PRINCIPLES AND PRACTICE

OF

OPERATIVE DENTISTRY

BY

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To the Memory of my more than Friend

THE LATE

DR. JAMES W. WHITE

EDITOR OF THE DENTAL COSMOS

WHO THROUGH THE NOBLENESS OF HIS CHARACTER BECAME
THE INSPIRATION OF EVERY YOUNG MAN WHO CAME
WITHIN THE SPHERE OF HIS INFLUENCE

THIS VOLUME

IS AFFECTIONATELY DEDICATED BY

THE AUTHOR

PREFACE TO SECOND EDITION.

THE call for a second edition of this work within a little more than three years of its publication is good evidence that the profession have appreciated the labors of the author and his publishers. Such appreciation is certainly very gratifying, and they trust the kindly reception given the former publication will be extended to the second edition.

The work has been thoroughly revised and many additions of important new material will be found within its pages.

It has been the endeavor of the author, however, not to load the text with material that has not stood the test of laboratory and practical clinical experience. Teaching which will not stand the test of searching investigation and critical clinical observation has no place in a text-book which aims to present the subjects of which it treats from a safe and conservative standpoint.

Many new theories and operative procedures which have from time to time been taken up with enthusiasm as great improvements over the older theories and methods, have finally proved to be of little or no value when the search-light of scientific investigation has been turned upon them, or the practical test has been applied.

The evolution of operative dentistry must necessarily, from the very nature of the subjects and processes involved, be slow. Combining as it does so much of art and science, it becomes necessary to view each department from its individual standpoint and then from the standpoint of their unity before passing judgment upon them. Many theories and methods of operative procedure which have seemed, from the artistic standpoint, to be all that could be desired, have been found, when the *scientific* test was applied, to be valueless; while others, which gave the greatest promise of scientific value based upon laboratory research, have proved to be of no real value when the *practical* test had been applied.

It is, therefore, evident that the elements of time and practical experience must always be considered in passing judgment upon any new theory or operative procedure which has for its object the conservation of the teeth or the cure of dental disease. Furthermore, conservative operative dental surgery is based upon sound surgical principles, and any theory or operative procedure which is in contradiction to these principles should be looked upon as either unsafe or worthless.

These facts the author has kept constantly in mind in the preparation of both editions of this work, and it is hoped that the teaching upon all subjects comprising this volume will be found to be built upon safe and conservative practice.

June, 1905.

THE AUTHOR.

PREFACE.

In the preparation of this volume the author has kept in mind the needs both of students and of practitioners of dental surgery.

It has been his endeavor so to present the subject-matter as to give the student a comprehensive view of the principles and practice of operative dentistry, arranged in a natural and orderly sequence. This plan has also been carried out in the presentation of each individual topic, in the hope that the student will thereby be helped in his understanding of the various phases of each department of the subject and likewise taught to be methodical in his studies and operations. It is also hoped that the dental practitioner will find in the work material which will assist him in his investigations of those pathologic conditions of the teeth and their contiguous parts, and the surgical methods employed in their treatment, that occupy so large a part of his time, energy, and skill.

The methods of constructing artificial crowns and bridge-work have not been included in this volume, because in the opinion of the author they properly belong to the department of prosthetic dentistry. The subject of orthodontia has also been excluded, for the reason that this branch has assumed the proportions of a separate specialty, and would therefore occupy more space than could be given to it in a work of this size and character.

The author desires to acknowledge his great indebtedness to his friend Dr. Vida A. Latham, of Chicago, for her valuable services in the preparation of numerous original and interesting photomicrographs of normal and pathologic dental tissues and of bacteriologic specimens; also to his friends Dr. R. R. Andrews, of Cambridge, Massachusetts, and Mr. James S. Shearer, of Bay City, Michigan, for the use of a number of original photomicrographs from their valuable collections; to Dr. W. D. Miller, of Berlin, Germany; to Dr. J. Leon Williams, of London, England; to Dr. Filandro Vincentini, of Naples, Italy; to Dr. Matt H. Cryer, of Philadelphia, and to Dr. Frederick B. Noyes, of Chicago, for the privilege of reproducing and using several illustrations from the published accounts of their investigations.

The author also acknowledges the courtesy extended by Dr. Wilbur F. Litch, Dr. G. V. Black, and the publishers of the "American System of

Dentistry;" by Dr. Edward C. Kirk and the publishers of the "American Text-Book of Operative Dentistry;" by the late Dr. Henry H. Burchard and the publishers of his "Dental Pathology, Therapeutics, and Pharmacology;" by Mr. Charles Tomes, F.R.C.S., of London, England; by the S. S. White Dental Manufacturing Company, and by others, for the privilege of reproducing many valuable illustrations.

Acknowledgment is also due to his friend Dr. Bertha E. Bush, of Chicago, for much valuable and time-saving assistance in reading and correcting the proofs.

Chicago, August 1, 1901.

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PRINCIPLES AND PRACTICE

OF

OPERATIVE DENTISTRY.

CHAPTER I.

CLASSIFICATION AND DESCRIPTIVE ANATOMY OF THE TEETH.

NEARLY all of the mammalia possess a more or less complicated dental system. These organs are applied to various purposes, mainly, however, to that of procuring food by seizing and killing living prey, or gathering and biting off portions of vegetable material, and more indirectly in tearing or cutting through the hard protective coverings of food substances, such as the husks and shells of nuts, or in grinding, crushing, or otherwise mechanically dividing the solid materials before swallowing, so as to prepare them for digestion in the stomach. Fig. 3 shows the peculiar form of the teeth of the mole.

In many animals certain teeth are excessively developed, and are used as weapons of offence and defence; in others the presence or excessive development of certain teeth mark the male sex.

Man is an *omnivorous* animal (the term *omnivorous* comes from the Latin *omnis*, all, and *voro*, I eat), and, as the term implies, eats all kinds of food. He has been endowed by nature with organs of mastication suited to the requirements of cutting, tearing, and grinding these various forms of food. Man's teeth, therefore, represent in part those of the *carnivora*, or flesh-eating animals, and those of the *herbivora*, or vegetable-eating animals; in other words, certain of his dental organs are representative of both of these types of animals. The incisors and molars are typical of the herbivora, and are suited to cutting and grinding vegetable fibre and grains, while the cuspids and bicuspids represent the teeth of the carnivora, and are adapted to seizing, tearing, and cutting animal food.

NUMBER AND CLASSIFICATION OF THE TEETH.

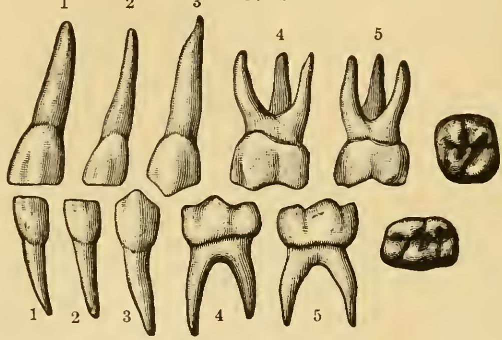
Man, like many others of the *mammalia*, is endowed with two distinct sets of dental organs, one designed to serve the purposes of the economy during infancy and early childhood, the *deciduous*, temporary, or milk teeth; and the other a larger, stronger, and more numerous set, which replaces the deciduous teeth, and is designed to serve the purposes of the economy from childhood to old age; these are designated as the *permanent* teeth.

The *deciduous* teeth are twenty in number, ten in each jaw, and are expressed by scientists in the following formula:

$$\text{I.}\ \frac{2\ 2}{2\ 2}\ \ \text{C.}\ \frac{1\ 1}{1\ 1}\ \ \text{M.}\ \frac{2\ 2}{2\ 2} = 20.$$

The formula is read as follows, beginning at the median line: incisors, two above, two below; cuspids, one above, one below; molars, two above, two below, which equals ten on either side of the median line, or twenty in all.

FIG. 1.

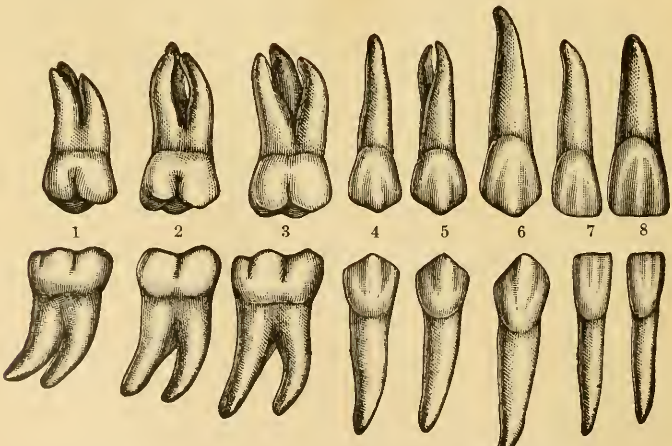


Deciduous teeth of the left side. (Gray.) 1 and 2, incisors; 3, cuspidati; 4 and 5, molars.

The *permanent* teeth of man are thirty-two in number, sixteen in each jaw, the formula for which is written thus:

$$\text{I.}\ \frac{2\ 2}{2\ 2}\ \ \text{C.}\ \frac{1\ 1}{1\ 1}\ \ \text{B.}\ \frac{2\ 2}{2\ 2}\ \ \text{M.}\ \frac{3\ 3}{3\ 3} = 32.$$

FIG. 2.



Permanent teeth of the right side. (Gray.) 1, third molars; 2, second molars; 3, first molars; 4, second bicuspidati; 5, first bicuspidati; 6, cuspidati; 7, lateral incisors; 8, central incisors.

Beginning at the median line, it reads as follows: incisors, two above, two below; cuspids, one above, one below; bicuspids, two above, two

FIG. 3.—Vertical section of inferior maxilla and teeth *in situ* of mole. × 15.

FIG. 4.—Showing structures of a tooth. 1, enamel; 2, cementum; 3, dentin; 4, pulp-chamber.

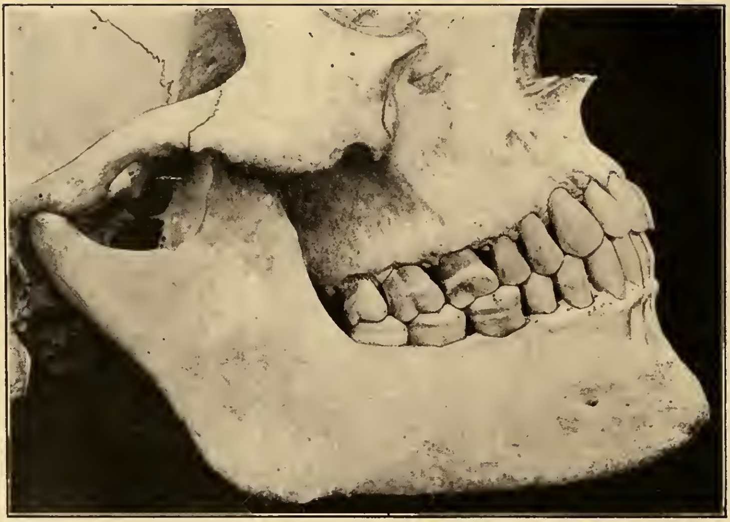


Fig. 5.—Occlusion of the teeth. (After Cryer.)

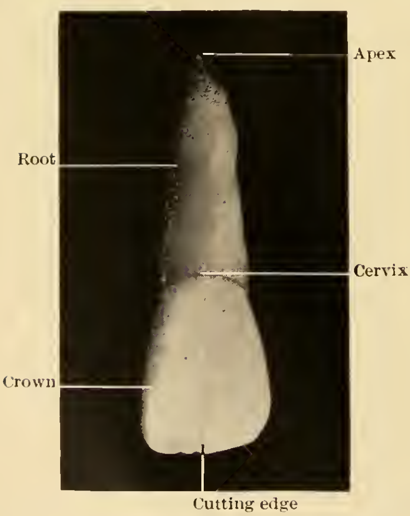


Fig. 6.—Superior left central incisor, labial surface. (Enlarged.)

Fig. 7.—Superior right central incisor, labial surface showing short root. (Enlarged.)

below; molars, three above, three below, equals sixteen on either side of the median line, or thirty-two in all.

The ten anterior permanent teeth of each jaw are sometimes called the *teeth of replacement*, or *succedaneous* teeth, from the fact that they replace the deciduous teeth. The permanent incisors and cuspids take the place of the temporary teeth of the same name, while the bicuspids assume the positions occupied by the temporary molars. The permanent molars appear one by one behind the position occupied by the second deciduous molars.

DESCRIPTIVE ANATOMY OF THE TEETH.

The *teeth* are specialized organs of mastication implanted within the alveolar processes of the superior and inferior maxillæ in man and in many animals. The teeth are composed of five tissues (Fig. 4) : a vitreous-like substance which completely covers the crown—the *enamel* (1) ; a bone-like substance which envelops the root—the *cementum* (2) ; and a hard substance, less dense than enamel but harder than bone, which forms the interior or body of the organ—the *dentin* (3) ; while a small mass of soft tissue occupies a central cavity (4) within the crown and the root—the *pulp ;* and a fibrous membrane covers the cementum of the root—the *pericementum.*

In a normally developed individual of the genus *homo* the teeth are arranged in the form of two parabolic or elliptical curves, the superior arch describing a trifle larger curve than the inferior, so that the teeth of the former slightly overreach their antagonists in the latter. The buccal cusps of the superior bicuspids and molars close over the buccal cusps of the inferior teeth; this brings the buccal cusps of the lower teeth within the sulci of the upper, and the lingual cusps of the upper teeth within the sulci of the lower. The incisors, cuspids, and bicuspids of the lower jaw are smaller than the corresponding teeth in the upper, the greatest difference being in the size of the incisors. The superior incisors and cuspids are slightly longer than the inferior and overlap them, while the bicuspids and molars not only over-reach their opposites in the inferior maxilla, but so interlock at their occlusal surfaces that each tooth, except the superior third molars, occludes or antagonizes with two of its fellows in the opposite jaw when the teeth are brought into their normal occlusion (Fig. 5). This arrangement permits the whole of the occlusal surfaces of these teeth to be brought into contact by the various movements of the jaws in mastication, thus rendering the function of triturating the food and preparing it for digestion most effective.

A normal incisor tooth presents certain characteristics which are common to all the dental organs of man; it will therefore serve the purpose of illustrating the anatomical divisions of the teeth, which are as follows: the *crown*, the *cervix*, the *root*, the *pulp-cavity*, the *morsal** or *cutting edge*, the *apex*, and the *apical foramen.* A more minute description relative to the cusps, surfaces, angles, margins, grooves, fissures, etc., will be reserved for the special anatomy of the individual teeth.

* The term *morsal* is used, following the suggestion of Dr. Thompson, in the place of *incisive* or *cutting edge* and *occlusal* surface.

The *crown* is that portion of the tooth which is visible within the mouth, projecting beyond the gum; the *cervix* or *neck* is that part represented by a constriction between the crown and the root at the point where the enamel and the cementum meet, or, in other words, the portion grasped by the margin of the gum; the *root* is that part which is implanted within the alveolar process of the jaw and covered by the gum; the *morsal edge* or cutting edge is that portion of the crown which occludes or antagonizes with a tooth in the opposite jaw; the *apex* is the terminal end of the root, that portion farthest removed from the crown (Fig. 6); the *pulp-cavity* is an opening or canal occupying the central portion of the tooth, extending from the apical foramen to the centre of the crown; the *pulp-chamber* is a cavity or *cul-de-sac* located within the crown, and may be termed a coronal enlargement of the pulp-canal which extends through the centre of the root from its apex to the pulp-chamber within the crown; the *apical foramen* is the orifice or entrance to the pulp-canal located in the apex of the root.

ARCHITECTURAL DESIGN OF THE TEETH.

It is important to the dental student that he understand and appreciate the architectural design upon which nature has constructed the dental organs. The more closely he studies this design, in both their gross and minute anatomy, the more will he become impressed with the perfection of the general plan and the admirable adaptation of their form, their structure, and their tissues to perform the functions for which they were created.

The form of the teeth is designed upon the plan of the *cone*, modified to meet the individual requirements of the several classes of teeth; some are composed of a simple cone, like the incisors and cuspids, while others are a combination of two or more cones, as in the bicuspids and molars. In no way can these facts be taught so well as by modelling in clay the forms of the various classes of teeth, commencing with the simple forms as expressed in the single-rooted teeth, and progressing to the more complex through a series of double and multiple cones in the formation of the bicuspids and molars.

THE INCISORS.

There are eight incisor teeth in the dental series of man, four in the upper jaw and four in the lower, two situated upon either side of the median line of the jaw; the first are termed the *central* incisors, and those next in order upon the distal side of the centrals are known as the *lateral* incisors.

The situation of the central incisors in the extreme anterior portion of the jaw upon opposite sides of the median line causes their mesial surfaces to approximate each other.

The function of the incisor tooth is to cut or incise the food,—hence its name, which is derived from the Latin, *incido*, to cut.

These teeth are all designed upon the form of the truncated cone, with slight modifications, to meet the requirements of the individual organ.

The Superior Central Incisor.—This tooth is in form a modified truncated cone with its base flattened out to form the *morsal* or cutting edge. It presents for examination four surfaces,—*labial*, *lingual*, *mesial*, and *distal;* two angles,—*mesial* and *distal;* and a *morsal edge.* The general form of the crown is that of the wedge or chisel, the edge being quite thin, the angles rounded, and the thickness rapidly increasing to the cervix of the tooth. It is also slightly curved from the cervix to the morsal edge, and curved over mesio-distally, so that the labial surface is somewhat convex and the palatal concave.

The *labial surface* (Fig. 7) of the crown is in general outline an imperfect quadrilateral, the cervical margin being rounded. This surface has four margins,—*mesial, distal, cervical,* and *morsal* or *incisive.* (Fig. 8.)

The *mesial margin* begins at the morsal margin or cutting edge, and extending upward, usually with a slight distal inclination, unites with the cervical margin. The *distal margin* also begins at the morsal margin, and extends upward with a slight mesial inclination, uniting with the cervical margin. Both of these margins are more or less convex. The *cervical margin* is somewhat rounded, the form following the outline of the gingival border, where it unites with the mesial and distal margins. The *morsal margin* extends from the mesial margin to the distal margin.

The union of the mesial and morsal margins form the *mesial angle,* while the union of the distal and morsal margins form the *distal angle.* The mesial angle is usually pointed and square, while the distal is much more obtuse. Two shallow grooves or depressions—the *labial grooves*—traverse the labial surface in a longitudinal direction, dividing it into three lobes, the *mesial, median,* and *distal.* These grooves extend from the morsal edge to the middle or upper third of the labial surface, where they broaden out and disappear. They are termed *developmental lines* (Black), and represent the three primitive plates of calcification in the development of the tooth, the grooves being formed by the union of these plates with each other. Occasionally one or more transverse ridges are found upon the cervical portion.

The *lingual surface* (Fig. 9) of the crown is triangular in outline, smaller than the labial surface, and presenting a more or less angular concavity, the *lingual fossa.* This fossa is bounded by three marginal ridges and the morsal or cutting edge.

The *mesio-marginal ridge* extends from the mesial angle upward to the cervico-marginal ridge, following the curvature of the mesial margin.

The *disto-marginal ridge* extends from the distal angle to the *cervico-marginal ridge,* following the curvature of the distal surface.

The *cervico-marginal ridge* forms a curved line at the cervix or base of the crown, uniting by its extremities with the mesial and distal marginal ridges. The marginal ridges are often high and conspicuous, and the cervico-marginal ridge is sometimes developed into a cusp, the ridge at the base forming a girdle or cingulum. The lingual fossa is usually smooth, but occasionally it forms a deep depression or pit, while a fissure may extend from it into the cervico-marginal ridge. Two longitudinal grooves are sometimes seen traversing the lingual fossa, which correspond to the developmental grooves upon the labial surface.

The Mesial and Distal Surfaces.—The outlines of these surfaces (Figs.

10 and 11) are irregular triangles, with the base directed towards the root and the apex terminating at the incisive or morsal edge. The base of the triangle is concaved at the cervical margin, and the apex rounded or convex at the morsal edge.

These surfaces have three margins,—*labial*, *lingual*, and *cervical*. The *mesial surface* is slightly longer than the distal surface, and presents a more or less convex and rounded form, slightly flattened near the cervical margin.

The *distal surface* is rounded as in the mesial, but more curved in its longitudinal axis. The labial margins of these surfaces are convex, following the outline of the labial surface, while the lingual and cervical margins present concave outlines, following the curves of the lingual surface, and the cervical line.

The *incisive edge* or *morsal margin* of the crown is formed by union of the labial and lingual surfaces, and extends in a nearly straight line from the mesial to the distal surface, with a slight downward pitch towards the median line. In a recently erupted tooth this line is often broken by the presence of the developmental grooves; these, however, soon disappear with use, leaving the line comparatively straight. In a normal occlusion these teeth shut over the lower incisors, but occasionally they will be found to occlude squarely with their fellows of the lower jaw.

The *cervix or cervical line* or *margin* is clearly and distinctly marked by the free extremity of the enamel which covers the crown of the teeth. The termination of the enamel at the neck of the tooth marks the extent of the peridental membrane. The enamel edge, which slopes off more or less abruptly to meet the cementum, does not form a straight line around the tooth, but curves upward upon the root at the labial and lingual surfaces and downward at the mesial and distal surfaces, thus forming in outline a double convexity and a double concavity.

The *root* in section of the tooth at the cervix shows it to be broader on the labial than the lingual surface,—pear-shaped,—and this condition is maintained throughout the greater length of the root.

In general outline the root has the form of a slender cone. The average length of the superior central incisor is 0.88 inch (2.23 centimetres), of the crown 0.39 inch (0.99 centimetre), and of the root 0.49 inch (1.24 centimetres).*

The *pulp-chamber* is large, and the pulp-canal usually gives free access to the apex. In young teeth the *cornua* extend well towards the angles, while in old persons the pulp-chamber and canal is often constricted, making it difficult of access.

The Superior Lateral Incisor.—This tooth is the second in the dental arch from the median line, and approximates the central incisor upon its distal surface. It is a little shorter, and about a third narrower than the central incisor, has the same general form and architectural design, and is possessed of the same developmental grooves.

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* All measurements of the teeth are taken from Black's Dental Anatomy.

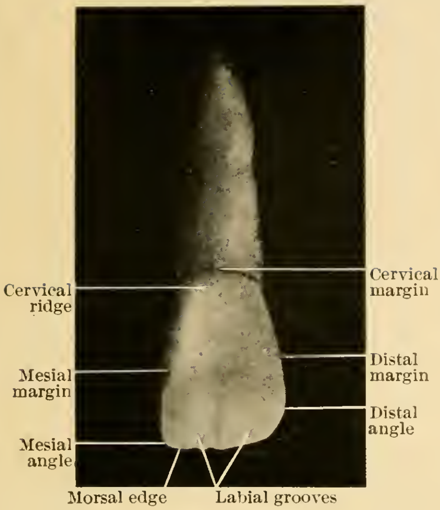


FIG. 8.—Superior left central incisor, labial surface. (Enlarged.)

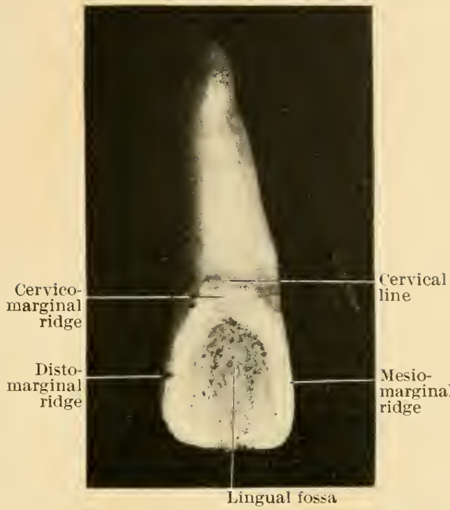


FIG. 9.—Superior left central incisor, lingual surface. (Enlarged.)

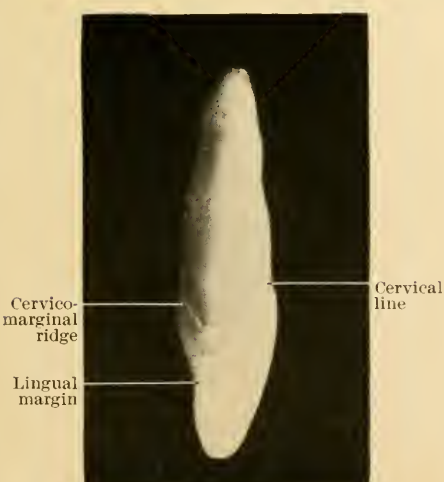


FIG. 10.—Superior left central incisor, mesial surface. (Enlarged.)

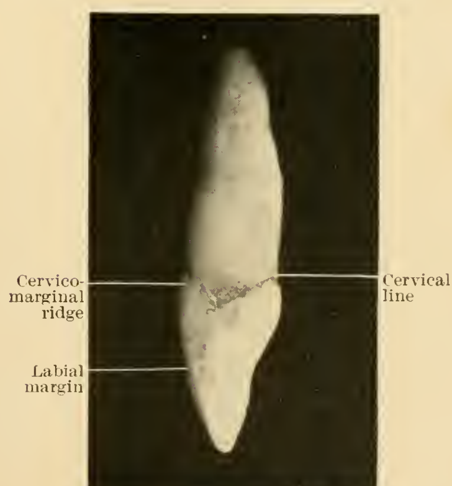


FIG. 11.—Superior left central incisor, distal surface. (Enlarged.)

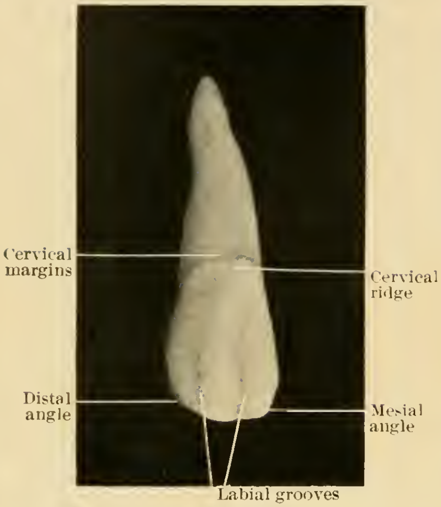


FIG. 12.—Superior right lateral incisor, labial surface. (Enlarged.)

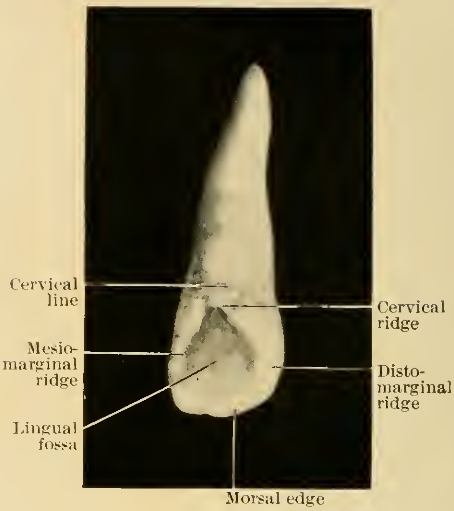


FIG. 13.—Superior right lateral incisor, lingual surface. (Enlarged.)

FIG. 15.—Superior right lateral incisor, mesial surface. (Enlarged.)

FIG. 16.—Superior right lateral incisor, distal surface. (Enlarged.)

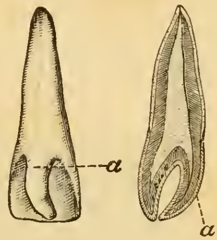
The crown presents for examination four surfaces, *labial, lingual, mesial,* and *distal*; a *cervical margin*, an *incisive* or *morsal edge*, a *mesial* and a *distal angle*.

The *labial surface* of the crown (Fig. 12) is more rounded than in the central, the mesial angle is acute, and the morsal edge slopes upward to a rounded and obtuse distal angle. The mesial half of the crown seems to partake of the form of the central incisor, while the distal half approaches the form of the cuspid. In the young tooth the morsal edge, as in the central, presents three tubercles, more or less distinct, with the developmental grooves passing between them.

The *lingual surface* (Fig. 13) in a majority of instances is the broadest part of the crown. It is less concave than in the central, but more depressed at the base of the cervical ridge. The mesial and distal marginal ridges are in proportion to the size of the tooth, broader and stronger than in the centrals. The cervical ridge is also well marked and proportionately broader and stronger than in the central.

Occasionally, however, the marginal ridges are but slightly developed; the surface is then quite smooth. The lingual fossa may be divided by a longitudinal ridge with slight depressions upon either side between it and the marginal ridges. The cervical ridge is sometimes very prominent, forming a cingulum, at the centre of which a tubercle is often developed. An exaggerated development of this cusp or cingule is shown in Fig. 14, *a*, from a case reported by W. H. Mitchell.

Fig. 14.



As a consequence of this greater prominence of the cingulum, and the marked depression or pit so often found at its base, *caries* is more liable to occur upon the lingual surfaces of the superior laterals than upon those of the central incisors.

The *mesial* and *distal surfaces* (Figs. 15 and 16) present a triangular or V-shaped outline similar to that of the central incisor. The *mesial surface* is rounded near the morsal edge, but considerably flattened near the cervix. A slight depression sometimes exists at this point, while the mesio-labial angle occasionally presents a flattened or depressed point midway between the morsal edge and the cervix. The *distal surface* is convex in all directions, and quite full at the morsal or incisive third; from this point it slopes towards the cervical line, where it becomes quite flat.

The *morsal edge* is divided into two parts by a more or less prominent tubercle. The mesial half is straight, like that of the central, while the distal half has a slight upward slope, terminating in a rounded distal angle. When the tubercle becomes worn off, the edge is straight, with a pitch towards the median line.

The *cervix* is considerably flattened mesio-distally. Section of the root at this point shows the form to be a flattened oval. The cervical line follows the same course as in the central incisor, having an upward curve upon the labial and lingual surfaces, and a downward curve upon the mesial and distal surfaces.

The enamel margin does not, as a rule, end so abruptly as in the central incisors, although occasionally it will end in a sharply defined ridge.

The *root* of the tooth is conical, but more or less flattened mesio-distally; its labio-lingual diameter at the neck is about one-third greater than its mesio-distal diameter. The root is generally straight, but in many specimens the apex has a slight distal curvature. Occasionally it is very crooked. The average length of the superior lateral incisor is 0.85 inch (2.15 centimetres), of the crown 0.34 inch (0.86 centimetre), and of the root 0.51 inch (1.29 centimetres).

The lateral incisors are the most variable in size and form of all the dental series of man, and they more frequently fail to appear in the dental arch—*suppressed*—than any others except the third molars. They are often imperfectly developed, and not infrequently present a conical or peg-shaped form. In one instance which has come under the observation of the writer, the superior lateral incisors have been absent in certain members of a family for three generations. The father had never erupted these teeth, his only daughter had the same deformity, and of her four children, two boys and two girls, the eldest son and both daughters have never erupted them, while these teeth in the second son are developed and peg-shaped.

The *pulp-canal* partakes of the shape of the root, which is generally flattened, and when the root is straight it can be readily entered and followed to the apex; but in operating for the removal of the pulp, the possibility of encountering a root with a curved apical end must not be overlooked.

THE INFERIOR INCISORS.

The *inferior incisors* have the general outlines of the superior laterals, but they are in every way smaller, the roots are much more flattened mesio-distally, and often have a groove upon the mesial and distal surfaces, running from the cervix to the apex.

The labio-lingual diameter of the root is much greater than its mesio-distal diameter. They are located in the anterior portion of the lower jaw, upon either side of the median line, opposite the superior incisors, with which they occlude in cutting food. The developmental lines are the same, but the tubercles upon the morsal edge and the labial grooves are less strongly marked than in the superior incisors.

The inferior central incisor is the smallest tooth of the dental series of man. It is chisel-shaped in form. The crown, viewed mesio-distally and labio-lingually, is composed of a double wedge. The widest portion of the crown is the morsal edge, which is thin and straight. From this point it slopes slightly to the cervix, where it is only about one-half as wide as at the edge.

The *labial surface* (Fig. 17) has the outline of a slender wedge, its widest portion at the morsal edge, and its narrowest at the cervix. It is nearly straight, or only slightly convex near the edge, but as it approaches the cervix it becomes more rounded and convex. The cervical margin is well defined and concave towards the root. The mesio-labial and disto-labial

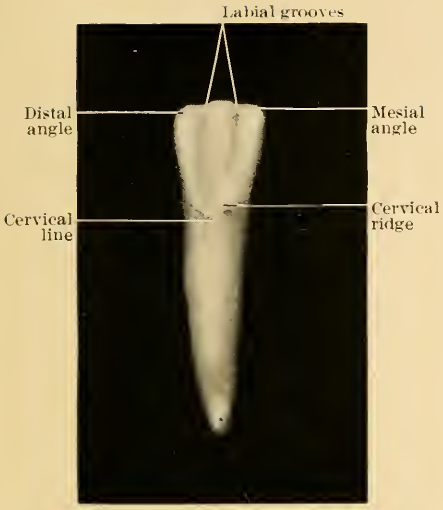


FIG. 17.—Inferior right central incisor, labial surface. (Enlarged.)

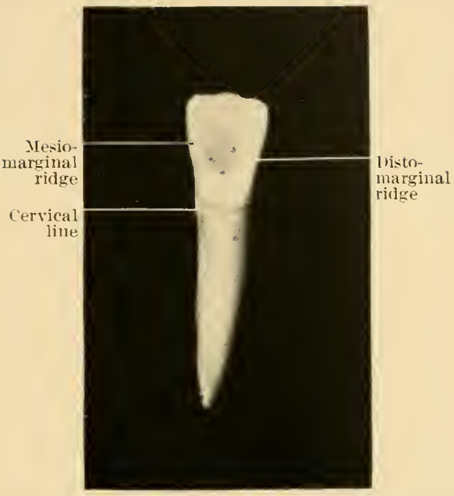


FIG. 18.—Inferior right central incisor, lingual surface. (Enlarged.)

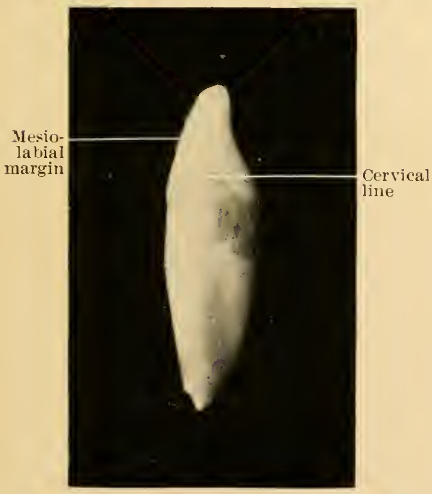


FIG. 19.—Inferior right central incisor, mesial surface. (Enlarged.)

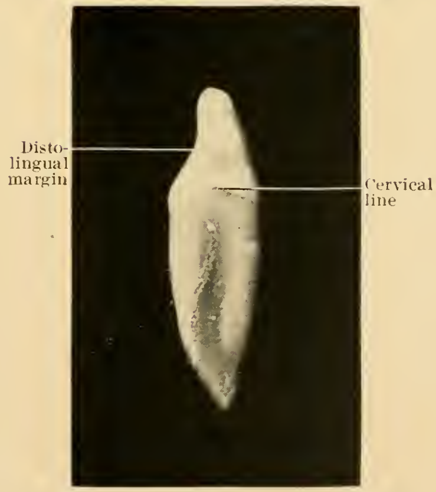


FIG. 20.—Inferior right central incisor, distal surface. (Enlarged.)

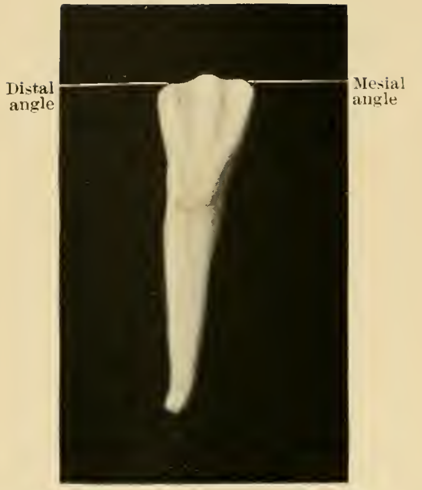


FIG. 21.—Inferior right lateral incisor, labial surface. (Enlarged.)

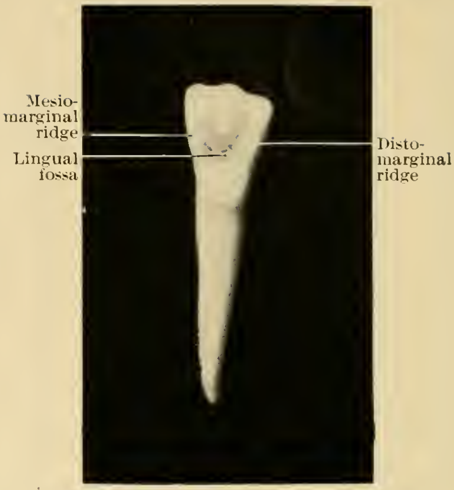


FIG. 22.—Inferior right lateral incisor, lingual surface. (Enlarged.)

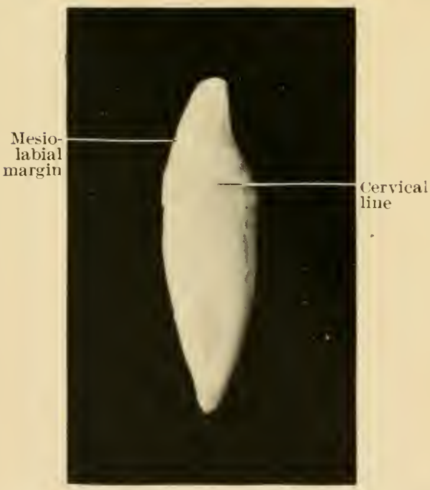


FIG. 23.—Inferior right lateral incisor, mesial surface. (Enlarged.)

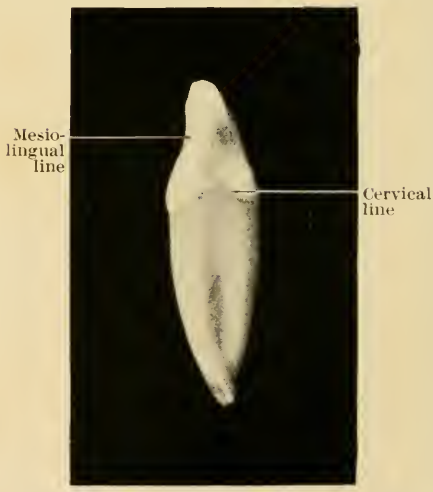


FIG. 24.—Inferior right lateral incisor, distal surface. (Enlarged.)

margins are rounded off at the expense of the labial surface. The mesial angle is quite acute, and the distal angle slightly obtuse and rounded.

The *lingual surface* (Fig. 18) is concave from the mesial edge to the cervix, but is nearly flat, or only slightly concave mesio-distally. The marginal ridges are not strongly marked.

The *mesial* and *distal surfaces* (Figs. 19 and 20) are V-shaped in outline, with the apex directed towards the morsal edge of the crown. They are convex near the edge, but become flattened and even slightly concave at the cervix.

The *cervix* is flattened mesio-distally, the greatest diameter being the labio-lingual. Section at this point gives the form of a compressed oval.

The *root* is flattened like the cervix, for its entire length. The apex sometimes has a distal curve. The groove upon the mesial and distal surfaces is sometimes quite deep and occasionally results in bifurcation.

The *pulp-canal* is thin and flattened, partaking of the form of the root; in some instances it is with great difficulty that the canal can be entered with the most delicate instruments. The average length of the inferior central incisor is 0.81 inch (2.05 centimetres), of the crown 0.34 inch (0.86 centimetre), and of the root 0.47 inch (1.19 centimetres).

The **inferior lateral incisor** (Figs. 21, 22, 23, and 24) is similar in form to the inferior central, but, unlike the superior incisors, it is distinctly larger than the centrals, not only in width of crown, but also in the length of the root, while the marginal ridges are more strongly marked and the fossa more distinct. The morsal edge has a slight distal pitch, and the distal angle is obtuse and rounded.

The average length of the inferior lateral incisors is 0.85 inch (2.15 centimetres), of the crown 0.35 inch (0.88 centimetre), and of the root 0.50 inch (1.26 centimetres).

THE CUSPIDS.

There are four cuspids in the dental series of man, two in each jaw. They are situated just in front of the angle of the mouth, between the lateral incisor and the first bicuspid tooth; they are the third in order from the median line, and form the spring of the superior dental arch. These teeth are variously known as cuspids, *cuspidati*, and canines. The term *cuspid* comes from the Latin *cuspis*, a point.

The cuspid teeth are in all respects larger and stronger than the incisors, the crown is thick and spear-pointed, and the root long and heavy.

The architectural form of these teeth adapts them for seizing, piercing, and tearing animal food, and they represent the carnivorous element in man.

The Superior Cuspids.—The crowns of the superior cuspids present for examination four surfaces, the *labial*, *lingual*, *mesial*, and *distal*, two margins, the *cervical* and *morsal*, and two angles, the *mesial* and the *distal*. The general outline of the crown is that of a short cone with its base at the gum line, and it represents the primitive conical teeth of many of the fishes.

The *labial surface* (Fig. 25) of the crown in outline is spear-shaped. It is convex in all directions, and is much more rounded mesio-distally than the incisors. The developmental grooves and ridges are often quite prominent. The distal groove is usually most strongly marked, which brings the central and distal lobes into greater prominence. This surface is bounded by five margins, the mesial, distal, cervical, mesio-morsal, and disto-morsal.

The *mesial* and *distal* margins are rounded and convex from the morsal edge to the cervical margin; the convexity being greatest in the distal margin. The distal margin is slightly shorter than the mesial on account of the sharper slope of the disto-morsal edge.

The *cervical margin* follows the contour of the gum line, and unites with the mesial and distal margins.

The *morsal margin* is divided by a prominent cusp, from the summit of which gradually slope away the mesio-morsal and disto-morsal margins.

The *mesio-morsal margin* slopes slightly upward, and is usually a trifle concave, though occasionally it is convex.

The *disto-morsal margin* may be described in the same manner, except that it is a little longer, and has a slightly more pronounced upward slope and a deeper concavity. The widest part of the labial surface is at a line drawn from the mesial to the distal angles; the narrowest part is at the cervical margin.

The *lingual surface* (Fig. 26) presents nearly the same general outline of the labial surface, with the exceptions that it is more flat, sometimes concave, and has three generally well-defined marginal ridges. The *mesio-marginal* and *disto-marginal* ridges arise at the mesial and distal angles, and pass upward, where they unite with the cervico-marginal ridge, which may be said to be formed by the union or continuation of the two former ridges. The *cervico-marginal* ridge is sometimes quite prominent, terminating in a more or less pronounced tubercle or cusp. Between the mesio- and disto-marginal ridges there is a prominence known as the lingual or triangular ridge, upon either side of which are sometimes deep fossa or fissures, but more frequently they are shallow and ill-defined.

The *mesial surface* (Fig. 27) resembles that of the central incisor in many respects. It is convex in all directions at the mesial angle, but as it approaches the cervix it becomes flattened and occasionally concave.

The *distal surface* (Fig. 28) in general outline is similar to the mesial surface, except that it is more rounded, and, as it nears the cervix, not quite so flat. The distance from the cervix to the distal angle is nearly one-third shorter than the distance on the mesial surface from the cervix to the mesial angle.

The *morsal edge* by its form gives to the cuspid tooth a double function, that of incising and penetrating. The morsal edge combines a cusp which is placed near the centre, to the long axis of the tooth, and two cutting or incisive edges which slope away from it in an upward direction, and terminate at the mesial and distal angles. The distal edge is longer than the mesial, and it has a more acute upward slope. The sharp cusp is soon worn off, and in old age the morsal edge may be reduced to a straight line.

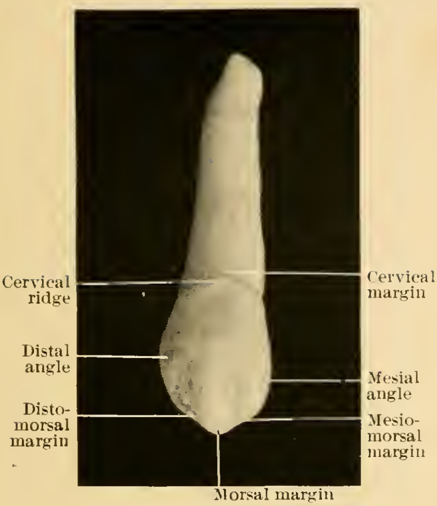


Fig. 25.—Superior right cuspid, labial surface. (Enlarged.)

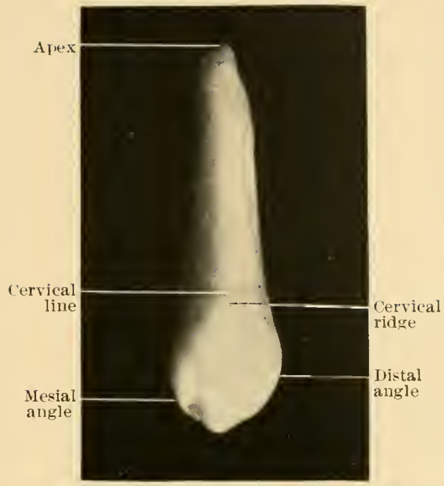


Fig. 26.—Superior right cuspid, lingual surface. (Enlarged.)

Fig. 27.—Superior right cuspid, mesial surface. (Enlarged.)

Fig. 28.—Superior right cuspid, distal surface. (Enlarged.)

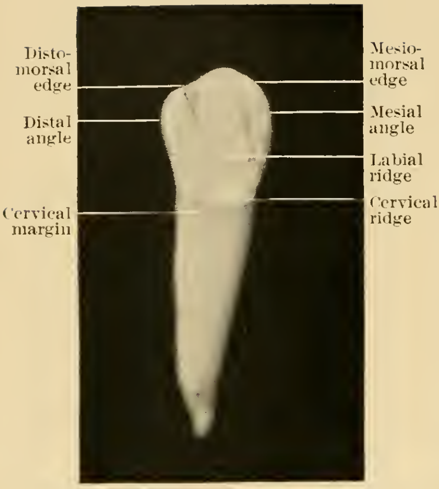


FIG. 29.—Inferior right cuspid, labial surface. (Enlarged.)

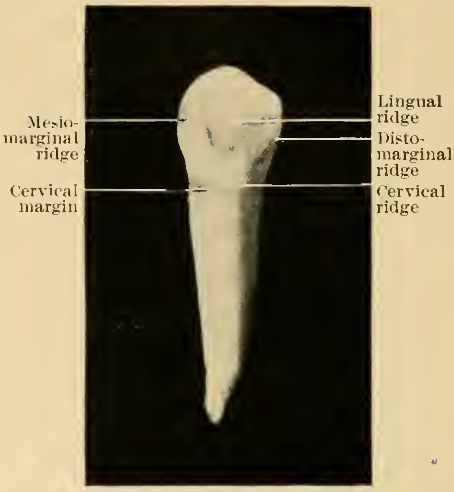


FIG. 30.—Inferior right cuspid, lingual surface. (Enlarged.)

FIG. 31.—Inferior right cuspid, mesial surface. (Enlarged.)

FIG. 32.—Inferior right cuspid, distal surface. (Enlarged.)

The *cervix* on section presents a flattened oval. The enamel line maintains about the same outline as in the central incisors, curving upward upon the labial and lingual surfaces, and downward upon the mesial and distal. Occasionally it presents a slight depression both mesially and distally, which may be continued upon the root as a groove.

The *root* is the longest of all the human teeth, and is irregularly conical in form, tapering to a slender point; it is usually straight, but may be curved or very crooked. In size it is about one-third larger than the central incisor. It is flattened slightly mesio-distally, and occasionally grooved.

The *pulp-canal* is large and accessible, usually of the same form as the root, and except when the root is curved or crooked, can be easily followed to its apex.

The average length of the superior cuspid is 1.05 inches (2.66 centimetres), the average length of the crown is 0.37 inch (0.94 centimetre), and of the root 0.68 inch (1.72 centimetres).

The Inferior Cuspids.—There is probably a greater similarity between the superior and inferior cuspids than between any other class of teeth in the human mouth. They are alike in form and outline, though the inferior are somewhat smaller. The crowns are a little longer, and this makes them appear more slender; they are also more flattened mesio-distally at the cervix and in the root. These teeth are heavily built and firmly set in their alveoli, in order to enable them to perform the double function of incising and tearing food. The cusp is generally more prominent and pointed than in the superior cuspids. The crown opposes the lingual surface of the superior cuspid near the mesio-morsal angle, and the lingual surface of the superior lateral incisor near its disto-morsal angle.

The *labial surface* (Fig. 29) of the crown is smooth and convex, the developmental grooves are less prominent than in the superior cuspids; the labial ridge, however, is well developed, and extends from the cusp to the cervical margin, giving additional strength to the crown. Transverse ridges are also occasionally present in the cervical region. To accommodate the occlusion of the superior teeth, the labial surface of the crown is inclined inward.

The *lingual surface* (Fig. 30) is quite smooth, the ridges and grooves being less strongly marked than in the superior cuspids. The lingual ridge, which extends from the cusp to the cervical ridge, is, however, sometimes quite prominent. In exceptional cases the cervical ridge is strongly developed, forming a fossa at its base.

The *mesial surface* (Fig. 31) is rounded at the eminence, flattened at the cervical third, and nearly straight with the surface of the root, which gives the crown the appearance of being bent backward or having a distal inclination.

