Since effective quantities of chloroform are more dangerous than the first two mentioned substances, it is advisable to secure the service of a skilled colleague to administer the anesthetic.

To prevent *accidents* during and after the narcosis, the following fundamental laws should be observed. They hold true for all anesthetics, whether ethyl bromid, nitrous oxid or chloroform.

The anesthetic must be fresh and absolutely clean. Ethyl bromid and chloroform must be kept in dark bottles, for light decomposes them.

The heart must be carefully examined before the operation; if a serious form of heart disease exists, narcosis is contraindicated, and, if it cannot be avoided, only ether is permissible.

Artificial teeth must be removed lest they fall into the larynx.

Tight clothing which interferes with respiration (collars, corsets, etc.) must be loosened or removed.

During anesthetization the operator must not lose sight of the patient for a moment. He must constantly watch the pulse, the respiration, the appearance of the patient, and eventually the reflexes.

If the pulse becomes irregular, the color of the face pale or dark red, and the breathing should cease, etc., the anesthetic must be removed immediately. The tongue, which has fallen back is rapidly drawn forward, and artificial respiration instituted.

The vapor of the anesthetic must not be too concentrated, but must always be mixed with some air, and immediately after the operation the air in the room must be renewed.

It is recommended by many that in the case of collapse, the patient should inhale amyl nitrite, or receive subcutaneous injections of camphor and ether. Better than these artificial stimuli is the mechanical assistance obtained by stretching the patient out flat, so that the blood flows to the brain, and then energetically practicing artificial respiration.

In conclusion, we wish to particularly advise that anesthetization be never instituted with out professional assistance, for, aside from the fact that frequent erotic dreams, in which the unconscious patient imagines she was ruined, have led to penal law suits, an assistant is also required for the institution of artificial respiration.

By fulfilling all of these requirements, one may have a clean conscience if an accident happens, and also the eventual resulting legal decision will not be unfavorable.

PREPARATION OF THE MOUTH FOR ARTIFICIAL TEETH.

The loss of teeth leads to an interference with *mastication* and to *weak digestion*. A large number of gastric diseases may be traced to this condition. If the lost teeth are replaced by artificial ones, the general health of the patient shows a remarkable improvement in a surprisingly short time. We may, therefore, conclude that *artificial teeth* are capable, from a physiologic point of view, of replacing natural teeth. The same holds true of articulation, as well as of appearance in deficiency of the front teeth.

According to the condition of the oral cavity, more or less preparatory treatment of the mouth is required. The object of such treatment is to establish conditions which will favor long use of the artifical teeth. Therefore, all carious teeth, if any are present, must be filled. *Reactionless roots,* which occupy an awkward position, and which are suffering from periosteal disease, should be extracted. Since, after extraction of the tooth, the portion of the alveolus concerned shrinks, it is advisable not to insert the artificial substitutes until after the elapse of some

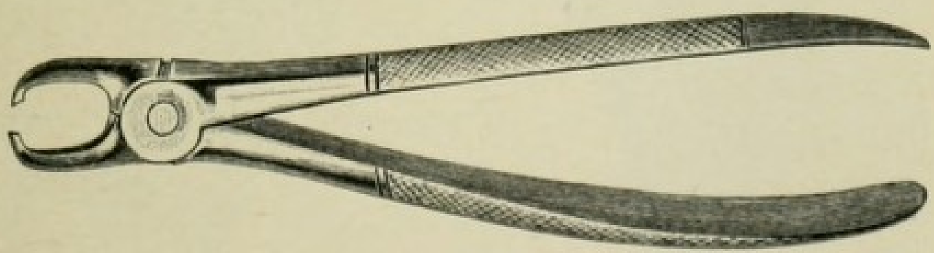

FIG. 151.—Simple nippers.

time; that is, from two to three months, or even a longer time. If, for some important reason, this postponement is not possible, then apply a provisional set of teeth, which should be replaced by a permanent set in the space of from four to six months.

Protruding portions of roots, which for any reason we may decide not to extract, are removed with a pair of nippers (Fig. 151 illustrates the simplest form), or with root forceps and small stones in the dental engine.