The *distal surface* (Fig. 32) is quite convex and the disto-morsal angle prominent; as it approaches the cervix it becomes more or less flattened, and at the cervical margin may present a slight concavity.

The *morsal edge* presents a more or less prominent cusp and a mesial and a distal incisive edge. The distal edge is longer than the mesial, and slopes away rapidly to the distal angle. The differences, however, are not so marked as in the superior cuspids. The angles are pronounced, but the mesial less so than the distal.

The *cervix* is generally found on section to be oval in form, although sometimes it is flattened mesio-distally, and when the root is grooved it may present a modified hour-glass outline. The curves of the enamel line are not so variable as in the incisors, nor the termination of the enamel quite so abrupt as in the superior cuspids.

The *root* is long, straight, tapering, and flattened mesio-distally. It is shorter than the superior cuspid, and not infrequently presents a decided depression or groove upon its mesial and distal surfaces, showing a tendency towards bifurcation. The apex is slender and sometimes curved in a labial direction.

The *pulp-canal* has the same general outline as the root, and when the longitudinal grooves upon the mesial and distal surfaces are deep, the canal is constricted in the middle, making it more or less difficult to enter with instruments. The average length of the inferior cuspids is one inch (2.53 centimetres), of the crown 0.40 inch (1.01 centimetres), and the root 0.60 inch (1.52 centimetres.)

THE BICUSPIDS.

The *bicuspids*, or *premolars*, as they are sometimes termed, are the fourth and fifth teeth from the median line, and are situated between the cuspid and first molar teeth. There are eight bicuspids in a normal denture of man, two upon each side in the upper and lower jaws. The one which is situated next to the cuspid tooth is termed the *first bicuspid*, and the one located between the first bicuspid and the first molar is known as the *second bicuspid.* The term *bicuspid* is derived from the Latin *bi*, two, and *cuspis*, a point,—two-pointed or bi-cusped; a tooth, therefore, with two cusps.

Architecturally the bicuspid tooth is formed of two cones fused together. This structure, from the mechanical stand-point, is weak and faulty, as its power of resistance to the mechanical force applied in mastication depends upon the strength of the mesial and distal marginal ridges which bind the cones together upon the morsal surface; when these for any reason have been destroyed, the greatest weakness of the structure is developed, ending in the separation of the cones under stress and the loss of one or both cusps. Fractures of this character occur more frequently in the bicuspids on account of their mechanical weakness than in any of the other teeth.

The bicuspids succeed and replace the deciduous molars, and by reason of their smaller size give extra space in the jaws for the permanent cuspids, which are much larger than their deciduous predecessors, and are, as a rule, erupted at a later period.

The function of the bicuspids is to divide the food into small pieces and prepare it to be triturated by the molars.

The superior first bicuspids, viewed from the morsal surface, have the form of a rounded quadrilateral, the buccal margin being broader than the lingual. Section through the crown just beyond the cusps shows a somewhat pear-shaped outline. The design of this form is to make it pos-

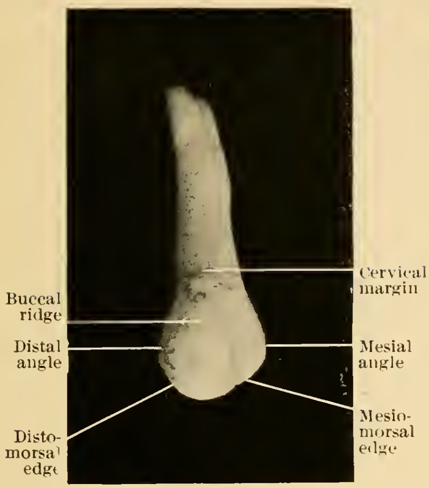


FIG. 33.—Superior right first bicuspid, buccal surface. (Enlarged.)

FIG. 34.—Superior right first bicuspid, lingual surface. (Enlarged.)

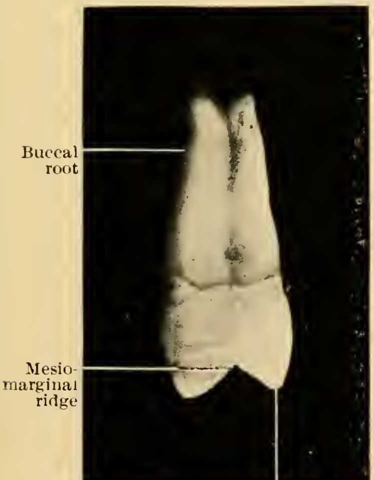


FIG. 35.—Superior right first bicuspid, mesial surface. (Enlarged.)

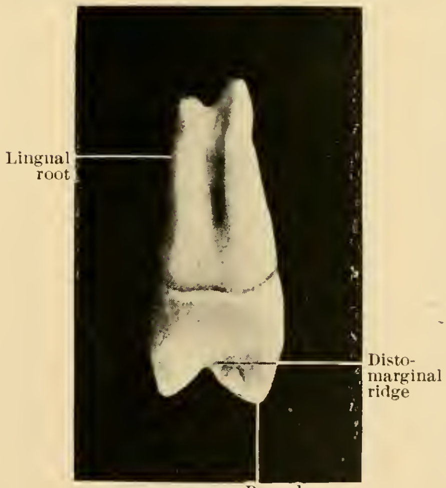


FIG. 36.—Superior right first bicuspid, distal surface. (Enlarged.)

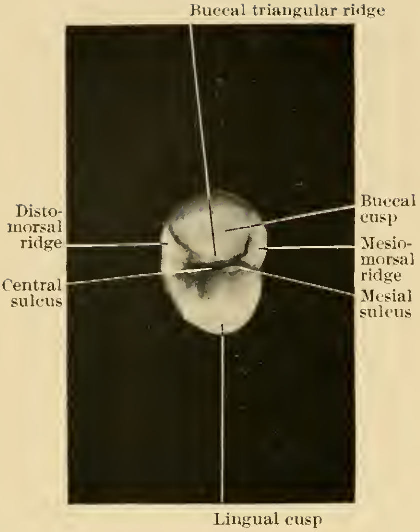


FIG. 37.—Superior right first bicuspid, morsal surface. (Enlarged.)

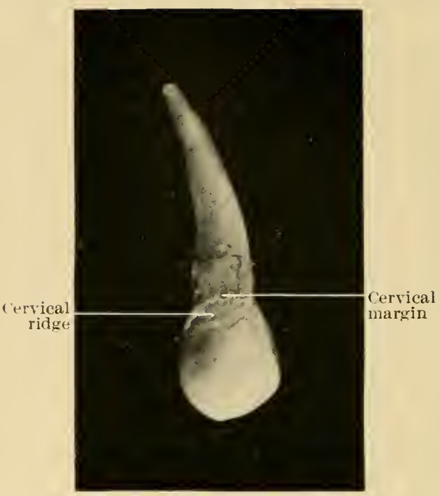


FIG. 38.—Superior right second bicuspid, buccal surface. (Enlarged.)

FIG. 39.—Superior right second bicuspid, lingual surface. (Enlarged.)

FIG. 40.—Superior right second bicuspid, mesial surface. (Enlarged.)

sible for these teeth to follow the curve of the alveolar arch. The bucco-lingual diameter of the crown is about one-third greater than its mesio-distal diameter.

The *buccal surface* (Fig. 33) of the crown is almost a counterpart of the corresponding surface of the superior cuspid, with the exception that the cusp is placed nearer the centre of the crown, thus making the mesial and distal morsal margins nearly of the same length. The central or buccal ridge which springs from the cusp is prominent, while the mesial and distal ridges or lobes are rarely conspicuous. The developmental grooves or furrows between them are, therefore, shallow and extend only about half-way to the cervix, where they are lost in the smooth convexity of the cervical half of this surface. The surface is considerably narrower at the cervical margin, which gives it the general outline of a cone, with the apex at the cervical margin. This difference in the width of the buccal surface at the angles and at the cervix gives the "bell-shaped" form to these teeth.

The *lingual surface* (Fig. 34) is mesio-distally regularly convex. From the lingual cusp to the cervix it presents a nearly straight line, though many times it is slightly convex, and occasionally fully as much so as the buccal surface. Mesio-distally the surface is not so broad as the buccal surface, and the lingual cusp is not quite so long.

The *mesial surface* (Fig. 35) bucco-lingually is much flattened, but slightly convex; from the mesio-morsal marginal ridge to the cervix it is also slightly convex, although examples are numerous in which a shallow concavity is presented at the cervical margin, which extends to the side of the root in a more or less sharply defined groove. The marginal angles formed by the union of this surface with the buccal and morsal surfaces are well defined, but the mesial and lingual surfaces are so blended and rounded that it is difficult to designate their line of union as an angle.

The *distal surface* (Fig. 36) is so nearly like the mesial surface that it needs no especial description except in the points of difference. It is rather more convex than the mesial surface, has rarely a convexity at the cervical margin, and the disto-morsal angle is more prominent than the mesio-morsal.

The *morsal* or *occlusal surface* (Fig. 37) presents an abrupt change in form and function as compared with the morsal edge of the cuspid tooth. This surface is composed of two well-defined cusps or points divided by a deep sulcus having a mesio-distal direction, and bound together at their bases mesially and distally by two strong and prominent ridges termed the *mesio-morsal* and the *disto-morsal ridges*.

One of these cusps is situated at the buccal margin, and the other at the lingual, and from their situation are designated as the *buccal* and the *lingual* cusps. The *buccal cusp* is usually sharper, longer, and more prominent than the lingual cusp. The lingual cusp is broader and more rounded. From the summit of the buccal cusp four ridges slope away at right angles, one mesially to form the *mesio-morsal edge* of the crown; one distally to form the *disto-morsal edge;* one to the buccal surface, forming the *central buccal ridge*, and another slopes downward in an opposite direction to form the *buccal triangular ridge*, which ends either in the central sulcus or joins a similar ridge descending from the summit of the lingual cusp, and forms the *transverse ridge*. The mesio-morsal and disto-morsal edges enter into the formation of the mesial and distal *morsal angles* at their extremities.

The *lingual cusp* is usually blunt, and its margins, which are not sharply defined, unite with the marginal ridges at both angles. The lingual triangular ridge arises at the summit of the lingual cusp, and either terminates at the central sulcus or joins its fellow of the buccal cusp to form the transverse ridge. The lingual triangular ridge is seldom prominent, and sometimes is entirely absent.

The *central sulcus* extends from one lateral ridge to the other in a mesio-distal direction, and widens into the mesial and distal sulci at each end.

The *mesial* and *distal sulci* are not always well defined, and are seen passing over the central portion of the mesial and distal marginal ridges. The mesial and distal *triangular grooves* are situated at the base of the marginal ridges, and are directed towards the mesial and distal angles, dividing the marginal ridges from the triangular, where they are either lost or may be traced as slight depressions near the angles. These sulci often become the seat of caries.

The *cervix* is flattened laterally, its bucco-lingual diameter being somewhat greater than its mesio-distal. The enamel line curves slightly upward at the buccal and lingual cervical margins, and dips downward a very little, or may describe a nearly straight line at the mesial and distal cervical margin.

The *root* is considerably flattened laterally, and is generally more or less deeply grooved from the cervix to the apex, and often bifurcated for from one-third to two-thirds of its length. The root over the buccal cusp is the buccal root, and that over the lingual cusp is termed the lingual root.

Bifurcated roots in the first superior bicuspid is the rule in the negro and other races of a low order of intelligence, and also in the apes. It is often very crooked, or may be triple-rooted.

The *pulp-canal* usually takes the form of the root, and may be either single or double. It is narrow at the neck, and often constricted in the middle, giving it the outline of an hour-glass. More often, however, it has two distinct pulp-canals. The coronal portion of the canal terminates in two well-defined cornua or horns which point towards the cusps of the crown.

The average length of the first bicuspid is 0.80 inch (2.03 centimetres), of the crown 0.32 inch (0.81 centimetre), and of the root 0.48 inch (1.21 centimetres).

The **superior second bicuspid** so nearly resembles the first that its differences only need to be noticed. It is in every way a little smaller; the cusps are reduced, while the lingual cusp equals or exceeds the buccal cusp in size and length. The marginal ridges are broader, and the morsal surface more flattened, and often presents several shallow wrinkles or supplemental grooves and ridges, which radiate from the central sulcus. The triangular ridges are often united, thus increasing the strength of the tooth. The crown is narrower mesio-distally, and the cervix more oval,

FIG. 41.—Superior right second bicuspid, distal surface. (Enlarged.)

FIG. 42.—Superior right second bicuspid, morsal surface. (Enlarged.)

FIG. 43.—Inferior right first bicuspid, buccal surface. (Enlarged.)

FIG. 44.—Inferior right first bicuspid lingual surface. (Enlarged.)

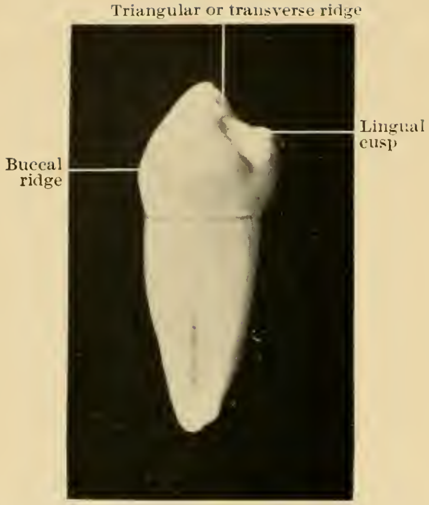


FIG. 45.—Inferior right first bicuspid, mesial surface. (Enlarged.)

FIG. 46.—Inferior right first bicuspid, distal surface. (Enlarged.)

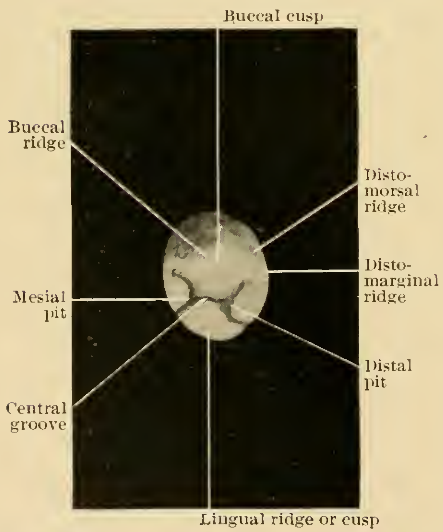


FIG. 47.—Inferior right first bicuspid, morsal surface. (Enlarged.)

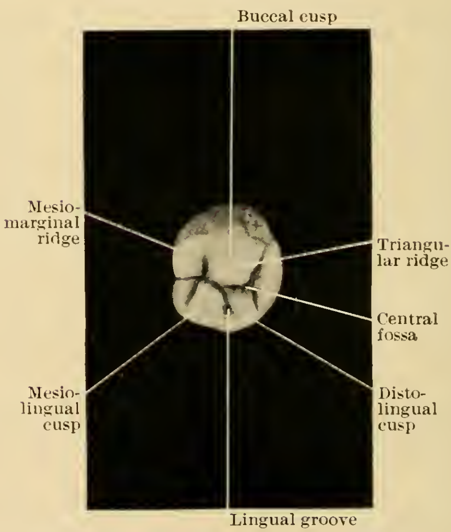


FIG. 48.—Inferior right second bicuspid, morsal surface. (Enlarged.)

while the cervico-marginal line curves slightly downward upon the mesial surface only. The greatest difference between these teeth is in the root, which is a little longer than the first; very rarely bifurcated; is much flattened from the cervix to the apex, and often deeply grooved upon the mesial surface at the apical third. (See Figs. 38, 39, 40, 41, and 42.) Occasionally the root is rounded and conical. Crooked roots are of more frequent occurrence than in the other bicuspid, and it has a tendency to be rotated in its alveolus, more frequently in a distal than in a mesial direction.

The pulp-canal is usually single, and gives free access to its apex.

The average length of the tooth is 0.84 inch (2.13 centimetres). The average length of the crown is 0.29 inch (0.73 centimetre), and of the root 0.55 inch (1.39 centimetres).

THE INFERIOR BICUSPIDS.

These teeth occupy the same relative positions in the lower jaw that the superior bicuspids occupy in the upper jaw. They are the smallest of the bicuspid teeth, and are distinctive in form, particularly in their morsal surface. The transition in form from bicuspids to molars is more marked in the lowers than in the uppers.

In the inferior first bicuspid the lingual cusp is rudimentary, and in the second it is large and broad, and divided bucco-lingually through the centre by a more or less deep furrow, giving it the appearance of a tricuspid tooth.

In architectural form, these teeth are constructed from a single cone, the peculiarities of the crown being the result of various additions or cingules to the primitive cusp. Unlike the superior bicuspids, the buccal and lingual cusps are connected by a transverse ridge.

The Inferior First Bicuspid.—This tooth is the smallest of all the bicuspids, and more nearly resembles a cuspid than a bicuspid, on account of the imperfect development or suppression of its lingual cusp, which is often little more than a cingule. In general outline the crown is much more rounded than the superior bicuspids, and its bucco-lingual and mesio-distal measurements are nearly equal.

The *buccal surface* (Fig. 43) viewed from the buccal aspect, looks like a cuspid. In form the buccal surface is a long oval, surmounted by an acute point. It is convex in all directions. The buccal cusp is situated a little to the distal of the centre of the crown, while the curvature of the buccal surface towards the lingual side places the buccal cusp nearly in a central position to the long axis of the tooth.

The *lingual surface* (Fig. 44) is convex mesio-distally, and nearly straight from cervix to morsal margin. The tooth is slightly bent at the cervix in a lingual direction, which gives the crown a lingual inclination. The length of this surface depends upon the length of the lingual cusp or cingule; usually it is only about half as long as the buccal surface.

The *mesial* and *distal surfaces* (Figs. 45 and 46) are convex bucco-lingually, slightly flattened at the cervix, and becoming convex towards the morsal margin, which gives a bell shape to the crown when viewed from the buccal aspect.

The *morsal surface* (Fig. 47) is so different from the superior first bicuspid that a separate description is necessary. In general outline this surface approaches a rounded triangle, the width at the buccal, mesial, and distal margins being greater than at the lingual margin. It is surmounted by a prominent buccal cusp which is located nearly in the centre of the surface, and a small lingual cusp, though this is sometimes entirely absent, and its place occupied by a more or less prominent lingual ridge. The buccal cusp has four well-defined ridges descending from it like those of the superior first bicuspid. The buccal ridge arises from the summit of the cusp and descends to the buccal surface; the mesial and distal morsal ridges usually form a curve with its concavity towards the lingual, and are merged into the marginal ridges to form rounded angles; the triangular or transverse ridge descends towards the lingual cusp or ridge. On either side of this ridge are pits, the *mesial* and *distal pits*. The marginal ridges are usually well defined. The central groove sometimes crosses the transverse ridge; at other times the ridge is divided by a deep sulcus.

The *cervix* is very much constricted, and the cervical line but slightly curved except at the buccal margin. The enamel at this point sometimes forms a prominent ridge.

The *root* is single, flattened laterally, long and slender, occasionally grooved mesio-distally, is rarely bifurcated, and inclined to be crooked.

The *pulp-canal* is small and flattened, and difficult of access. The difficulties are increased by the lingual inclination of the crown and the tendency of the root to be crooked.

The average length of the inferior first bicuspid is 0.84 inch (2.13 centimetres), of the crown 0.30 inch (0.76 centimetre), and of the root 0.54 inch (1.37 centimetres).

The **inferior second bicuspid** resembles the first so closely in general form of both the crown and the root that an especial description, except of its morsal surface, would be unnecessary.

The *morsal surface* (Fig. 48) of the tooth presents the most marked deviation in form of any of the bicuspid teeth. It is triangular in outline, like the first, but a trifle larger. The buccal cusp is larger and rounded; the lingual cusp not quite so fully developed, and divided bucco-lingually, through the centre, by a deep groove, which gives the crown the appearance of being a tricuspate. The mesio-lingual cusp or tubercle is sometimes developed at the expense of the disto-lingual, but it is always present. Occasionally it appears as a mere cingule on the disto-marginal ridge. A well-defined triangular ridge descends from each of the cusps, and terminates at the central groove.

The marginal ridges are well marked. The central groove is generally straight, but often curved or angular; the lingual groove is straight, and united with the central groove, forming at the point of union the *central fossa*. The other surfaces are shown in Figs. 49, 50, 51, and 52.

The average length of the inferior second bicuspid is 0.87 inch (2.20 centimetres), of the crown 0.31 inch (0.78 centimetre), and of the root 0.56 inch (1.42 centimetres).

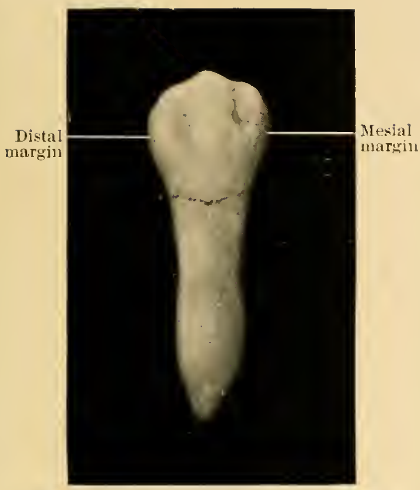


FIG. 49.—Inferior right second bicuspid, buccal surface. (Enlarged.)

FIG. 50.—Inferior right second bicuspid, lingual surface. (Enlarged.)

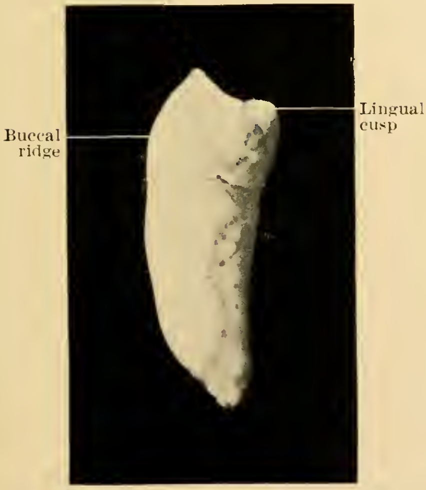


FIG. 51.—Inferior right second bicuspid, mesial surface. (Enlarged.)

FIG. 52.—Inferior right second bicuspid, distal surface. (Enlarged.)

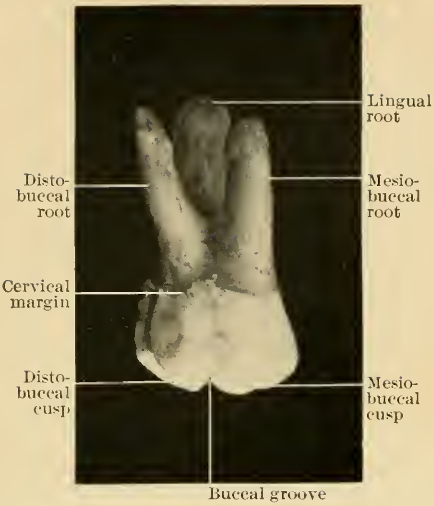


FIG. 53.—Superior right first molar, buccal surface. (Enlarged.)

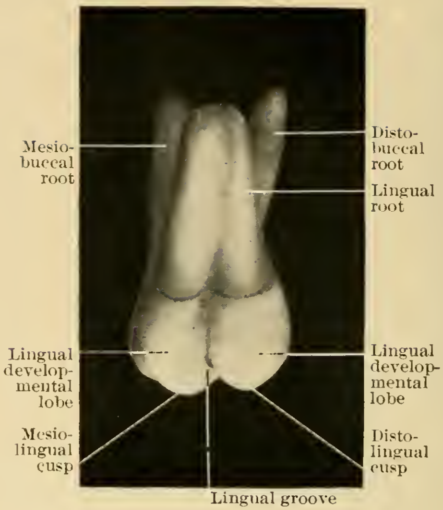


FIG. 54.—Superior right first molar, lingual surface. (Enlarged.)

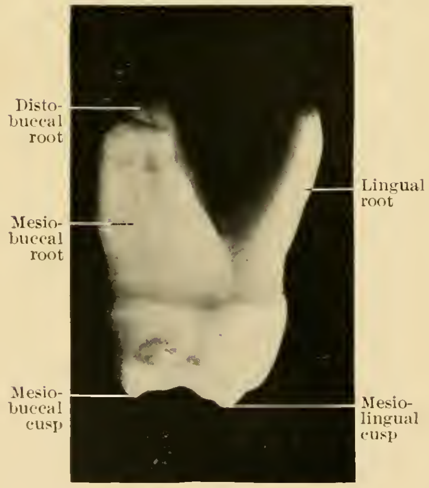


FIG. 55.—Superior right first molar, mesial surface. (Enlarged.)

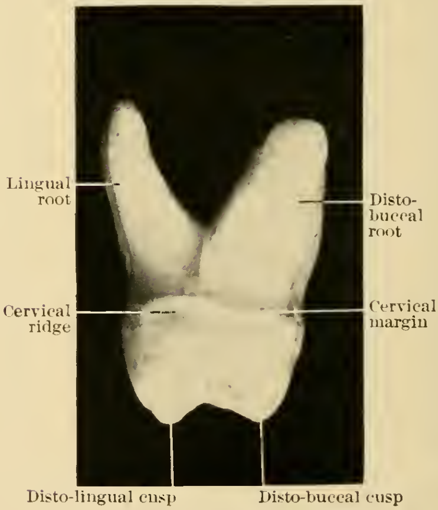


FIG. 56.—Superior right first molar, distal surface. (Enlarged.)

THE MOLARS.

The *molars*, or *tuberculate teeth*, as they are sometimes termed, are very different in form and architectural design from those which have been previously described. The most simple form of tooth is that designed from the single cone. This is the architectural form of the incisors and cuspids.

The bicuspids are more complex, being formed of two cones. But the inferior first bicuspid has but one well-developed cusp and a lingual cingule. The superior bicuspids have two well-developed cusps, and the inferior second bicuspids have three cusps.

The superior molars are still more complex, being formed by the addition of a third cone to the bicuspid type. This gives the tooth three roots, upon which three or four cusps are supported.

The inferior molars are the most complicated in form of all the teeth, being composed of four cones supporting four or five cusps.

There are twelve molars in man, three upon either side of each jaw, above and below. They are situated in the posterior part of the jaws, behind the bicuspids, and are designated as the *first*, *second*, and *third molars*. The third molar is sometimes termed the *dens sapientia*, or wisdom-tooth, because of its late eruption. The molars occupy the sixth, seventh, and eighth places, respectively, from the median line; the first molar approximating the second bicuspid distally, the second molar approximating the first molar distally, and the third molar occupying a similar position to the second molar. The function of the molars is to crush and triturate the food, and fit it to be acted upon by the gastric juice of the stomach. The loss of these teeth, therefore, seriously impairs the function of mastication, and inevitably leads to various derangements of digestion, and these again to imperfect assimilation and nutrition. The preservation of these teeth, therefore, becomes of vital importance to the individual.

The **superior first molar** is located upon the distal side of the second bicuspid. It is the largest and most strongly marked of the superior molars, and may therefore be taken as the typical form. It possesses three strong roots, and the crown is surmounted by four more or less prominent cusps. In general contour the crown is an irregular quadrilateral, having its angles rounded, two of its sides convex, and two slightly flattened. The bucco-lingual diameter is a little greater than the mesio-distal, while the height of the crown is about equal to the mesio-distal diameter. It presents for examination five surfaces,—buccal, lingual, mesial, distal, and morsal.

The *buccal surface* (Fig. 53) is formed by the union of the mesio- and disto-buccal *developmental lobes*, and is divided by the *buccal groove* into a mesial and a distal half, which are quite similar in outline. This surface is about twice the width of the bicuspids. It is widest at the morsal margin, narrowing towards the cervix, giving a bell shape to the tooth. The morsal margin is surmounted by the mesio- and disto-buccal cusps, which are separated by a deep notch, through which passes the buccal groove to the cervical margin. Sometimes this groove terminates in a pit midway between the morsal and cervical margin. Descending from each buccal cusp is a longitudinal ridge,—*the buccal ridges*,—which are at first well defined, but gradually disappear in their course towards the cervix.

The *lingual surface* (Fig. 54), like the buccal surface, is formed by the union of the two *lingual developmental lobes*, and is divided into a mesial and a distal half by the *lingual groove*. Both halves are smoothly convex in all directions. The morsal margin is surmounted by the *mesio-* and *disto-lingual* cusps, the mesial being the larger. The mesial lobe often carries a tubercle or cingule,—a rudimentary fifth cusp. The mesial and distal margins converge rapidly towards the cervix, conforming to the palatal root.

The *mesial surface* (Fig. 55) is nearly flat, except near the morsal margin, where it is slightly convex, and at the cervical margin, where it is sometimes depressed towards the lingual or palatal root. The buccal and lingual margins are rounded. The morsal margin is concave in the direction of the root, while the cervical margin is concave in the direction of the morsal surface.

The *distal surface* (Fig. 56) is similar to the mesial surface, except that it presents a somewhat greater convexity, converging more sharply towards the cervix, and more rounded towards the lingual root.

The *morsal surface* (Fig. 57) is surmounted by four rounded cusps or tubercles designated as the *mesio-buccal*, the *disto-buccal*, the *mesio-lingual*, and the *disto-lingual* cusp; the latter being, as a rule, smaller than the others, and sometimes only appearing as a small tubercle. The surface is bounded by four marginal ridges of nearly equal length,—the *buccal*, the *lingual*, the *mesial*, and the *distal*,—which unite the bases of the cusps.

Arising from each cusp and descending towards the centre of the tooth is a triangular ridge. The triangular ridges of the mesio-lingual and disto-buccal cusps unite to form the prominent *oblique ridge*.

On the mesial and distal sides of the oblique ridge are two fossæ, the *central* and *distal*. The bottom of the *central fossa* is deeply lined by two of the developmental grooves, the *mesial* and *buccal grooves*. The former arises on the mesial surface, crosses the *mesio-marginal ridge*, and continues in an irregular line to the bottom of the fossa; the latter begins upon the buccal surface, crosses the *bucco-marginal ridge*, and terminates also in the central fossa, thus forming the *mesio-buccal triangular groove*. A supplemental groove arises from the central pit of this fossa, extending distally across the oblique ridge, which is termed the *distal groove*. It is rarely well defined, but occasionally it may divide the oblique ridge.

The *distal fossa* is not so large as the central, and is of an entirely different form, partaking more of the outline of the sulcate groove. This fossa is traversed by a deep developmental groove, the *disto-lingual groove*, which arises on the distal margin, follows the line of the fossa, crosses the lingual margin, extending on to the lingual surface to form the lingual groove.

When a fifth cusp is present—the *mesio-lingual*—it is separated from the lingual surface by a groove designated as the *mesio-lingual groove*. Various supplemental grooves or wrinkles are found upon the morsal surface of the molars, which radiate from these fossæ.

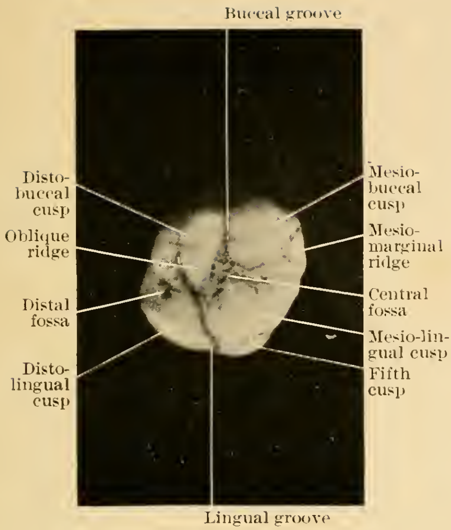


Fig. 57.—Superior right first molar, morsal surface. (Enlarged.)

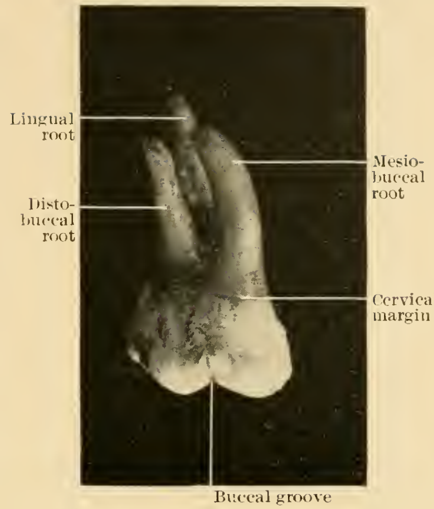


Fig. 58.—Superior right second molar, buccal surface. (Enlarged.)

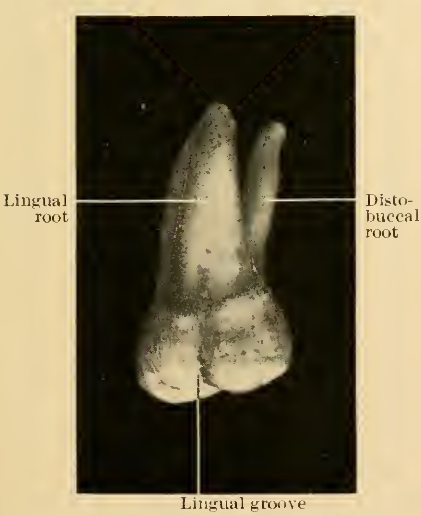


Fig. 59.—Superior right second molar, lingual surface. (Enlarged.)

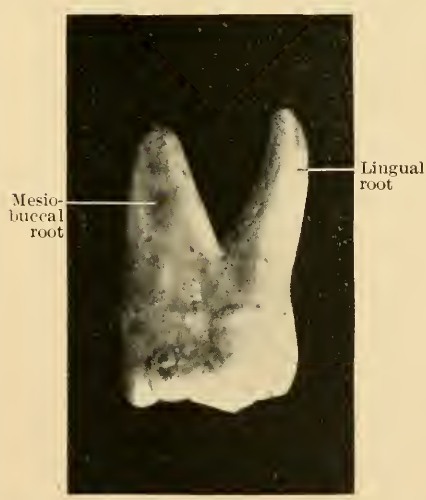


Fig. 60.—Superior right second molar, mesial surface. (Enlarged.)

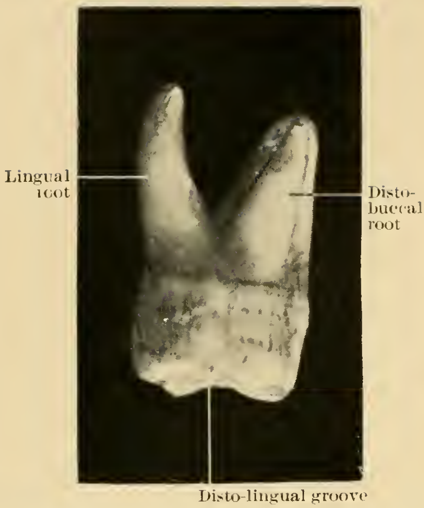


FIG. 61.—Superior right second molar, distal surface. (Enlarged.)

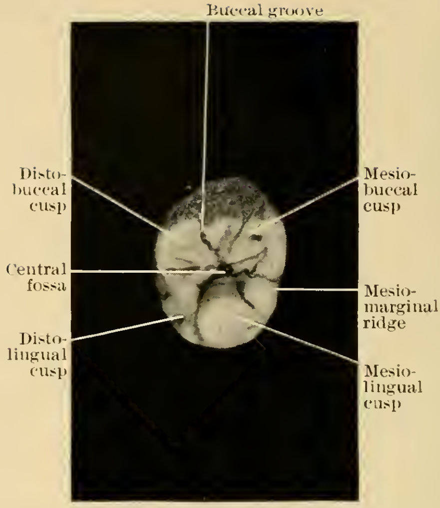


FIG. 62.—Superior right second molar, morsal surface. (Enlarged.)

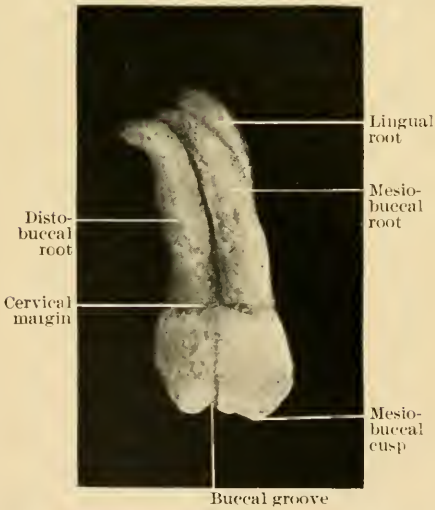


FIG. 63.—Superior right third molar, buccal surface. (Enlarged.)

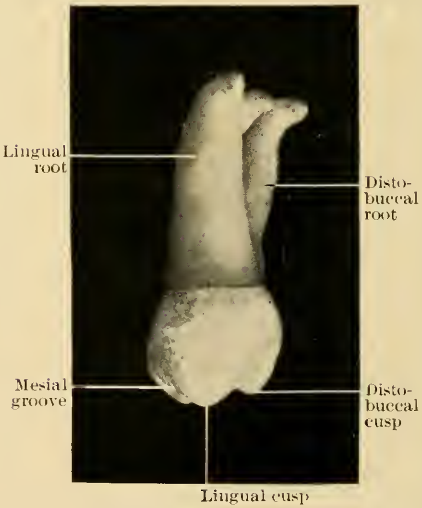


FIG. 64.—Superior right third molar, lingual surface. (Enlarged.)

The *cervix* of this tooth, on section, shows the form of a rounded rhomboid, widest upon its buccal aspect. The cervical line is nearly straight upon all four surfaces. A concavity occurs on the buccal side at the bifurcation of the buccal roots, and a slight depression upon the mesial and distal sides, with an inclination towards the lingual root.

The *root* is divided into three prongs or radicles, two upon the buccal side, which are small, tapering, and either flat or rounded, the *mesio-buccal* and *disto-buccal*, and one upon the lingual side, large, round, and tapering, the *lingual*. The roots are usually separated; their apices stand wide apart. Occasionally, however, they are united for some distance by a bridge of cementum; this most frequently occurs with the buccal roots. The *mesio-buccal* is the largest of the buccal roots. All of the roots may be more or less bent and crooked.

The Pulp-Chamber and Canals.—The pulp-chamber is large and divides into three branches, one for each root. The *lingual canal* is the largest, and is freely entered to its apex, except in those cases in which the root is bent or crooked. The *mesio-buccal* is the next largest canal, and can often be entered with ease, but occasionally it is small and narrow, and when the root is crooked it often becomes difficult or impossible to follow it. The disto-buccal canal is almost always so small and fine as to require great skill and much patience to properly cleanse it preparatory to filling. Many times the canal cannot be followed to the apex by any degree of skill or patience, thus making the proper treatment and filling of these roots one of the most difficult problems in the whole range of dental practice.

The average length of the superior first molar is 0.81 inch (2.05 centimetres), of the crown 0.30 inch (0.76 centimetre), and of the root 0.51 inch (1.29 centimetres).

The **superior second molar** is so nearly the counterpart of the first molar that the differences in its form need only be described. It is a little smaller than the first molar, not so nearly quadrilateral in form, but rhomboidal, being somewhat compressed mesio-distally.

The *buccal surface* (Fig. 58) is almost identical with that of the first molar. A slight difference is noticed in the mesio-distal width of the surface and in the location of the buccal groove, which in many instances is at the distal third rather than at the mesio-distal centre.

The *lingual surface* (Fig. 59) presents a greater convexity mesio-distally, and particularly so from the linguo-morsal margin to the cervix. The lingual groove is not so constant in its location, often being found between the mesio-distal centre and the extreme of the distal third of the surface.

The *mesial* and *distal surfaces* (Figs. 60 and 61) have only slight differences. The mesial is inclined to be concaved bucco-lingually; into this concavity the distal surface of the first molar closely fits, while the only difference in the distal surface is that it is more markedly convex.

The Morsal Surface.—The most marked differences in the character of the morsal surface (Fig. 62) of the second superior molar is the almost constant tendency to the suppression of the disto-lingual lobe. This carries the oblique ridge farther to the distal side, and enlarges the central fossa. The cusps are also not so prominent, and when the disto-lingual cusp is only rudimentary in size, and the oblique ridge prominent, the tooth becomes practically a *three-cusped tooth.* The various grooves are the same as on the first molar in the normally developed organ.

The *cervix* is less regular in outline and more constricted and flattened mesio-distally than in the first molar.

The *roots* are the same in number and general form as in the first molar; they spread less, however, and are quite inclined to be crooked or converge towards each other, or to be fused together.

Sometimes the buccal roots only are fused, while in others the mesial and lingual are joined, or all of the roots may be united in a single root, the outlines of the roots being marked only by shallow grooves.

The *pulp-canals* in a normally developed superior second molar are, as a rule, smaller and more difficult to enter than those of the first molar.

When the roots are fused together, all of the canals may coalesce, making a single canal, or when union of the buccal roots takes place these canals may unite. The uncertainty, however, as to their regularity in form adds greatly to the difficulties to be surmounted in the treatment.

The average length of the superior second molar is 0.79 inch (two centimetres), of the crown 0.28 inch (0.71 centimetre), and of the root 0.51 inch (1.29 centimetres).

The **superior third molars** are smaller than either of the other superior molars, and show greater deviations from the normal type, being very erratic as to the time of their appearance and in their form and structure. It is the eighth from the median line, and the last tooth of the upper dental arch. This tooth, when well formed, is a tricuspid, the disto-lingual cusp being suppressed. The oblique ridge then becomes the disto-marginal ridge. The crown is triangular in form and the angles well rounded.

The *buccal surface* (Fig. 63) is like that of the second molar, but more rounded and the lobes less strongly marked and the buccal groove shallow.

The *lingual surface* (Fig. 64) is usually full and convex in all directions. It has but a single lobe on account of the suppression of the disto-lingual cusp.

The Mesial and Distal Surfaces.—The mesial surface resembles the same surface of the second molar but is reduced in size, while the distal surface is shorter and more rounded (Figs. 65 and 66).

The *morsal surface* (Fig. 67) in a well-developed third molar presents a *mesio-buccal*, a *disto-buccal*, and a *mesio-lingual* cusp, with the suggestion of a *disto-lingual* cusp, in the form of a cingule or tiny tubercle. In this case it will also present a central and distal fossa, with the developmental grooves more or less distinctly marked. More often, however, the disto-lingual cusp is entirely suppressed, and with it the distal fossa. Many times the cusps will be so blunted around the central fossa as to give the appearance of a continuous marginal ridge, occasionally sharply defined, or it may be broadly rounded.

The *cervix* is constricted, and in form, on section, gives the outline of a rounded triangle.

The *roots* have very rarely the form of the typical molar in the higher civilized races. As a rule, the roots are fused together to a greater or less

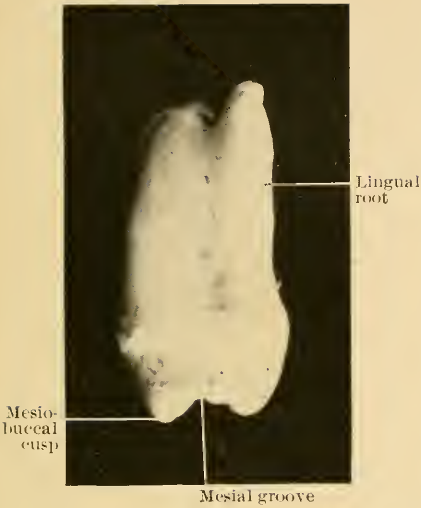


FIG. 65.—Superior right third molar, mesial surface. (Enlarged.)

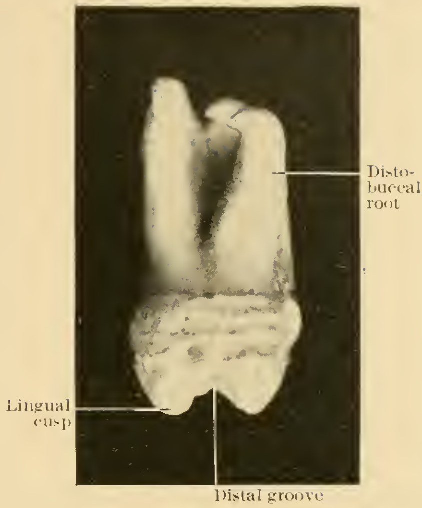


FIG. 66.—Superior right third molar, distal surface. (Enlarged.)

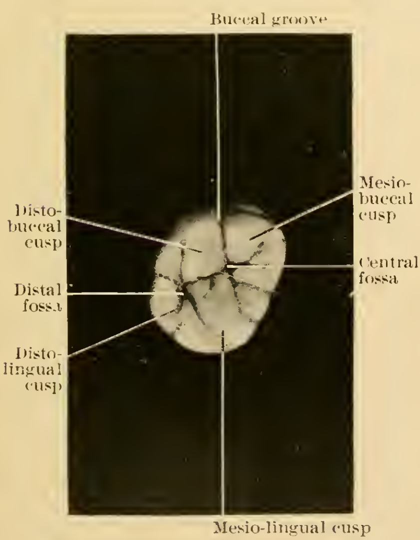


FIG. 67.—Superior right third molar, morsal surface. (Enlarged.)

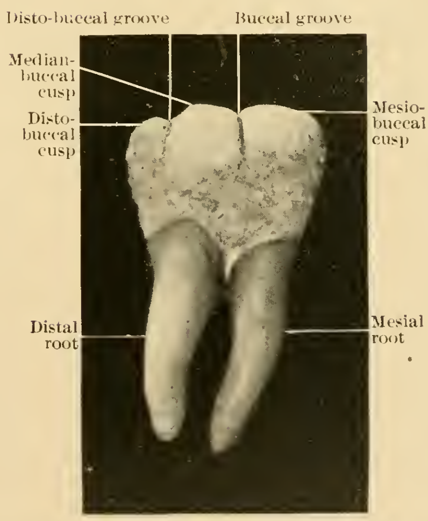


FIG. 68.—Inferior right first molar, buccal surface. (Enlarged.)

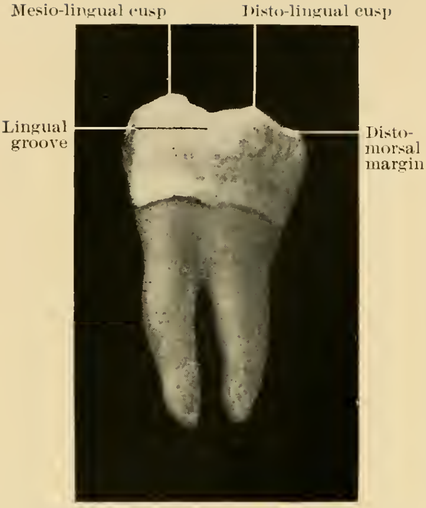


FIG. 69.—Inferior right first molar, lingual surface. (Enlarged.)

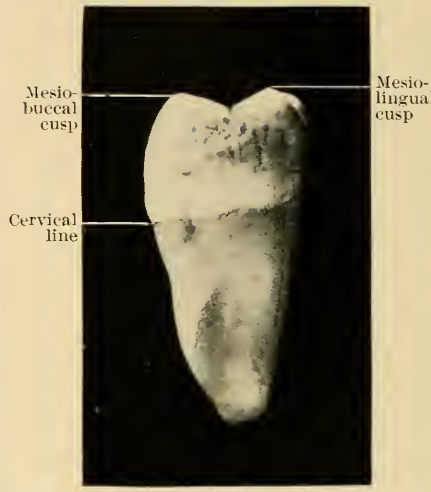


FIG. 70.—Inferior right first molar, mesial surface. (Enlarged.)

FIG. 71.—Inferior right first molar, distal surface. (Enlarged.)

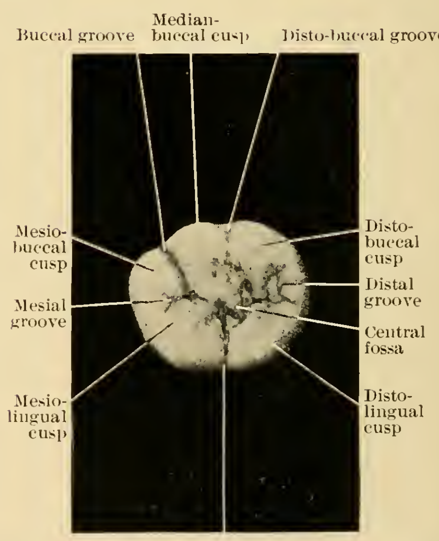


FIG. 72.—Inferior right first molar, morsal surface. (Enlarged.)

extent, sometimes forming a single root, and they are often curved distally towards the maxillary tuberosity. Sometimes they have multiple roots, which may be curved in various directions.

The *pulp-canals* are usually blended into one, but when the roots are separate there are individual canals. The difficulties presented in the treatment of the root-canals of these teeth are greatly enhanced by the positions which they occupy in the jaw and their great liability to have crooked roots.

The average length of the superior third molar is 0.68 inch (1.72 centimetres), of the crown 0.24 inch (0.6 centimetre), and of the root 0.44 inch (1.11 centimetres).

THE INFERIOR MOLARS.

The inferior molars are three in number, and are designated according to their positions in the jaw as the *first*, the *second*, and the *third*. They occupy respectively the sixth, seventh, and eighth positions in the inferior arch from the median line.

As already stated, these teeth are constructed upon the architectural design of a combination of four cones united at their bases to form the crown, while the apices are united in pairs to form the *mesial* and *distal roots*.

The inferior molars differ from the superior in that they have two roots instead of three; are inclined to have multiple cusps; have a greater diameter mesio-distally than bucco-lingually; and the buccal surface slopes towards the centre of the tooth to accommodate the overlocking of the cusps of the occluding teeth.

The **inferior first molar** is the sixth tooth from the median line, and approximates the second bicuspid upon its distal surface. "Next to the superior first molar it is the largest tooth in the denture." (Black.)