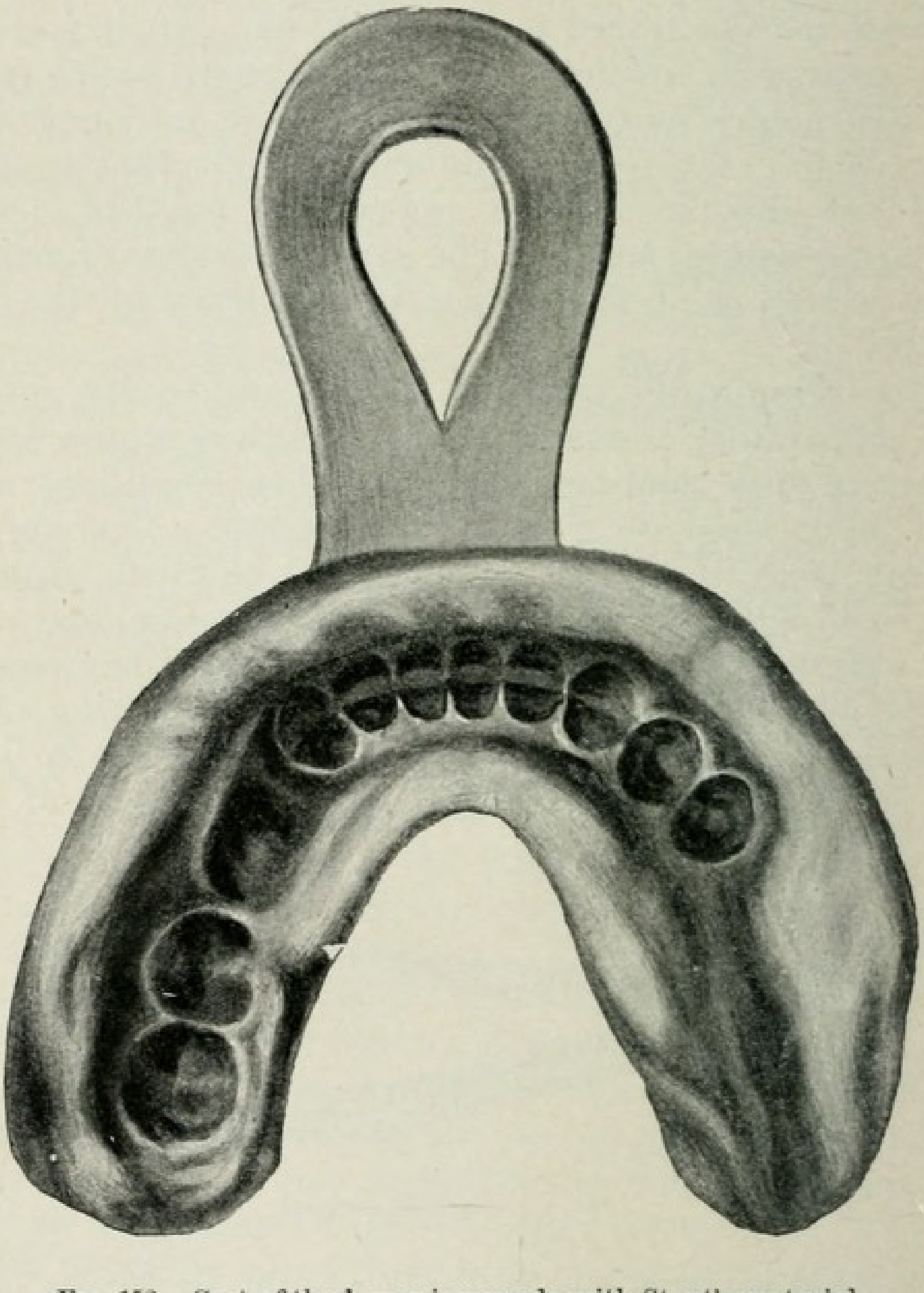

Fig. 152.—Cast of the lower jaw made with Stent's material.

For the success of the prosthesis, a proper cast is important. For obtaining such a model, a specially formed impression-tray is employed, which is filled with a plastic material. The tray or cup filled in this manner is then placed into the mouth, and pressed against the alveolar process until the impression material has stiffened.

The materials usually employed are plaster of Paris, and preparations of Stent, Ash, etc.

Plaster of Paris is particularly adaptable in toothless jaws, but if teeth are present, this material is removed with difficulty after it is once hardened, because of its hard and unyieldy nature. However, because of these properties, such impressions or casts are very exact, and far more preferable in certain cases than casts made from a substance of softer consistency. In order that the plaster of Paris may rapidly harden, it is stirred in warm water, to which a little salt has been added; as soon as it has assumed the consistency of gruel, it is ready for the impression. Care must be taken not to place too much of this material in the tray, for, otherwise it may flow into the pharynx, and excite coughing and vomiting, both of which interfere with obtaining a proper impression. The plaster of Paris may also be prevented from flowing backward by inclining the head forward. The impression must not be removed from the mouth until the plaster of Paris is thoroughly hardened, which requires several minutes.

Stent's composition is particularly useful for jaws which still contain teeth, for, without distorting the cast, it yields sufficiently to allow of its removal. This substance is softened in warm water, and the resulting mass is placed into the tray in such a manner that it will have a smooth surface. Cold water is then allowed to flow over the tray, in order that the mass may stiffen rapidly, and also prevent injury to the mucous membrane from the heat. Next, the mass is rapidly passed through a flame, which makes it soft and easily impressionable. The impression-tray is introduced into the mouth in the same way as was described for plaster of Paris. After it has been placed into its proper position in the mouth, it is fixed upon the alveolar process with uniform pressure, until the mass has hardened. Fig. 152 shows exactly how the details are reproduced in a Stent's impression.

A discussion of the way in which the model is prepared from such an impression, and in what manner the prosthesis is produced, does not belong here, as has already been stated in the Preface, but rather in a text-book on technic.

INDEX

SAUNDERS'
MEDICAL HAND-ATLASES

IN planning this series of books arrangements were made with representative publishers in the chief medical centers of the world for the publication of translations of the atlases in thirteen different languages, the lithographic plates for all being made in Germany, where work of this kind has been brought to the greatest perfection. The enormous expense of making the plates being shared by the various publishers, the cost to each one was reduced approximately to one-tenth. Thus, by reason of their **universal translation** and reproduction, affording international distribution, the publishers have been enabled to secure for these atlases the **best artistic** and **professional talent,** to produce them in the **most elegant style,** and yet to offer them at a **price heretofore unapproached in cheapness.**

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