The *buccal surface* (Fig. 68) is an irregular trapezoid in form, the morsal margin being wider than the cervical, due to the convergence of the mesial and distal surfaces towards the cervix. The surface is convex in all directions, and the mesial and distal margins are rounded. The morsal margin is usually surmounted by three cusps or tubercles, the *mesio-buccal*, the *median-buccal*, and the *disto-buccal*, which are separated by the *buccal* and *disto-buccal grooves*. The buccal groove is a little to the mesial of the centre of the tooth, while the disto-buccal groove is near the disto-buccal angle. These grooves generally terminate near the middle of the surface in pits, which often become the seat of caries.

The *lingual surface* (Fig. 69) is slightly convex in all directions, and inclines towards the lingual. The surface is not so wide as the buccal surface on account of the convergence of the mesial and distal surfaces towards the lingual. The morsal margin forms a rather sharp angle with the morsal surface; it is surmounted by two cusps or tubercles, the *mesial* and *distal*, and is divided through its centre by the *lingual groove*, which separates the mesial and the distal cusps. This groove is shallow and rarely extends farther than the middle of the surface.

The *mesial* and *distal surfaces* (Figs. 70 and 71) are flattened bucco-lingually and convex from morsal margin to cervix, the distal surface more than the mesial. They are wider at the morsal margin than at the cervix.

The mesio-morsal margin is deeply concaved, and the disto-morsal margin is notched, sometimes deeply, by the *distal groove.*

The *morsal surface* (Fig. 72) is trapezoidal in form, the buccal side being the longest. The surface is surmounted by five cusps, designated as follows: the *mesio-buccal*, the *median-buccal*, the *disto-buccal*, the *mesio-lingual*, and the *disto-lingual;* three are arranged upon the buccal half of the surface, and two upon the lingual. The cusps are united at their bases by *four marginal ridges*, the *mesio-marginal ridge*, joining the mesio-buccal and the mesio-lingual cusps; the *bucco-marginal ridge*, uniting the mesio-buccal, median-buccal, and disto-buccal cusps; the *linguo-marginal ridge*, joining the mesio-lingual and disto-lingual cusps; and the *disto-marginal ridge*, uniting the disto-lingual and disto-buccal cusps. These ridges slope towards the centre of the teeth to form the *central fossa.* There are *five triangular ridges* which descend from the five cusps towards the central fossa. The morsal surface is traversed by five developmental grooves, the mesial, buccal, disto-buccal, lingual, and distal.

The *mesial groove* arises in the central fossa and crosses the mesio-marginal ridge to the mesial surface; the *buccal groove* begins at the central fossa, crosses the bucco-marginal ridge between the mesio- and median-buccal cusps to the buccal surface; the *disto-buccal groove* takes a disto-buccal direction from the central fossa, dividing the bucco-marginal ridge between the median- and disto-buccal cusps; the *lingual groove* has its origin in the central fossa, crosses the linguo-marginal ridge in a deep sulcus between the mesio- and disto-lingual cusps, and is lost upon the lingual surface.

The *distal groove* arises also from the central fossa, crosses the disto-marginal ridge dividing the disto-lingual cusp from the disto-buccal. Various other pits and supplemental grooves are occasionally observed.

The *cervix* on section is rectangular in form, with the sides slightly concaved in the centre, and deepest at the buccal and lingual sides at the beginning of the bifurcation of the roots. The cervical line is convex upon the buccal and lingual sides, and concave upon the mesial and distal.

The *roots* are two in number, the *mesial* and the *distal.* They are long, flattened mesio-distally, and often have a decided distal curvature. They are implanted in their alveoli, with their long diameter in a transverse direction to the jaw. The distal root is larger and more rounded than the mesial, the latter having deeper grooves and a greater tendency to bifurcation.

The *pulp-canal* is in form like the roots, having a canal in each root. Occasionally the mesial root will have two canals. The distal canal is the largest and quite readily entered, while the mesial canal is inclined to be flat or hour-glass-shaped, showing the tendency of this root to bifurcate.

When separate canals are formed, they are usually very small, and often cannot be followed.

The average length of the inferior first molar is 0.82 inch (2.08 centimetres), of the crown 0.30 inch (0.76 centimetre), and of the root 0.52 inch (1.32 centimetres).

The inferior second molar differs from the first in that it has but four instead of five cusps, is more quadrangular, rounded, and symmetrical.

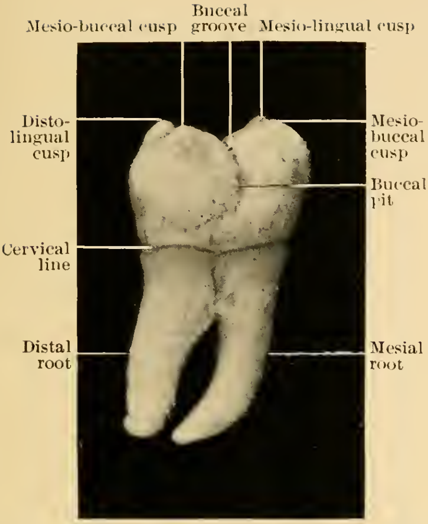


FIG. 73.—Inferior right second molar, buccal surface. (Enlarged.)

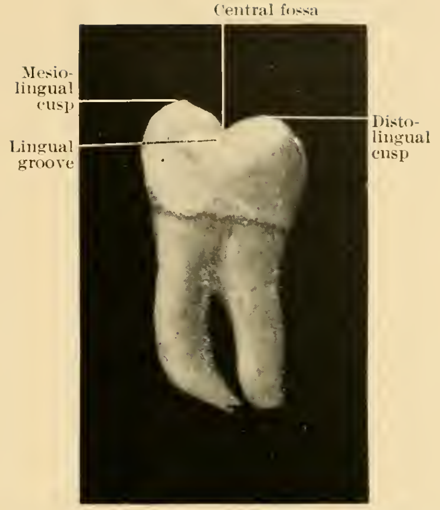


FIG. 74.—Inferior right second molar, lingual surface. (Enlarged.)

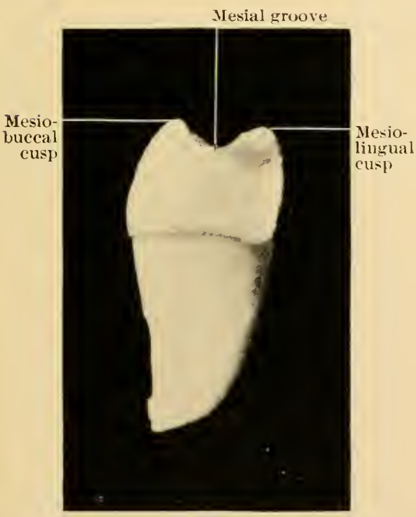


FIG. 75.—Inferior right second molar mesial surface. (Enlarged.)

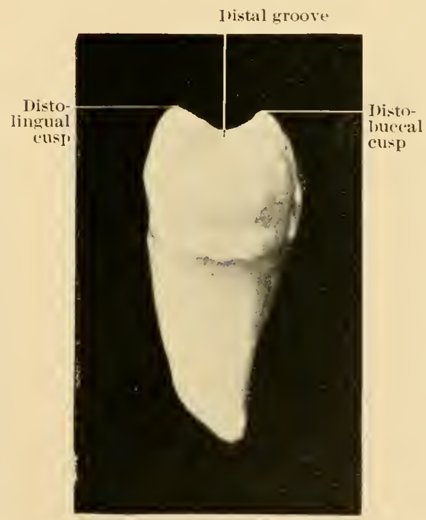


FIG. 76.—Inferior right second molar, distal surface. (Enlarged.)

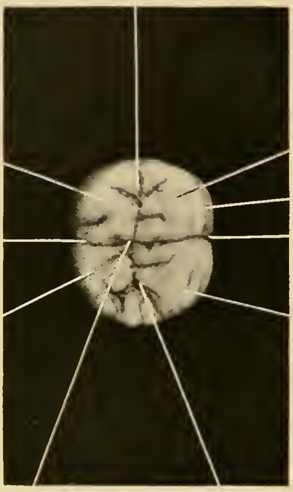


FIG. 77.—Inferior right second molar, morsal surface. (Enlarged.)

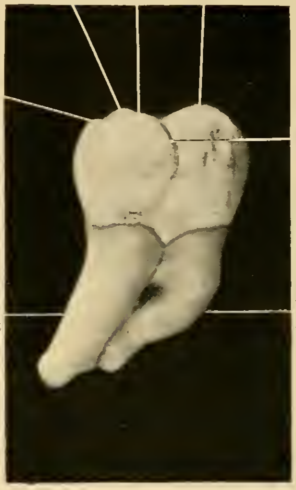


FIG. 78.—Inferior right third molar, buccal surface. (Enlarged.)

FIG. 79.—Inferior right third molar, lingual surface. (Enlarged.)

FIG. 80.—Inferior right third molar, mesial surface. (Enlarged.)

The *buccal surface* (Fig. 73) is convex in all directions, but is divided into two lobes by the buccal groove, which is usually shallow. A deep buccal pit is often observed in the centre of the surface. The morsal margin slopes towards the centre of the tooth as in the first molar, and the surface is widest at this point, while the convergence of the mesial and distal surfaces makes it narrowest at the cervix.

The *lingual surface* (Fig. 74) is similar to that of the first molar, with the exception that it is proportionately wider, being nearly as broad as the buccal.

The *mesial and distal surfaces* (Figs. 75 and 76) are similar to those of the first molar, except that the distal surface does not have the distal protuberance due to the presence of the fifth cusp ; both surfaces are smoothly convex.

The *morsal surface* (Fig. 77) is surmounted by four cusps, placed at the four corners of the surface. The cusps are rounded and symmetrical, the lingual being a little more pointed than the buccal. The marginal ridges are well formed and enclose a central fossa. The central fossa is traversed by four developmental grooves, all arising from the central pit, which cross the four marginal ridges. The triangular ridges are well marked, being more prominent than in the first molar.

The *cervix* is similar to that of the first molar, but more constricted. The cervical line describes about the same irregular curves.

The *roots* are about the same as the first molar, except that the divergence is not so great. There is also a tendency to fusion of the roots. Examples of complete fusion are not rare. The roots are usually curved distally, or otherwise crooked.

The *pulp-canals* are similar to those of the first inferior molar, the distal the largest, and the mesial usually much constricted. The same difficulties are encountered in opening the canals as are found in the first molars, which are augmented by the irregularity in the form of the roots.

The average length of the inferior second molar is 0.77 inch (1.95 centimetres), of the crown 0.27 inch (0.68 centimetre), and of the root 0.50 inch (1.26 centimetres).

The **inferior third molar** is similar in many respects to the other lower molars. It is the eighth from the median line, and the last tooth in the lower dental arch. It approximates the second molar upon its distal surface. It is probably the most erratic in its form of any tooth in the whole dental series. There are *two typical forms*, one having four cusps, and separated by four developmental grooves, like the second molar, and the other having five cusps and five developmental grooves like the inferior first molar. While these two forms are the most common, there are many variations from these types ; the morsal surface is often divided by numerous developmental grooves, so that six, seven, and even eight well-defined cusps are presented.

The *buccal surface* (Fig. 78) of this tooth is more convex than either the first or second molars, but in all other respects it has the same form. When the tooth has four cusps, this surface partakes of the outlines of the second molar, being surmounted at its morsal margin by two cusps, divided by the buccal groove. When it has five cusps it is like the buccal surface of the first molar, being surmounted at its morsal margin by three cusps, which are divided by the buccal and disto-buccal grooves.

The *lingual*, *mesial*, and *distal surfaces* (Figs. 79, 80, and 81) correspond so nearly to the same surfaces of the other lower molars that no separate description is necessary, except to notice that the distal surface is more convex, and when the fifth cusp is present, often very prominent.

The *morsal surface* (Fig. 82) exhibits the greatest variations from the other lower molars.

In the four-cusped tooth, which is the more common form, it is the counterpart of the second molar, with the exceptions that the distal cusps are rarely so large and well formed as the mesial, and the central fossa is sometimes occupied by a central tubercle.

In the five-cusped tooth, it partakes of the form of the first molar, and is frequently larger than the second. The distal cusp is usually placed more disto-lingually, the buccal surface is more rounded, and numerous supplemental grooves and ridges are often present.

The morsal surface is sometimes surmounted by six, seven, or eight cusps, as many supplemental grooves, and one or more supplemental ridges within the central fossa.

Such teeth are always very large, the grooves deeply fissured, and the structure poorly organized, predisposing them to early destruction from caries. Occasionally the inferior third molar is much smaller than the second, having a circumference of not more than two-thirds as large as this tooth.

A common feature of the crown is its inclination towards a circular form.

The *cervix* is similar in shape, in the typical forms, to the second molar.

The *roots* are, in comparison, smaller and more rounded than in the other lower molars. They are generally divided, but have a greater convergence, and in some instances are fused together in the form of a single cone, but in either case they are almost invariably curved distally, sometimes very considerably, so that their extraction is often a difficult operation. Occasionally the tooth may have three or more roots.

The *pulp-canal* is sometimes single, but usually it is divided. The canals are, as a rule, difficult to enter on account of the location of the tooth, the generally small size of the canals, and the almost certain distal curvature of the roots.

The average length of the inferior third molar is 0.62 inch (1.57 centimetres), of the crown 0.26 inch (0.66 centimetre), and of the root 0.36 inch (0.91 centimetre).

THE DECIDUOUS TEETH.

The deciduous teeth resemble in every way the same class of teeth in the permanent set, with the exception of the first molars. They are, however, all much smaller than the permanent teeth, and are much whiter in color.

The *incisors* and *cuspids* of both jaws are similar in form to the teeth which succeed them. The cervix, however, is more constricted, and the enamel ends more abruptly. The process of resorption of the roots of the

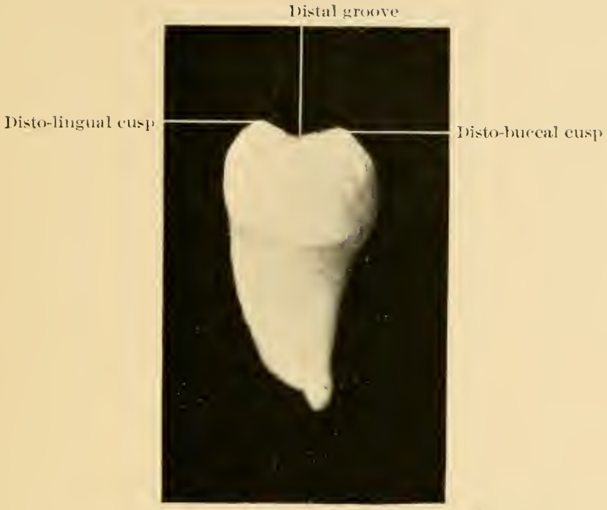


FIG. 81.—Inferior right third molar, distal surface. (Enlarged.)

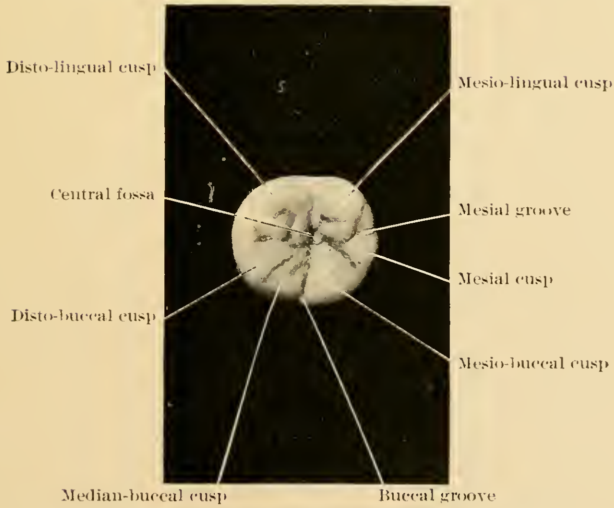
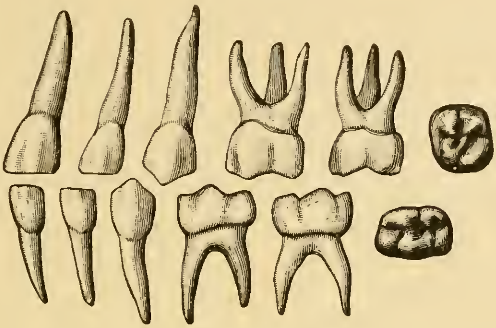


FIG. 82.—Inferior right third molar, morsal surface. (Enlarged.)

deciduous teeth, which allows their crowns to fall away, begins in the central incisors at about the *fourth year*, and is completed at about the *seventh.*

In the lateral incisors this process begins at about the *fifth year*, and is completed at about the *eighth ;* while in the cuspids it is delayed until the *ninth* year, and completed at the *twelfth.*

FIG. 83.



The **superior first deciduous molars** are unlike the molars of the permanent set in that the crown has but three lobes or cusps, *mesial*, *distal*, and *lingual*, which are divided by three developmental grooves, the *mesial*, *distal*, and *buccal.* The cusps converge towards the centre of the crown, giving the morsal surface the appearance of being smaller than the base of the crown. The cervix is constricted, while the enamel ends so abruptly at the bucco-cervical margin as to form a prominent ridge,—the *buccal ridge.*

Another distinctive feature is that the marginal ridges, triangular ridges, and angles are more acute than in the permanent molars. Its greatest diameter is bucco-lingually.

The **superior second deciduous molars** are larger than the first ; the morsal surface is wider, and is surmounted by four cusps, and in other ways the prototype of the superior second permanent molar.

The **inferior deciduous molars** are similar in general form and outline to the permanent molars. The first molar has four cusps upon its morsal surface, while the second molar, unlike the second permanent molar, has five cusps. The cusps and the marginal and triangular ridges are more marked and prominent ; the central fossa is large and deep, being sometimes divided by the triangular ridges forming two or more fossæ or pits. The cervix is constricted and the bucco-marginal ridge prominent. The mesio-distal diameter of the crown is greater than the bucco-lingual.

The *roots* of the deciduous molars differ from the permanent in that they are relatively thinner and longer, and are much more spread or divergent to accommodate the crowns of the succeeding bicuspids.

The *pulp-chamber* is proportionately much larger than in permanent molars, but the root-canals are thin and narrow, making their treatment difficult.

The process of resorption in the roots of the first molars begins at about the *sixth year*, and is completed at the *tenth*, while for the second molars it begins at about the *eighth* year and is completed at the *eleventh.*

CHAPTER II.

ORIGIN, DEVELOPMENT, AND MORPHOLOGY OF THE TEETH.

Definition.—Morphology (from the Greek μορφή, form, and λόγος, a discourse). The science of biologic forms, including their relations, changes, and analogies; the science of the shape and modifications of organs or parts considered under the idea of unity of plan.

Anatomists until quite a recent period have looked upon the teeth as members of the *osseous* framework of the body, but they are now classified as portions of the *dermal* skeleton. This change in the classification was brought about by prolonged study and research into their origin and development.

The invention of the compound microscope has made it possible for the scientist to delve into the hidden mysteries of nature and reveal to the world the wonders of many of her processes and the secrets of her laboratories; to picture the wonderfully minute elemental or embryonic cells from which organized structures are formed, and the marvellous delicacy and precision with which these are arranged in the building of tissues and organs.

The discoveries made by the microscope during the last three or four decades in the morphology and the histology of vegetable and animal tissues, and in pathology and bacteriology, have been truly wonderful, and in no department of science have greater discoveries been made than in that department of medicine known as dentistry.

The researches of Hunter, Bell, and Goodsir marked the beginnings of dental morphology and histology, and prepared the way for the later investigations into the evolution of the teeth.

The errors into which these earlier investigators fell were due largely to the non-possession of adequate facilities for studying the minute structures of the embryonic tissues. With the higher powers of the microscope it became possible to delve deeper into the mysteries of the evolution of the dental tissues than these old masters had been permitted to do. The results of these investigations have proved conclusively that the enamel-organs had their origin in the epithelial tissues, and hence were formed from the same tissue elements as the hair, the nails, and the epithelial lining of the glandular structures of the skin and the mucous membrane, —namely, *epithelial cells.*

EVOLUTION OF EPITHELIAL TISSUE.

In order that the student may approach the subject of the evolution of the teeth with a clear understanding of the tissue elements which enter into their structure, it will be advisable to present in brief review the morphology and the character of epithelial tissue in general.

In all animals which are developed from an *ovum* (Fig. 84), as soon as impregnation has taken place and the proper conditions of incubation are

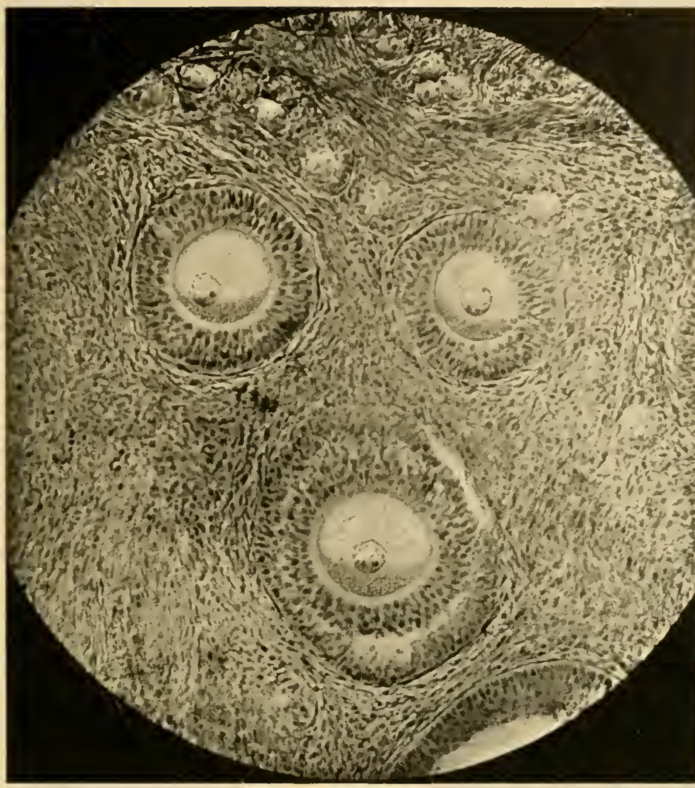


FIG. 84.—Graafian follicles, or ova, in various stages of development. × 80.

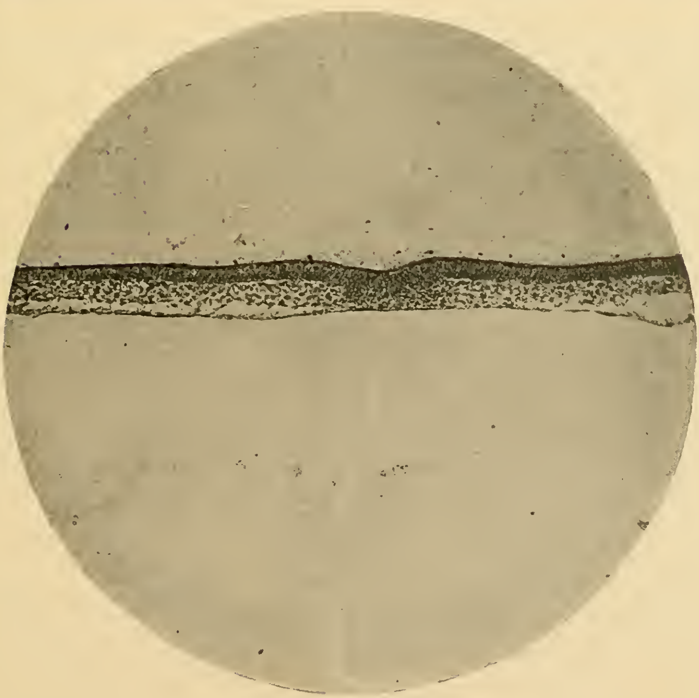


FIG. 86.—Transverse section of embryo of chick, eighteen hours incubation, showing epiblast and hypoblast. (After Aby.)

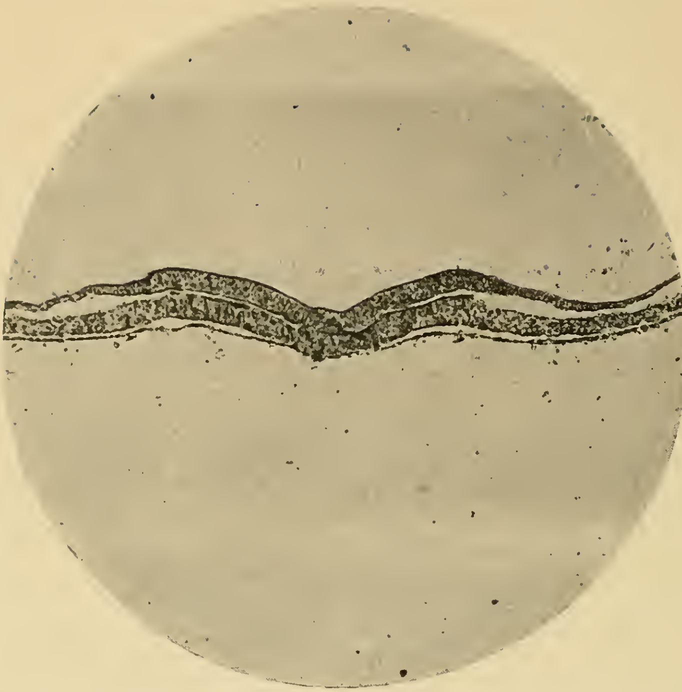


FIG. 87.—Transverse section of embryo of chick, twenty-four hours incubation. (After Aby.)

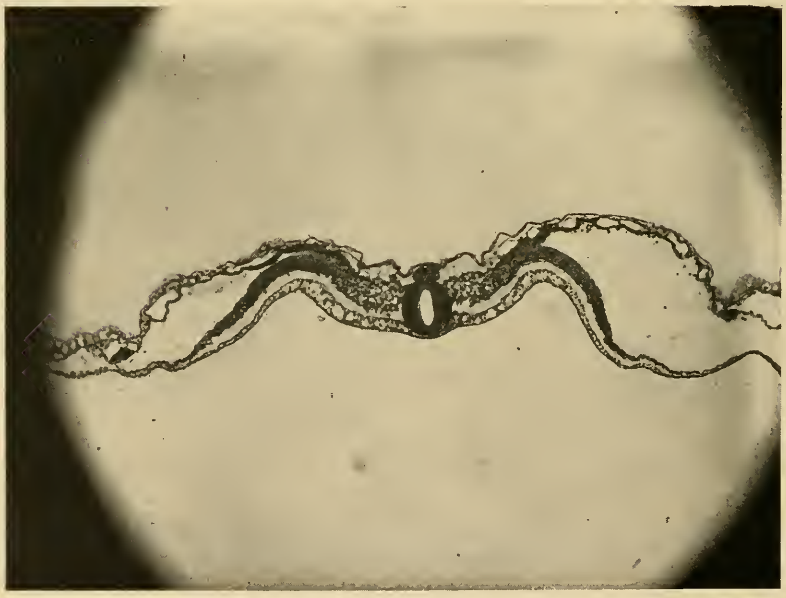


FIG. 88.—Transverse section of embryo of chick, thirty-six hours incubation. (After Aby.)

FIG. 89.—Vertical section of human skin. × 87.

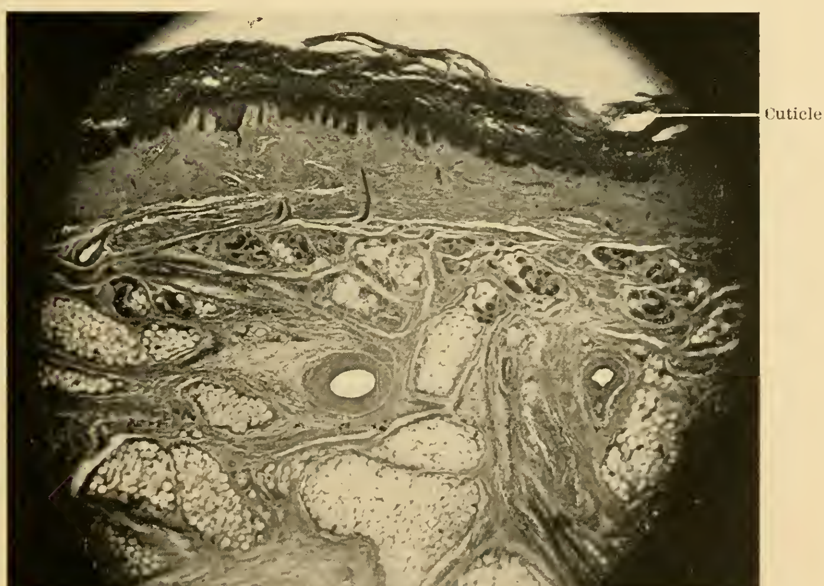


FIG. 90.—Vertical section of skin of middle finger. × 50.

FIG. 91.—Squamous epithelium from buccal cavity. A, squamous epithelial cells; B, salivary corpuscles. × 162.5. (V. A. Latham).

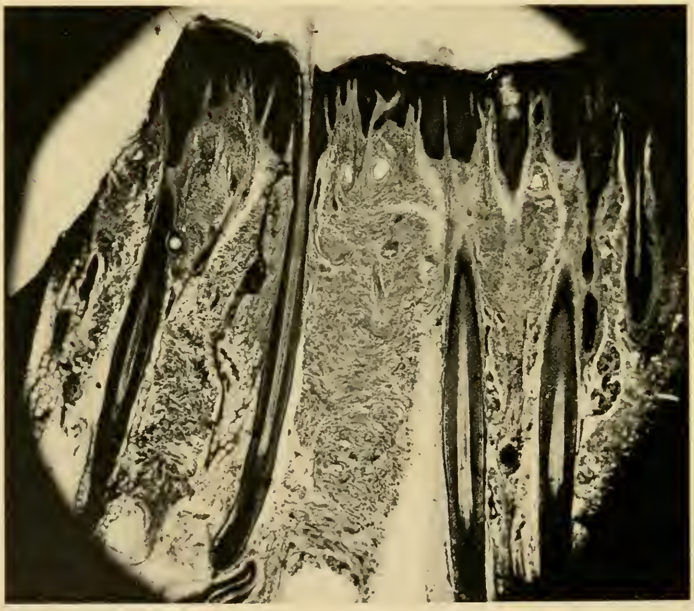
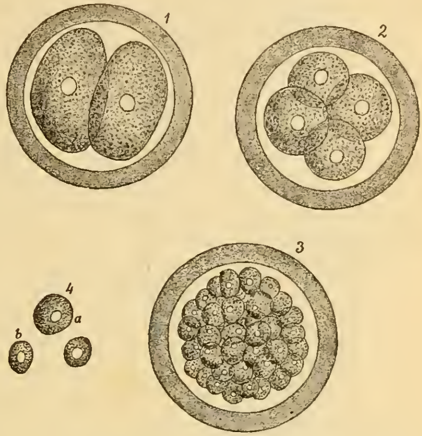


FIG. 92.—Longitudinal section of lip of kitten. × 30.

established,—and this is best studied in the egg of the barn fowl,—there occurs a rapid proliferation of embryonic cells in the *germinal spot* or disk of Pander. This disk is at first composed of a germinal cell, which by the process of karyokinesis—indirect division or segmentation of the cell—produces a rapid multiplication of these elemental cells (Fig. 85, 1, 2, 3, 4).

Fig. 85.



Division of mammal ovum (half diagrammatic). 1, the yolk divided into two globules (cells) with nuclei; 2, quadrupled; 3, a large number of nucleated cells; 4, *a*, *b*, isolated cells.

These embryonic cells soon arrange themselves into *two layers*, known as the *epiderm* or *epiblast*, and the *hypoderm* or *hypoblast*, the epiblast forming the upper layer and the hypoblast the lower (Fig. 86). Later a third stratum of cells is developed between the epiblast and the hypoblast, which is known as the *mesoderm* or *mesoblast* (Figs. 87 and 88).

From these three layers all of the tissues and the various organs of the body are developed. From the epiblast are developed the various layers of the skin (Fig. 89),—viz., the *epidermis*, or cuticle, the *derma*, or true skin, and the *rete mucosum*, or Malpighian layer,—the glandular appendages of the skin, the hair, the nails, and the entire nervous system.

From the hypoblast are developed the lining mucous membrane of the alimentary tract, of the air-passages, of the genital apparatus, the epithelial linings of the serous cavities, the lining membrane of the heart, the blood and lymphatic vessels, and the enamel organs of the teeth. From the mesoblast are developed the remaining portions of the body,—viz., the bones, muscles, blood-vessels, lymphatic vessels, connective tissue, etc.

Epithelial cells are common to both the skin and the mucous membrane, their peculiar characteristics depending upon their location and their particular function, as, for instance, in the skin (Fig. 90) they may form the *cuticle*, or horny layer, when they are *squamous* or scaly in shape (Fig. 91); if forming the lining of a tubule of a sweat-gland they are *cuboidal*; when entering into the formation of the hair-sheath they are *columnar* (Fig. 92), while in the shaft of the hair they become squamous, the cells being overlaid like the scales of a fish (Fig. 93).

In the development of the nail-plate they are also *columnar*, but rapidly become squamous and cornified.

In the mucous membrane of the mouth the most superficial layer of epithelial cells is of the squamous variety, while beneath this lies a layer of *spinous* or furrowed cells, the spines of which interlock with neighboring cells, and by this means are held together. Immediately beneath this stratum is another, the Malpighian layer, made up of small, soft, roundish cells, sometimes oval in form, and arranged in a regular order, standing upright upon the basement membrane (Figs. 94 and 95). Other peculiar epithelial cells found in the mucous membrane of the mouth are known as the ciliated columnar cell (Fig. 96) and the *goblet*-cell (Fig. 97), the functions of which with the mucous gland are to secrete mucus. The mucous glands are also lined with epithelial cells, usually in a single layer, and cuboidal or columnar in form.

From the deeper strata of epithelial cells, the Malpighian layer of the mucous membrane, the enamel organs of the teeth are formed.

Fig. 98.

Section of jaw of rabbit embryo, showing dental ridge cut across: *ec*, oral epithelium; *e*, epithelial outgrowth corresponding to future enamel organ; *m*, mesoblastic tissue.

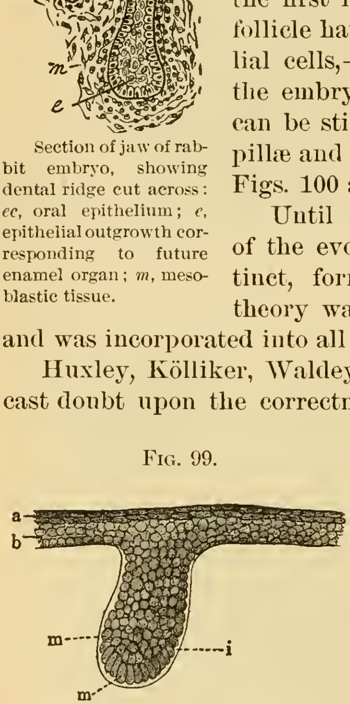
It is interesting to note the analogy in the morphology of the teeth and the hair.

By comparing Figs. 98 and 99, it will be seen that the first rudiments of the tooth-follicle and the hair-follicle have their origin in the lower layer of epithelial cells,—Malpighian layer,—which dips down into the embryonic tissue of the mesoblast. The likeness can be still further traced in the formation of the papillæ and the invagination of the flask-like bud. (See Figs. 100 and 101.)

Until 1837, when Goodsir published his theory of the evolution of the teeth, there had been no distinct, formulated teaching upon this subject. This theory was at once adopted by anatomists generally, and was incorporated into all standard works on anatomy and histology.

Huxley, Kölliker, Waldeyer, Kollman, and Guillot were the first to cast doubt upon the correctness of the theory of Goodsir. In 1860 there appeared a treatise by Robin and Magitot, entitled "The Genesis and Development of the Dental Follicle to the Eruption of the Teeth;" this proved the Goodsir theory to be based upon errors due to methods of manipulation. It also contained serious errors in the order of the genesis of the dental tissues, the most conspicuous of which was the statement that the dentin bulb was the first part of the follicle to be formed.

Fig. 99.



First rudiments of a hair from the human embryo of sixteen weeks. a, b, layers of cuticle; m, m, cells of the rudimentary hair; i, hyaline envelope.

It was not, however, until the appearance of the treatise "The Origin and Formation of the Dental Follicle," by Legros and Magitot, that the Goodsir theory was fully overthrown.

The teaching of these authors has stood the test of more than thirty years of investigation without a single important statement having been successfully controverted. Many facts, however, in relation to the development of the individual dental tissues have since been discovered and become a part of dental histology. We may, therefore, feel fairly certain that in so far as the evolution of the dental follicle is concerned, we are resting upon a solid, scientific foundation.

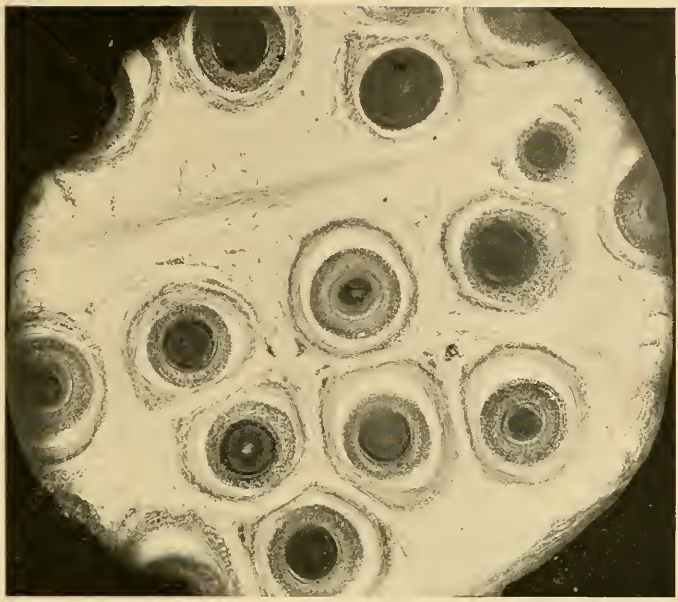


FIG. 93.—Transverse section of hairs of scalp. × 50.

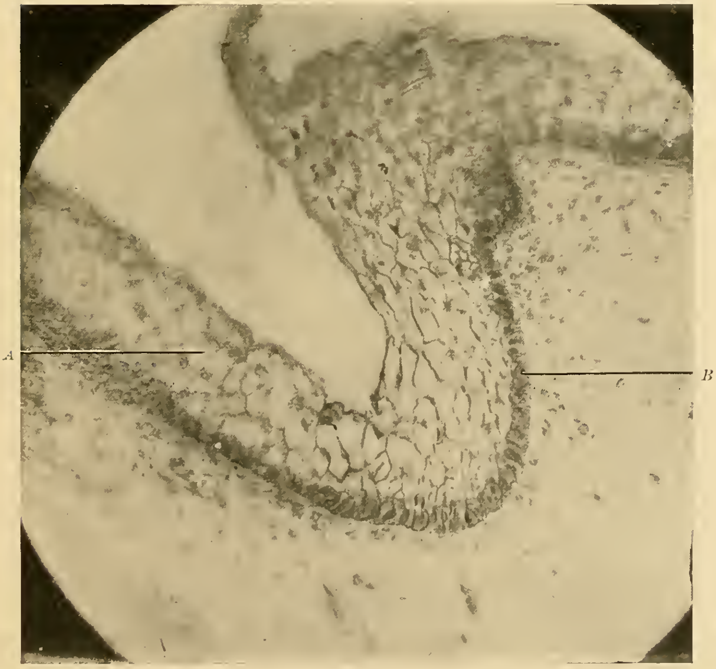


FIG. 94.—Epithelial layer of the mucous membrane. *A*, squamous cells; *B*, columnar cells. (R. R. Andrews.)

Fig. 95.—Columnar epithelial cells. × 670.

Fig. 96.—Ciliated columnar epithelial cells. × 670.

Fig. 97.—Goblet-cells. × 500.

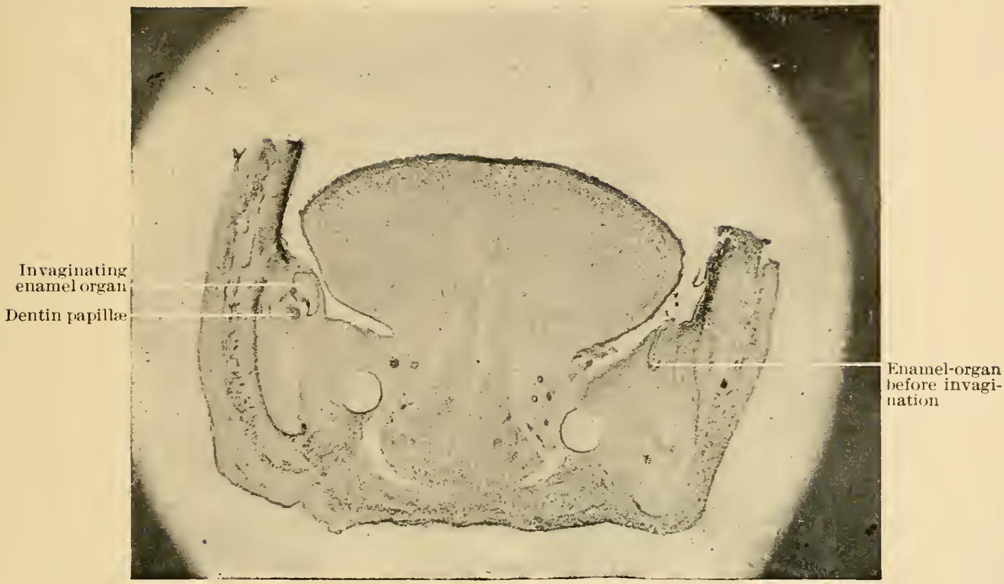


FIG. 100.—Lower jaw of human embryo, ninth to tenth week. × 80.

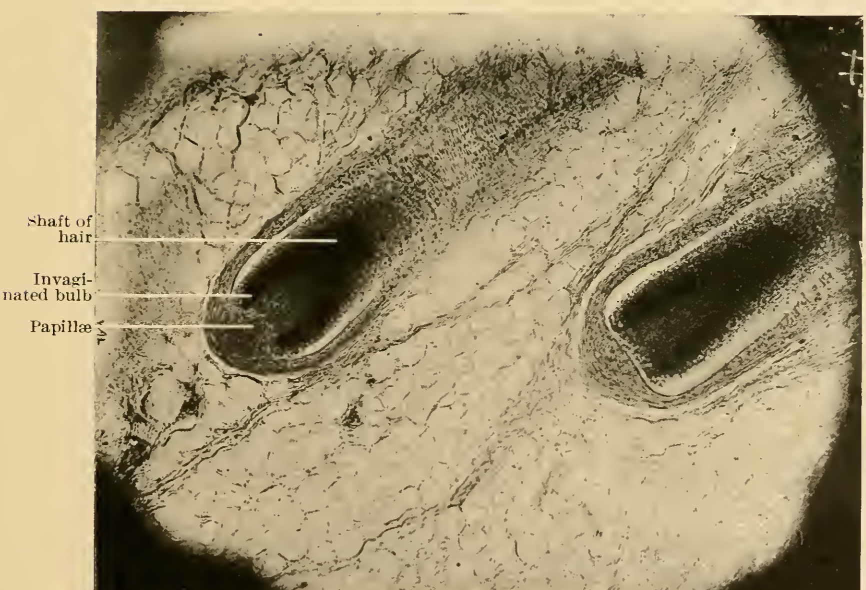


FIG. 101.—Vertical section of the skin, showing bulbous ends of two hairs. × 55.

FIG. 103.—Vertical section through head of human fœtus, showing completed rudimentary jaws, etc. × 80.

FIG. 104.—Lower jaw of human fœtus, showing Meckel's cartilage. × 80.

Before proceeding to a study of the accepted theory of the evolution of the teeth let us briefly review the theory of Goodsir.

Goodsir stated that at a very early period of fœtal existence a depression or groove, which he termed the *primitive dental groove*, was formed in the mucous membrane along the entire circumference of the alveolar border of both jaws; that from the bottom of this groove in each jaw papillæ arose, ten in number, isolated and uncovered, which represented the future deciduous teeth; that later these papillæ became closed in by the approaching of the walls of the groove and by the formation of separate septa between the papillæ, thus enclosing each of them in an independent follicle.

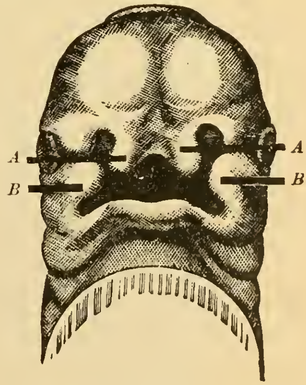
The permanent teeth, except the molars, were formed in like manner, within what he termed the *secondary dental groove*, which he located behind the primitive dental groove, and formed from the inner or lingual lip of the primitive dental groove. In this secondary dental groove were formed the ten anterior permanent teeth,—the teeth of replacement,—while the first permanent molar was evolved within the posterior portion of the primitive dental groove, which had remained open for this purpose; and the second permanent molar is developed from a papilla given off from the first permanent molar at the seventh or eighth month after birth, and the third molar from a papilla given off from the second permanent molar at a still later period in childhood.

A study of the origin and development of the teeth should take into account, also, the evolution of the jaws, which may be briefly outlined as follows:

THE EVOLUTION OF THE JAWS.

In the human subject the first evidence of the formation of the superior maxilla is seen very early in the life of the embryo,—viz., at about the eighteenth day after conception, by the development of four tiny buds, tubercles, or processes near the central portion of that surface of the rudimentary head which is destined to form the face (Fig. 102), and which are denominated the *superior* or *frontal processes* or tubercles, and the *lateral*, *oblique*, or *maxillary processes* or tubercles.

Fig. 102.



Head of human embryo. (His.) *A*, *A*, superior processes; *B*, *B*, oblique processes.

The superior processes elongate downward, and at the same time approach each other towards the median line, where they finally coalesce, at about the twenty-fifth day, to form the intermaxillary bones and the central portion of the upper lip. The lateral processes likewise elongate, and approach each other towards the median line, where they finally, at about the twenty-eighth day, meet the superior processes, and unite with them, thus forming the lateral halves of the rudimentary superior maxillary bone, palate bones, the cheeks, the lateral portions of the upper lip, and the velum palati (Fig. 103).

Coincidently with the development of the superior maxillæ, a similar process of development has been going on for the formation of the inferior maxilla. At about the eighteenth day two similar tiny buds or processes appear just beneath the *lateral processes*, and grow rapidly towards the median line, where they unite at about the twenty-eighth day, and complete the arch of the lower jaw. Very soon afterwards a little *cartilaginous band* makes its appearance within the central portion of the rudimentary jaw, *Meckel's cartilage* (Fig. 104). This cartilaginous band is composed of two parts, which arise from the mallei of the ears, and extend forward until they unite at the mental symphysis. Meckel's cartilage gives form and stability to the inferior maxillary arch until ossification takes place, when it disappears by absorption or becomes calcified, forming a part of the maxillary bone.

EVOLUTION OF THE TEETH.

The earliest evidences of the evolution of the teeth are to be found at about the seventh week of intrauterine life, in the shape of a depression or involution of the Malpighian stratum of the epithelial cells upon the alveolar border of the rudimentary jaws (Fig. 105), forming what is known as the *epithelial band*. This band is composed of the same cell elements that are found in the epithelial tissue of the oral mucous membrane, the band or groove being bounded by a layer of columnar or prismatic cells, which include a mass of polyhedral nucleated cells, the cells in the centre often being of the denticulated or spinous variety.

Fig. 105.

Involution of the Malpighian stratum. Section of jaw of rabbit embryo, showing thickening of epiblastic epithelium (*ec*) from which the Malpighian stratum (*e*) begins its growth into the mesoblast (*m*) to form the epithelial band. (Piersol.)

This band or groove, as it descends into the embryonic tissue of the jaw, curves slightly inward, and is filled and heaped up with flattened epithelial cells, making what is known as the *dental ridge*, the *maxillary rampart* of Kölliker, Waldeyer, and Kollman. The next step in the evolution of the dental follicle occurs between the seventh and eighth weeks, when the epithelial band or groove sends off a thin lamina or process upon its lingual aspect in each jaw,—the *epithelial lamina*,—which occupies a horizontal position to the epithelial band. Buds or processes also appear upon the extremity or edge of the lamina,—the *primitive epithelial cord*,—which elongates and dips down into the embryonic tissue of the jaw. At about the eighth week the *enamel-organs* are clearly defined as club-shaped enlargements upon the extremities of the primitive epithelial cords (Fig. 106), and the *dentin papillæ*, or dentin bulbs, can be discovered as opaque points directly beneath the enamel-organ in the mesoblastic tissue.

Fig. 107 represents the epithelial cord in the preceding illustration, highly magnified, and Fig. 108 shows the same in cross-section.

The process of evolution advances synchronously at this period in all the follicles of the deciduous teeth.

Fig. 106.—Lower jaw of human embryo, seventh to eighth week. × 75.

Fig. 107.—Vertical section of epithelial cord, or primitive enamel-organ. × 300.

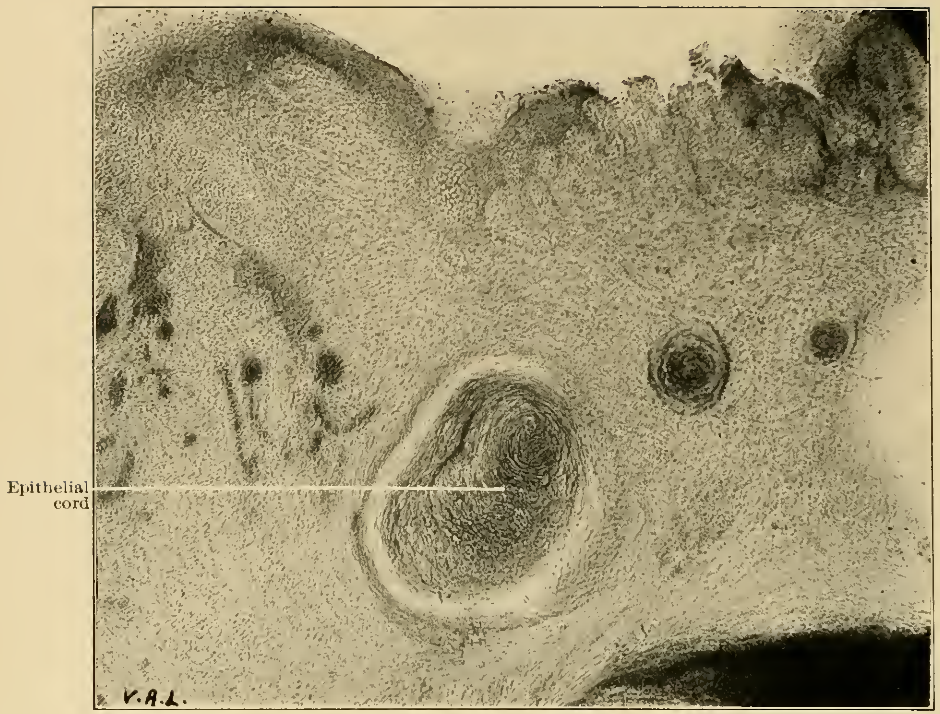


FIG. 108.—Cross-section of epithelial cord. × 300.

FIG. 109.—Primitive epithelial cord, showing a peculiar turning of the end. × 45.

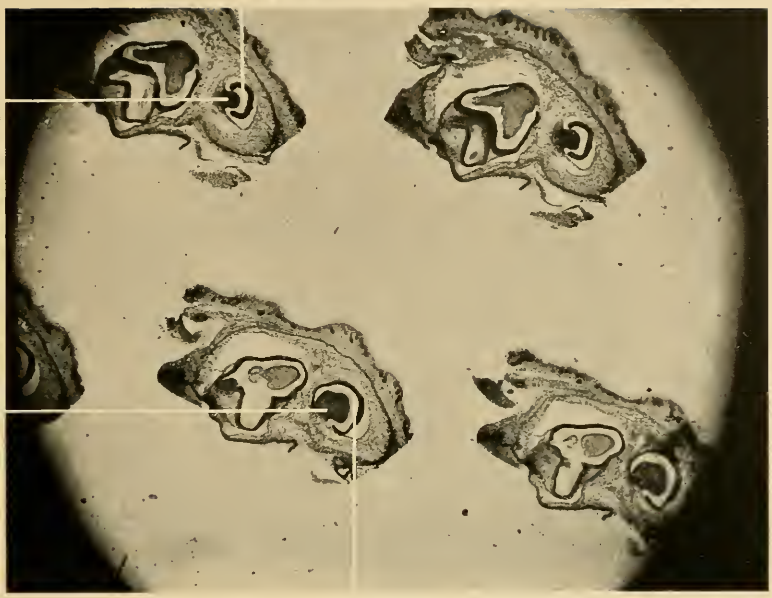


FIG. 110.—Vertical section through lower jaw of embryo field mouse.

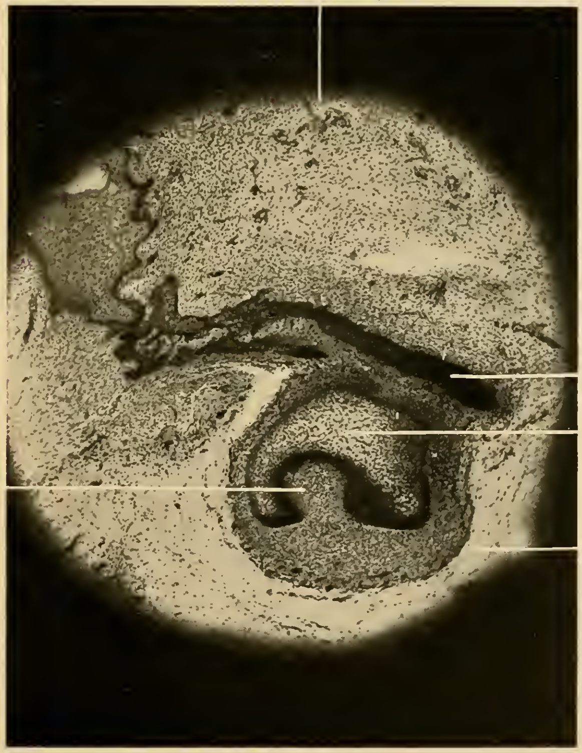


FIG. 111.—Evolution of dental follicle at about the ninth week, showing invagination of enamel-organ. × 70.

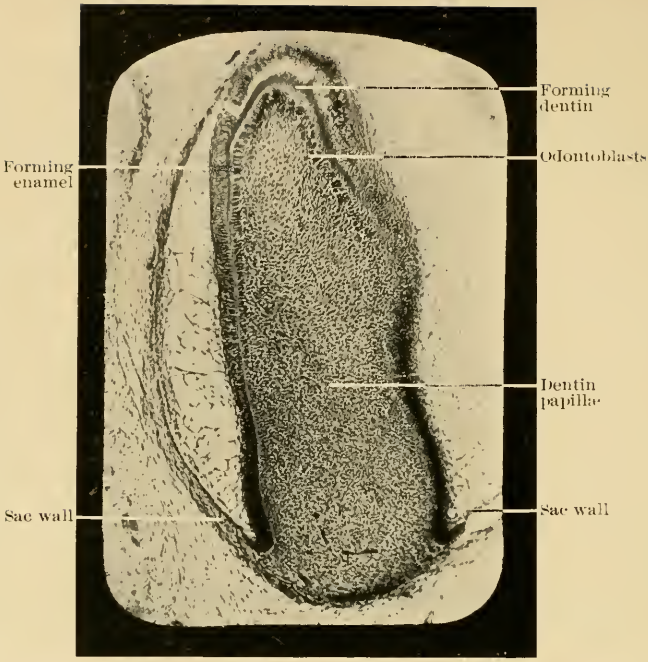


FIG. 112.—Developing human cuspid.

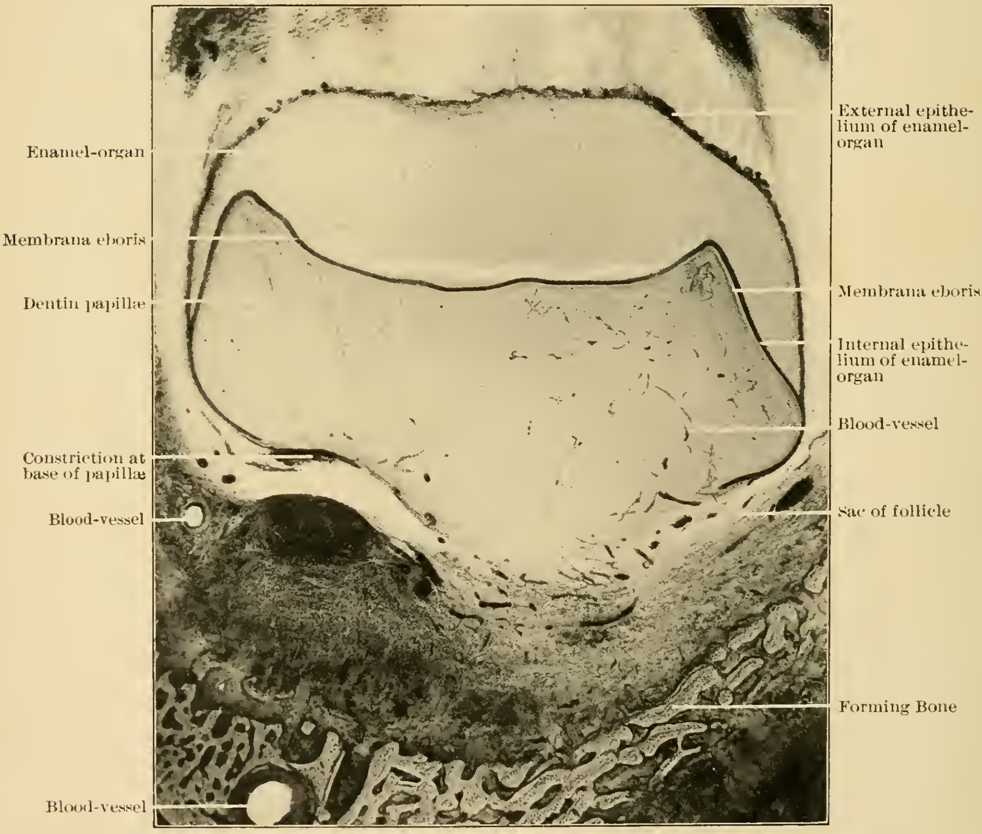


FIG. 113.—Follicle of human molar at about the eleventh week. × 50.

The club-like enamel-organs now rapidly enlarge and become pear-shaped in form. In Fig. 109 a peculiar hook-shaped termination is noticed, which is doubtless a malformation, as no reference is made to it by other observers, and has not been seen before by the writer. This pear-shaped enlargement is due to a rapid proliferation of the polyhedral epithelial cells contained within them, and of the columnar cells which form the outer boundary. The enamel-organ has now attained its full size, and occupies a position within the deeper structures of the jaw, and slightly inclined towards its lingual aspect.

The next important feature in the development of the follicle is the *invagination* of the enamel-organs, as shown in Fig. 110. This change occurs simultaneously with the appearance and growth of the dentin papillæ. Immediately beneath each enamel-organ is developed from the mesoblastic tissue a cone-shaped bulb or papilla similar to the papillæ found in the gums and mucous membrane of the mouth.

The *dentin papillæ* (Fig. 111) in its earliest stage of development is composed simply of embryoplastic neucleated cells, but soon afterwards it contains fusiform and stellate cells; it also contains a vascular loop, but Robin and Magitot were unable to discover in it any nerve-fibres.

As soon as this new organ has assumed a conical form, which occurs at about the ninth week, there arises from its base, as seen in microscopic sections, two opaque processes, which are the first traces of the *wall* or *sac* of the future follicle. These processes, which really surround the base of the papillæ like a collar (Fig. 112), elongate as the bulb increases in size and length, converging towards each other until they finally embrace the bulb and enamel-organ in their entirety.

As the dentin bulb enlarges and elongates it comes in contact with the inferior portion or lower plane of the enamel-organ, which is gradually carried upward until it is completely invaginated, thus forming a double-walled cap or hood over the dentin papilla.

It is interesting to note the fact that during the growth of the dentin papilla and the invagination of the enamel-organ a reciprocal adaptation of these organs takes place from the commencement of the process, and continues throughout all subsequent phases, the enamel-organ at all times covering the dentin bulb, and being adapted to its varying contours (Fig. 113). At no time, however, during the process of development do the tissues of these two organs become united.

Sudduth confirms the teaching of Legros and Magitot, and says there is no union between the enamel-organ and the papilla, nor have vessels or nerve-fibres ever been demonstrated as passing from one to the other.

Bödecker takes an opposite view, and states that when the enamel-organ is detached from the dentin papilla, as frequently occurs in making sections, there appears upon the outer surface a delicate fringe, which he believes to be the true connection between the enamel-organ and the papilla.

Fig. 114 is here introduced to show the stage of general development of the human embryo at the eleventh or twelfth week.

At about the eleventh week a notable change has taken place in the shape of the dentin papillæ, which have now assumed the forms of the crowns of the teeth which they represent. At this time, also, a narrowing or constriction takes place at the base of the papilla, forming a kind of neck at the free border of the enamel-organ (Fig. 113).

In examining vertical sections of the dentin bulb at this period, the existence of a thin, clear, transparent zone of amorphous material upon the periphery of the organ is discovered. This amorphous material is destitute of anatomic elements, somewhat more transparent and denser than the subjacent tissue of the dentin papilla, and capable of being detached from the surface of the latter. This condition led Raschkow and others to suppose the papilla to be invested with a distinct membrane, the *membrana præformativa* of Raschkow, and the *membrana eboris* of later writers. This zone of amorphous material lies between the enamel-organ and the dentin papilla (Fig. 115).

Black, in speaking of this layer, says, "Just before the calcification, and even before the odontoblasts make their appearance, the ameloblasts and the tissues of the pulp are separated by a well-marked double pellucid layer, which in section appears as a double band." Andrews says, "If the tissue has been carefully prepared, minute glistening bodies—*calcospherites*—are seen under the higher powers of the microscope, in the dentin bulb and within this layer, which indicates the near approach of the process of calcification. The first layer of odontoblasts is formed within the transparent amorphous material, and although the ameloblasts make their appearance first, calcification does not take place in them until after the odontoblasts have formed a cap of calcified dentin upon which the enamel-rods are to rest (Fig. 116).

The character of the cells contained within the body of the enamel-organ have also become greatly changed, and appear as stellate bodies within a reticular structure (Fig. 117).

The next important change in the process of development is seen at about the sixteenth week, in the form of a tiny but well-defined cap of calcified dentin at the tips of the incisors and cuspids, and about a week later in the molars (Fig. 118). Calcification has not yet begun in the ameloblasts, although they are fully developed and well defined. The primitive epithelial cord is still attached to the enamel-organ, and the sac is not yet closed.

Another important change also takes place at this time,—viz., the budding of all the primitive cords upon their lingual aspect to furnish the enamel-organs for the ten anterior permanent teeth in each jaw. The buds rapidly assume a pear-shaped form, as shown in Fig. 119, followed by the appearance of the dentin papillæ and invagination of the enamel-organs shown in Fig. 120.

Black believes the epithelial cords of the permanent follicles often spring directly from the Malpighian layer of the epithelial band (Fig. 121), instead of from the primitive epithelial cords, as taught by Legros and Magitot.

At the eighteenth or nineteenth week the sacs of the primitive dental follicles are closed, and the follicles separated from their epithelial cords

FIG. 114.—Human embryo at eleven to twelve weeks after conception.

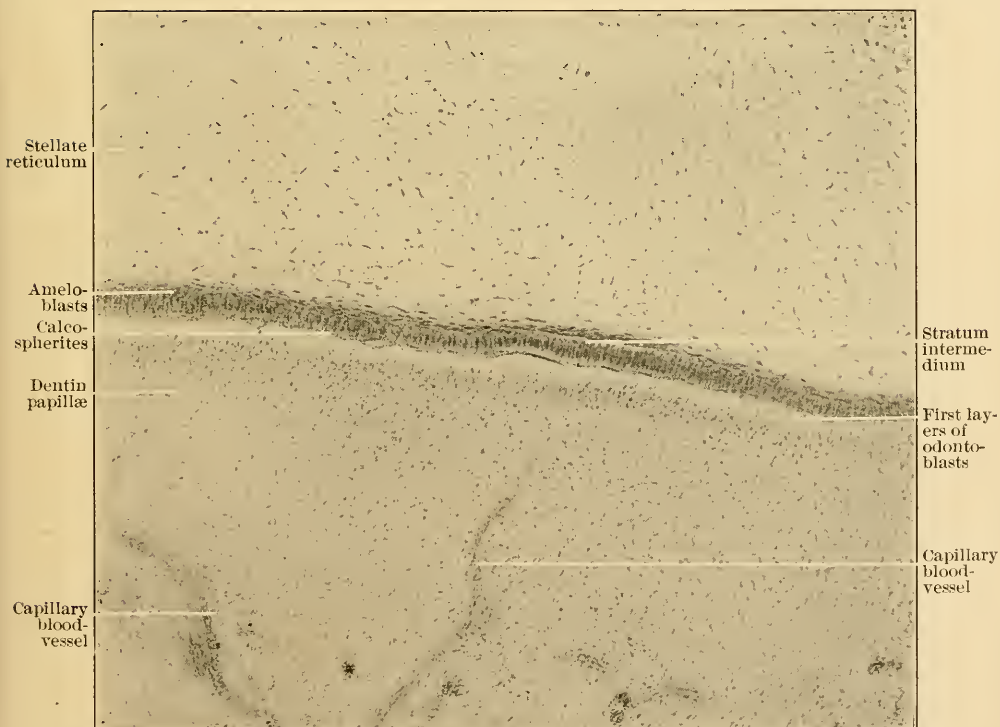


FIG. 115.—Vertical section of human molar at junction of enamel-organ with dentin papillæ, showing early stage of cell differentiation and zone of amorphous material. (V. A. Latham.) × 300.

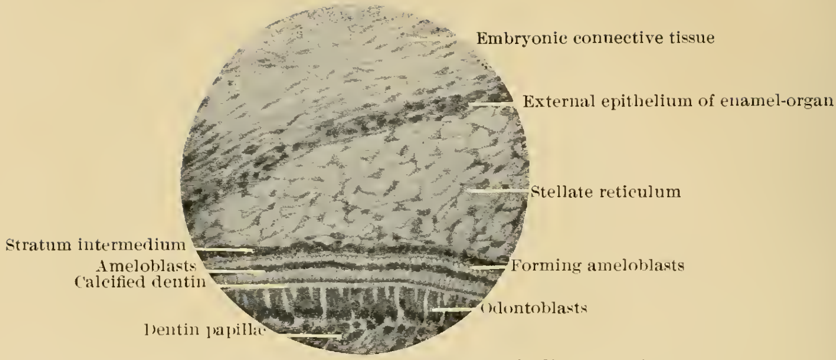


FIG. 116.—Vertical section of incisor of human fœtus (partly diagrammatic).

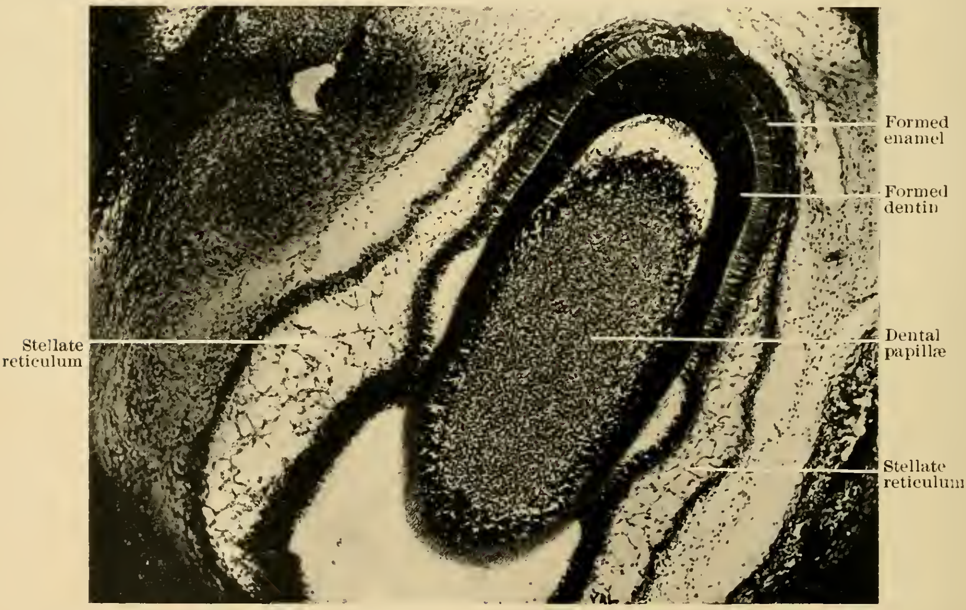


FIG. 117.—Oblique section of a dental follicle, showing stellate reticulum of the enamel-organ. × 83.

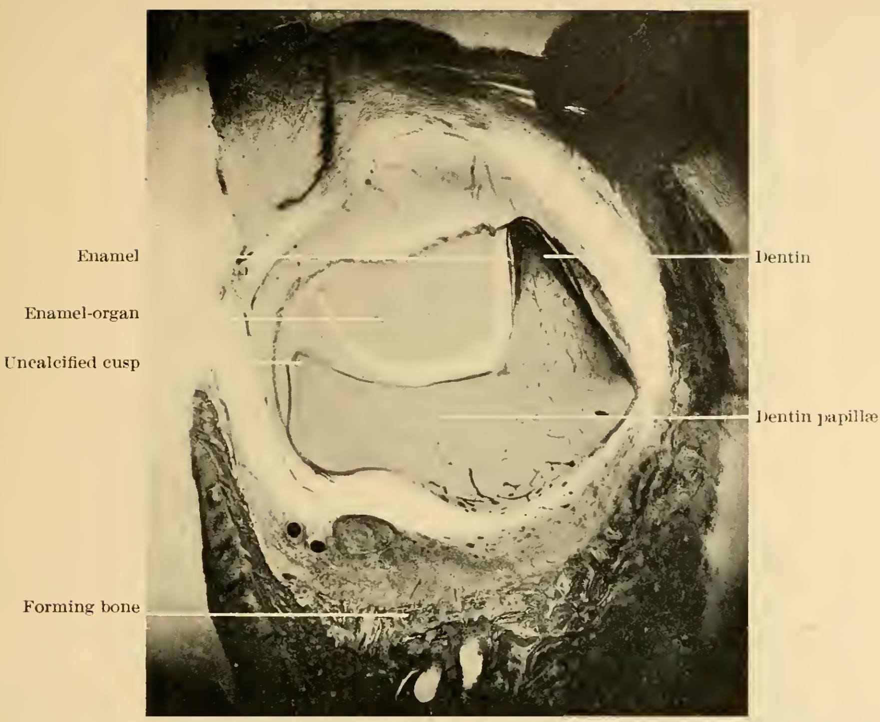


FIG. 118.—Vertical section of human molar, showing early stage of calcification of dentin and enamel. × 90.

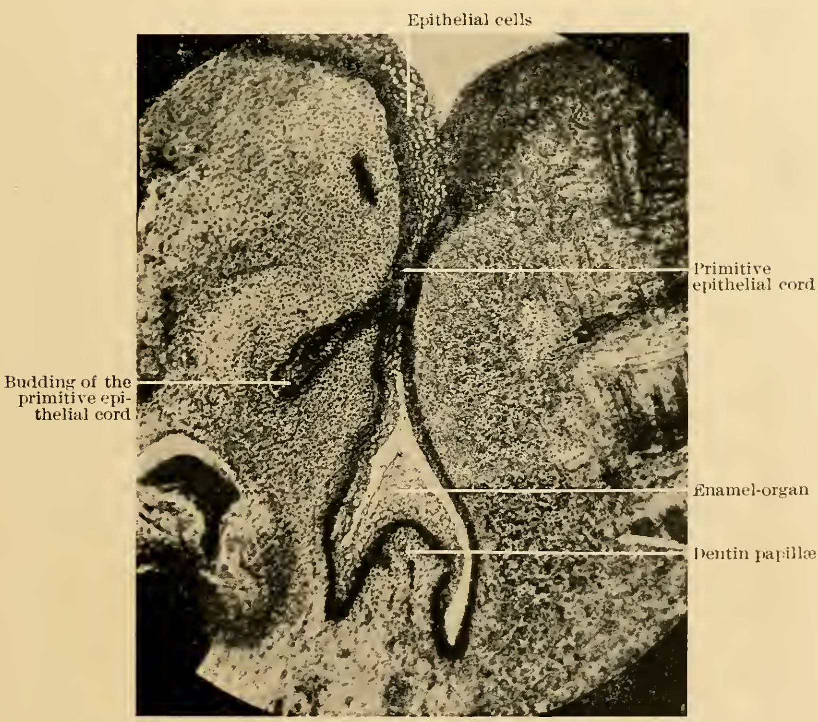


FIG. 119.—Vertical section of cuspid of human fœtus, showing the budding of the primitive epithelial cord. × 70.

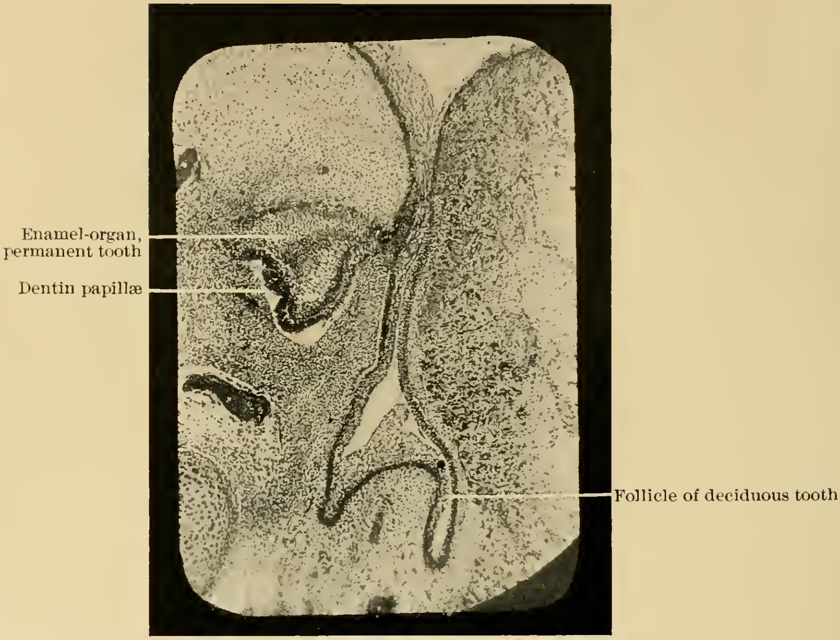


FIG. 120.—Vertical section of human fœtal maxilla, showing the deciduous follicle and pear-shaped enlargement and commencing invagination of the enamel-organ of the permanent cuspid. × 70.

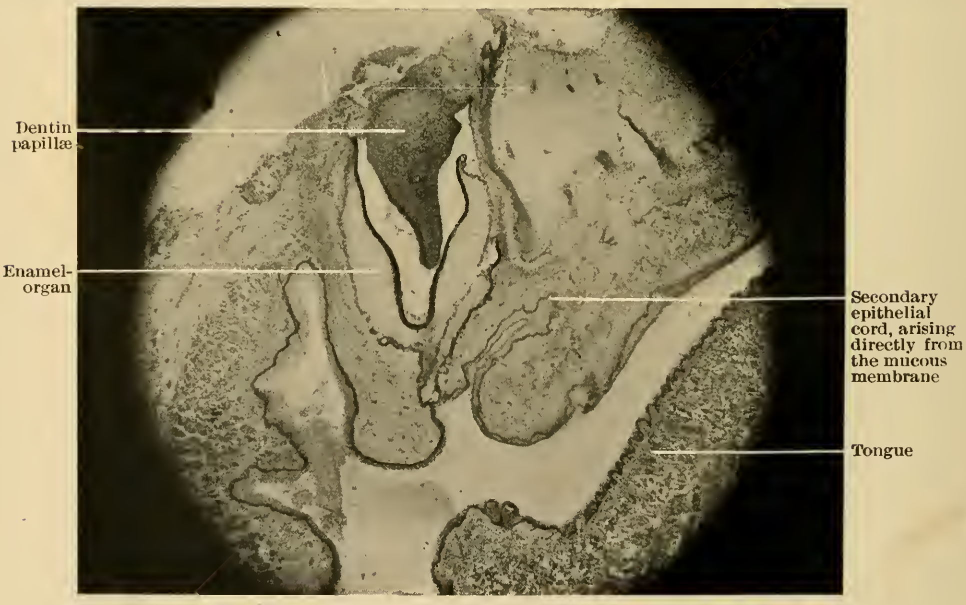


FIG. 121.—Vertical section of incisor tooth, human embryo. Superior maxilla. (V. A. Latham.) × 50.

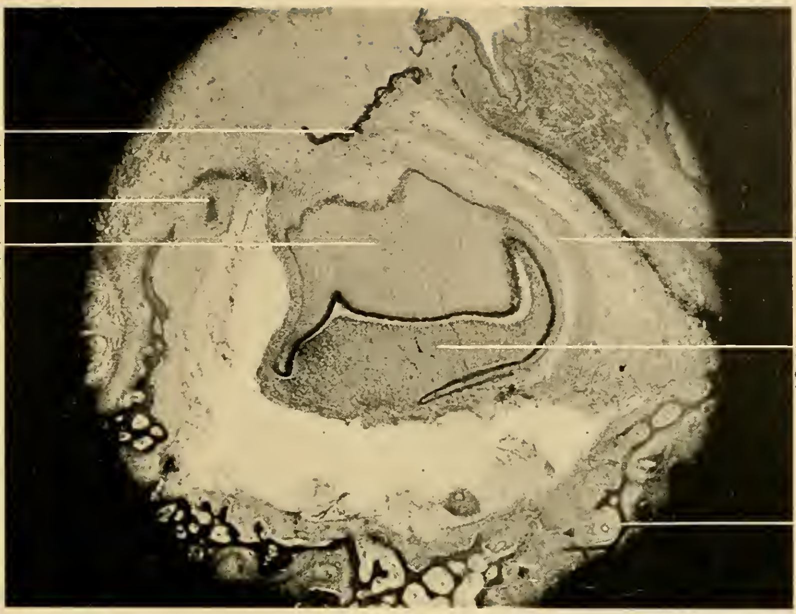


FIG. 122.—Section of human developing tooth, showing the follicle closed and the primary epithelial cord severed from its enamel-organ.

FIG. 123.—Vertical section of dental follicle of cat, showing the follicle closed. , 9.

FIG. 124.—Vertical section of cuspid, human fœtus, showing complete closure of the sac. × 50.

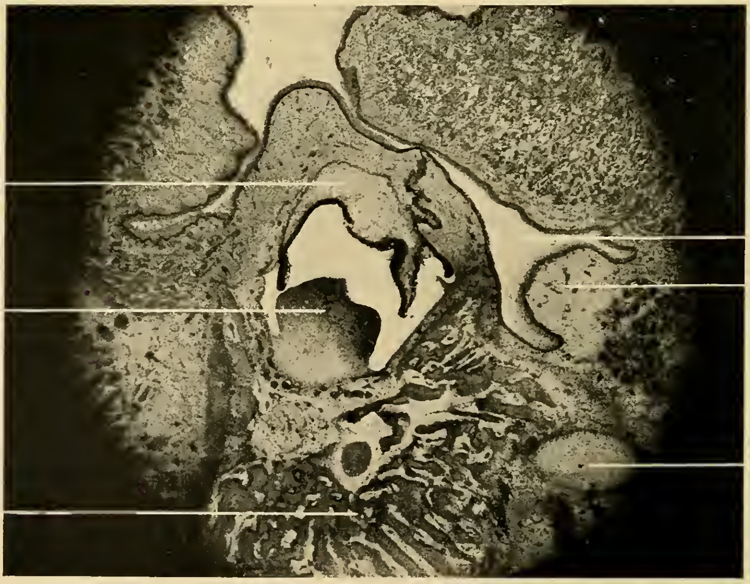


FIG. 125.—Vertical section of molar, human fœtus, showing deciduous follicle and complete invagination of the enamel-organ of the permanent follicle. × 70.

(Figs. 122, 123, and 124), then evolution goes on without further connection with the parent epithelial layer.

The follicles of the permanent teeth (Fig. 125) remain attached to the cord from which they had their origin, sink deeper into the embryonal tissues, and take their places beneath the follicles of the deciduous teeth which they are at a later period to replace.

The permanent molar teeth do not have their origin from the epithelial cords of the deciduous teeth. The follicle of the first permanent molar has its genesis at the posterior end of the epithelial lamina, beyond the origin of the follicle of the second deciduous molar in a bud derived directly from the epithelial lamina at about the seventeenth week. The follicle of the second permanent molar has its origin in a bud given off from the epithelial cord of the first permanent molar at about the second or third month after birth, while the follicle of the third permanent molar is evolved in the same manner from the epithelial cord of the second permanent molar at about the third year after birth.

Sudduth and Broomell believe, as a rule, the epithelial cords of the permanent molars arise directly from the Malpighian layer of the oral mucous membrane, while Bödecker maintains that all the permanent molar teeth are an offspring of the enamel-organs of the second deciduous molars.

It is not necessary to follow the various phases of the evolution of the follicles of the *permanent teeth* farther, as they are identical with those described as occurring in the development of the *deciduous teeth.*

CHAPTER III.

HISTOLOGY OF THE DENTAL TISSUES.

Calcification.—In the preceding chapter the process of development of the dental organs was studied to the stage of calcification of the dentin and enamel. It was then noticed that although the enamel-organ was the first to be formed, and that a layer of specialized columnar epithelial cells, the *ameloblasts*, were arranged in a definite order resting upon the coronal surface of the *dentinal papilla* or dentin germ (Fig. 126), apparently ready for the process of calcification; it is not until later that the deposition of lime salts really begins for the formation of the enamel. The formation of the dentin begins first by the development of a layer of specialized connective-tissue cells, the *odontoblasts*, covering the dentin germ; and these immediately begin the process of building the first tiny cap of dentin upon each of the lobes or centres of calcification by the deposition of lime-salts.

The odontoblastic cells, which are clearly defined, are somewhat broader than the ameloblasts, which are situated immediately above them, and are arranged in a single layer. They are at this stage ovoid in form, and are apparently embedded in a transparent and structureless gelatinous substance, in which small globular masses—calcospherites—are already forming.

The function of the odontoblasts is to superintend the process of calcification of the dentin by the deposition of calcific material, layer within layer, upon the coronal surface of the dentin germ, which by this process constantly decreases in size until the limit of nature is reached.

The function of the ameloblast is also that of superintending the laying down of the lime-salts which are to form almost the entire bulk of this tissue.

Definition.—The term *calcification* comes from the Latin, *calx*, lime, and *fiere*, to become,—to become lime; hence the term is used to express the physiologic process by which a deposition of calcium salts, or other insoluble crystalline matter, is laid down within an especially prepared matrix, as in the formation of bone, cementum, dentin, and enamel; or a pathologic deposition of calcareous materials within tissues where they do not normally belong, as in the calcification of the arteries, inorganic deposits within serous membranes; the calcification of tubercular deposits, etc.

By the physiologic process of calcification various tissues are formed or built up,—by the aid of especially endowed cells,—like bone, cementum, dentin, and enamel. The exact *modus operandi* by which this process is accomplished has not been fully established.

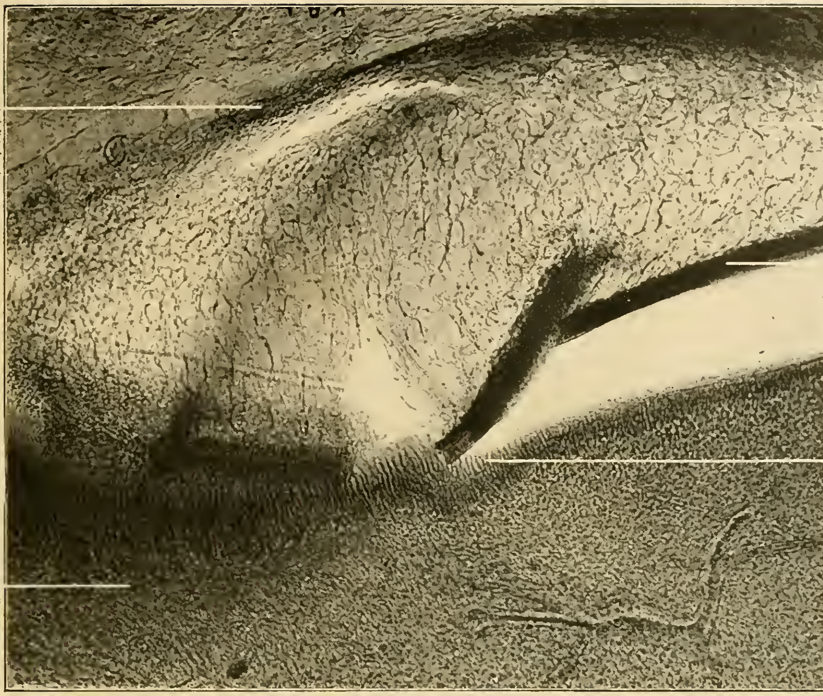


FIG. 126.—Section of dental follicle, showing first layers of ameloblasts and odontoblasts. × 1000.

FIG. 127.—Section of human femur, six months' fœtus, showing osteoblasts. × 109.

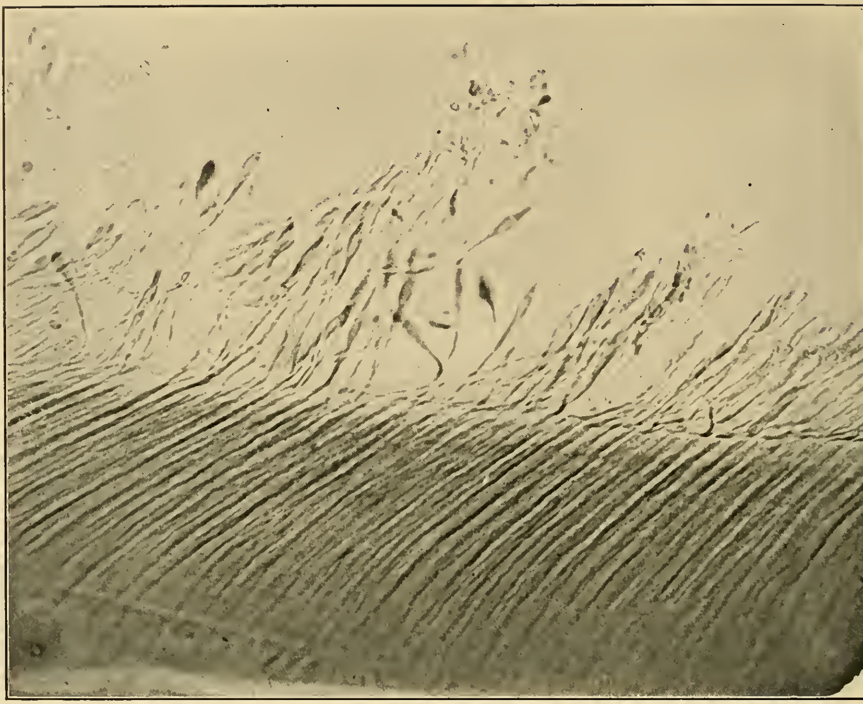


FIG. 128.—Forming dentin, showing odontoblasts. (V. A. Latham.) × 1000.

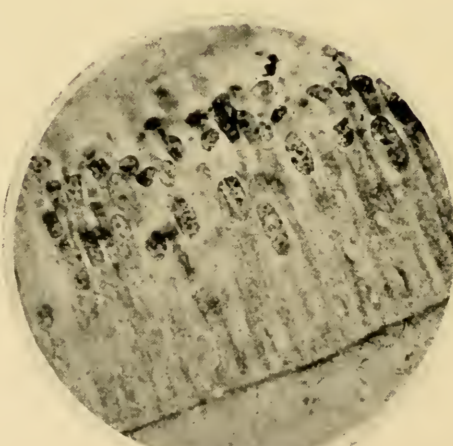


FIG. 129.—Enamel-cells, with nuclei. (R. R. Andrews.)

That these especially endowed cells, *osteoblasts*, or bone-builders (Fig. 127), *cementoblasts*, or cement-builders, *odontoblasts*, or dentin-builders (Fig. 128), and *ameloblasts*, or enamel-builders (Fig. 129), are the active agents in the construction of these tissues is a generally conceded fact.

The term used to express calcification of the bone is *ossification;* in the calcification of cementum, *cementification;* in the calcification of dentin, *dentinification;* and in the calcification of enamel, *amelification.* The process in the first three of these is substantially the same.

There are two methods by which a calcified tissue may be formed,—one by the deposition of calcium salts within the substance of a formative organ, thus converting it into a calcified structure; and the other by a formative organ excreting from its surface both organic and inorganic constituents. The former method is the process by which bone, cementum, and dentin are formed; while the latter is the process by which the shells of many mollusks are developed, and by most histologists thought to be the method by which enamel is built up.

The calcium and other salts necessary for the calcification of these tissues are held in solution or in minute particles, so small as to be almost beyond the reach of demonstration by the highest powers of the microscope, in the gelatinous or protoplasmic fluid in which these specialized cells are embedded. It is from this fluid or semi-fluid medium, the intercellular substance, charged with these salts, that the cells derive the necessary pabulum for their nourishment and for the performance of their functions. The supply of nourishment is derived and maintained by the abundant vascular net-work of the neighborhood.

Rainey discovered, and Professor Harting and Dr. Ord further elucidated the fact, that the calcium salts in the presence of albuminoid substances are changed chemically, uniting with the organic compounds to form small globular bodies which were afterwards called *calcospherites.* These bodies are always present in the intercellular substance just before and during the process of calcification.

Rainey found in experimenting with the calcium salts that if calcium carbonate be slowly formed in a thick solution of mucilage or albumin, it resulted in the formation of tiny globules, laminated in structure, from the centre outward; these globules when in contact coalesced to form single laminæ in larger masses.

In the laminated structure of the larger masses, formed by the coalescence of the tiny globules into single laminæ one upon another, Rainey claimed to find the explanation of the development of shells, bones, and teeth. A precipitate of calcium carbonate alone in gelatin was at first membranous, but rapidly passed into the globular and crystalline forms, while a precipitate of calcium phosphate alone became at once crystalline, without passing through any colloid stage, but a precipitate of the bicarbonates and phosphates retained for an indefinite period the colloid form. This is interesting from the fact that in calcified tissues like bone, dentin, and enamel, the carbonates and phosphates are invariably found associated together.

Professor Harting discovered that the calcospherite is composed of a "profoundly modified albumin," which he termed *calcoglobulin*, and in which the calcium salts are held in some form of chemical combination. The calcoglobulin, which is the matrix of the calcospherite, is exceedingly resistant to the action of acids, alkalies, and boiling water, and is capable of maintaining its form and structure even after the greater portion of the calcium has been removed.

Tomes, in commenting upon the character of calcoglobulin, says, "It is a very suggestive fact that in the investigation of calcification we constantly meet with structures remarkable for their indestructibility; for example, if we destroy the dentin by the action of very strong acids or by variously contrived processes of decalcification, putrefaction, etc., there remains behind a tangled mass of tubes (Fig. 130), the "dentinal sheaths" of Neumann, which are really the immediate walls of the dentinal tubes.

Or if bone be disintegrated by certain methods, there remain behind large tubes, found to be the linings of the Haversian canals (Kölliker), and small rounded bodies recognizable as isolated lacunæ; and in the cuticula dentis—Nasmyth's membrane—we have another excellent example of this peculiarly indestructible tissue.

In point of fact, as will be better seen after the development of the dental tissue has been more fully described, on the borderland of calcification, between the completed fully calcified tissue and the formative matrix as yet not fully impregnated with lime, there very constantly exists a stratum of tissue which in its physical and chemical properties very much resembles calcoglobulin.

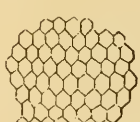
It would seem, therefore, that the indestructible organic matrix of bone, cementum, dentin, and the cuticula dentis was in all probability composed of this "profoundly modified" albumin, "calcoglobulin."

Hoppe-Seyler believes the calcium salt which chiefly enters into the hardening process in the calcification of bone, dentin, and enamel, is a double salt of carbonate and phosphate, one equivalent of calcium carbonate combined with three equivalents of calcium phosphate.

ENAMEL.

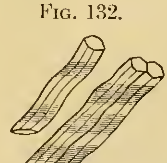
Definition.—Enamel is a vitreous, hyaline substance, covering the entire crown of the tooth in varying thickness, and composed chiefly of phosphate and carbonate of calcium.

FIG. 131.



Section of enamel at right angles to the course of its columns, exhibiting the six-sided character of the latter; highly magnified.

FIG. 132.



Three enamel-columns, exhibiting the six-sided prismatic and waving or varicose character; highly magnified.

Histologically, enamel is composed of numerous minute hexagonal prisms (Fig. 131), measuring in transverse diameter from 0.0034 to 0.0045 millimetre and in length from three to five millimetres (Frey), and having

FIG. 130.—Dentinal sheaths, the residue which remains after decalcification of dentin with strong acids. × 70.

FIG. 133.—Section of developing human molar. Enamel teased from the dentin, and showing ends of enamel-rods. × 1000.

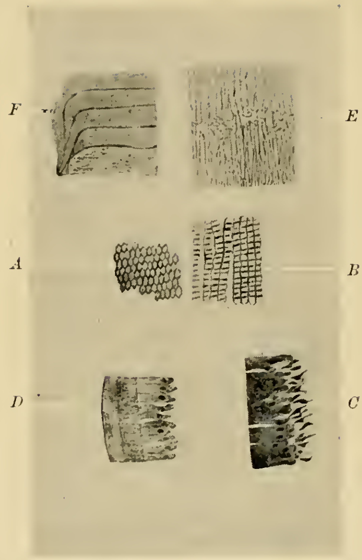


FIG. 134.—*A*, transverse section of enamel-rods; *B*, longitudinal section of enamel-rods: *C*, odontoblasts, showing processes; *D*, odontoblasts, fœtal kitten; *E*, dentin, showing interglobular spaces; *F*. dentin, showing laminated structure. (After Stowell.)

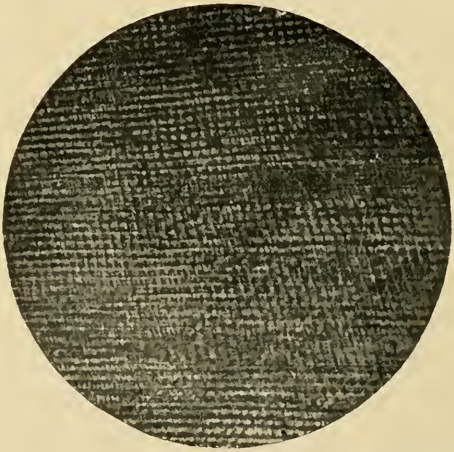
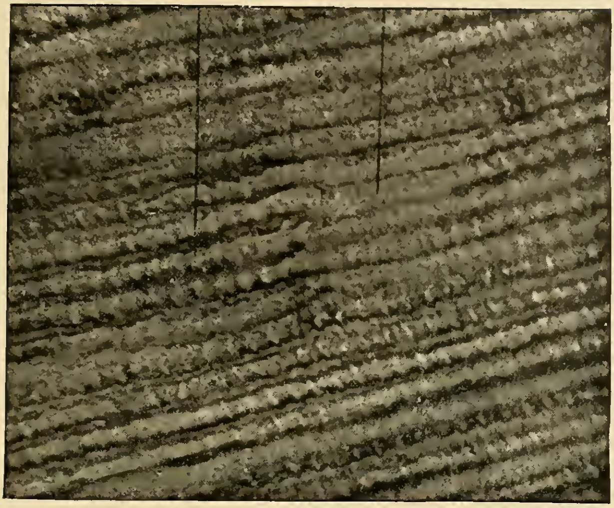
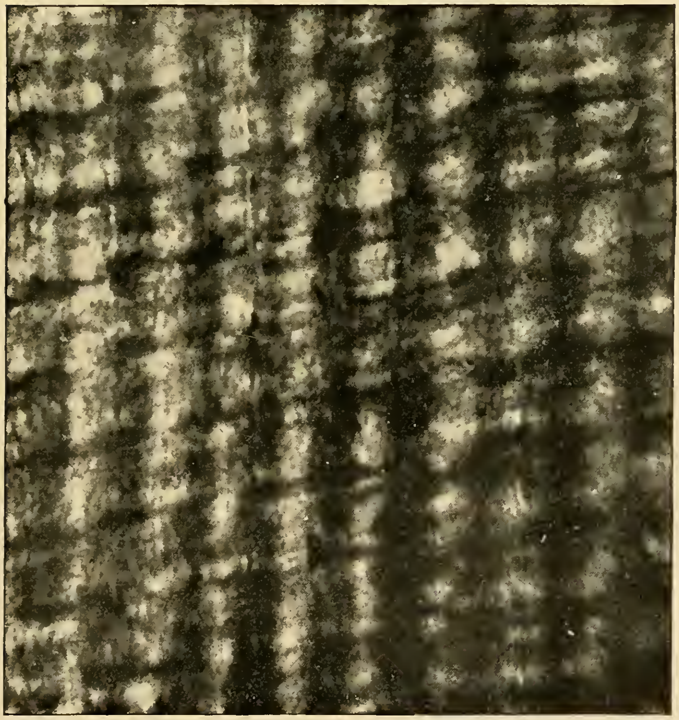


FIG. 135.—Vertical section of enamel-rods, showing their varicosities. × 350.

PLATE I.

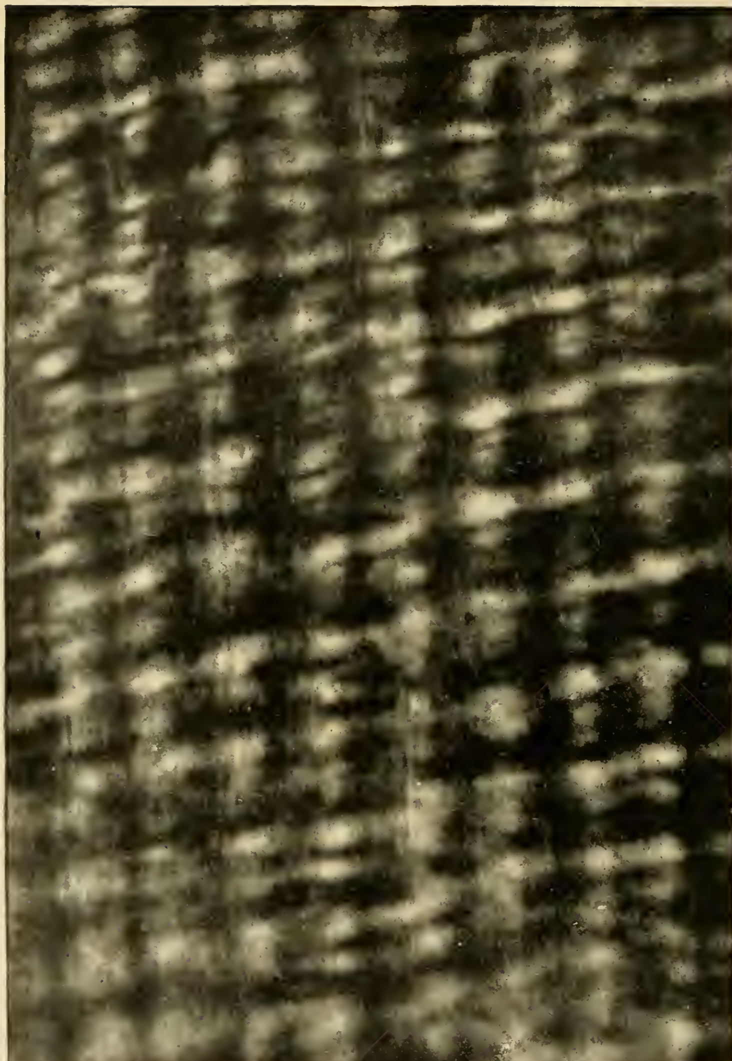


Showing varicosed enamel-rods. (After Dr. J. Leon Williams.)



Showing varicosed enamel-rods more highly magnified. (After Dr. J. Leon Williams.)

PLATE II.



Showing varicosed enamel-rods very highly magnified. (After Dr. J. Leon Williams.)

a common direction at right angles to the surface of the dentin upon which they rest.

These prisms are known as enamel-prisms, enamel-rods, or enamel-columns. As a rule, the rods are continuous from the dentin to the outer surface, and with the exception of numerous varicosities, are the same size throughout their entire length; they are not perfectly straight, however, but have a wave-like or spiral course (Fig. 132). At the outer surface, and particularly at the angles of the crown, numerous short rods are found, which extend only a little distance from the surface, and fill in the interspaces between the longer rods caused by the increase in the circumference of the outer surface and the turning of the angles.

A section of enamel viewed from the ends of the rods or prisms has the appearance of a finely tessellated pavement (Fig. 133). The rods are hexagonal in outline (Fig. 134, *A*), and are separated from each other by an interprismatic substance, the nature of which has formed a subject for much discussion (Fig. 134, *B*).

The individual enamel-rods appear under the higher powers of the microscope to be regularly varicosed, the varicosities not interdigitating as formerly taught, but opposite each other, and the interspaces filled with the interprismatic substance (Fig. 135).

Transverse Striations.—With the exception of faint transverse striations, the enamel-rods seem to be structureless. Hertz claimed this appearance was due to intermittent calcification of the enamel-rods. Kölliker and Waldeyer believed the striations were due to the varicosities of the individual fibres. Bödecker declares that normal, fully developed enamel is non-striated, and von Ebner holds the same opinion, and claims that this appearance of transverse striations is due to the method of preparing the specimens, which are usually mounted in Canada balsam, and as a result suffer from a slight acid reaction sufficient to produce the striated appearance. Sudduth and Febiger hold to the opinion of Kölliker and Waldeyer, that the striations are due to the varicosities. Williams also maintains the same opinion, and in his recent investigations denies the statements made by Hertz, Bödecker, and von Ebner, and claims that while in some specimens the varicosities are dimly apparent in some parts, they are decided in others, but that they are always present. It has also been stated that each varicosity represents a calcified ameloblast, but Williams claims that he has counted fifteen such varicosities within the length of a single ameloblast, and that he has never found less than eight to each cell. The varicosities he believes to be due to the globular form of the individual enamel-globules which build up the enamel-rods. (See Plates I. and II.)

Brown Striæ of Retzius.—With low powers of the microscope another and larger form of striation is visible, consisting of brownish lines (Fig. 136), the "brown striæ of Retzius." They are seen in broad lines, nearly or quite parallel with the outer surface of the enamel.

Tomes suggests that inasmuch as they coincide with what was at one time the outer surface of the enamel cusp, they are in some sense marks of its stratification in its primary deposit. Williams is of the opinion that they are due to a real pigmentation.

Lines of Schreger.—Another class of markings upon the surface of sections of enamel are known as the "lines of Schreger." These lines are invisible by transmitted light; but with reflected light are plainly seen. They are well defined at the point nearest the dentin, but become gradually less marked as the outer surface of the enamel is reached; irregularly formed lines extending in a longitudinal direction with the enamel-rods are sometimes seen in the enamel near the surface of the dentin. They have the appearance of open spaces or cavities, and are sometimes in communication with the dentinal tubes. Cracks and fissures are often seen upon the surface of the enamel, but these have no special significance except as they may be predisposing causes of dental caries.

Nasmyth's Membrane.—Covering the enamel of young, newly erupted teeth is a thin membrane, the *cuticula dentis*, or Nasmyth's membrane. This membrane is thought to be formed from the outer layer or tunic of the enamel-organ, and measures in thickness from 0.001 to 0.0013 millimetre. It is exceedingly resistant to the strongest acids, alkalies, boiling, and maceration, but is soon worn from the teeth by the friction of mastication. It yields no gluten. (Kölliker).

Chemic Composition of Enamel.—Enamel is the hardest structure of the body, and at the same time, by the arrangement and character of its component parts is capable of great resistance to mechanical force and the attrition due to the mastication of food. It is almost if not entirely destitute of organic matter, and possesses no nutritive canals.

Von Bibra gives two analyses of enamel, the first from an adult man, the second from an adult woman.

	1. Man.	2. Woman.
Calcium phosphate and fluoride	89.82	81.63
Calcium carbonate	4.37	8.88
Magnesium phosphate	1.34	2.55
Other salts	0.88	0.97
Cartilage	3.39	5.97
Fat	0.20	a trace
	100.00	100.00
Organic matter	3.59	5.97
Inorganic matter	96.41	94.03
	100.00	100.00

Williams says, "Enamel is a solid mineral substance, and the finest lenses reveal not the slightest difference between enamel ground moist from the living tooth and that which has lain in the earth for a hundred centuries;" and also, that "mature, completely calcified enamel contains no trace of organic matter, therefore no physiologic change is possible in completely formed enamel."

The chemic analyses which have been published from time to time have estimated the organic material in the enamel of a human adult tooth at from two to seven per cent. The organic material in these analyses was estimated simply by loss of weight on ignition. This is evidently the source of error, for no account is made of water being a constituent of dried enamel. C. Tomes found that after drying elephant's enamel for a

FIG. 136.—Section of enamel, showing the brown striations of Retzius. (V. A. Latham.) × 110.

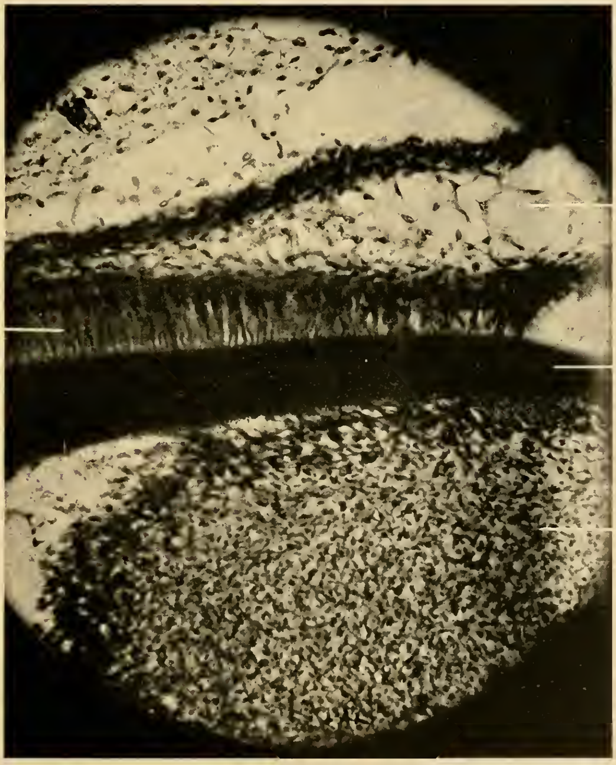


FIG. 137.—Transverse section of dental follicle, showing first layer of ameloblasts. (V. A. Latham.) × 325.

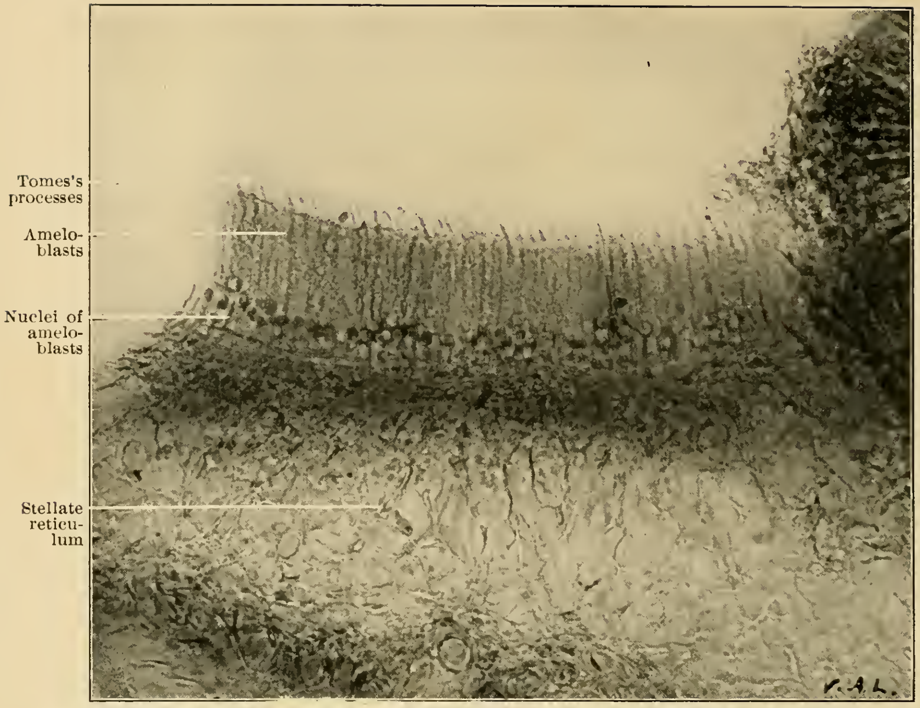


FIG. 138.—Teased section of developing human molar, showing the ameloblasts. (V. A. Latham.) × 1000.

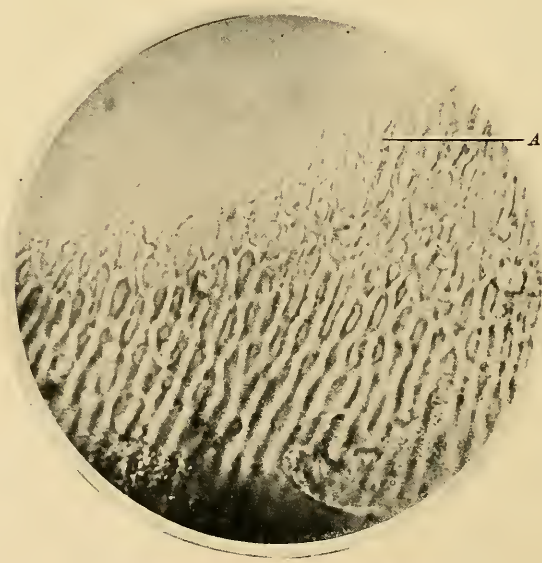


FIG. 139.—Developing enamel, showing Tomes's processes at A. (R. R. Andrews.)

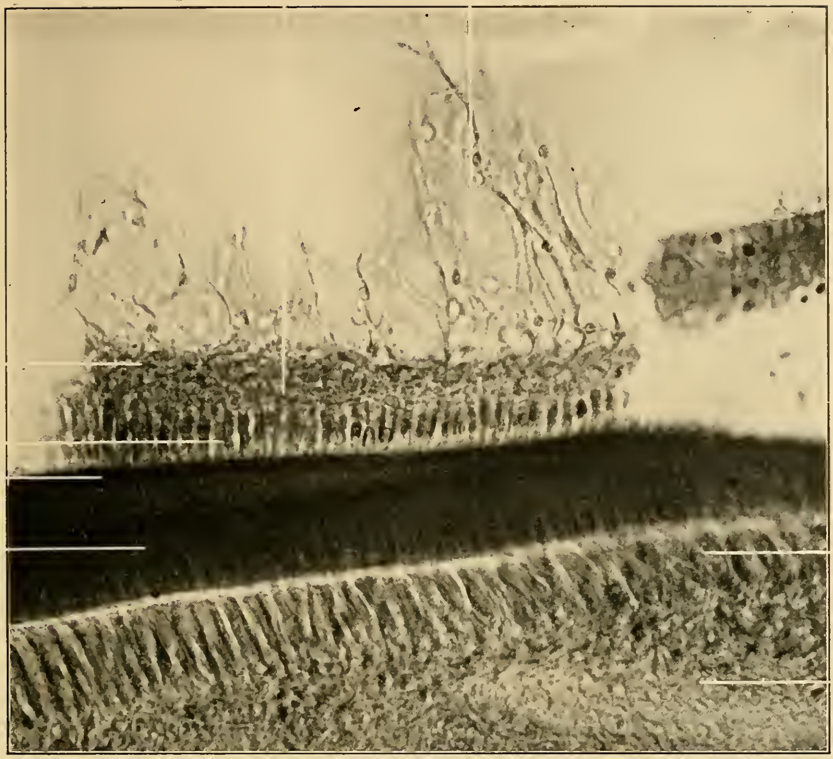


FIG. 140.—Section of developing human molar, showing the relations of the various structures. (V. A. Latham.) × 1000.

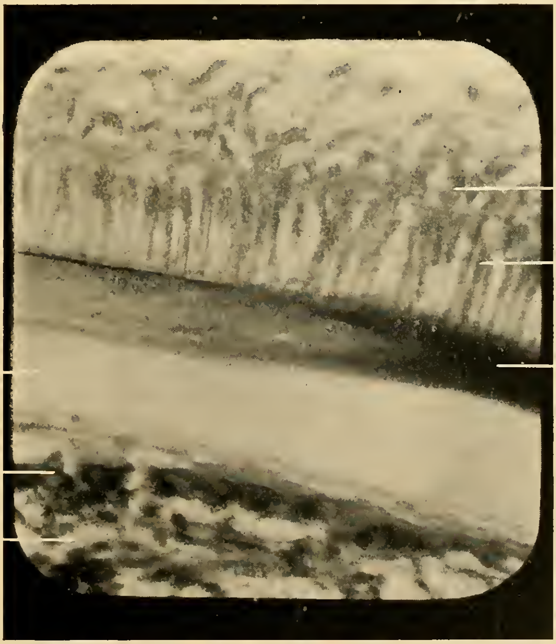


FIG. 141.—Section of developing human tooth, showing ameloblasts highly magnified. (Zeiss one-twelfth oil immersion.)

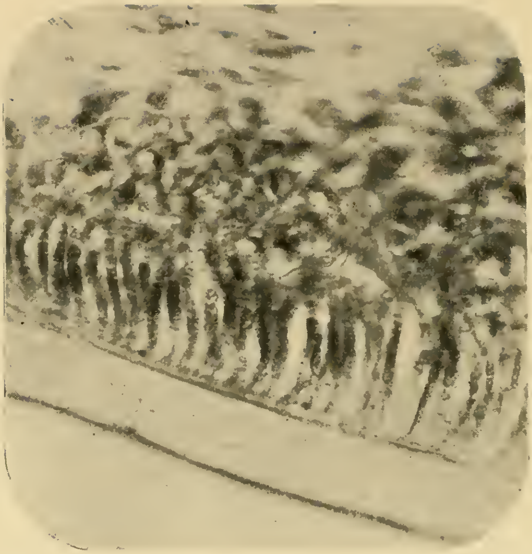


FIG. 142.—Section of developing tooth, showing ameloblasts more highly magnified.

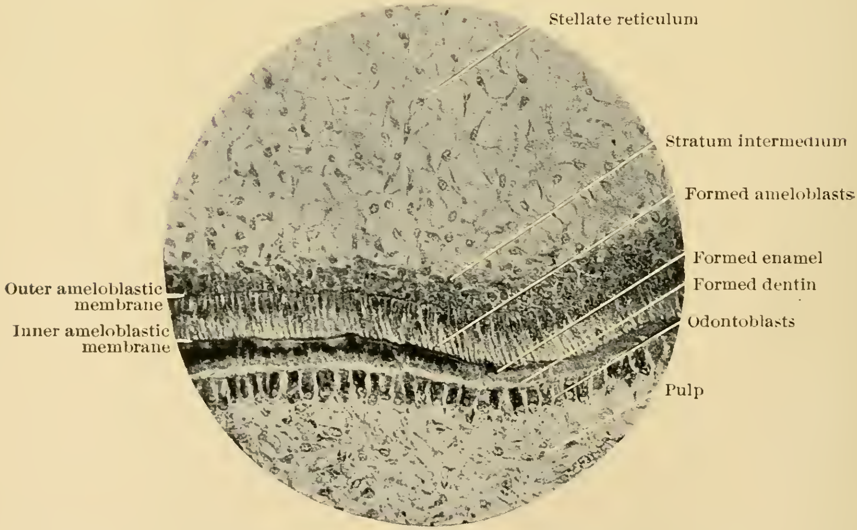


FIG. 143.—Transverse section of developing tooth, showing the arrangement of the tissues. (After Andrews.) × 275.

long time at a temperature of 300° F. that it still contained about four per cent. of water.

In decalcifying sections of fully formed enamel by the aid of acids, it is found that the interprismatic substance is first attacked, and the rods fall apart, which proves conclusively that the interprismatic substance is a calcium cement material, more readily acted upon than the rods themselves. If the process of decalcification is continued, the enamel-rods are attacked, and the whole structure is destroyed, leaving behind no evidence of an organic matrix.

CALCIFICATION OF ENAMEL.

Amelification is the process by which the calcium salts are deposited within the matrix constructed by the ameloblasts for the formation of enamel.

As previously stated, the process of calcification first begins in the *dentin papilla*, by the formation of a layer of dentin at those points which are denominated the lobes of the morsal edge and the cusps of the morsal surface.

Upon this layer of dentin, which is as yet only partially calcified, the first layer of ameloblasts is arranged (Fig. 137). These cells are somewhat in the form of columnar epithelial cells, have oval nuclei and tapering processes projecting from their inner ends,—Tomes's processes (Figs. 138 and 139). The ameloblasts stand close together, with one end resting upon the newly formed dentin, and the other in contact with the stratum intermedium, and this again in contact with the stellate reticulum (Fig. 140). This is further and more beautifully shown in Fig. 141. In this illustration the ameloblasts are seen resting upon the formed enamel, while the opposite ends are in contact with the stratum intermedium. Fig. 142 is a higher magnification of the same section.

Stratum Intermedium.—In the earlier stage of enamel formation, various observers have described the presence of what has appeared to be a structureless membrane lying between the odontoblasts and the first layer of ameloblasts, and another between this layer of ameloblasts and the stratum intermedium, the formation and character of which has not been demonstrated (Fig. 143).

Williams has designated these layers by the terms *inner* and *outer ameloblastic membranes*, and describes them as being composed of a finely fibrous structure. The outer layer or membrane is particularly interesting from the fact that it seems to be composed of two sets of fibres running in nearly opposite directions, but neither direction corresponding with the long axis of the ameloblasts.

One set of these fibres passes in a somewhat more oblique course than the others, and becomes confluent with the ends of the enamel-prisms, while the other set sweep downward in a circular course, crossing the more oblique-running fibres and the enamel-prisms nearly at right angles. Mummery has beautifully shown the interlacing of these fibres.

Sometimes both sets of fibres join and twist about each other in a rope-like design, and pass along the course of the enamel-prisms. A third set of fibres may sometimes be seen running parallel to the ends of the ameloblasts. These fibres, he thinks, are identical with the plasm-strings first discovered by Andrews, which are often visible in the ameloblasts.

With a magnifying power of from one thousand to two thousand three hundred diameters, he discovered the inner and outer ameloblastic membranes to be composed of several layers of protoplasmic strings or fibres. These processes or strings are often seen to emerge from the inner ends of the ameloblasts, and turn to the right and left. He thinks it quite possible that the structures, which he has designated as the *inner* and *outer ameloblastic membranes*, are formed by the accumulation of the calcific albuminous product of the stratum intermedium within the meshes of these plasm-strings, which spread out on both ends of the ameloblasts, forming a structure resembling a membrane (Fig. 144.)

Blood-Supply of the Enamel-Organ.—Wedl, Magitot, Tomes, Sudduth, Andrews, and others have stated that they have uniformly failed to detect blood-vessels in any part of the enamel-organ. A reference to Fig. 145 will show the enamel-organ to be abundantly supplied with blood-vessels, which cover its entire outer surface. But Williams has shown conclusively in recent papers published in the *Dental Cosmos* for 1896 and 1897, accompanied by numerous most excellent photo-micrographs, that not only are blood-vessels seen within the enamel-organ, but that they are found within the stratum intermedium in an intricate plexus. The ameloblasts are surmounted by epithelial papillæ, which Williams terms "secreting papillæ" (Figs. 146 and 147), and these are surrounded by a free distribution of capillary loops. The ameloblasts seem to be connected with the papillæ by root-like processes, which are lost in the substance of the papilla to which they belong.

The papillæ (Figs. 148 and 149) are from five to six times as large as the ameloblasts, and may therefore supply from twenty to twenty-five ameloblasts. These he believes to be secreting organs.

He further states that, although the stratum intermedium in forming human enamel is not very striking in its resemblance to glandular tissue, aside from the arrangement of its blood-vessels, that nevertheless in studies of the evolution of the enamel-organ of the mouse and rat its place among glandular structures at once becomes evident. He also states as his opinion that the function of the stratum intermedium is undoubtedly to select from the blood brought to it by its capillary vessels the necessary material for the construction of the enamel. He explains the difficulty in the theory of the formation of enamel before the development of the stratum intermedium, by suggesting that the *material necessary for the commencement of enamel formation is stored up in the stellate reticulum of the enamel-organ.*

Charles Tomes does not agree with Williams in his conclusions in reference to the presence of blood-vessels in the stratum intermedium or in the supposed secreting function of the papillæ of the stratum intermedium.

Spee and Andrews have taught that the process of calcification of the enamel was due to the deposition of "droplets" or spherules of calcoglobulin formed within the ameloblastic cells, and excreted or shed out

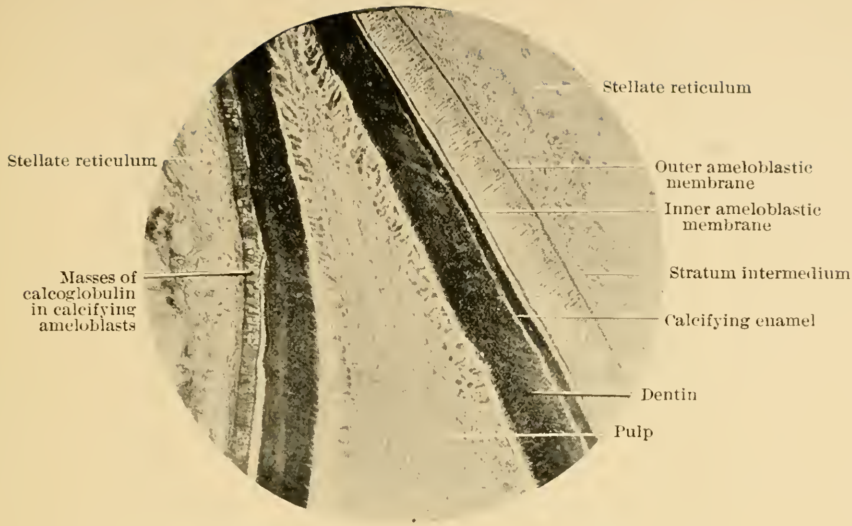


FIG. 144.—Developing tooth of embryo lamb. (After Andrews.) × 105.

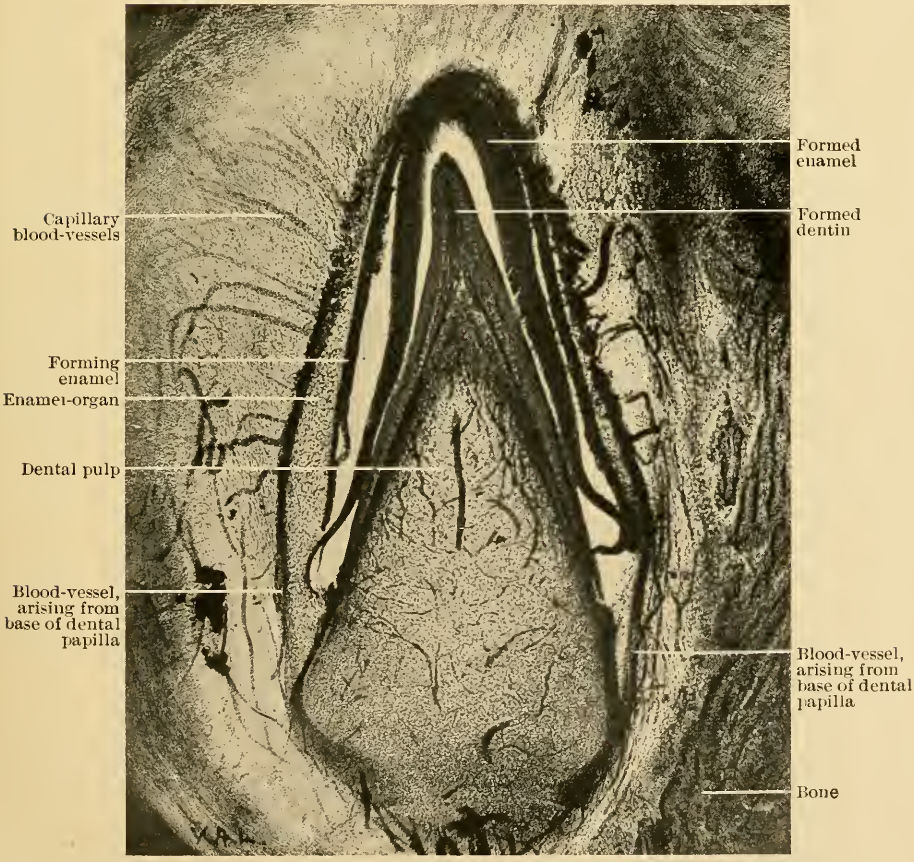


FIG. 145.—Vertical section of central incisor of human fœtus (injected), showing blood-supply of enamel-organ. (V. A. Latham.)

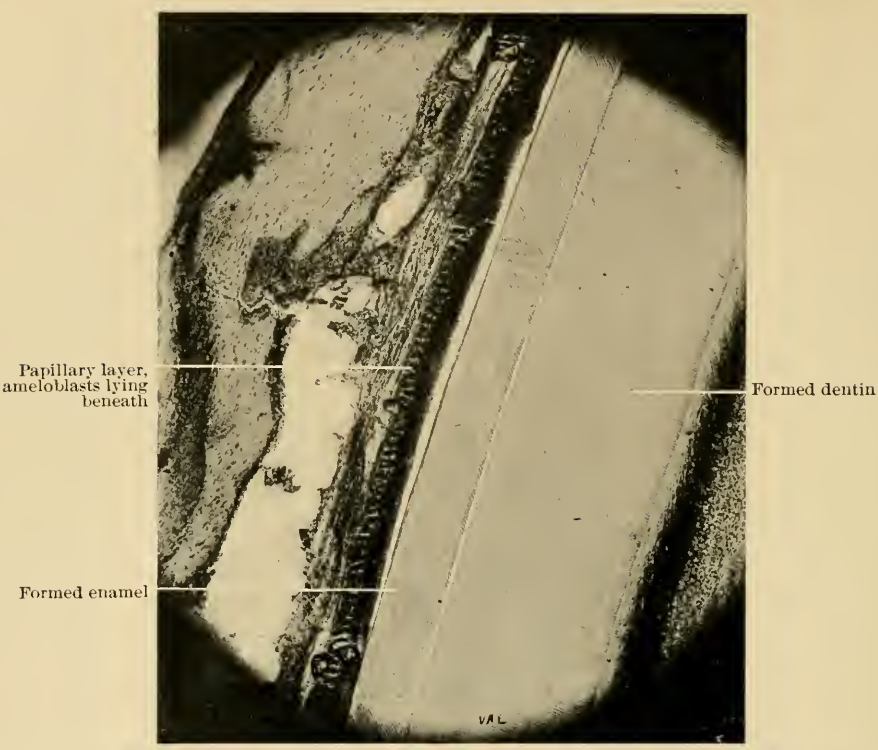


FIG. 146.—Transverse section of dental follicle of rat, showing papillary layer. (V. A. Latham.) × 90.

FIG. 147.—Section of forming enamel from jaw of rat, showing enamel papillæ, blood-vessels, and fibrillæ. (V. A. Latham.) × 325.

FIG. 148.—Section of incisor of a rat. (J. Leon Williams.) × 80. *A*, capillary loops torn out of secreting papillæ; *B*, secreting papillæ after removal of capillary loops; *C*, ameloblasts; *D*, enamel; *E*, dentin.

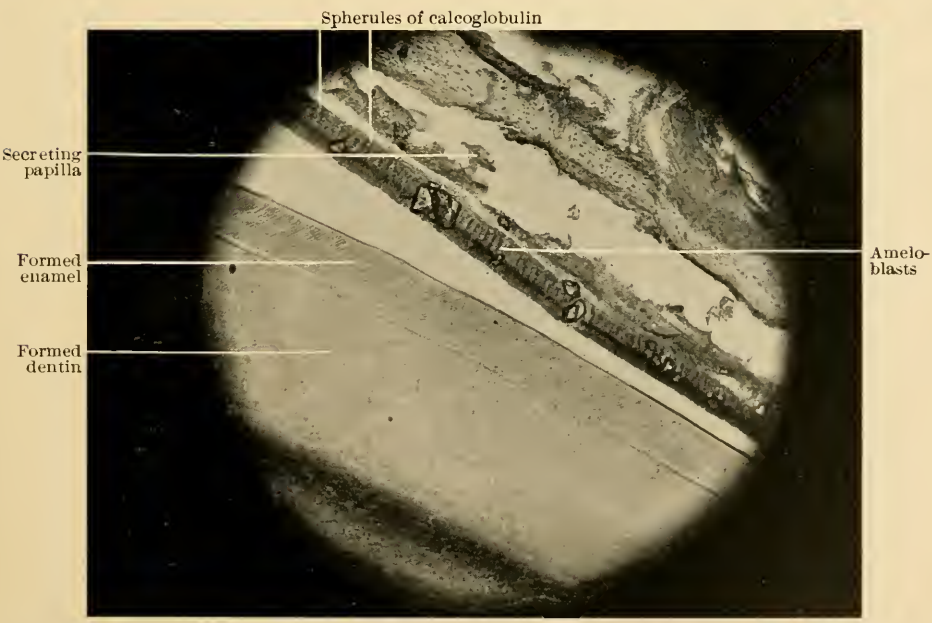


FIG. 149.—Ground section of developing tooth of rat, showing secreting papillæ of Williams. (Von Koch method.) (V. A. Latham.) × 97.

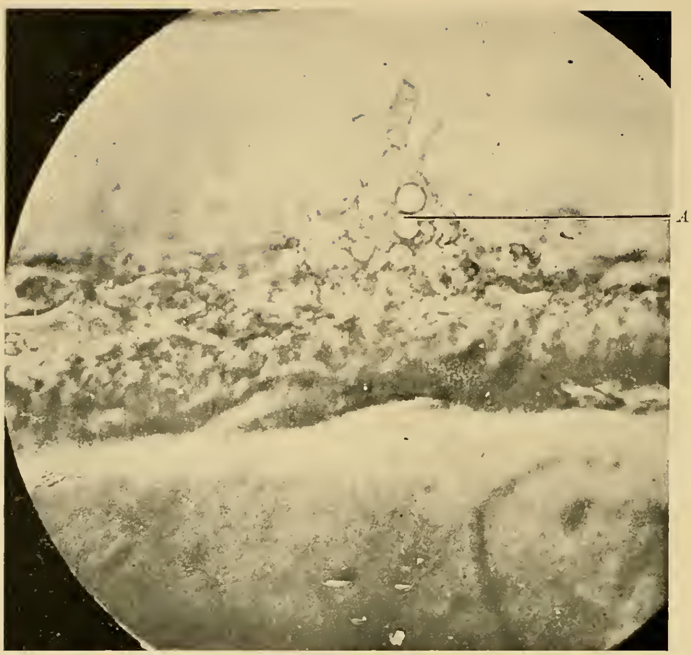


Fig. 150.—Forming enamel. (R. R. Andrews.) *A*, globular bodies of calcoglobulin forming enamel-rods.

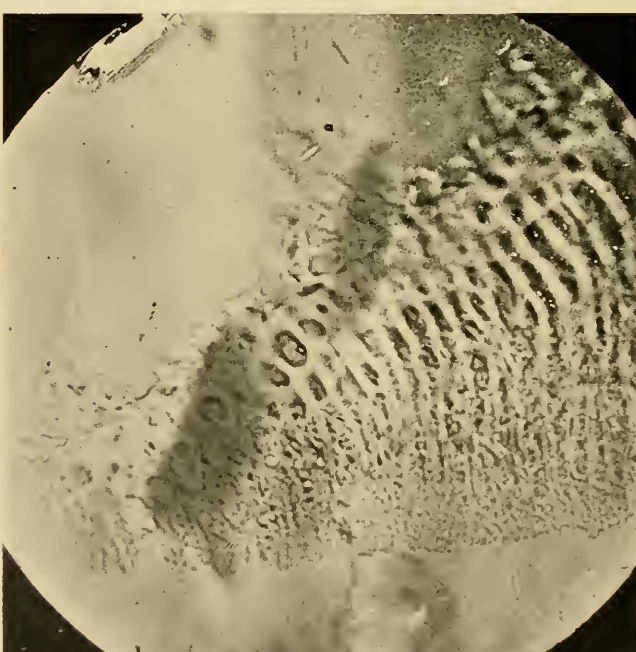


Fig. 151.—Section of forming enamel, showing nucleus of ameloblasts and calcospherites forming the enamel-rods. (R. R. Andrews.)

(Kölliker) by them at the extremities nearest to the odontoblastic layer to form or build up the individual enamel-rods, the fibres of Andrews, acting as a sort of reticulum or scaffolding to determine their arrangement.

Williams states that the "albumin-like substance secreted from the blood-vessels by the cells of the stratum intermedium" is absorbed by the ameloblasts and deposited by them in globular masses, which he terms "enamel-globules," to form the enamel-rods (Fig. 150).

He thinks these "globular masses of spongioplasm" are successively formed within the ameloblasts themselves. "The cytoplasm of the ameloblasts has a fairly uniform structure, which consists of a number of globular masses of spongioplasm of the same diameter as the cell, and united longitudinally by somewhat coarser plasm-strings, the fibres of Andrews.

He says further, "there are many indications that these 'enamel-globules' are formed by the nucleus of the ameloblast, and they appear to pass down the cell by the natural process of growth as new ones are formed above, to be finally shed off the inner ends of the cells onto the surface of the forming enamel, where they become completely infiltrated with the albumin-like lime-conveying substance and calcified" (Fig. 151).

The "enamel-globules," which are uniform in size (Fig. 152), are, according to Williams, quite distinct from the more transparent and irregularly sized masses of calcoglobulin, and that the enamel-rods are built up by the successive, rhythmical, orderly deposit of these "enamel-globules," while the larger and more irregular-sized bodies of calcoglobulin melt and flow together to form the interprismatic substance.

The elder and younger Tomes both held the theory that the cell-wall of the ameloblasts may be calcified to form the interprismatic substance, while the cell-contents solidify into the enamel-rods proper.

Heitzmann and Bödecker promulgated the theory that the interprismatic substance was composed of a reticulum of living matter, and that enamel formation was due to the breaking up of the ameloblasts into "embryonal corpuscles," which afterwards become calcified to form the enamel-rods. This theory for a time dominated the minds of a very large proportion of American dentists, influencing their practice accordingly.

This view taught that physiologic changes took place from time to time in the structure of the enamel through its reticulum of living matter. Later investigations have demonstrated the fact that these authors were mistaken in their conclusions, and as a result the theory has to-day few advocates.

DENTIN.

The **dentin** is an organic calcified tissue, non-vascular, less dense than enamel, and harder than bone, which it somewhat resembles. It forms the central portion and greater bulk of the hard structures of a tooth, completely investing the pulp from which it is generated; it is covered and protected at the crown by a layer of enamel, while the root is encased with a layer of cementum (Figs. 153 and 154.) If the enamel and cementum should be removed, the dentin would still retain the general form and characteristic features of the tooth.

The dentin is a dense, highly elastic substance, white or yellowish-white in color, and to some extent translucent.

Vascular canals are occasionally seen in human dentin, but they are to be considered as abnormal conditions.

The dentin consists of an *organic matrix strongly impregnated with the calcium salts.*

The Matrix.—The matrix of fully formed dentin appears to be structureless, although there are instances in which there are indications that at some time during the development of the dentin connective-tissue fibres were present (Mummery).

The proportions of the organic and inorganic constituents are so variable that no chemic analysis could be considered other than approximating the exact amounts in even the same individual, as the relative quantities are constantly changing from childhood to old age. The relative proportions are also very variable in different individuals.

Von Bibra gives the following analysis of perfectly dried dentin, the first an adult man and the second a woman twenty-five years old :

	1. Man.	2. Woman.
Organic matter (tooth cartilage)	27.61	20.42
Fat	0.40	0.58
Phosphate and fluoride of calcium	66.72	67.54
Carbonate of calcium	3.36	7.97
Phosphate of magnesium	1.08	2.49
Other salts	0.83	1.00
	100.00	100.00

Galippe gives the relative proportions of organic and inorganic matter in dentin as follows :

Water and organic matter	25.29
Mineral matter	74.71
	100.00

Mineral Matter.

Soluble ash (alkaline chlorides and phosphates)	0.54
Calcium carbonate	0.35
Magnesium carbonate	1.13
Calcium	45.11
Magnesium	1.67
Phosphoric acid	23.70
Silicates	0.04
Undetermined	1.30

Black, in his experiments upon the "Physical Characters of the Human Teeth," *Dental Cosmos*, 1895, found the analysis of the dentin of two hundred and sixty-eight teeth taken from one hundred and eleven different persons to give the following results :

Average age of the individuals from whom the teeth were taken was, in years	32.33
Specific gravity of the dentin	20.92
Percentage of water	11.06
Percentage of lime salts	63.54
Percentage of organic matter	25.36

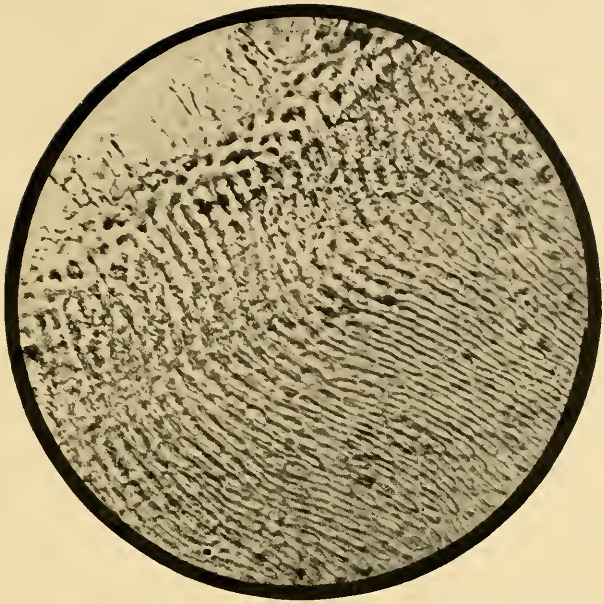


FIG. 152.—Section of forming enamel, calcoglobulin spherites being deposited to form the enamel-rods. (R. R. Andrews.)

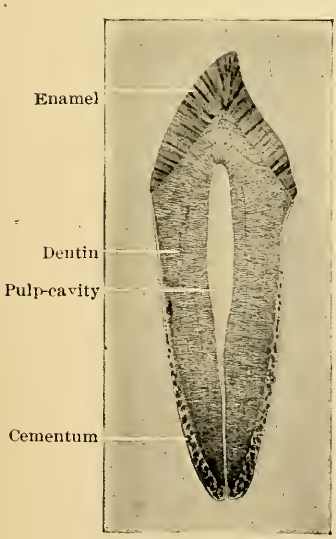


FIG. 153.—Longitudinal section of an incisor. (After Stowell.)

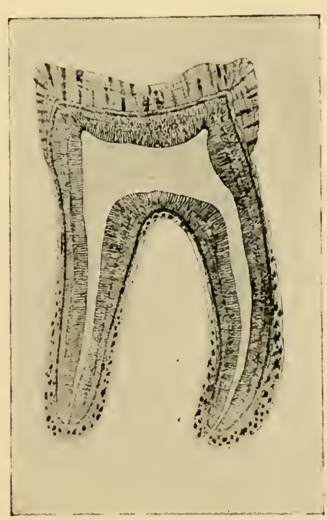


FIG. 154.—Longitudinal section of an inferior molar. (After Stowell.)

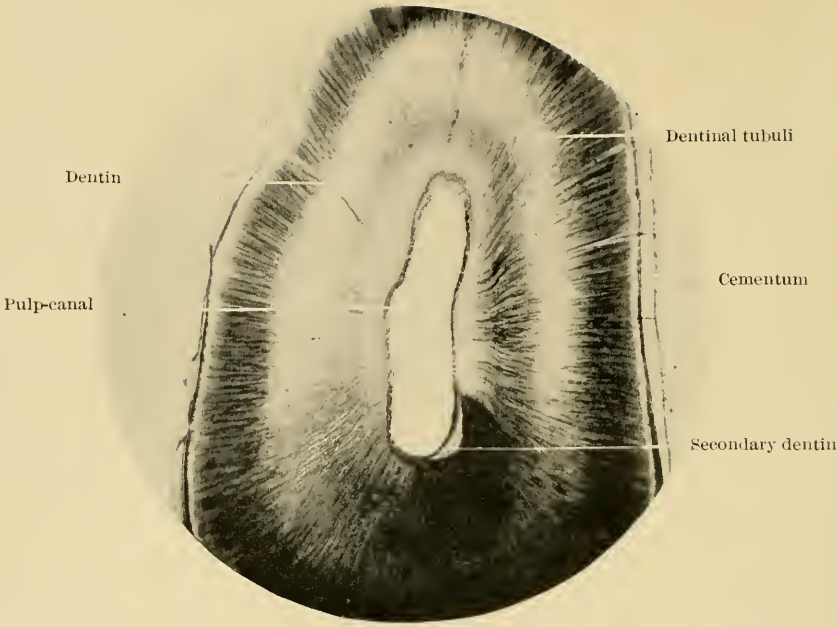


FIG. 155.—Transverse section of root of human bicuspid, showing radiation of the dentinal tubuli.

FIG. 156.—Normal dentin at dento-enamel junction, showing dentinal tubuli. (F. B. Noyes.) × 760.

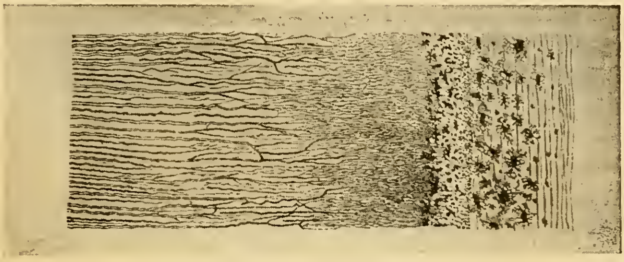
The Dentinal Tubuli.—The matrix is everywhere permeated by a system of parallel canaliculi or tubuli, the *dentinal tubuli*, which radiate from the pulp-cavity towards the outer surface of the dentin (Fig. 155). The diameter of the tubuli is from 0.0011 to 0.0023 millimetre and upward (Frey). (Plate III.)

The dentinal tubules are similar to the canaliculi of bone in that they are provided with a special lining layer or sheath, the *dentinal sheath of Neumann.*

In following the course of the dentinal tubuli, it will be noticed that they do not form a straight line in their passage from the pulp-canal to the surface of the dentin, but that they describe two, more often three, undulating curves, and within these many very small, more or less angular or spiral bends, of which about two hundred may be counted in the length of a line (Fig. 156). (Retzius.)

It is further observed that like the canaliculi of bone the dentinal tubuli give off numerous branches in their course which unite with neighboring tubuli and with each other (Fig. 157). As the tubuli approach the sur-

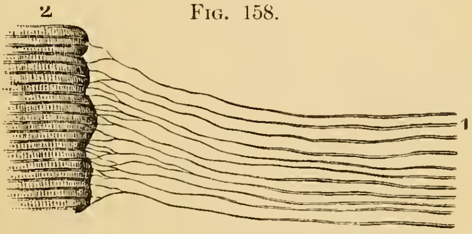
FIG. 157.



Section of root, parallel to dentinal canals. (After Stowell.)

face the division is more rapid, and the size of the branches is correspondingly decreased. At the external surface of the dentin many of the tubules unite by anastomosis (Fig. 158), others terminate in the granular layer of Purkinje and Tomes, while a third set penetrates the cementum and may unite with its lacunæ through their canaliculi; or enter the enamel by means of the open spaces, or interstices between the enamel-

FIG. 158.



1, tubuli of dentin ; 2, enamel.

rods, already referred to as existing in that portion of the enamel next to the dentin (Fig. 159). This system of canals terminates, or rather has its beginning, in free openings upon the internal surface of the pulp-canal.

Fig. 160, which is highly magnified, shows the dentinal fibrillæ crossing from the dentin to the enamel and apparently passing between the enamel rods.

The Dentinal Sheaths.—The dentinal sheaths, or walls of the tubuli, as they are termed, are composed of a singularly indestructible substance, which is peculiarly resistant to the action of acids, boiling in caustic alkalies, or to putrefaction ; caries does not destroy them, and they can also be demonstrated in fossil teeth ; this substance is in all probability "calcoglobulin."

Neumann and Henle are of the opinion that the dentinal sheaths are calcified. The existence of the dentinal sheaths can be demonstrated by decalifying the dentin with strong acids. This process requires several days for its accomplishment. The residue is found to be composed of a tangled mass of a fibrous-appearing material (Fig. 161) which upon careful examination is found to be composed of the dentinal sheaths.

Magitot and Sudduth are of the opinion that the dentinal sheaths do not exist as structures distinct from the fibrils.

Röse demonstrated the presence of the sheaths of Neumann by Golgi's rapid method of staining with nitrate of silver. If the tooth is previously prepared by Weil's method, the soft parts, including the dentinal fibrils, do not take the stain, so that in transverse section the fibril is seen as a bright point in the centre of the black dentinal sheath. (Plate III.)

Tomes is inclined to the belief that the dentinal tubuli possess definite lining walls ; but yet suggests that it is possible that their seeming existence may be the result of the action of the agents used in the preparation of the specimen. He also calls attention to the fact that that part of the matrix immediately embracing the fibrils differs in chemic constituents from that which makes up the bulk of the matrix.

Dentinal Fibrils.—The dentinal tubules (Plate IV.) are occupied for their entire length by solid fibrillæ or processes given off from the odontoblasts, which are known as *Tomes's fibrils*, or the *dentinal fibrils*, the function of which, it is supposed, is to transmit sensation and possibly nutritive fluid from the plasma of the blood. These questions, however, have never been satisfactorily settled. The fibrils of Tomes are solid structures which fill the lumina of the dentinal sheaths, so that it would seem impossible for them to carry fluid except by a process of osmosis. Histologists have not been able to determine the real nature of the fibrils, though there is no doubt from the clinical stand-point that they carry sensation.

Some writers have asserted that the terminal nerve-fibres of the pulp pass between the odontoblasts, and either unite with the dentinal fibrils or accompany them into the dentinal tubuli. Others are of the opinion that the non-medullated fibres of the pulp become united with the stellate layers of cells which lie beneath and are connected with the odontoblasts, and that thus the power of carrying sensitive impressions is conveyed to the dentinal fibrils ; while still others have thought that the sensitiveness of the dentin was due to the transmission of vibrations to the pulp, through a fluid contained in the tubules, or some other inert conductor.

Boll (1868) was the first investigator to make authentic observations in

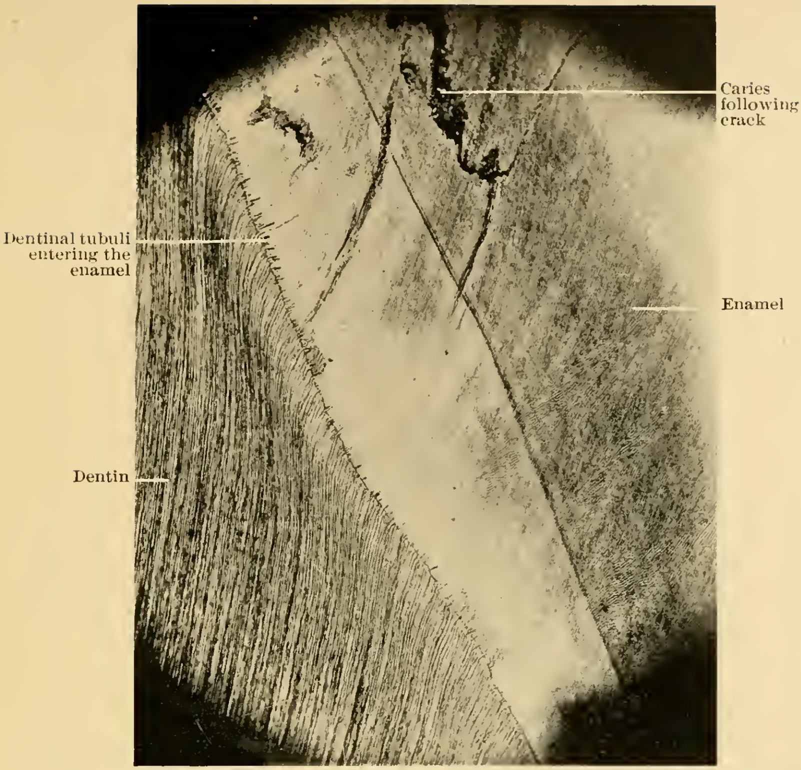


Fig. 159.—Section of dentin and enamel, showing tubuli entering the enamel. (V. A. Latham.)

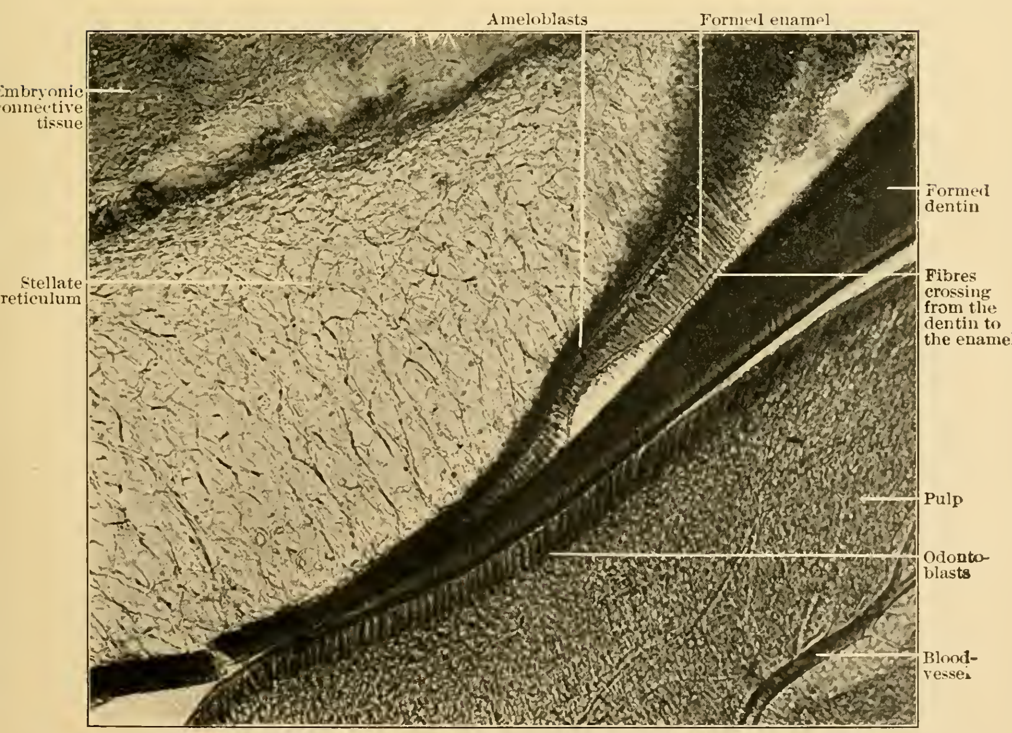


Fig. 160.—Vertical section of developing human tooth, showing dentinal fibres passing from the dentin to the enamel. × 1000.

FIG. 161.—Dentinal sheaths isolated by decalcification of the dentin. × 273.

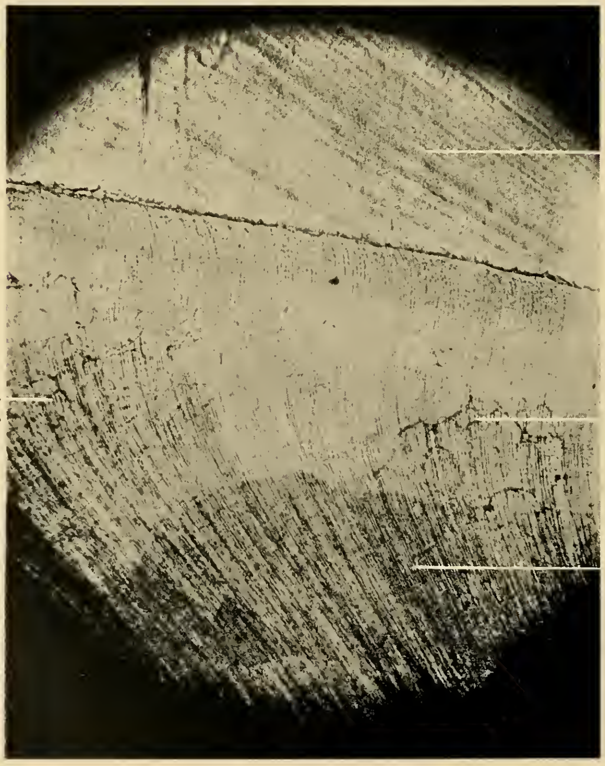
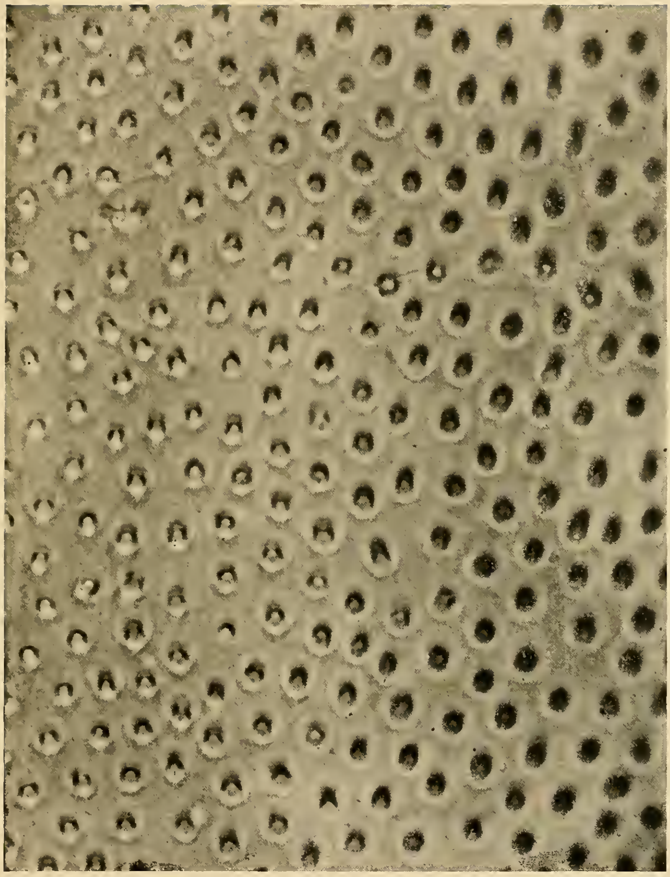


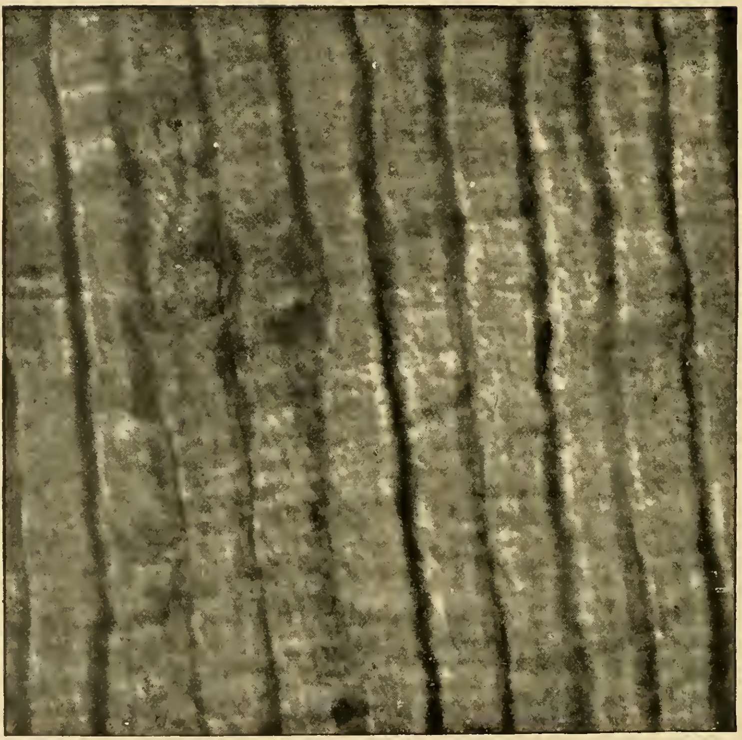
FIG. 162.—Vertical section of enamel and dentin, showing interglobular spaces. × 50.

PLATE III.



Normal dentin showing tubuli in cross section. (F. B. Noyes.) Highly magnified.

PLATE IV.



Normal dentin showing tubuli in longitudinal section. (F. B. Noyes.) Highly magnified.

the endings of the nerves of the pulp. His observations were made upon the pulps of the canine teeth of young rabbits and guinea-pigs, some of which were stained with gold-chloride; others were fixed for a short time in dilute chromic acid solution, teased out and mounted in this solution. With the gold-chloride method the results were negative. The chromic acid method enabled him to make out numerous medullated and non-medullated nerve-fibres in the tooth-pulp. Lying beneath the odontoblastic layer was an especially dense net-work of non-medullated nerve-fibres. From this net-work he discovered fine fibrillæ passing between the odontoblasts, some of which could be traced for a considerable distance beyond. He did not, however, succeed in tracing these fibrillæ into the dentinal tubules, but he felt sure, although unable to demonstrate it, that they did enter the tubules, and he assumes there are two kinds of tubules in the dentin, those which carry the dentinal fibrils and those which carry the nerve-fibrils.

Underwood and Mummery have demonstrated by the gold-chloride method the presence of nerve-fibres arising from the deeper portions of the pulp which run directly to the dentin, and appeared as though they entered it, thus far confirming the observations of Boll.

Tomes says, the dentinal "fibrils are not nerves in the ordinary sense, and were never supposed to be; but there are many examples of cellular structures which are connected with the termination of sensory nerve-fibres, such as the goblet-cells in the olfactory membrane of the frog, and it is quite possible that the odontoblasts may stand in some such relation to the nerves of the pulp, the terminations of which have even not yet been satisfactorily traced."

Mummery found later that by following Boll's method of preparation, by Weil's process, and also by decalcification processes, that he could trace a great number of fibres which pass from the pulp to the dentin, these fibres being much smaller than the dentinal fibrillæ.

He was not, however, able to see what became of them after they reached the dentin. By means of various stains, especially iron, followed by tannin, he was able to show them stained, and they appear to be traceable backward into nerve-trunks a little below the surface; these trunks consisted of bundles of non-medullated nerve-fibres, in fact, axis-cylinders. He believes the dentin is permeated by dentinal fibres and also by much finer fibres, some of which run up towards it from fusiform cells which lie near the surface of the pulp, while others appear to come from points deeper down in the pulp, and to be devoid of fusiform enlargements.

Charters White is of the opinion that these fibres, after they leave the bases of the germinal corpuscles, enter the fibrous tissue of the pulp and become fused in the outer coat of the nerve, but that as yet these facts have not been positively demonstrated.

Coleman compares the odontoblasts to tactile corpuscles, Pacinian bodies, the rods and cones of the retina, and the termination of the auditory nerves in the cochlea. He believes that a connection exists between the odontoblasts and the nerve-fibres, but does not consider it as absolutely necessary to make out such a connection between the nerve-fibres and the sensitive part. He says, "The impression received by the long processes of the odontoblasts might be conducted from these bodies through numerous cells which intervene between them and the nerve-fibres, or possibly the connective tissue of the pulp may perform this office."

Magitot speaks very positively of the terminal fibrils of the nerves of the pulp being continuous with a layer of reticulate cells, which lie immediately beneath the odontoblasts, and that these communicate freely with the processes of the odontoblasts, so that there is a very direct communication between the nerves of the pulp and the dentinal fibrils.

Sudduth has never been able to demonstrate any connection between the terminal nerve-fibres of the pulp and the odontoblasts.

Klein maintains that the only function of the odontoblasts is to form the dentin matrix, and that the dentinal fibrils are long processes given off from the deeper cells of the dentinal papilla, and that they run up between the odontoblasts and enter the dentinal canaliculi.

Robertson found, in examining sections of the tooth-pulp of the ox which were prepared by fixing and teasing in osmic acid, that the axis-cylinders of the medullated nerve-fibres lose their medullary sheaths, and after extending for a greater or less distance, become continuous with the pulp processes of the odontoblasts, which, therefore, with their dentinal processes may be considered as nerve-end organs.

Bödecker says, "In specimens of nine-month fœtal pulps, sufficiently stained with gold chloride, I have observed that the medullated nerve-fibres upon approaching the periphery of the pulp are destitute of their myelin sheath, and now become bare axis-cylinders, split up into numerous extremely delicate beaded fibrillæ, the axis-fibrillæ."

Dentz made sections from embryos in which about one-half of the dentin was formed, and discovered pear-shaped bodies arranged with great regularity a short distance within the border of the dentin, the small ends being directed towards the pulp and connected by the small ends with one or more dentinal tubes. Each of these pear-shaped bodies had two or three nuclei, and upon the whole quite closely resemble certain forms of nerve-end organs.

Retzius demonstrated (1895), by the aid of Golgi's method of staining sections from the teeth of rats, that the nerves of the pulp resolve themselves into fine varicosed fibrils, which extend through a layer of odontoblasts as far as the dentin, but did not penetrate into the latter.

Huber found by the use of the intravenous methylene-blue method of Ehrlich,—injection of a methylene-blue normal salt solution into the vessels of a narcotized animal which produces a stain of the peripheral nerves,—in which a one per cent. of methylene-blue normal salt solution was used, was injected into the carotid artery of a rabbit immediately after killing it with chloroform. Thirty minutes later the jaw was removed, broken open, and the teeth removed, care being taken not to injure the pulps. The pulps were then removed and placed at once upon a slide moistened with a normal salt solution.

Such freshly prepared specimens showed the axis-cylinders of the pulp-nerves stained with the characteristic blue color, the other tissues not at all or only faintly blue. Such specimens must be fixed at once, as the color will otherwise fade very quickly. As fixatives, Huber used a saturated solution of ammonium picrate, or a solution of ammonium molybdate. The former was mounted in a mixture of glycerol and the ammonium picrate solution, the latter dehydrated and mounted in balsam. By these methods the tissues of the pulp become very clear.

In examining the terminal branches of the medullated nerve-fibres of the tooth-pulp, he found that on approaching the surface of the pulp they lose their medullary sheath, and the non-medullated terminal branches, after repeated division, form a plexus immediately beneath the odontoblasts.

The non-medullated terminal branches are often beset with nuclei; they branch and rebranch into long, delicate varicose fibres which may often be followed for long distances.

This accords with the observations of Retzius with the Golgi method. Huber found as did Retzius, "that terminal fibrils given off from the plexus of a varicose fibre found under the odontoblasts pass up between the cells, to terminate usually in *fine granules near the free end of the odontoblasts.* Now and then some small fibril may be traced as it takes a tangential course over the free ends of the odontoblasts, as was found by Retzius."

These observations, he thinks, taken with those of Retzius, "warrant the statement that the terminal branches of the pulp-nerves end between the odontoblasts near their free surface, occasionally between these cells and the dentin, and that they do not make any connection with the odontoblasts nor with any of the cellular elements of the pulp."

He was never able to trace any nerve-fibril beyond the odontoblastic layer.

Interglobular Spaces.—The "interglobular spaces of Czermack" are a system of irregular cavities of extreme variableness in size, which exist normally in the dentin, and are the interstices or spaces between the rounded projections of numerous spheroidal or rounded bodies or masses grouped together within the basis substance of this tissue, and designated as *dentin globules* (Figs. 162 and 163). They are found principally at the union of the dentin with the cementum, where they are small and very numerous, forming what is generally known as the "granular layer of Tomes" (Fig. 164).

Many of the dentinal tubuli have their endings in these spaces. The granular layer is also found in that portion of the dentin which lies beneath the enamel, but in this location it is not so strongly marked. Although the interglobular spaces are most numerous at the periphery of the dentin, they are not confined to this location, but may be found in all parts of this tissue. These spaces, which in dried sections of dentin appear as *open* spaces, with irregular outlines and sharp-pointed processes, extending in all directions, giving them the appearance of lacunæ, are in the fresh state filled with calcoglobulin which has not become fully calcified.

Broomell claims they are filled with a soft living plasma, having a structural arrangement similar to the basis substance or matrix of the dentin.

Tomes is inclined to the opinion that the larger interglobular spaces found in the deeper portions of the dentin ought not to be considered as a normal condition, but rather as an indication of an arrested development.

The dentinal tubuli are not arrested by the interglobular spaces, but pass through them without interruption in their course.

Bödecker claims that the spaces of the granular layer are filled with living plasma, and that through this the soft fibrils within the tubuli are in communication with the soft contents of the lacunæ and the canaliculi of the cementum.

Incremental Lines.—Certain lines are to be seen, particularly in the crown of the tooth, indicating the laminated structure of the dentin; these have been called the "contour lines of Owen" and the "incremental lines of Salter" (Fig. 165). They find their explanation in the laminar growth of the dentin, as already indicated.

Development of the Root.—The root of the tooth is formed as a result of the progressive lengthening of the pulp (Fig. 166 and Fig. 167) and the continued production of Tomes's fibres, of the canaliculi and the ground substance or matrix, through the agency of the odontoblasts or other formative cells. The process is the same as that already described in the development of the crown,—viz., the formation of cup-like layers or laminæ one within the other.

If a forming tooth is examined at that stage in which the crown has been completed, a deep cup-shaped depression will be noticed over the whole radial end of the crown, this being occupied by the formative pulp. The deposition of calcoglobulin begins at the outer circumference of the pulp, building each time a quoit-like layer, with its rim always at the outer circumference of the pulp and its convexity directed towards the crown. As fast as the dentin of the root is formed, it is covered by a deposition of cement material formed by the cementoblasts lying within the developing pericementum or wall of the tooth-follicle.

Dentinification.—Calcification of the dentin begins at about the sixteenth week of intrauterine existence by the formation of a tiny cap or layer of calcific material at the tips of the incisors and cuspids (Fig. 168), and about a week later in the cusps of the molars. The process begins upon the surface of the dentinal bulb or papilla, by the formation of layers or laminæ, one within the other, the size of the papilla gradually decreasing as each new lamina is formed until it reaches the size prescribed for it by nature.

Some time before the beginning of the process of calcification of the dentin there is a layer of cells developed upon the surface of the papilla, ovoid in form, and having a long process upon the end, which points towards the enamel-organ (Fig. 169). These cells have already been mentioned, and were termed by Waldeyer the *odontoblasts* or dentin-building cells.

This layer of cells constitutes the *membrana eboris* of the older writers.

The form of the odontoblasts varies considerably at different periods of the evolution of the dentin. In the early stage, just prior to the commencement of the process of calcification, the cells are generally ovoid and have

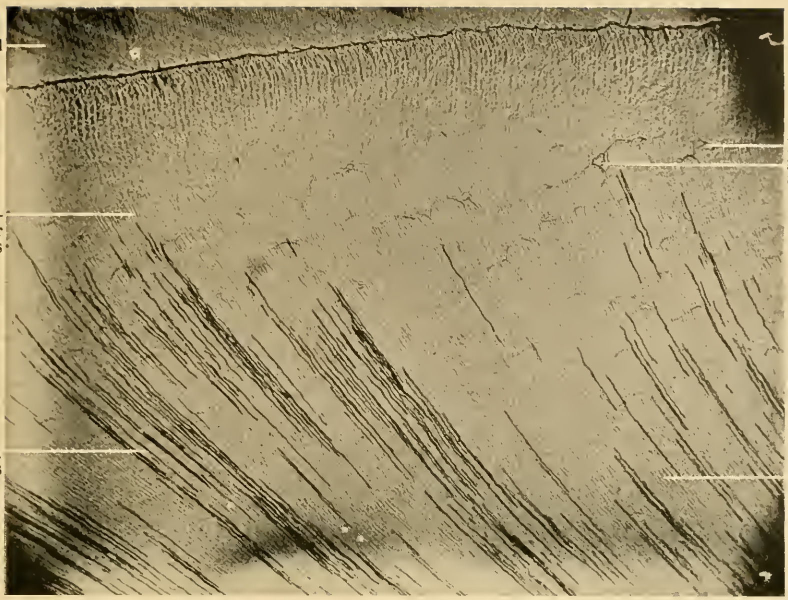


FIG. 163.—Vertical section of enamel and dentin, showing interglobular spaces. × 110.

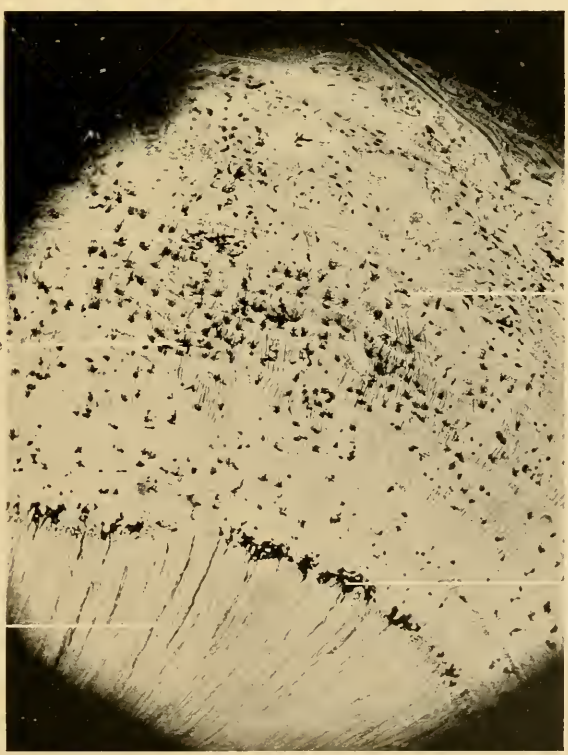


FIG. 164.—Transverse section of dentin and cementum. × 97

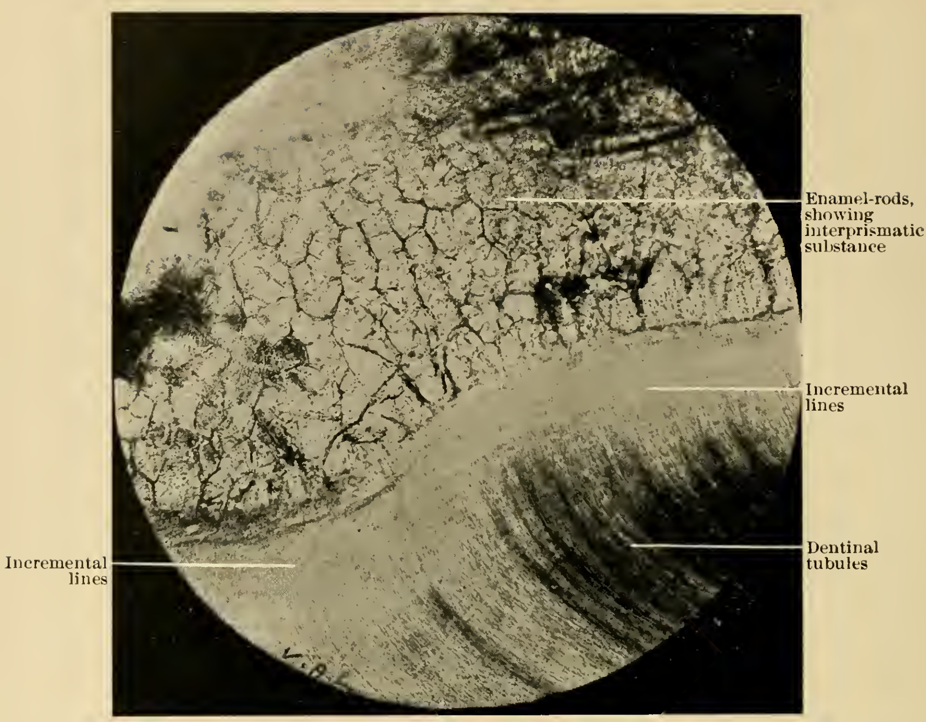


FIG. 165.—Oblique section of enamel and dentin, showing incremental lines. (V. A. Latham.) × 500.

FIG. 166.—Vertical section of face of human embryo, showing the beginning of the formation of the roots of the teeth. (V. A. Latham.) × 7.

FIG. 167.—Section of human lower jaw, showing blood-vessels and nerves at base of the tooth-follicle, and the beginning of the formation of the root. (V. A. Latham.) × 9.

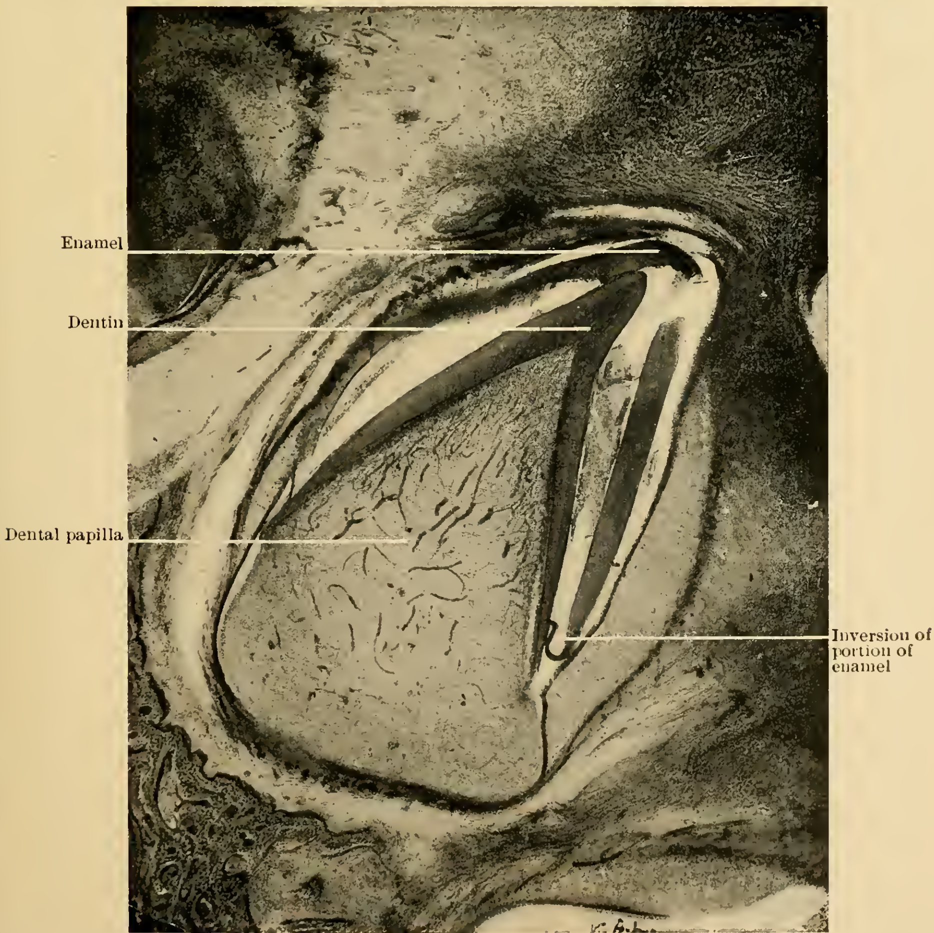


FIG. 168.—Vertical section of developing human cuspid, showing early stage of calcification. (V. A. Latham.) × 100.

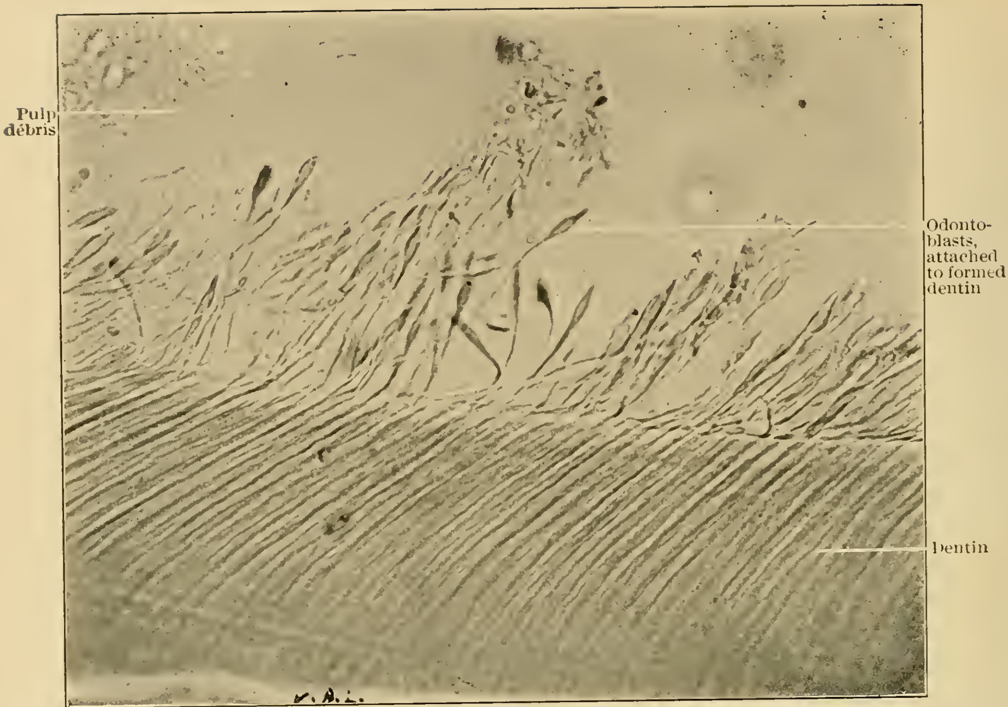


Fig. 169.—Teased section of developing human molar, showing the odontoblasts and their processes. (V. A. Latham.) × 1000.

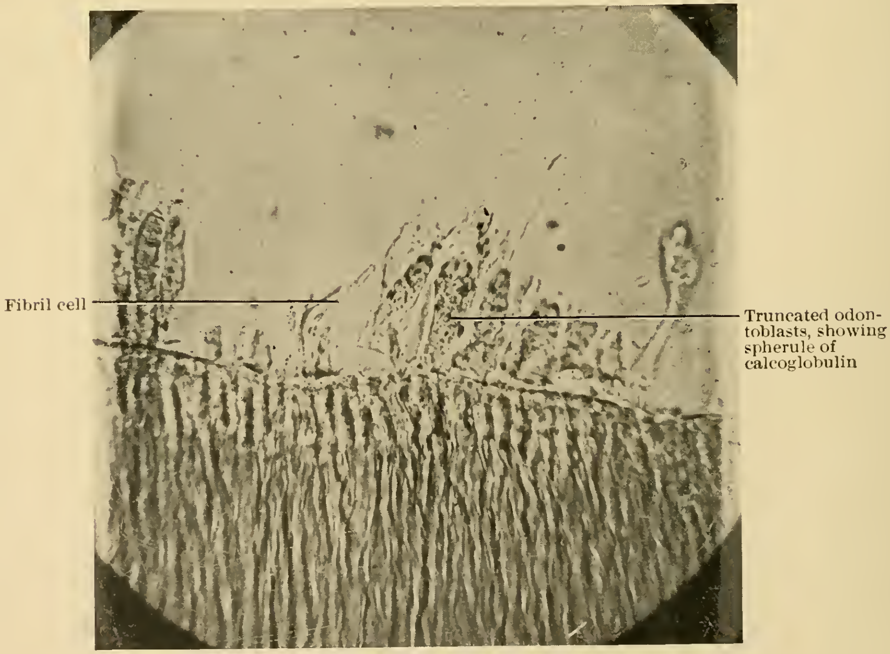


Fig. 170.—Truncated odontoblasts and fibril cells. (R. R. Andrews.)

a single process, but during the active stage of development the cells are flat and broad, or truncated at the end directed towards the forming dentin (Fig. 170). During this period the odontoblasts often present two or more processes; Boll has counted no less than six, proceeding from a single cell. Each cell possesses a single ovoid nucleus, which is located in the end of the cell nearest to the dentinal papilla (Fig. 171). The nucleus is sometimes pointed at the extremity nearest the forming dentin. The body of the cell is finely granular, and Waldeyer and Boll both found the cell destitute of any semblance of membrane. The processes of the cells pass into the dentinal tubuli, and constitute the dentinal fibrils.

Stowell (1887) says there are three separate forms of processes arising from each odontoblast: first, those that unite it to its fellow; second, those by which it forms its attachment to the connective-tissue cells of the pulp proper; and third, those that pass into the dentinal tubules, the dentinal fibrils, the latter as they approach the periphery of the dentin branch and finally unite with the cells of the granular layer and the cementoblasts.

After the active stage of dentin formation has passed, the odontoblasts again resume their original ovoid form, tapering off to the dentinal process.

Several theories, more or less divergent, have from time to time been advanced as to the process by which the dentin was developed, the main point in controversy being the part played by the odontoblasts in this process.

Waldeyer, Frey, Boll, Beale, and others support the theory that the dentinal fibrils, the sheaths of Neumann and the matrix surrounding them, are formed from the odontoblasts by a metamorphosis of these cells, these structures representing three stages in the conversion of the same substance. Beale expresses it as *protoplasm,*—the dentinal fibrils; *formed material,*—the dentinal sheaths; *calcified formed material,*—the matrix, the completed, fully calcified tissue.

Von Ebner has discovered the existence of a delicate fibrillar structure in both bone and dentin, and although von Ebner and Röse both believe that the whole of the dentin is derived from the odontoblasts, they say their axial portions persist as the dentinal fibrils, while their outer portions are metamorphosed into a delicate fibrillar gelatinous tissue, a sort of connective tissue, which forms the matrix and receives the deposition of the lime-salts.

Tomes says upon this question, "The close relation of these cells to the dentin, their change in form according as dentin-building was or was not actively going on, their resemblance in position and apparent consistence to osteoblasts, and the absence of any other of the large cells which we associate elsewhere with elaboration of special products, would naturally lead to the inference that they were the chief factors in the segregation of lime-salts and their incorporation in the dentin."

Andrews (1887) called attention to pear-shaped cells, which he termed "*dentin corpuscles,*" lying between the square-end odontoblasts so uniformly present during the active stage of dentin formation (Fig. 172).

The odontoblasts he considers as simply matrix formers, having nothing whatever to do with the formation of the dentinal fibrils, as they are membraneless masses of protoplasm, while the pear-shaped cells—"dentin corpuscles"—form the dentinal fibrils by the elongation of their processes, and which also possess the important function of nourishing the dentin matrix.

Mr. Mummery, in following still farther the investigations of von Ebner, noted the appearance of connective-tissue fibres, or bundles of fibres, just in advance of the main line of calcification, which had not been derived from the odontoblast, but from the connective-tissue cells of the dentin papilla. He discovered further, in young developing teeth, by the aid of Koch's method of preparing sections, as modified by Weil, the presence of a distinct reticulum of fine connective-tissue fibres, which passed in bundles between the odontoblasts and enveloped them. Within this reticulum he believes the calcium salts are deposited for the building of the dentin matrix. He also found other cells than the odontoblasts applied to the connective-tissue fibres, both in man and in fish, which recall the cells attached to the osteogenetic fibres of bone.

In view of these discoveries it would seem that the process of calcification of dentin is more nearly like that of bone than has been previously supposed, and if Mr. Mummery is right, the question very naturally arises as to the actual part taken by the odontoblasts in the formation of the dentin. It would seem, however, that the fact is fairly well established that the odontoblasts form the dentinal fibrils by the elongation of their processes, and that they are the active agents in the development of the dental tubuli; but whether the odontoblasts or the cells of Mummery superintend the elaboration and deposition of the calcific material to form the dentin is a matter of doubt, and further investigation will be necessary before the question can be settled.

Andrews, in speaking of the odontoblasts and the pear-shaped cells described by Mummery, says, "The odontoblasts are masses of protoplasm, without membranes, and are at a certain stage of growth square and abrupt against the matrix. It is an easy matter to find among them, and immediately adjacent, large numbers of pear-shaped cells, tapering into the dentinal fibril. The odontoblasts, when calcification is active, are scarcely more than masses of protoplasm, filled with minute globules. The fibrils which appear to come from them are described by Tomes under three divisions, —viz., "*pulp, lateral,* and *dentin processes,*" which originate probably from a fibril-forming cell. These pass through the soft substance of the odontoblasts (protoplasm), and seem to be a part of them, but in fresh, young sections the so-called processes move in the substance of the odontoblasts by pressure of the cover-glass, and the fibril may be traced to a pear-shaped cell beyond. There will usually be found as many processes going out from the sides and ends of the odontoblasts towards the pulp as there are going into the matrix from the dentin end of the cell. In cross-sections of the odontoblasts, delicate, light spots are seen in the substance, which are probably the cut fibres. When the layer of odontoblasts is teased away from the forming dentin, fibrils are seen bridging the gap, apparently off-shoots from the odontoblasts; but on careful examination there will

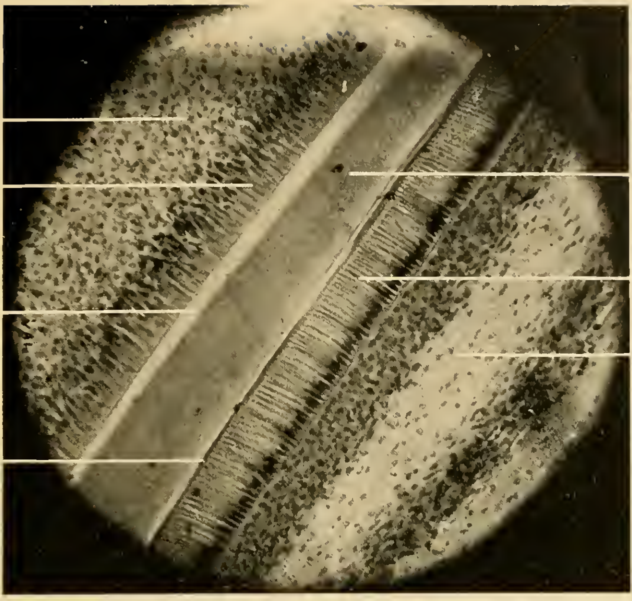


FIG. 171.—Section of tooth-follicle (human), showing the nuclei of the odontoblasts and of the ameloblasts, and the truncated ends of these cells. (V. C. Latham.) × 325.

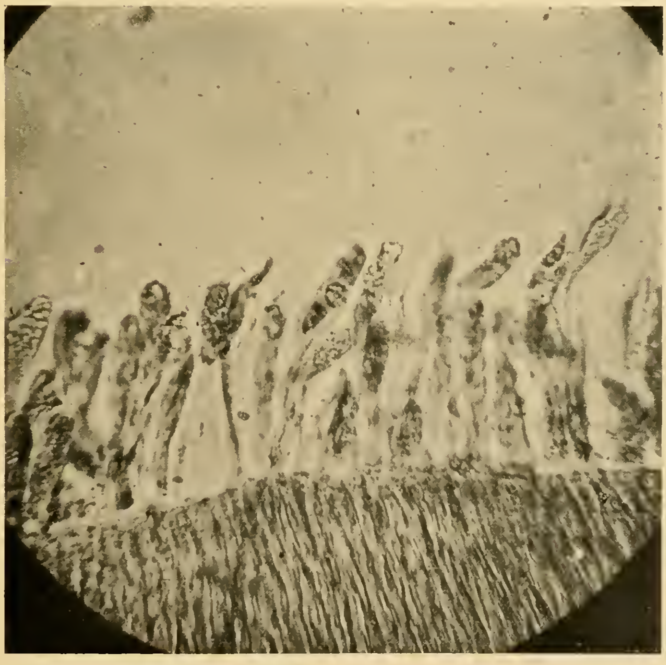


FIG. 172.—Odontoblasts, showing truncated cells and pear-shaped bodies lying between the dentin corpuscles. (R. R. Andrews.)

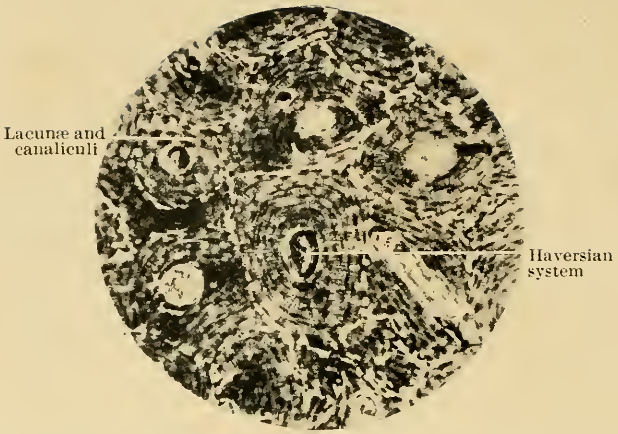


FIG. 173.—Bone, showing Haversian system, lacunæ, and canaliculi. × 60.

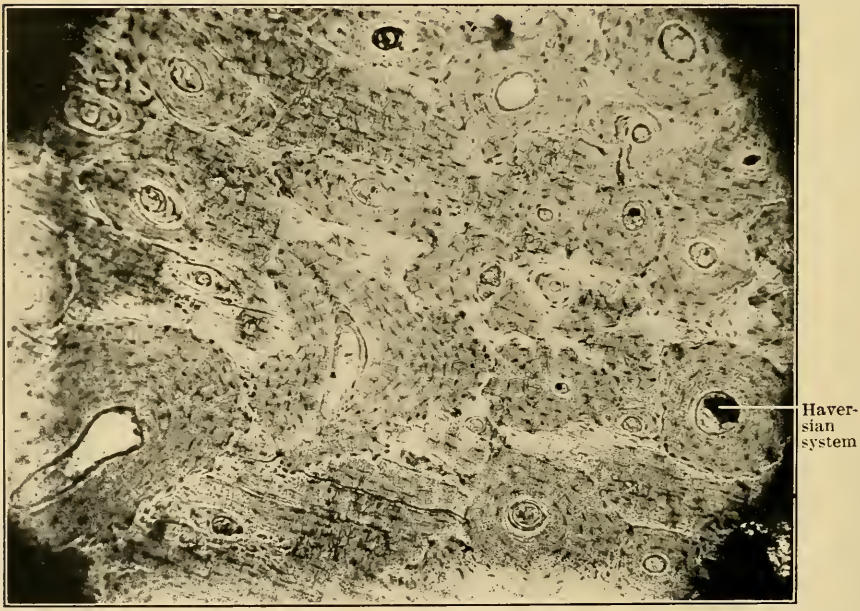


FIG. 174.—Transverse section of human femur, mature bone. × 60.

usually be found a decided line of demarcation across the fibre at the point where it meets the square end of the odontoblast. This line seems to show that the fibril was not continuous with the protoplasm of the cell. Other sections which have been separated by teasing, show odontoblasts having their side masses of protoplasm drawn away from the fibril which apparently has run through it. Some of this protoplasm is left upon the fibril, giving it a ragged appearance as it passes from a canal in the matrix across to the separated pulp-tissue, bridging the gap.

The pear-shaped cell has perhaps a more important function than the odontoblast proper. It is to supply the life and nourishment to the whole of the calcified matrix, as the bone-corpuscle within its "lacuna supplies life and nourishment to bone and cementum."

One of the strongest arguments, however, in support of the older theory that the odontoblasts elaborate or secrete the calcium salts and superintend the deposition of this material in the formation of the dentin matrix, is the fact that calcospherites of different sizes are found in these cells during the active stage of calcification.

Robin and Magitot noted the presence of globular spherical forms—calcospherites—in the young pulps of human teeth. Henle also discovered them in the young tooth-pulps of the herbivora, as did also Robin and Magitot.

In the early history of the dentinal papilla, just before the beginning of calcification, numerous globular, glistening bodies—calcospherites—are to be seen in the papilla and within the odontoblasts, but most abundantly upon the surface of the papilla next to the inner tunic of the enamel-organ, just where the first layer of dentin is to be formed.

The calcospherites are seen to collect in large numbers at this point, where they arrange themselves in groups and coalesce to form larger globules of calcoglobulin, as already described. These again melt together to form the first layer of dentin, the matrix forming around the processes of the odontoblasts, which recede as each additional layer of dentin is laid down, the processes of the odontoblasts elongating to accommodate the increasing thickness of the dentin matrix.

What becomes of the superabundance of odontoblasts resulting from the continual decrease in the size of the dentin papilla during the formation of the dentin is a question that the author does not remember to have seen or heard discussed. It is a well-established fact that, as a rule, cells and tissues which have performed their functions, and for which nature has no further use, either atrophy or disintegrate, are resolved into their original elements, and are then absorbed. This may be the process by which the used-up cells are removed in the formative pulp. But in seeking an explanation of the *modus operandi* by which the tubules of the dentin become branched, it has occurred to the author that certain of the odontoblasts may coalesce from time to time as the decrease in the size of the papilla makes it necessary for their numbers to be lessened, thus forming branching dentinal processes around which the dentin matrix is formed, the larger fibril or main trunk representing the persistent odontoblast, while the branches represent the fibrils of the cells which have been merged into the persisting cell. This would also explain the presence of the odontoblasts having multiple processes which are so common during the active stage of dentin formation.

The presence of the transverse processes which seem to unite the odontoblasts laterally may be explained by the recent discovery of von Ebner and Mummery of a connective-tissue net-work of fibres passing between and surrounding the odontoblasts, and just in advance of the main line of calcification.

CEMENTUM.

Cementum, or *crusta petrosa*, is a specialized product of specialized osteoblasts or bone-producing cells, the cementoblasts.

Mature cementum, chemically and physically, is very little different from the compact tissue of bone, with the exception that it is generally devoid of Haversian canals. Figs. 173 and 174 show the structure of mature bone.

Cementum is the external covering of the roots of the teeth. In many animals it also forms a part of the covering of the crown, being associated with the enamel in separate vertical laminæ.

The cementum begins at the neck of the tooth, at the free margin of the enamel, in a thin layer (Fig. 175), and gradually increases in thickness towards the apex of the root (Figs. 176 and 177). In teeth with roots closely associated the cementum often extends from one root to the other, resulting in a firm osseous union.

The cementum is thicker in adult life than in childhood, and in aged people it is thicker than in adult life. Black thinks it grows at intervals during the life of the individual.

Histologically it is composed of a matrix consisting of a gelatinous substance combined with the salts of lime. Within the matrix are numerous little hollow spaces, the lacunæ, filled with protoplasmic substance, and from which branch in all directions many minute processes, the canaliculi; these often anastomose with neighboring canaliculi and with the intergranular layer (Fig. 178).

The *matrix* is composed of collagenous fibrils in fine or coarse bundles, combined with calcium salts, and permeated by vascular canals in the thicker portions near the apex of the root. These vascular canals correspond to the Haversian canals of bone. Like bone, when boiled it yields gelatin, and when decalcified it retains its form. At times it appears to be structureless; at others finely granular or interspersed with small globules (Tomes).

The matrix is laminated in structure, the incremental lines running parallel to the long axis of the tooth; but, although the cementum is thin at the cervix and thick at the apex, the number of lamellæ is about the same in all parts of the tissue.

The *lacunæ* in dried sections are irregular cavities with their long axis corresponding to the long axis of the tooth. The processes are given off most frequently at right angles to the direction of the lamellæ, and most abundantly upon that side towards the exterior surface of the root. The size and form of the lacunæ in cementum are very variable, while the

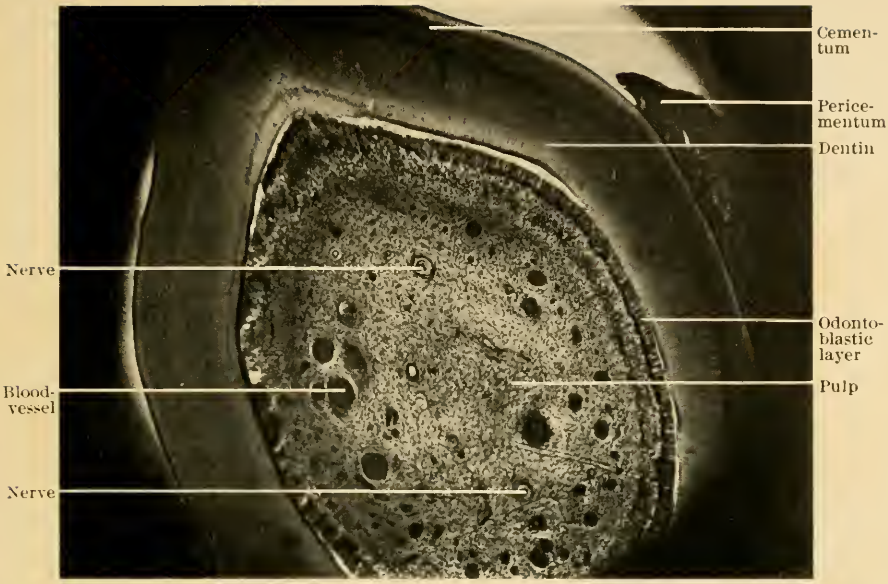


FIG. 175.—Transverse section of human cuspid, at cervix. × 150.

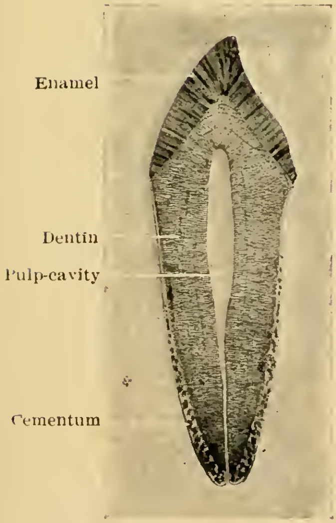


FIG. 176.—Longitudinal section of young cuspid.

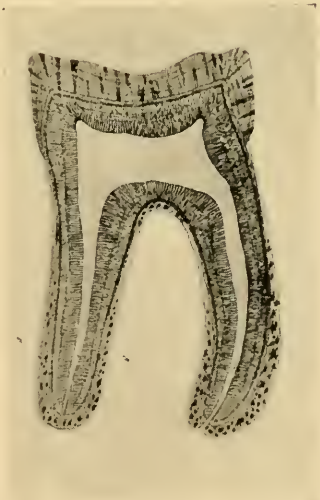


FIG. 177.—Longitudinal section of young molar.

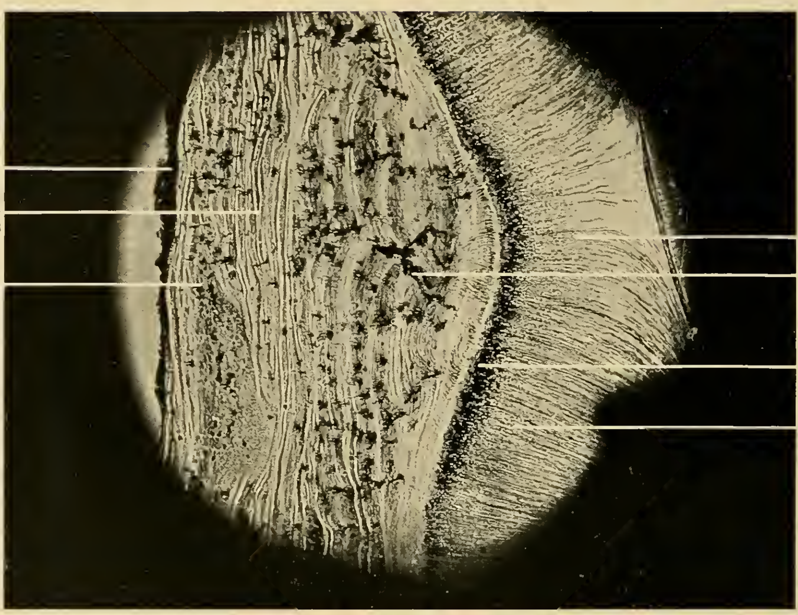


FIG. 178.—Transverse section of apex of human molar. × 97.

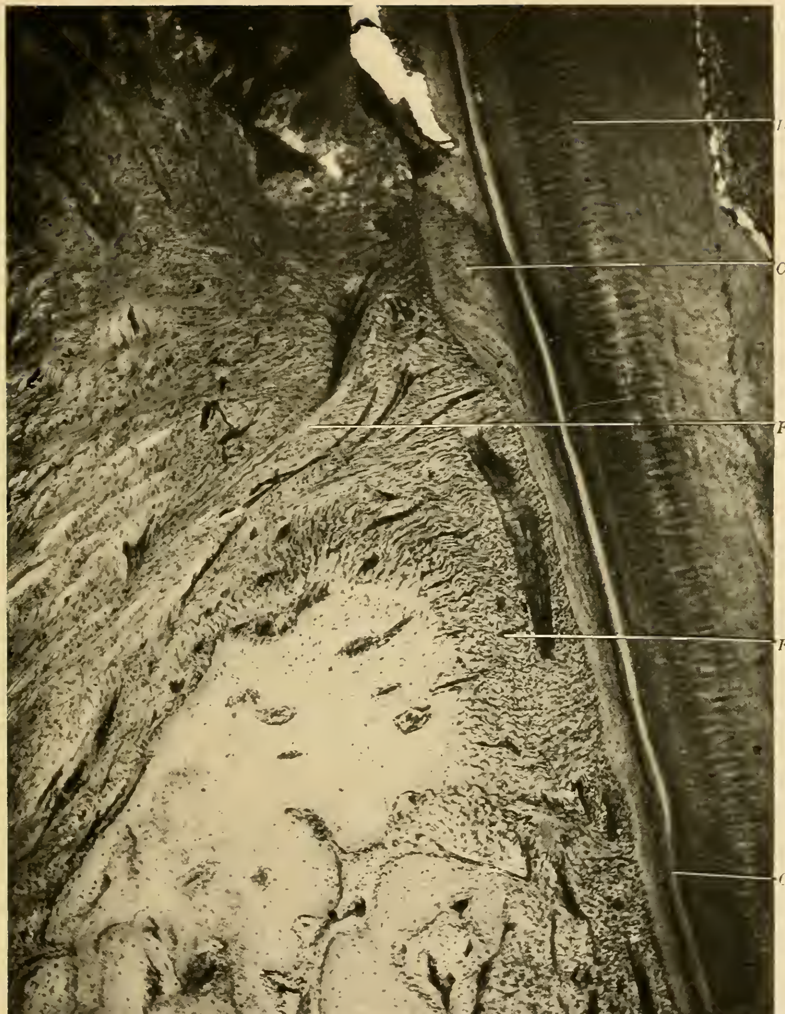


FIG. 179.—Longitudinal section of root of tooth and alveolus, showing tissues of root and alveolus *in situ*. (F. B. Noyes.) × 80. *D*, dentin; *C*, *C*, cementum; *F*, fibres passing over edge of process to outer layer of periosteum; *F′*, fibres passing to bone (Sharpey's fibres).

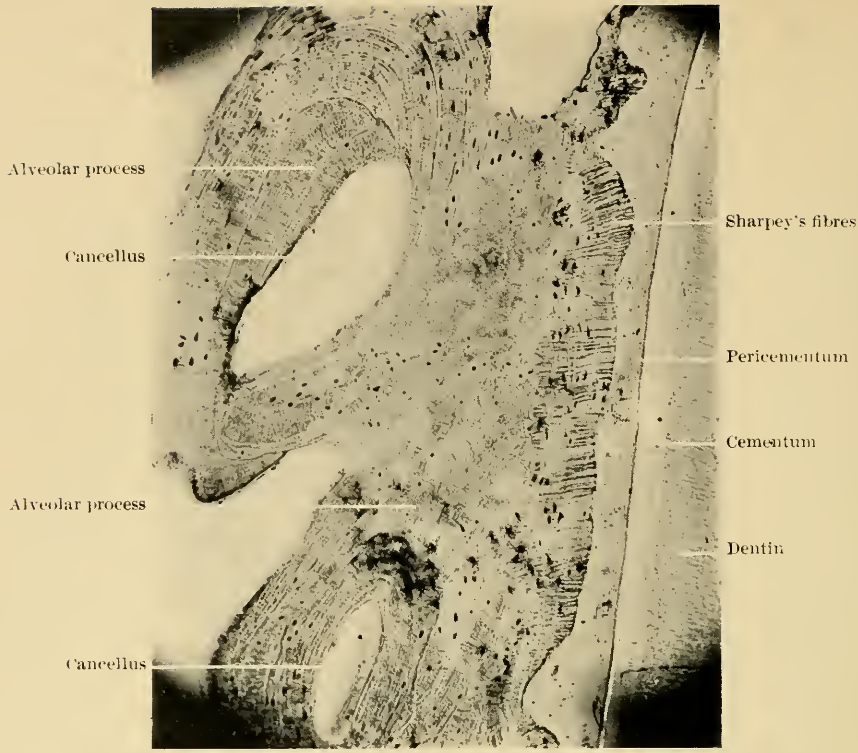


FIG. 180.—Vertical section of human alveolar process and cuspid tooth *in situ*. (V. A. Latham.) × 100.

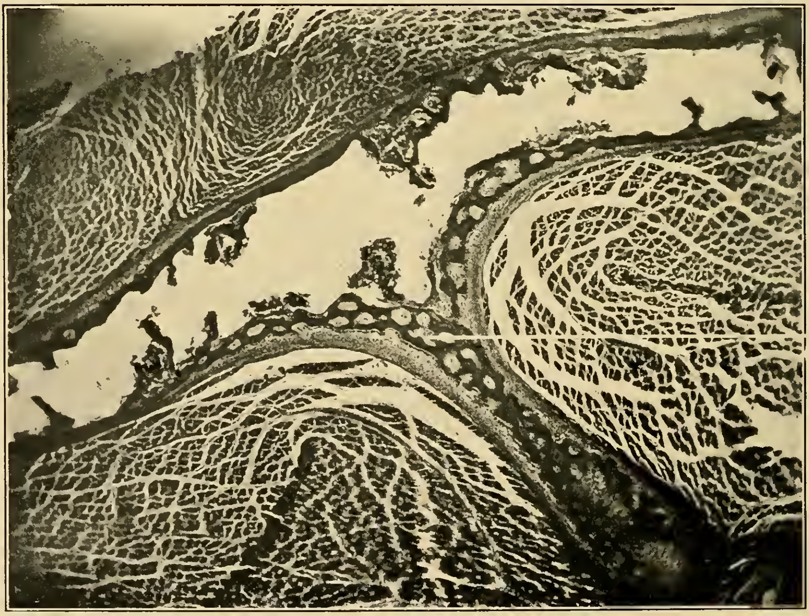


FIG. 181.—Developing bone from human scapula. (V. A. Latham.) × 50.

number and length of their processes are excessive when compared with bone.

The lacunæ are formed by cementoblasts or nests of cementoblasts, which have been encapsuled during the process of calcification, but which have maintained their individuality. These are sometimes termed *cement-corpuscles.*

Sharpey's fibres are found in the cementum, having the appearance of rods which run through its substance. They are composed of connective-tissue fibres, and form the medium of connection between the alveolo-dental membrane, or pericementum, and the cementum. Figs. 179 and 180 show Sharpey's fibres in the alveolar process.

The dentin and the cementum are inseparably connected through the medium of the granular layer of the dentin, the fusion of the two tissues being so complete that the line of union is often difficult or well-nigh impossible to make out.

CEMENTIFICATION.

According to the common classification adopted by writers upon ossification, the methods by which bone is formed are stated as follows: 1, intracartilaginous or endochondral; 2, subperiosteal; and 3, intramembranous; but the essential nature of the process is the same in all.

In the intracartilaginous method the bone is first formed or *preformed* in cartilage (Fig. 181). In the subperiosteal the bone has not been preformed by the cartilage, but the tissue in which the bone is to be formed is fibrous and vascular; osteoblasts appear along the bundles of fibres beneath the periosteum, which become calcified, and bone is formed around them (Stedman) by the deposition of calcoglobulin, as already described. Many of the fibrous bundles persist in the formed bone as Sharpey's fibres, while in the intramembranous form the bone is developed, as in the cranial bones, from a preceding membranous structure. Sudduth adds a fourth, interstitial, a division of the intramembranous group, which he thinks is necessary to explain the method by which the maxillæ are formed. He claims that osteoblasts are found in the embryonal tissue of the future maxillary bones "before there are any indications of a condensation of the connective tissue into a membrane such as is found when ossification first begins in the skull-cap. A few osteoblasts, independent of the influence of either membrane or periosteum, arrange themselves in groups here and there. These groups are the points of ossification, and from them the process extends as the jaw develops." The bone formed in this manner is *provisional* bone, and is later removed by internal resorption, as is the case with all fœtal bone, and replaced by a permanent bone formation.

Cementification is a slightly modified form of *subperiosteal* ossification. We have seen in our study of the origin and development of the teeth that the enamel-organ and the dentin bulb were enclosed within a sac or follicle.

Calcification of the enamel and dentin has progressed within this follicle, but the walls of the follicle have taken no part in the process. In the formation of the root the follicle takes an active part by becoming the cement organ. The walls of the follicle are composed of two layers. The *outer* layer is a dense, firm, fibrous structure, while the *inner* layer is thin, frail, and somewhat transparent; both are supplied with a rich net-work of blood-vessels.

From the outer layer of the follicular wall the alveolo-dental periosteum, or pericementum, is developed, while from the inner layer are formed the cementoblasts, which are speedily converted into cementum.

The dentin of the root is in most part formed during the passage of the crown from its bony crypt and eruption through the gum. The process of building the root is from the outer circumference towards the centre; the diameter of the root is thus fixed by the outer layer of the dentin, while the increase in length is by extension. The formation of the cementum, like that of the enamel, is from within outward; the first layer of the cementum being deposited upon the outer circumference or periphery of the dentin of the root; upon this layer is deposited another, and so on until the typal thickness is reached and the cement-tissue is completely formed.

The following table by Underwood will be found valuable as a ready reference of the composition of the various calcified dental tissues and their comparison with bone:

CHEMICAL COMPOSITION OF THE CALCIFIED TISSUES (APPROXIMATE TABLE).

	Adult Enamel.	Infantile Enamel.	Adult Dentin.	Adult Cementum.	Adult Bone.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Organic matter	3.50	15.50	28.00	32.00	33.50
Calcium phosphate	88.00	75.50	64.50	57.00	51.00
Calcium carbonate	4.50	7.00	3.50	7.00	11.50
Calcium fluoride	2.00	2.00	2.00	2.00	2.00
Magnesium phosphate	1.50	1.50	1.50	1.50	1.50
Other salts	0.50	0.50	0.50	0.50	0.50
	100.00	100.00	100.00	100.00	100.00

It will be seen the amount of organic matter varies considerably between infancy and adult life. Galippe (*Journal British Dental Association*, 1886, p. 361) has a very exhaustive paper on the chemical composition of the teeth.

Hoppe-Seyler has found in the enamel of the new-born child as much as 22.29 per cent. of organic matter, 9.71 per cent. in the young pig, and in the fossil rhinoceros 3.16 per cent. Bibra gives two per cent. of organic matter in the adult male and five per cent. in the adult female.

NASMYTH'S MEMBRANE.

The origin and function of Nasmyth's membrane has furnished matter for a considerable difference of opinion and much speculation. Tomes and Magitot regard it as a thin covering of cementum, as it is similar to and continuous with the cementum covering the root, lacunæ being found in its substance.

FIG. 182.—Vertical section of human enamel and Nasmyth's membrane, showing the latter to be composed of what appears to be two layers of columnar epithelial cells. (V. A. Latham.) × 250.

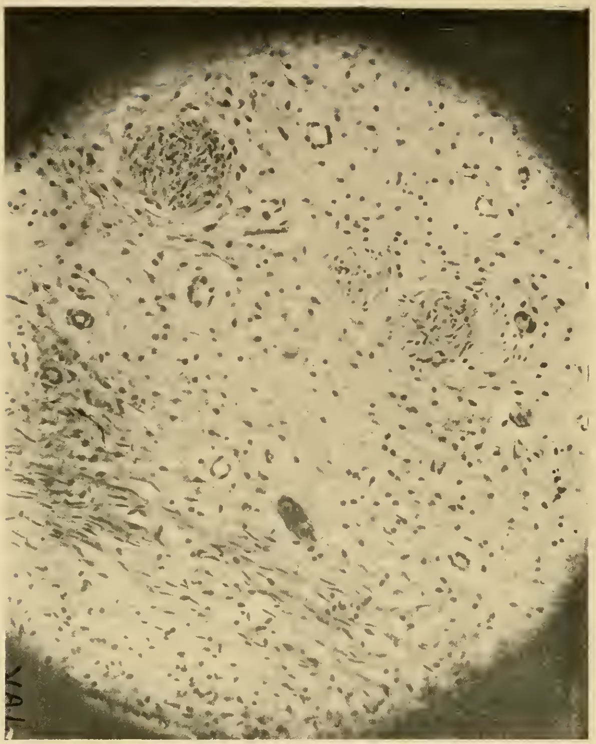


FIG. 183.—Section of normal pulp-tissue, showing its various forms of cells and the hair-like processes. (V. A. Latham.) × 143.

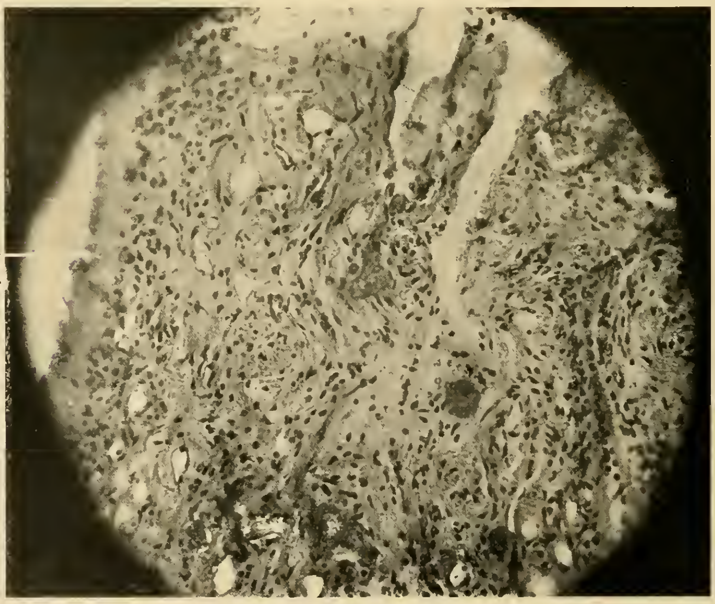


FIG. 184.—Section of normal pulp-tissue, showing odontoblastic layer. (V. A. Latham.) × 115.

Fig. 185.—Injected blood-vessels of the pulp. (After Stowell.)

Fig. 186.—Vertical section of developing teeth of kitten. Injected to show blood-supply of pulp. (V. A. Latham.) × 10.

Fig. 187.—Vertical section of human deciduous molar *in situ*. Injected to show blood-supply of the pulp. (V. A. Latham.) × 50.

Huxley, Kölliker, Waldeyer, and Röse have each maintained that the *cuticula dentis* was derived from the epithelium of the enamel organ, Waldeyer stating that it was the product of the outer tunic of the enamel organ.

Paul (1896) has shown that the membrane was composed of flat epithelial cells. These could come from no other source than some part of the enamel-organ, probably from the outer tunic. Paul suggests that its function is to protect the enamel from the action of acids. C. S. Tomes, who formerly held the view of his father, now agrees substantially with Paul. He says, "The more recent investigations of Dr. Paul have thrown a fresh light upon the matter, and have shown that the points upon which I chiefly relied are susceptible of quite a different explanation."

Sudduth thinks it is derived from a metamorphosis of the ameloblastic layer, the prismatic cells of which assume a horizontal direction. Mrs. Emily Nunn Whitman has noted these changes in studying the development of the teeth of the rat and the rabbit, and has "traced the gradual transition of the enamel-rods into a perfectly homogeneous membrane, the cylindrical cells growing shorter and shorter as they approached the surface of the crown, until, instead of being columnar, they are almost square, and finally flattened, while at the last the outlines of the cells quite disappear, and there is left a perfectly homogeneous membrane."

From the appearances in the illustration (Fig. 182) of a vertical section of the enamel and Nasmyth's membrane, it would seem that it was undoubtedly formed from the outer tunic of the enamel-organ, and that the columnar character of the cells was maintained in the formation of the membrane. It will be noticed by a reference to the illustration that in this case the membrane is composed of two layers of columnar cells superimposed one above the other. The section illustrated was taken from a depression in the surface of the enamel where it would be protected from wear. This membrane, from its resistance to acids and alkalies, putrefaction, boiling, etc., would seem to be composed of the same substance as the matrix of dentin.

THE TOOTH-PULP.

The *pulpa dentis*, the organ occupying the central cavity or pulp-chamber of a mature tooth, is the remnant of the formative organ of the dentinal tissue, and the source of the nutrition and nerve supply of the fully formed dentin.

The tooth-pulp, which is often erroneously termed the "nerve," is composed of a very delicate connective tissue, nucleated cells, blood-vessels, and nerves, while in general outline it corresponds very closely to the exterior form of the tooth. The *matrix*, or *basis substance of the pulp*, is composed largely of a kind of undeveloped soft connective tissue, possibly belonging to the mucous or gelatinous species containing numerous cellular elements (Ziegler) of rounded, oval, and spindle forms, with slender, hair-like processes (Fig. 183).

The interspaces between the fibres are large and filled with a jelly-like material, which gives it an appearance common to many forms of embryonic tissue.

The *cells of the pulp* are fairly abundant, but not sufficiently numerous to form a tissue of themselves; they are found scattered throughout the matrix, embedded in the jelly-like material within the interspaces, and upon the periphery.

The form and distribution of the cells varies very considerably in different parts of the pulp. In the deeper coronal portions the cells are not numerous; they may be spheroidal, oval, or spindle-shaped, and have no definite order or relations to each other, while in that portion within the root-canals the cells are arranged parallel with each other and with the root. As the periphery of the pulp is approached the arrangement of the cells becomes more orderly, many cells having three or more processes are seen, some extending towards the pulp, while the others are directed towards the dentin and pass between the odontoblasts. The last-named cells—the odontoblasts—are arranged in a definite order, side by side, in a single layer over the whole periphery of the pulp, covering it as with a delicate membrane or epithelium (Fig. 184). The odontoblasts are furnished with three sets of processes, as already described, one set connecting it with its fellows, another with the connective tissue of the pulp proper, and a third which pass into the dentinal tubuli.

The *blood-vessels* of the pulp are numerous; three or more arteries often enter at the apical foramen, divide into innumerable branches, and form an extensive net-work, as shown in Fig. 185, terminating in a rich capillary plexus beneath the layer of odontoblastic cells. This is well illustrated in Fig. 186, made from a section of the jaw and developing teeth of a kitten injected for this purpose. The veins are also numerous and somewhat larger than the arteries. The blood-supply, however, is better shown in Fig. 187, which is made from an injected human decidulous molar. They form frequent anastomoses near the surface, as shown in Fig. 188, which is also made from an injected specimen. *Lymphatics* have never been demonstrated in the pulp.

Fig. 189.

Nerves of dental pulp.

The *nerves of the pulp* enter the apical foramen either in a simple large trunk or by several smaller ones. They pursue a parallel course, giving off but few branches until the pulp-chamber is reached, when they divide into numerous branches, going in all directions, and forming a minute net-work just beneath the odontoblasts, where they end in non-medullated fibres (Fig. 189). Many terminal fibres pass between the odontoblasts to the dentin; but the final distribution of the fibres has never been satisfactorily demonstrated.

THE PERIDENTAL MEMBRANE.

The peridental membrane, pericementum, or the *alveolo-dental periosteum* (Fig. 190), is a fibrous connective-tissue structure which covers or invests the root of the tooth from the cervix to the apical foramen (Fig. 191), just as the periosteum invests the bones (Fig. 192) and lines the walls of the alveoli, having few elastic fibres, and richly supplied with

FIG. 188.—Section of injected dental pulp.

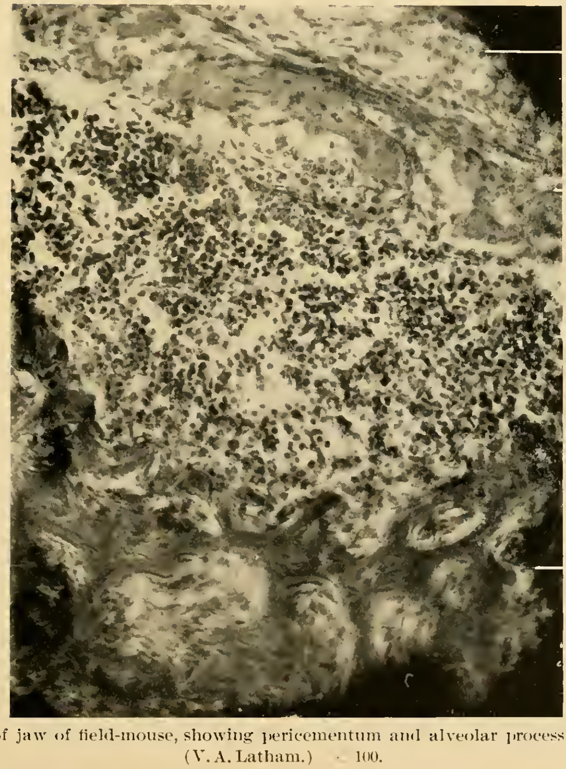


FIG. 190.—Section of jaw of field-mouse, showing pericementum and alveolar process between the teeth. (V. A. Latham.) × 100.

FIG. 191.—Transverse section through pulp-chamber of human cuspid tooth.

FIG. 192.—Transverse section of forearm of a child, showing periosteum surrounding the bones. × 13.

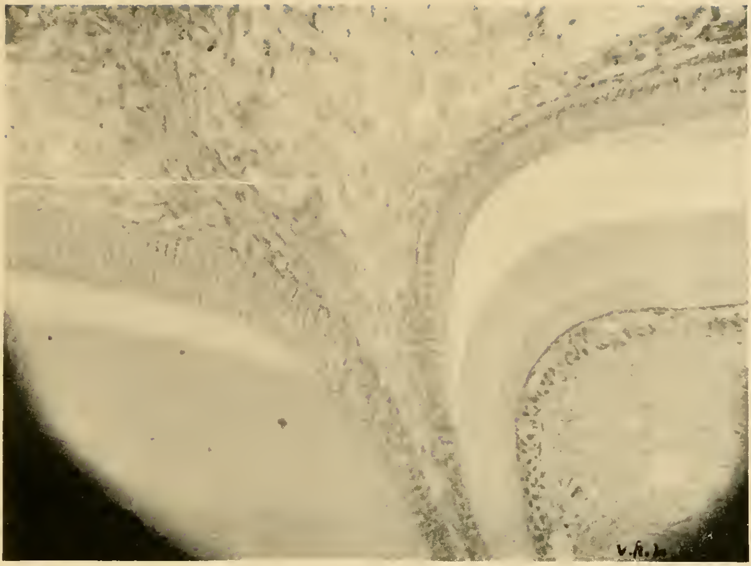


FIG. 193.—Transverse section through roots of forming tooth of field-mouse, showing peridental membrane dipping in between the roots. (V. A. Latham.) × 175.

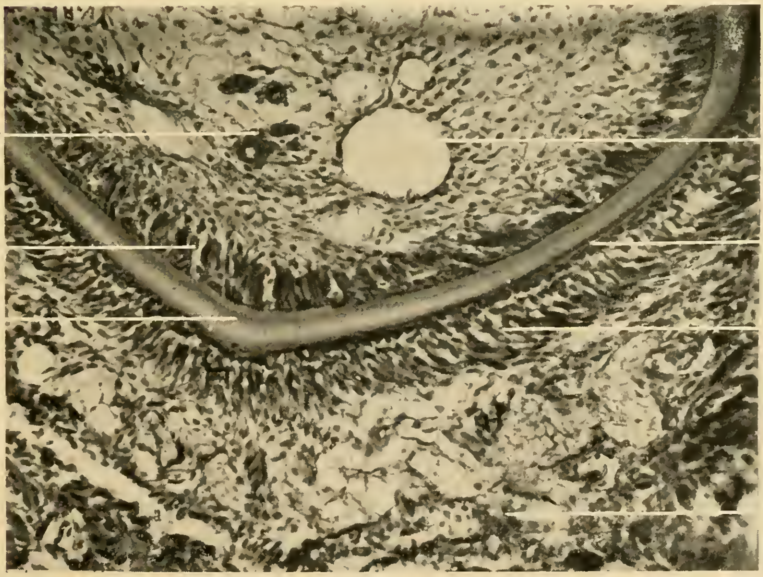


FIG. 194.—Transverse section of developing tooth of field-mouse at base of the dentin papillæ, showing peri-dental membrane. (V. A. Latham.) × 75.

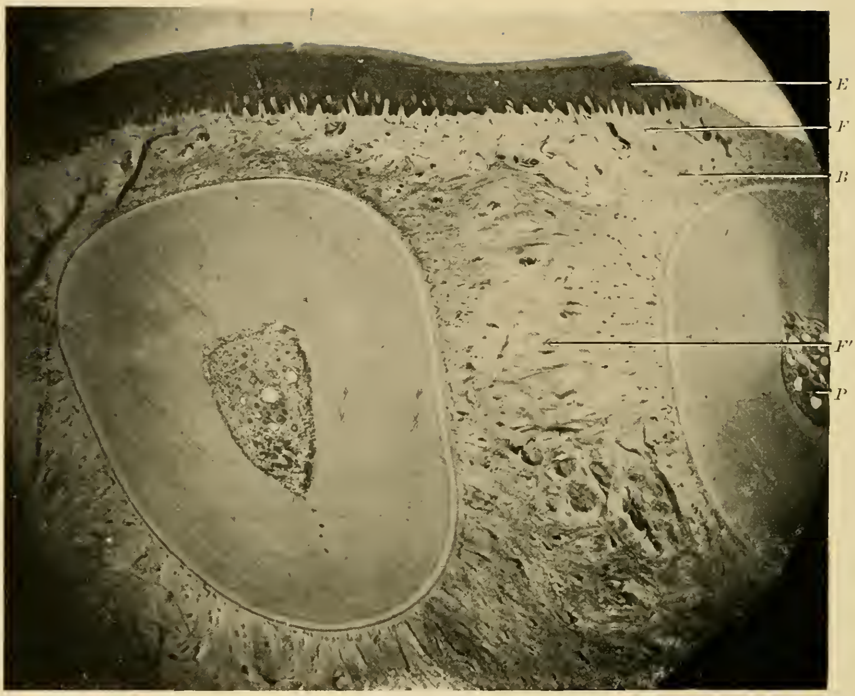


FIG. 195.—Transverse section of jaw through alveolar process, showing tissues of root and alveolus *in situ*. (F. B. Noyes.) × 30. *E*, epithelium; *F*, subepithelial connective tissue; *B*, point where pericementum fibres are lost in fibrous mat of gum; *F′*, fibres extending from tooth to tooth (Sharpey's fibres); *P*, pulp.

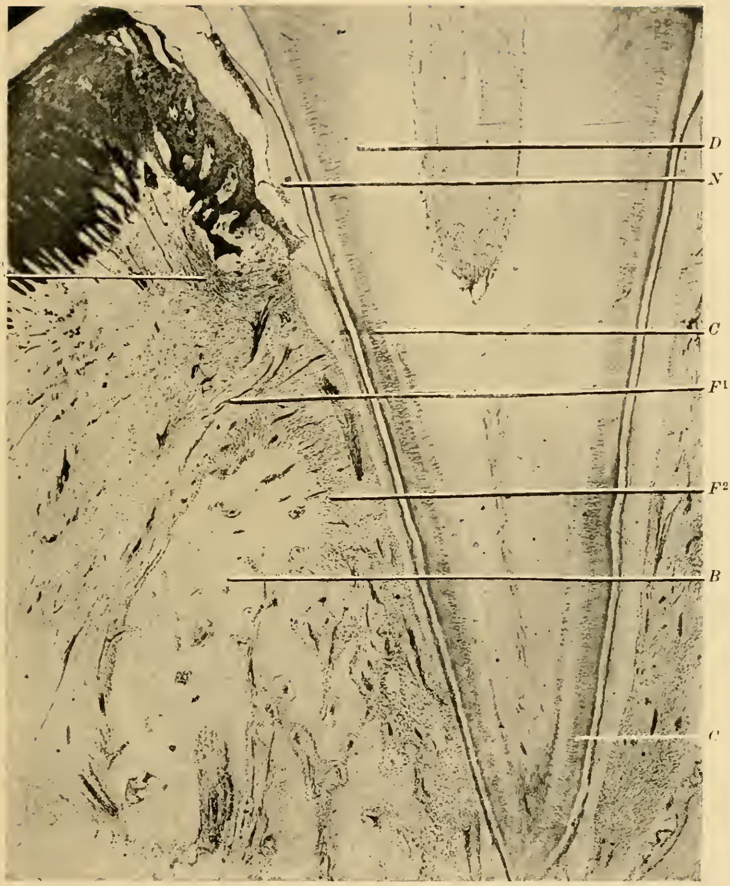


FIG. 196.—Longitudinal section of root of tooth *in situ*, showing relation of the tissues and Sharpey's fibres in the alveolar process. (F. B. Noyes.) *D*, dentin; *N*, Nasmyth's membrane; *C*, *C*, cementum; *F*, fibres supporting gingivus; F^1, fibres joining the outer layer of periosteum over the alveolar process (Sharpey's fibres); F^2, fibres running from cementum to bone; *B*, bone or alveolar process.

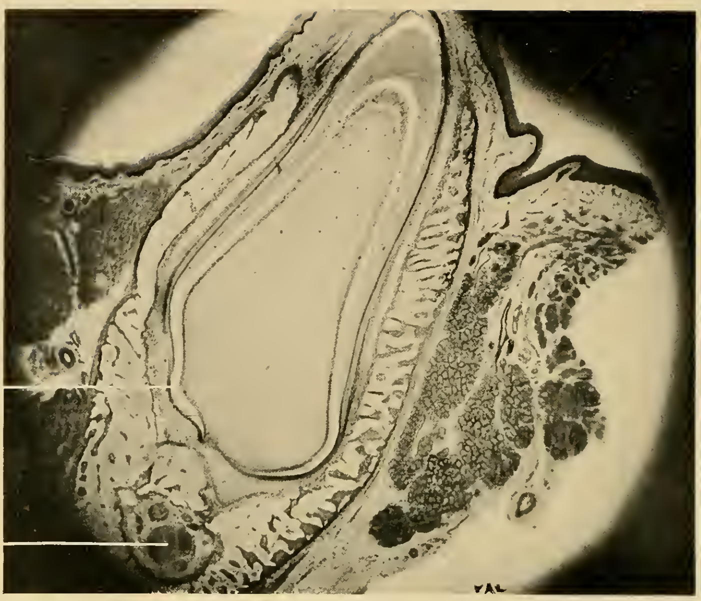


FIG. 197.—Vertical section of a dental follicle, showing the blood-vessels and nerves entering at the base of the follicle and a peculiar turning under of the enamel-organ at the base of the dental papillæ. (V. A. Latham.) × 96.

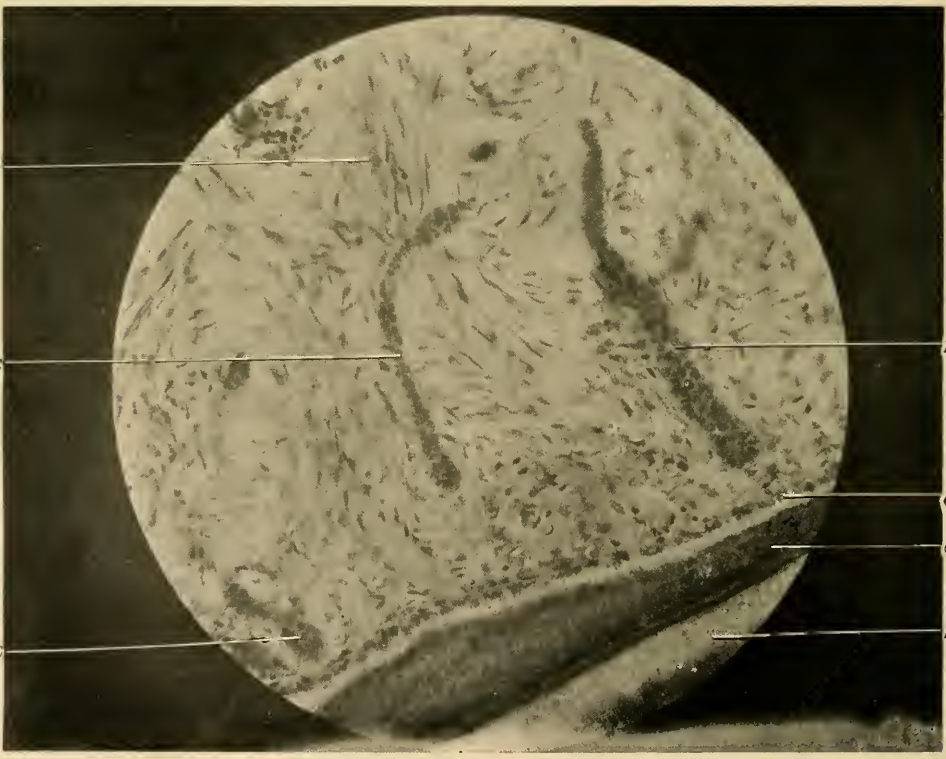


FIG. 198.—Section of pericementum *in situ*, showing epithelial bodies. (F. B. Noyes.) × 408. *D*, dentin; *C*, cementum; *Cb*, cementoblasts; *Fb*, fibroblasts; *F*, *E*, *E*, epithelial structures.

vessels and nerves. It is in reality periosteum, slightly modified to adapt it to its environment and special functions.

The peridental membrane is derived from the sacculus of the dental follicle. It is continuous with the periosteum of the alveolar process, and appears to be a reflection of this membrane, to line the walls of the alveoli and invest the root of the tooth. Fig. 193 shows the membrane at an early developmental period dipping in between the forming roots of the tooth of a field-mouse.

The *dental sacculus* is composed of two layers, the external being made up of a fairly dense fibrous connective-tissue structure, while the internal layer is rich in cellular elements and retains a softer and more embryonic character. The external layer upon the eruption of the tooth becomes the peridental membrane, while the internal layer furnishes the cellular elements for the formation of the cementum (Fig. 194) ; in other words, it becomes the *cement organ.*

The pericementum is a single membrane common to the cementum and the alveolar wall. There is no evidence whatever of a double membrane.

The peridental membrane of a mature tooth is thickest near the cervix and at the apex of the root. The general direction of its fibres is transverse ; in other words, they run through the thickness of the membrane from the cementum to the alveolar wall (Fig. 195). The attachment of the pericementum is increased by the presence of bundles of fibres,—Sharpey's fibres,—which penetrate the bone upon the one side and the cementum upon the other (Fig. 196), but in general the membrane is more strongly adherent to the cementum than to the walls of the alveolus. Sharpey's fibres are found most abundant at the cervix. "They are white connective-tissue fibres, the ends of which are included in the matrix of the cementum sufficiently to make them apparent when the lime-salts are removed, but when both are calcified they cannot be demonstrated except in cases where there is imperfect calcification of the fibres" (Black).

The *functions of the pericementum* are fivefold,—viz., first, by its cementoblasts to form the cement-tissue ; second, to furnish connection and attachment of the root to its alveolus ; third, to act as an elastic cushion or buffer between the root and the alveolus, thus providing against injury from the severe concussion and lateral strain incident to mastication ; fourth, to provide nutrition for the cementum through its abundant vascular supply ; and fifth, to give sensation to the cementum and the tactile sense to the tooth through its plexus of nerves.

The *blood-supply of the pericementum* is derived from two sources, the principal one being the main artery entering the deepest point of the alveolus (Fig. 197). This, entering the thicker portion of the membrane at the apex of the root, divides into several branches, one or more of which pass through the membrane and enter the apical foramen to supply the pulp ; while the others are distributed to the substance of the pericementum, and through their capillaries furnish nutrition to the cementum. Numerous minute branches derived from the blood-vessels of the alveolus also penetrate the membrane and freely anastomose with the vessels derived from the apical plexus.

Wedl says the vascular supply is derived from three sources: the gums, the vessels of the bone, and the vessels destined for the pulp of the tooth, the last being the most important.

Black has recently demonstrated the presence of certain bodies, of epithelial structure (Fig. 198), which from their form and location he is inclined to believe are *lymph-glands* lying within the pericementum; he describes them as being lobulated in form, and filled with lymphoid cells. These gland-like bodies are beautifully shown in the accompanying photomicrographs (Figs. 199 and 200), prepared by Professor F. B. Noyes, of the Northwestern University Dental School. Black was unable, however, to fully demonstrate the existence of a duct or channel leading from any of the glands.

The *nerve-supply* of the pericementum is from two sources, and is distributed in a manner similar to that of the blood-supply. The principal source of nerve-supply is from the dental nerve; a single branch is given off, which enters the alveolus with the blood-vessels, where it divides into several filaments, a portion going to the pulp and the others being distributed to the pericementum; numerous other filaments enter the membrane from various minute channels in the alveolar walls and the intervening septa to unite with those derived from the dental nerve.

The vital connection of the human tooth with the living organism is very intimate, being abundantly supplied with blood-vessels and nerves, both to its pulp and pericementum.

Tomes, referring to this, says, "The dentin is organically connected with the pulp by the dentinal fibrils; these are connected with the soft cement-corpuscles, which again are brought by their processes into intimate relation with similar bodies in the highly vascular periosteum, so that between the pulp on the inside and the periosteum on the outside there is a continuous change of living plasm."

THE GUMS.

The *gums*, or *gingivæ*, are formed of a layer of tough, fibrous, non-elastic, vascular connective tissue (Fig. 201) covering the alveolar processes, being closely associated with the periosteum, the fibres of which intercommunicate, and covered with the common mucous membrane of the mouth (Fig. 202). It unites with the pericementum at the cervix of the tooth without any line of demarcation. Numerous papillæ are present, single and compound. The papillæ are long and cylindrical near the free margin of the gum, like the fingers of a glove, and they become shorter and expanded in passing towards the jaw and palate. Each papilla contains a single capillary loop (Salter). The gum-tissue is abundantly supplied with blood-vessels, but nerve-filaments are rarely found. Lobulated gland-like structures are to be seen; these are the so-called glands of Serres (Fig. 203). They appear to be aggregations of small, round pavement epithelium, and are located just beneath the surface. It is not known that they have any special function. Tomes considers them to be remnants of the dental formative organs, as similar appearing bodies are found in the neighborhood of developing tooth germs, which are doubtless the remains of the

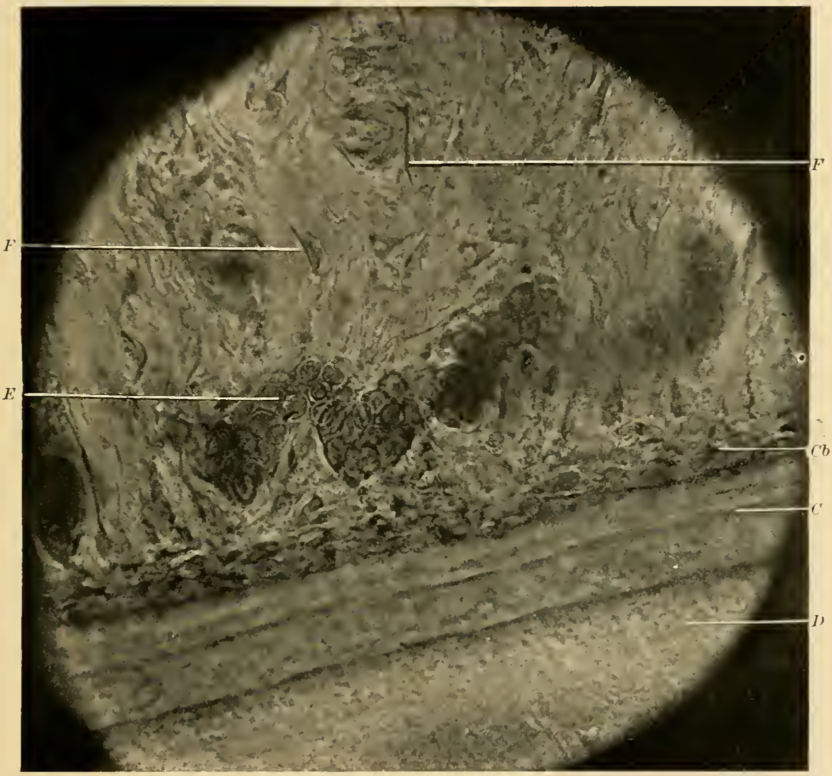


FIG. 199.—Section of peridental membrane, showing epithelial bodies or glandular structures. (F. B. Noyes.) × 700. *D*, dentin; *C*, cementum; *Cb*, cementoblasts; *E*, epithelial bodies; *F*, *F*, white fibres.

FIG. 200.—Section of peridental membrane, showing epithelial bodies or glandular structures. (F. B. Noyes.) × 900. *D*, dentin; *C*, cementum; *Cb*, cementoblasts; *E*, epithelial bodies; *F*, white fibres.

FIG. 201.—Transverse section of the jaw through the mucous membrane, gum, and alveolar process. (V. A. Latham.) × 60.

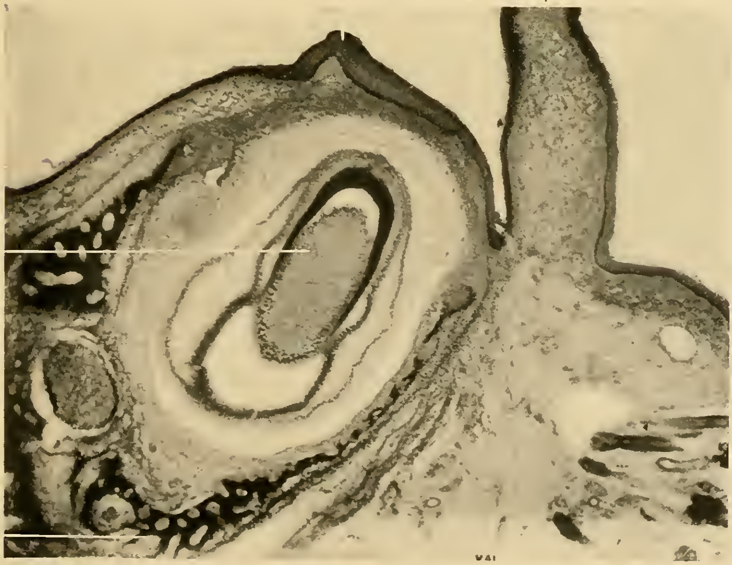


FIG. 202.—Oblique section of dental follicle and mucous membrane. (V. A. Latham.) × 26.

FIG. 203.—Glands of Serres. × 50.

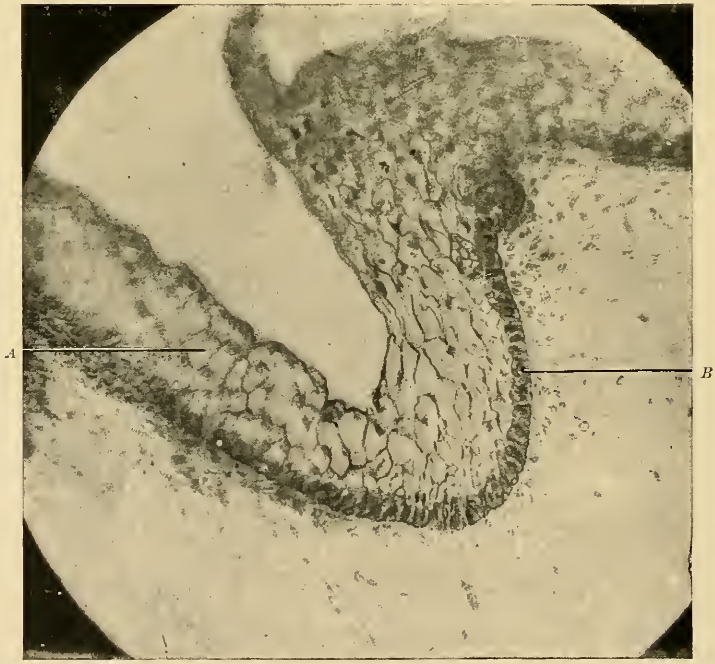


FIG. 204.—Epithelial layer of mucous membrane in its embryonic stage. *A*, squamous epithelial cells; *B*, columnar cells—rete Malpighii.

dental lamina undergoing retrogressive change preparatory to their final disappearance.

The margins of the gums closely invest the necks of the teeth, forming festoons which occupy the interapproximal spaces.

The epithelium of the mucous membrane covering the gum is composed of a dense laminæ of tessellated cells, which are derived from the deeper layer of columnar cells,—the *rete Malpighii* (Fig. 204). The epithelium is very tough and hard. This fits it in a remarkable degree to withstand the severe abrading action of certain forms of foods during their mastication. The structure of the gums at the cervical margins and the festoons is much modified; the papillæ disappear and the hard, tough, squamous epithelium is lost. The surface is soft and covered with a small round epithelium.

No true glandular structures have been discovered in the tissue of the gums, but the surface is "cupped and folded between the ramifications of a beautiful capillary network" (Salter). This, Black terms the *gingival organ*, from the fact that it suggests a gland-like formation of the simplest variety, and that it has the function of "emitting a profusion of small round cells which are constantly found in the fluids of the mouth and generally called *mucous corpuscles*" (Salter). It is a question whether these bodies are all produced by the gingival organs, but it is certain that a large proportion have such origin.

These bodies are found in greatest numbers around the necks of the teeth at the free margin of the gum, and appear as a yellowish creamy material not unlike pus in its general aspect. Koelliker looked upon these corpuscles as a modified form of pus, but inasmuch as this material can always be found in this location, even in healthy mouths, the corpuscles must be considered as a normal product of the gingival organs.

The writer has noticed very frequently in chronic gingivitis that this material was greatly augmented in amount, having the appearance of pus under these circumstances. This would suggest the catarrhal nature of certain cases of chronic gingivitis, and also the probability that this material is the active agent in causing calcic deposits about the crevices of the teeth. The so-called glands of Serres seem to take an active part in all inflammatory processes involving the gum tissue, both *acute* and *chronic*, as the *mucous corpuscles* are always found in greater amount under these conditions.

Whether or no these so-called glands are responsible, when in an inflamed condition, for other diseased conditions of the gums remains yet to be proved, but the writer is of the opinion that in phagedenic conditions of this tissue the ulcerative process begins in these pseudo-glandular bodies, probably by the occlusion of their ducts and the accumulation of the secretions, somewhat like that which occurs in follicular inflammation of the oral mucous membrane, the follicles of which, upon rupturing, leave a broken surface and an area of degenerating tissue which sloughs away, leaving an ulcerating surface or patch.

In phagedenic conditions of the gingival tissue the ulcerative patches are always found in those locations where the so-called glands of Serres are most abundant—namely, at the festoons and free margins of the gums. It would seem, therefore, more than probable that they were involved either as the primary seat of the ulceration or by secondary infection.

In *ulcerative stomatitis* (cancrum oris) the disease begins in the festoons and margins of the gums, as does also mercurial stomatitis and the chronic poisoning by phosphorus, lead, and copper. From the foregoing observations it would seem very probable that these gland-like structures are in reality true glands possessing eliminating functions; and that in certain conditions of the system, like auto-intoxication and intoxication from such drugs as those named, these structures become involved in various inflammatory processes as a direct result of the irritation produced upon them by the selective action of certain ptomaines and poisonous drugs.

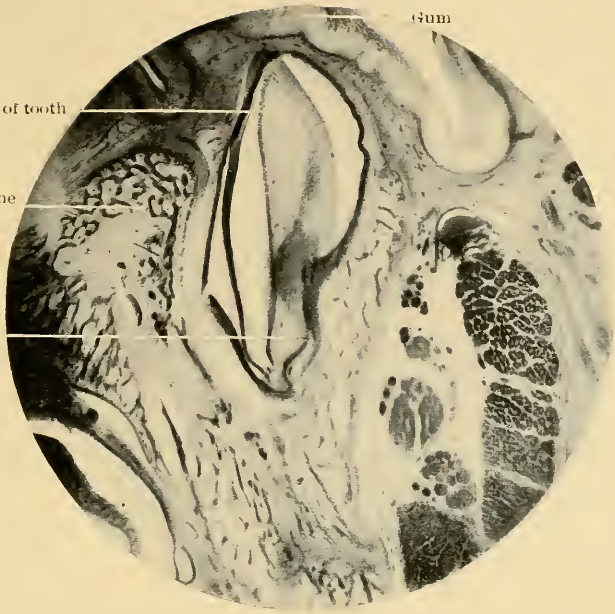


FIG. 205.—Vertical section of the jaw, showing forming root. × 15.

FIG. 206.—Section of jaw of rabbit, showing deciduous teeth and follicles of permanent teeth *in situ* at the period of the eruption of the primary teeth. × 22.

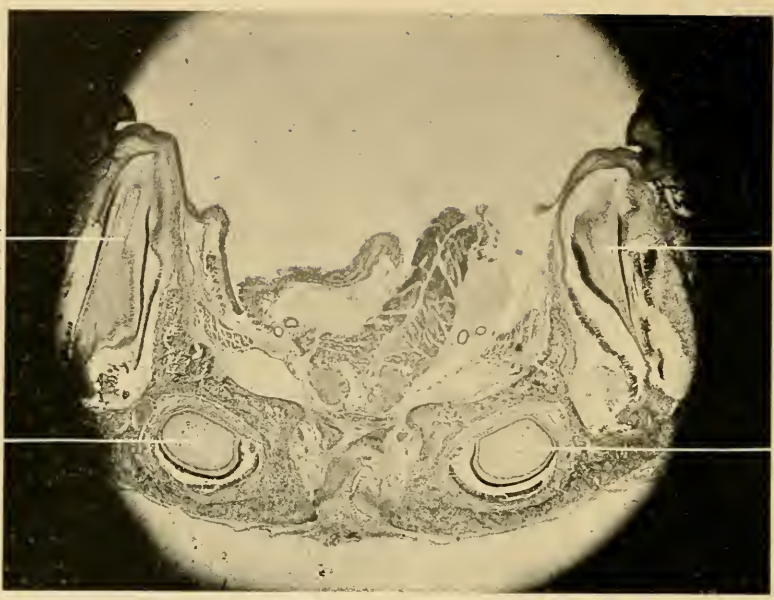


FIG. 207.—Lower jaw of fœtal field-mouse. × 80.

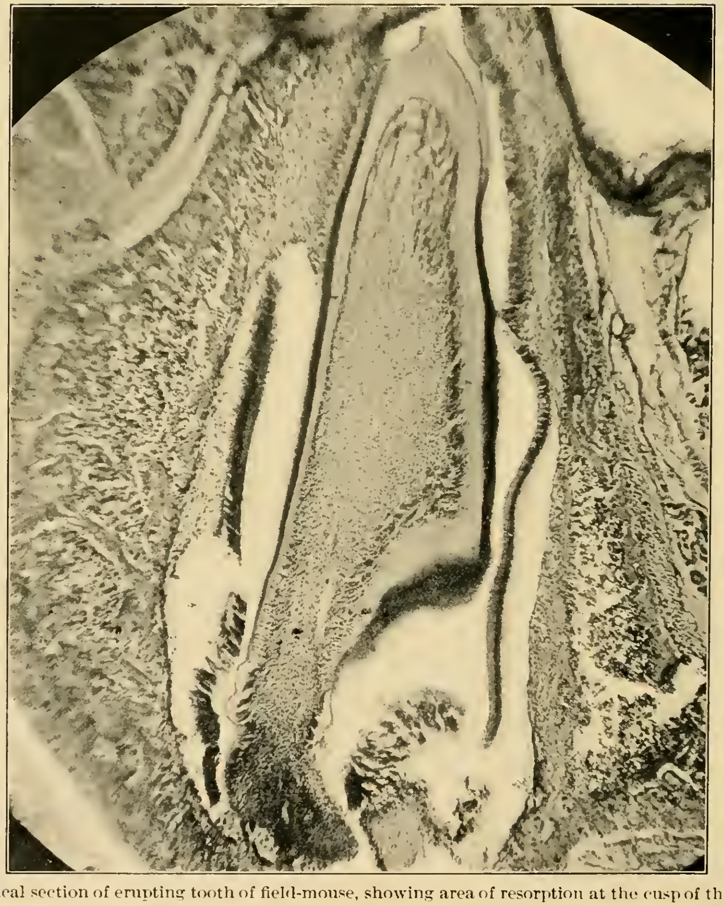


FIG. 208.—Vertical section of erupting tooth of field-mouse, showing area of resorption at the cusp of the tooth. × 65

CHAPTER IV.

ERUPTION OF THE TEETH.

Definition.—The process by which the teeth advance from the bony crypts, in which they have undergone the calcification of their crowns and a portion of their roots, and are forced through the gums.

Synonymes.—Teething; cutting the teeth; dentition.

Dentition is a physiologic process having no counterpart in the growth of other tissues. Fig. 205 represents a tooth in the process of eruption, the nearest approach to like conditions being the emergence of the hair-sheaths and the nails. In this use of the term dentition it will be understood that it has no reference to the process of development of the germs of the teeth, but refers only to the process of eruption. Fig. 206, made from a section of the jaw of a young rabbit, and Fig. 207, made from a section of the fœtal jaw of a field-mouse, show the relation of the primary and secondary teeth to each other at the period of the eruption of the primary teeth.

The process of dentition is divided into *primary*, the eruption of the deciduous or milk-teeth, and *secondary*, the eruption of the permanent teeth.

Normal *primary* or *deciduous dentition* begins between the fifth and eighth months after birth, and terminates between the twenty-fourth and thirty-second months. The following table represents the average period of the eruption of the various classes of teeth which constitute the temporary denture:

The central incisors	from 5 to 8 months after birth.
The lateral incisors	from 7 to 10 months after birth.
The first molars	from 12 to 16 months after birth.
The cuspids	from 14 to 20 months after birth.
The second molars	from 20 to 32 months after birth.

The inferior teeth usually appear a few weeks in advance of the superior. No general rule can be formulated from which, however, there will not be marked and frequent deviations. The variations are so marked in the dates of the eruption of the teeth that no two authors give them exactly alike. Tubercular and syphilitic children erupt their teeth very early, while in rhachitic children the process begins very late.

It has been stated that Richard Cœur de Lion of England and Louis XIV. of France were born each with several teeth.

It is not a very uncommon occurrence for children to be born with teeth. Haller, in his "Elements of Physiology," mentions nineteen cases of children that were born with one or more teeth fully erupted.

The author has several times been called upon to remove teeth from the mouths of newly born infants, and there are few physicians or dentists of twenty or twenty-five years' practice who have not had a similar experience.

Crump reported to the Virginia Society of Dentists a case of full dentition in a child at birth (Pepper); while, upon the other hand, the teeth are sometimes entirely suppressed.

Boxalli and Baumes have each recorded a case in which the individual reached old age without a single tooth ever having appeared. A few years ago a Russian family, father and young son, were on exhibition before medical and dental societies and in various museums under the name of "dog-faced men." The father had no teeth up to the age of seventeen, then four teeth appeared in the lower jaw but none in the upper. The son had four lower incisor teeth but no evidence of any others. The jaws of the father, who was a strong and powerfully built man, were no larger than those of his little son.

The Eruptive Process.—The *modus operandi* or the character of the agencies by which the teeth are stimulated to advance from their bony crypts and emerge through the gums has never been satisfactorily demonstrated or explained. Several views have been advanced to account for the process, but they are all open to serious objections.

The *first*, and perhaps the oldest, theory is that the tooth is impelled from its crypt and through the gum-tissue by *mechanical pressure induced by the growth or lengthening of the root from additions of dentin at its base.*

Several strong objections can be raised against this view: first, teeth with very short or stunted roots—roots which are much shorter than the distance from the margin of the gum to the base of the crypt—are often erupted; second, deciduous incisors are not infrequently found erupted at birth, or make their appearance a few weeks afterwards, which have very little or no roots at all, the crown only being developed; third, a tooth in which the root is completely developed may remain buried in the jaw until past middle life, and then make its appearance; fourth, normal teeth, particularly the superior cuspids, are so located in their bony crypts that in the process of the eruption of their crowns the distance travelled greatly exceeds in amount the addition made to the length of the root during the same period.

C. S. Tomes says,* "The tooth of a crocodile moves upward, tooth-pulp and all, obviously impelled by something different from mere elongation; and my own researches upon the development and succession of reptilian teeth clearly show that a force quite independent of increase in their length shifts the position of and 'erupts' successive teeth."

Another theory advanced to account for the process of eruption is *mechanical pressure induced by the lengthening of the dentinal papillæ or formative pulp.* The principal objection to this view is the improbability that the elongation of a delicate and more or less embryonic structure like the formative pulp could produce a sufficient amount of pressure upon the tooth-crown at its base to cause resorption of the overlying bony walls of its crypt without injury to its own structure, or causing deflection of the

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* Dental Anatomy.

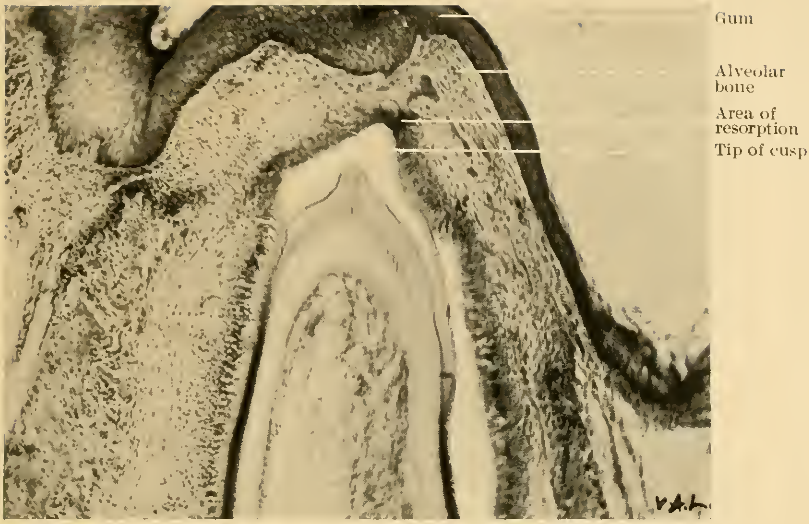


FIG. 209.—Vertical section of erupting tooth of field-mouse, showing area of resorption. × 75.

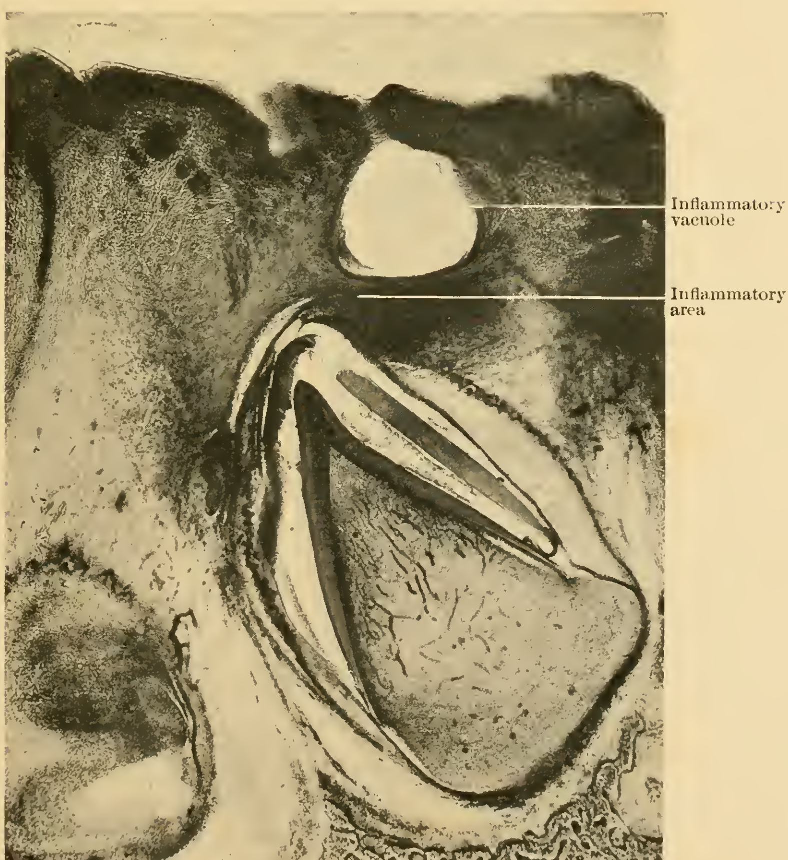


FIG. 210.—Vertical section of human cuspid. × 75.

apical end, and thus producing crooked roots, which is by no means a general condition.

Delabarre suggested that the advance of the tooth from its crypt and its passage through the gum was effected in precisely the same manner as the fœtus is expelled from the uterus. He regarded the sac, which he claimed was attached above to the gum and below to the neck of the tooth, as the active agent in the eruption of the tooth, induced by the contraction of its walls, and thus the crown of the tooth was lifted from the base of the follicle and ultimately forced through the uncapped crypt and the gum.

This is a very ingenious explanation, and is based upon the supposition that there are elastic fibres within the walls of the sac.

Nasmyth found the sac to be composed of two layers, the inner lamina composed of a layer of cells loosely arranged, with interspaces equal to one-half the diameter of the cell. This inner lamina he thought partook more of the characteristic of a serous than of a mucous membrane. This arrangement of the cellular elements of the inner layer is suggestive of contractile power and expelling force.

If elastic fibres could be positively demonstrated as forming a part of the structure of the sac, this would be the most rational theory yet advanced, as it would be based upon the known and demonstrable physiologic function of elastic tissue. In support of this supposition it has been stated that inasmuch as in the periosteum elastic fibres are present in that portion of the membrane which lies nearest to the bone, being in the form of a fine fibrous net-work, that they must also be present in the structure of the pericementum, which is very similar to that of the periosteum. Black, however, in his researches upon the histology of the pericemental membrane, was unable to positively demonstrate the presence of elastic fibres. He found the membrane to be composed almost entirely of white fibrous tissue, but when the white fibres were dissolved by the usual reagents—solutions of caustic potash—no elastic fibres could be discovered.

Another theory presented was that the eruption of the teeth was caused by the moulding or building of the alveolus around the roots. This theory is easily disposed of by the statement that the alveolus is not formed around the root, nor the root completed, until after the crown of the tooth has been erupted. At the time of the eruption of the tooth the osteoclasts have made an opening in the cap of the crypt (Fig. 208) large enough for the crown to easily pass; this leaves a considerable space between the bone and the root, which is occupied by the, at this time, thick pericemental membrane.

The latest theory is that suggested by Constant (*Journal British Dental Association*, 1896),—namely, that the blood-pressure may be the force which impels the tooth in its movement from the crypt and through the gum, on account of the difference in the blood-supply of the parts.

The pulp and the tissues beneath it have a very abundant vascular supply, while those above are not so richly endowed. C. S. Tomes, in commenting upon this theory, says, "It seems very possible that the blood-pressure keeping up a state of general tension may operate to push a solid body in any direction in which there is a diminished resistance, to take up, so to speak, any unoccupied space; but it is difficult to see how it could be efficient without some such concomitant action of absorption. For the movement of an erupting tooth is not always by any means in the direction of its long axis; for instance, the developing tooth of the frog, the newt, or of the crocodile takes a sidewise journey, by which it travels underneath the old tooth before it moves upward at all."

But if its path be prepared by absorption of the structures in its way, then it is very possible that the blood-pressure keeping up a certain general tension may suffice to move it along a track of diminishing resistance. Mr. Constant's suggestion, with a little modification, is the most plausible that has been offered, therefore, as to the actual motive force; whether it will be regarded as a final solution of the question time alone can show."

What are the forces which set in operation the process of eruption? is a question which very naturally arises in discussing this phase of the phenomenon of the eruption of the teeth. If the lengthening of the root, the elongation of the pulp, or the blood-pressure within the pulp are not sufficient as mechanical forces to produce the adequate pressure or mechanical irritation necessary to stimulate the osteoclasts to the performance of their function of tearing down the structures which their sister cells, the osteoblasts, had so lately built up, what other force or forces are operative in establishing this phenomenon? It is possible that it is due to some change in the nutrition of the walls of the crypt and the gums, induced, perhaps, by the withdrawal of a portion of its blood-supply, as a result of the greater activity in the growth of the tooth-follicle just preceding and during the period covered by the process of the extrusion of the crown. In some such change as this in the nutrition of the part the resorption of the alveolus is induced after the extraction of a permanent tooth.

The whole subject, it will be seen, is far from being satisfactorily settled, either as to the conditions which induce resorption or the forces which are operative in extruding the tooth-crown from its crypt to its normal position in the mouth.

When the formation of the tooth has arrived at that stage in which it is ready to be extruded, and this occurs in the deciduous central incisors, which are the first to be erupted, at the fifth to the eighth month after birth, a very active process of resorption, the result of a low inflammatory condition, takes place in the walls of the bony crypt in which the crown of the tooth is lodged. This process is most active at the anterior or labial wall and the roof of the crypt, by which the upper portion of the sac and the bony tissue are removed, as shown in Fig. 209, while the posterior or lingual wall remains unchanged, as it is required to form the labial wall of the crypt of the successional tooth. Prior to this, however, there is formed in the tissues immediately above the bony crypt of the follicle an inflammatory area in which resorption vacuoles are formed which gradually increase in size. The opening made by this process (Fig. 210) finally becomes larger than the diameter of the crown, thus giving it a roomy exit; but as soon as the crown has passed from the crypt and extruded through the gum, the process of resorption gives place to that of a deposition of new osseous material, which loosely embraces the cervix of the tooth.

FIG. 213.—Vertical section of jaw of embryo cat, showing deciduous tooth and follicle of permanent tooth. × 90.

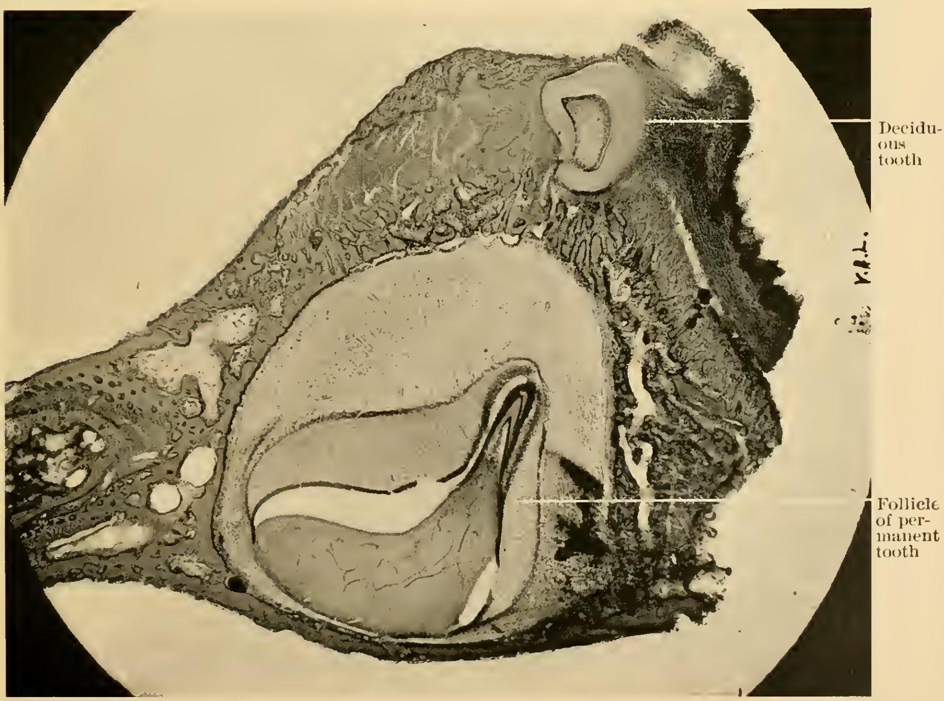
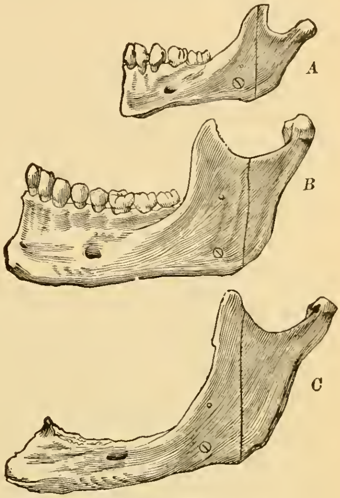


FIG. 214.—Oblique section of jaw of embryo cat, showing deciduous tooth and follicle of permanent tooth. × 80.

Growth of the Jaw.—As the root of the tooth increases in length additions to the margin of the alveolus keep pace with it; and as the process is a somewhat rapid one, the increase in the depth of the jaw is correspondingly rapid. This phenomenon begins first in the anterior portion of the jaw by the eruption of the incisor teeth. Later the first molars are extruded, and the jaw deepens posteriorly; then the cuspids make their appearance, and still later the second molars, producing a corresponding deepening of the jaw in these locations. During this time there has also been a steady lengthening of both the horizontal and the ascending rami of the mandible, with a considerable change in the angle formed by their union. These changes progress until adult life is reached, when they assume an angle of about forty-five degrees.

Fig. 211.



Rami at various ages. *A*, childhood; *B*, adult life; *C*, old age.

In old age, after the teeth are lost, the alveolar processes are resorbed, and the rami again assume a more obtuse angle, approaching that of childhood. (See Fig. 211.) The changes which occur in the superior maxilla are similar, so far as the deepening and lengthening of the jaw are concerned, to those which take place in the growth of the mandible, while the retrogressive changes are confined to the resorption of the alveolar processes.

The eruption of the teeth is not a continuous process, as was pointed out by Trousseau; the teeth being erupted in pairs or groups, with varying periods of rest between them.

The deciduous central incisors are the first of the dental series to be erupted; the appearance of these teeth is followed by a period of rest in the process of from one to two months; the lateral incisors are next extruded, and their appearance is followed by a rest of from five to six months. The first molars come next, and these are followed by the cuspids, with a period of inactivity in the process between them of from two to four months. The second molars are the last of the deciduous teeth to be erupted, and they make their appearance from six to twelve months after the extrusion of the cuspid. It will therefore be seen that the whole period of time consumed in the eruption of the deciduous teeth is about two years, but the actual time occupied by the various groups of teeth in the passage from their bony crypts and through the gum to their normal positions in the mouth is much less than this; the usual period of time consumed by each group is only from four to eight weeks.

The roots of the deciduous teeth are completed in formation at about the following periods and in the order named, but no positive rule can be laid down from which frequent deviations will not be observed:

The central incisors are completed at about the age of	2 years.
The lateral incisors are completed at about the age of	$2\frac{1}{3}$ years.
The first molars are completed at about the age of	$2\frac{1}{2}$ years.
The cuspids are completed at about the age of	$2\frac{2}{3}$ years.
The second molars are completed at about the age of	3 years.

Fig. 212 shows the jaws of a child at three to three and a half years of age.

MORBID PRIMARY DENTITION.

The eruption of the teeth in a normal child is productive of so little general or local disturbance that many times the teeth make their appearance within the mouth before the parent or nurse have realized the fact that the process of "teething" had really begun; while, upon the other hand, in children with impaired health and low vitality it often plays a

Fig. 212.

Jaws of a child of three to three and a half years of age.

prominent part in exciting various morbid conditions of the digestive, nervous, respiratory, and dermal systems. The subject becomes, therefore, one of considerable interest, alike to the general practitioner and to the dental specialist. There is no doubt that the dangers from dentition have been greatly exaggerated by some authorities, and that parents are often unnecessarily anxious for their offspring during this period; yet it must be borne in mind that in certain temperaments and under various physical conditions and environment there is a real degree of danger present, and that morbid phenomena are sometimes excited which may progress to a fatal termination.

According to the mortality tables of London, as cited by West, dentition was assigned as the cause of death of 4.8 per cent. of all children dying under one year of age, and 7.3 per cent. of those who died between the ages of one and three years.

The dangers surrounding the period of dentition are much greater in large cities and in overcrowded localities, particularly among the middle and lower classes of society, than in the suburban and county districts. But the greatest mortality is in the foundling hospitals and in overcrowded and filthy tenements.

It therefore becomes a question of how much of this mortality is really due to the nervous irritation induced by the eruption of the teeth, or to other concomitant causes. Errors in diagnosis of abnormal conditions occurring at this period are by no means uncommon, and it is to be feared that dentition is sometimes made the scapegoat for the ignorance of a medical or dental attendant, or the carelessness or indiscretions of the parents or nurse.

Contemporaneously with the eruption of the teeth there is a very important developmental process taking place in the follicular or glandular apparatus of the whole alimentary canal, in preparation for the necessary change soon to take place in the character of the food.

This is a physiologic process, and under normal conditions, when all of the functions of the body are nicely balanced, progresses without any disturbance of the general health ; but under opposite conditions it may be productive of serious gastric and intestinal complications, the causes of which are often entirely overlooked, and the disturbances which are the result of this process are attributed to morbid dentition.

The nervous system of the child at this period is also very impressible, the cerebro-spinal apparatus predominating to such an extent that slight irritations of almost any character, in children of certain temperaments, may be followed by more or less general systemic disturbance, with elevation of temperature, vomiting, diarrhœa, bronchitis, and other catarrhal conditions, or reflex nervous phenomena, like strabismus, twitching of the facial muscles, rolling of the eyes, convulsions, or meningitis.

Dental Irritation.—The nervous irritation accompanying the eruption of the deciduous teeth may be caused by one or all of the following conditions :

1. By the very active evolutionary process going on within the jaws at this period.

2. By the lateral pressure induced within the jaws by the contemporaneous evolution of two sets of teeth.

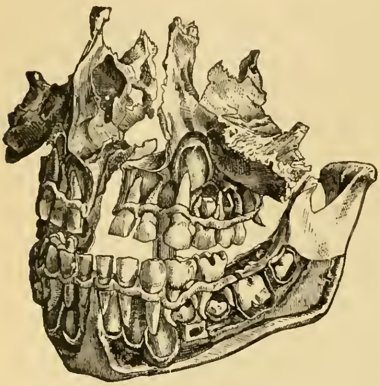
3. By peripheral irritation of the gingival nerves from the pressure of the advancing teeth.

(1) The very active evolutionary process which is going on within the jaws at the period of the eruption of the teeth calls for a much larger volume of blood within the parts than is normal at a later period in life. The illustrations shown in Figs. 213 and 214, made from the jaw of an embryo cat, show what a considerable amount of space is occupied in the jaws at this period of dental evolution by the follicles of the teeth. This, under certain conditions which have already been mentioned, often produces over-stimulation of the parts, followed by congestion, which may induce reflex nervous phenomena, or through the sympathetic nervous

system establish morbid conditions of the stomach, the bowels, the respiratory tract, the skin, etc.

(2) The lateral pressure induced within the jaws by the contemporaneous evolution of two sets of teeth must be very considerable at this period. If the jaws of a child six months old are examined it will be noticed that the permanent teeth in various stages of development are so crowded together that their crypts overlap each other, but each apparently is striving to obtain a normal position. As the growth and enlargement of the jaws takes place they gradually assume their proper positions within the arch, ready to advance as soon as the way is made clear for them by the lengthening of the jaws and the exuviation of the deciduous teeth (Fig. 215).

Fig. 215.



First and second dentition, upper and lower maxillæ.

(3) The peripheral irritation of the gingival nerves from the pressure of the advancing teeth is often under-estimated, as any individual will readily admit who has suffered from the eruption of a troublesome third molar.

In viewing the subject of dental irritation from this stand-point the wonder would seem to be that morbid phenomena are not more often manifested than they are during the eruption of the deciduous teeth.

Symptoms.—The symptoms of dental irritation may be classified under two heads,—viz., *constitutional* and *local.*

The *constitutional symptoms* which may be manifested as complications during the period of first dentition are fever, diarrhœa, vomiting, cough, bronchitis, various eruptions of the skin, occasionally swelling and suppuration of the lymphatic glands, and nervous phenomena like spasms of the facial muscles, "which send doting mothers into ecstasy over the heavenly smile of the sleeping infant," strabismus, chorea, convulsions, and meningitis.

Pyrexia, or *fever*, is perhaps the most common constitutional symptom or complication of morbid primary dentition. The character of the fever may be mild or intense, according to the degree of susceptibility of the child to nervous irritation, and there is a marked difference in children in this respect. In one child the elevation of temperature may be slight, not going above 100° F., while in another, with apparently no greater cause for an abnormal rise in temperature, it may reach 103° or 104° F., and be accompanied with gastric or intestinal disturbances or convulsions.

The fever of dentition, which is irritative in character, is peculiar in that it is very irregular in its manifestations. It is often higher in the morning than in the evening, reversing the usual order, and it varies considerably from day to day. A high morning temperature often follows a restless night, and a low evening temperature follows a quiet day. Great vigilance should characterize the care of children when suffering from the irritative fever of dentition. A feverish child is very susceptible to sudden changes of the weather from a dry to a damp atmosphere, from a warm to a cold room, or to cold draughts, and to improper feeding. Too much emphasis cannot be placed upon the importance of properly protecting the child against these contingencies. Catarrhal attacks at this period are far more likely to be the result of exposure which has induced a chill, or to improper feeding, than to mechanical irritation of the gingival nerves by an erupting tooth.

Diarrhœa is another very common complication of morbid dentition, but dental irritation is by no means the most common cause of diarrhœa. Catarrhal conditions of the stomach and bowels are very prevalent at this period; but in the opinion of the writer these conditions are more often the result of bad sanitary and hygienic surroundings, exposure to cold, or improper feeding and unwholesome food than to any other cause or causes.

Diarrhœa and vomiting are most prevalent during the hot months of the year, when the changes in the weather are often the greatest and the clothing of the child least likely to afford the proper protection against a sudden fall in the temperature. The food also is more liable to be rendered unwholesome by fermentative changes during the hot weather than at any other time. A chill or a cup of milk partially changed by lactic acid fermentation, or the impure, chemically preserved stuff often sold in our large cities as pure milk, are responsible for a large majority of the cases of gastric and intestinal disturbances and nervous phenomena.

Parents and nurses through ignorance or carelessness often feed little children with foods that their stomachs, at this early age, are incapable of digesting; for instance, meats, hard-boiled eggs, beans, cabbage, bananas, apples, cherries, and many other similar things; and then, if the child's stomach refuses afterwards to retain food, or it suffers from diarrhœa or cholera infantum or convulsions, and as a result gives up its puny life, the illness or the death is often charged to teething.

Bronchitis is usually attributed to ordinary exposure, and yet it sometimes occurs in children in whom every precaution has been taken to prevent chilling the surface of the body; under such circumstances it may be the result of dental irritation.

Cutaneous eruptions frequently occur during primary dentition, such as urticaria, eczema, impetigo, lichen, prurigo, and herpes zoster, which are often the expression of reflex nervous irritations.

Reflex nervous phenomena, associated with morbid dentition, are of the most varied character, both as to degree and the peculiarities of their manifestations. These manifestations are often difficult to understand, and still more difficult to trace to their origin. Pepper says, in explanation, "Doubtless the extensive ramifications of the great vagus nerve and its connections, both of origin and distribution, with the exquisitely sensitive fifth nerve, as well as with the facial nerve, and with the sympathetic system, will explain why the irritation should now be seated in the gastro-intestinal tract, giving rise to vomiting and diarrhœa; now in the respiratory tract, provoking cough more or less severe, or even a well-marked bronchitis; now manifests itself in various cutaneous eruptions; now accumulates in the cerebro-spinal axis, manifesting its presence by slight spasms, or discharging with terrific force in some of those convulsive seizures which are the dread of mothers and the cause of much anxiety to physicians."

The *second summer* is generally considered as the most critical period in the life of the infant, the popular notion being that the dangers and complications which arise are largely due to the eruption of the cuspid and molar teeth, as one or the other of these groups usually makes its appearance at about this time. There is really no reason why a cuspid or molar tooth should cause a greater degree of irritation than an incisor; while, upon the other hand, in a normal child, with the increase in the age and strength, there usually comes greater resistive power to such forms of irritation; consequently the second summer should be less dangerous than the first so far as dentition is concerned.

The dangers associated with the second summer do not in any great measure depend upon dental irritation, but rather upon improper feeding. Children of this age are prone to devour anything that may be given to them, or upon which they can lay their hands, and unless they are carefully watched and strict supervision instituted over their food, as to its kind, quality, and quantity, many illnesses are likely to occur; and if a group of teeth—the cuspids or molars—should be erupting when the illness supervened, the chances are that they would be considered the primary cause of the derangement rather than the ingestion of indigestible substances or foods in which fermentative processes had already been established. When these conditions are complicated with the debility consequent upon previous disease or a period of intense heat, the results often prove fatal.

A very large percentage of all the children born die before they reach the end of the fifth year as a result of the diseases and accidents peculiar to this period of life. Arbuthnot calculates that one in every ten children dies from the effects of the associative and influenced lesions of the age. (Garretson.) The mortality among hand-fed children is much greater than this. Camper is the authority for the statement that out of five thousand nine hundred and eighty-nine children admitted to foundling hospitals, only eight hundred and eighty-four were found living at the end of the fifth year (Garretson), or 85.239 per cent. had died.

Routh says, in this connection, "In England, out of one hundred children born and fed by hand, 15.2 per cent. will die the first month, 1.7 the second, and so on. In France, out of one million births, 20,121 die in the first week, 22,128 in the second, and 22,236 in the sixteen days following."

According to the English Life Table, "the annual rate of mortality among infants per thousand is equal to 571.3 in the first month of life, declining, however, to 91.6 per thousand in the eleventh month. The annual rate among infants aged one month and under one year does not exceed 114.6 per thousand, whereas among infants from birth to one year of age it is equal to 165.6 per thousand.

"Among infants of six months the mortality is but one-fifth of the rate which prevails during the first month of life." (*British Medical Journal*, vol. i., 1875, p. 785.)

The report of the Register-General of England for 1897 shows that "under the most favorable circumstances the mortality of infants under one year of age is very high. Reference to several life tables shows that the same rate of death is not again experienced until the age of about eighty years. But the mortality in the first year of life is by no means evenly spread over that year; about one-half of it occurs in the first three months. The following table shows the survivors at *three* months, *six* months, and *twelve* months out of one hundred thousand of each sex born in 1881–90; the deaths in the intervals are likewise shown."

England and Wales.		England and Wales.	
Born and Surviving at Each Age.		Dying in Each Interval of Age.	
Males.		*Males.*	
Born	100,000	Between birth and three months	7880
Three months	93,791	Between three and six months	3225
Six months	88,895	Between six and twelve months	4999
Twelve months	83,896		
Females.		*Females.*	
Born	100,000	Between birth and three months	6209
Three months	93,791	Between three and six months	2653
Six months	91,138	Between six and twelve months	4251
Twelve months	86,887		

The rate of mortality among infants of both sexes under the age of twelve months was equal to 142 per thousand births registered as compared with 149 per thousand in the preceding decennium. In 1881–90 the infantile rate among males was equal to 155 per thousand births, and among females to 128 per thousand, the rates in 1871–80 having been 163 and 134 respectively.

Local Symptoms.—The local symptoms which usually accompany first dentition are as follows: Salivation is the first indication of approaching dentition. From birth to the fourth or fifth month the salivary glands seem to remain nearly or quite inactive, but as the time approaches for the teeth to begin the process of eruption the salivary glands take on a marked activity, the flow of the secretion being so abundant as to cause it to dribble from the corners of the mouth and to wet the garments about the neck and chest. This wetting of the clothing is often responsible for the catarrhal attacks associated with dentition, while the swallowing of large quantities of saliva has been thought in some cases to be responsible (Pepper) for the diarrhœa by reason of its saline constituents, which may act as a mild cathartic.

Swelling or tumefaction of the gums is next observed, at about the sixth to the seventh month, in those locations where the teeth are about to be erupted. Sometimes the gums become congested, tense, glistening, hot, and painful; at times tender to the touch, but generally the painful sensations are relieved by pressure, hence the desire of the child to bite upon hard substances.

Accompanying these local symptoms there is often a slight elevation of temperature with flushing of one or both cheeks, irritability of temper, peevishness, and restlessness during sleep, with rolling of the head from side to side. Occasionally the child sleeps with the eyelids only half closed or the eyes rolled upward. Otalgia is not an uncommon occurrence, as may be inferred from the child poking its fingers into the external meatus or pressing its ear into the pillow or against the bosom of the nurse. In the ordinary cases of dentition these may be the only manifestations. In the more severe cases one or more of the constitutional symptoms above described may be present as complications.

Occasionally there exists a disposition to the formation of aphthous patches, *ulcerous stomatitis*, within the mouth, upon the lips, cheeks, gums, and tongue, most frequently, however, at the commissure of the lips, upon the buccal surface of the alveolar ridge, and the tip of the tongue; the latter being due, in all probability, to the friction of the sharp and serrated edges of the incisor teeth.

Sometimes in children suffering from debility the aphthous patches become confluent, forming large ulcerated surfaces; or the gums over the advancing teeth become ulcerated, exceedingly tender and painful,—*odontitis infantum*,—or gangrenous, forming large, foul-smelling sloughs,—*gangrena oris*,—which expose the teeth and the bone. Both of these conditions are difficult to cure, the latter often taking on the more severe and fatal form of gangrenous ulceration known as *noma*.

A more common but less severe form of stomatitis, in which there is a general inflammatory condition affecting the mucous membrane, and especially the mucous follicles of the tongue and cheeks,—*catarrhal stomatitis*,—accompanied by swelling of the submaxillary glands and infiltration of the surrounding connective tissue, is frequently seen in the children of the very poor, and is usually associated with bad or insufficient food and unsanitary surroundings.

Constitutional Treatment.—The treatment of morbid dentition with its constitutional and local complications generally falls to the lot of the family physician, and the dental surgeon or stomatologist is rarely consulted except in the more severe cases involving serious oral lesions or reflex phenomena dependent upon oral conditions. It will not be necessary, therefore, to dwell at length upon the treatment of the various general morbid conditions which accompany difficult dentition, as these belong to the realm of general medicine, and those especially interested in this part of the subject can refer to works devoted to this department of medical science. It will be sufficient to say, then, that the constitutional symptoms are to be treated upon general principles, the *first* of which is to ascertain the cause, *second*, to remove it if possible, and *third*, to assist nature in re-establishing a normal condition. It will not be amiss, however, to quote a few lines from Day ("Diseases of Children") upon this part of the subject. He says, "The treatment of dentition will depend upon the general symptoms that are present and the constitution of the patient. The practitioner must exercise his own judgment as to the treatment to be adopted, and not blindly attach himself to any routine plan. The strong and vigorous child who is feverish and thirsty, with a hot and tender gum, a full pulse, and constipated bowels, will demand quite a different mode of management from a puny and rickety child whose teeth are delayed. In strong children a grain of calomel with two or three grains of rhubarb will be required to clear the bowels. A saline mixture, as the citrate of potash, should be given to abate the pyrexia, and if the child is excited and sleepless, a few drops of tincture of henbane may be added, or a draught at bedtime containing hydrate of chloral and bromide of potassium should be given. The child's head should be kept cool, and whatever determines to cerebral congestion should, if possible, be prevented.

"In rickety children a mild aperient is occasionally required, such as bicarbonate of soda and rhubarb, to regulate the bowels and to correct the secretions. A teaspoonful of castor oil may be advisable now and then, and if the bowels are overactive, a grain of Dover's powder at bedtime is often of great service. If there is vomiting and flatulence, some carminative will be necessary. In cases where there is much restlessness and disturbance of the nervous system, bromide and iodide of potassium with sal volatile will often abate sickness and relieve head-symptoms if present."

Local Treatment.—In those cases in which the gums are considerably congested and swollen, *causing pain on pressure*, and accompanied with general febrile symptoms, vomiting, diarrhœa, or cough, almost immediate relief is often obtained by the free use of the gum-lancet. To be effective the lancet must reach the tooth. The incision for the six anterior teeth of each jaw should follow the line of the morsal or the cutting edge of each tooth, except in the cuspids when the cusp has penetrated the gum (Fig. 216), when the incision may be made as shown in Fig. 217, while for the

FIG. 216.

FIG. 217.

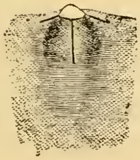


FIG. 218.

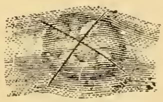


FIG. 219.

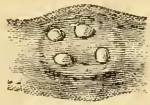
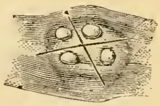


FIG. 220.



molars crucial incisions should be made, one from the disto-lingual cusp to the mesio-buccal, the other from the disto-buccal cusp to the mesio-lingual (Fig. 218.)

These incisions follow the line of the cutting edge in the six anterior teeth, and cut directly across the cusps of the molar teeth which are nearest the surface of the gum (Fig. 219), and for that reason are to be preferred to those which are made upon the lines of the sulci between the cusps, as shown in Fig. 220.

The indiscriminate use of the gum-lancet, however, should be deprecated. Much harm has often been done by a thoughtless or empirical use of this valuable means of treatment, while, upon the other hand, many lives have been saved by an intelligent use of it.

Many writers and physicians of experience have claimed that its use is never indicated, and when used it is productive of more harm than good. The same has been said of blood-letting in pneumonia, and yet in certain cases there is not a more valuable means of treatment known to medicine than this once much-abused and now often-maligned procedure. The difficulties and dangers in both of these methods of treatment do not lie in the methods, but in the discriminating power of the person who employs them.

If the gum-lancet is applied before the tooth has advanced from its crypt, the incision will necessarily be deep, and the end sought for—viz., the extrusion of the tooth through the gum—will not be realized; consequently the lips of the incision will unite again; and if this procedure is repeated, and it frequently is, a mass of cicatricial tissue is formed that is likely in a frail and debilitated child to become the seat of ulceration when the tooth shall finally make its appearance through the gum. Such an indiscreet use of the gum-lancet cannot be too strongly condemned, for the irritation certainly does not come from pressure upon the gingival nerves until the tooth advances from its crypt.

Dental irritation which does not produce local symptoms within the mouth—swelling or congestion of the gum, or both—is not due to pressure upon the gingival nerves, but rather to one or both of the other causes of dental irritation before mentioned.

The *operation of lancing the gums* is best performed with the assistance of a nurse. In operating upon the lower jaw the child should be seated in the lap of the operator, with its head against his breast, the hands and feet being controlled by the nurse. The left thumb of the operator is placed in the mouth of the child upon the tongue, the index-finger between the alveolar ridge and the lower lip, with the remaining fingers under the chin. In this way the head can be firmly held, the tongue controlled, and the lip held out of the way; it also gives a good view of the inferior alveolar arch, and permits the operator to reach any part of it with the lancet. The best form of gum-lancet is shown in Fig. 221, which is a flat blade turned at right angles to the shaft, and having a sharp, rounded edge.

FIG. 221.

Gum-lancet.

In operating upon the upper jaw the child should be laid upon its back in the lap of the nurse, with its legs passing under her arms, while the arms of the child are held firmly to its sides. The head should be held between the knees of the operator. One or more fingers of the left hand of the operator are then inserted within the mouth of the child, and the alveolar ridge grasped with the thumb and index-finger. The gum-lancet should be held in the right hand as a pen or pencil is held, and the hand should be steadied by resting the ring-finger and the little finger upon some convenient portion of the face while the incisions are being made.

Sometimes it becomes necessary in the eruption of the molar teeth to remove the band of overlying gum-tissue which remains after the cusps have pierced the gum, as it seems to retard the extrusion of the tooth. This can be best accomplished by a pair of sharp-pointed curved scissors (Fig. 222).

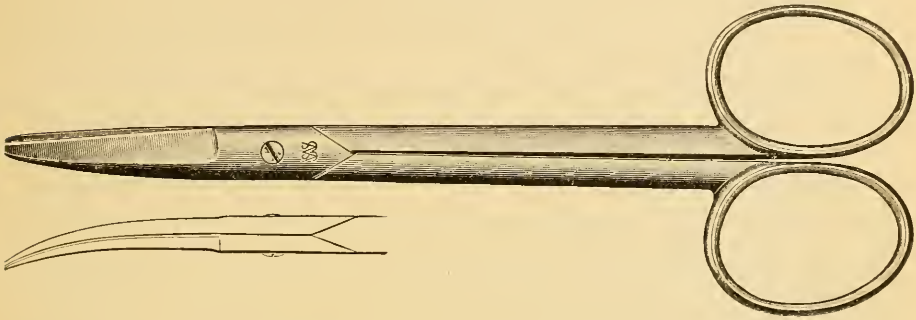
Troublesome hemorrhage occasionally follows lancing of the gums, but, as a rule, the bleeding is so slight as not to need any especial attention.

In troublesome hemorrhage the bleeding gums may be bathed with a strong solution of alum, or touched with an alum pencil, or tannic acid in glycerol may be applied upon a piece of gauze or absorbent cotton. In obstinate cases a compress applied to the bleeding part, and the jaws closed upon it and held in that position by a bandage passed under the chin and over the head, will usually control it.

Adrenalin chloride solution, 1 : 1000, is a valuable remedy in obstinate cases, as it is a most powerful astringent and hemostatic. It should be used with caution, however, in the mouths of little children, on account of its powerful stimulating effect upon the action of the heart. It should be applied to the bleeding surface upon a pledget of cotton, the excess fluid being removed before applying it.

The application of Monsel's solution or the nitrate of silver is recommended by several authorities, but this is rather dangerous practice, from

FIG. 222.



the fact that they cause sloughing of the surface of the gum-tissue ; this is often followed by secondary hemorrhage, which is sometimes more troublesome to control than the primary bleeding.

As a constitutional remedy, tincture of ergot in one- to five-drop doses in a little water, repeated every ten minutes until bleeding ceases, or until twenty to thirty drops have been administered, will usually prove effective.

EXUVIATION OR SHEDDING OF THE DECIDUOUS TEETH.

Definition.—The exuviation of the deciduous teeth is a peculiar physiologic process, whereby the roots of the teeth are gradually dissolved—organic and inorganic material—and their elements removed by resorption.

It may truthfully be said that the process of the evolution of the temporary teeth is hardly completed before preparations are made for a retrograde change which shall result in the tearing down of these structures, which have been so carefully and elaborately built, to make room for those larger and more permanent organs which are intended to serve the body to the end of life.

The process of exuviation begins in the central incisors in about a year, or a little more, after the complete formation of their roots,—viz., in the middle or latter part of the third year,—but it is not completed until about the seventh year, when their crowns fall out from lack of support. The lateral incisors are attacked a few months later than the centrals, and are shed at seven and one-half to eight years of age. The process begins in the first molars at the age of six and one-half to seven years, terminating in the exuviation of their crowns at about the tenth year. The second molars are attacked from six months to a year later, and the process is completed at about the eleventh year. The cuspids are usually the last of the deciduous teeth to be exuviated, although many instances will be observed in which they are shed before the second molars. The process begins in these teeth at about the eighth year, and is not completed until the twelfth year, or even later.

Individual teeth are often retained in the jaws much beyond the usual time for their exuviation.

These deviations from the normal order may be due to:

1. Tardy development of the permanent tooth which should replace it.
2. Non-development of the tooth which should replace it.
3. Malposition of the tooth of replacement, resulting in its eruption internal or external to the alveolar arch, or in some distant location.
4. Malposition of the permanent tooth, which makes it impossible for it to erupt.
5. Death of the pulp of the deciduous tooth from caries or traumatism.

Process of Resorption.—The elder Tomes was the first to accurately study the process of resorption of the deciduous teeth, and our present knowledge of the subject is largely based upon these investigations. If an incisor tooth is extracted at about the fourth year, pits or small excavations will be found at the apex or upon the sides of the root. Usually only one such excavation will be found, and that generally upon the side of the root nearest to the advancing permanent tooth. It is not an uncommon occurrence, however, to find one or more of these excavations in locations which are remote from the successional tooth, in fact, upon the opposite side or even well towards the cervix. These excavations progressively enlarge and deepen until, finally, the whole of the root is dissolved.

The process usually begins in the cementum, progresses to the dentin, and may finally attack the enamel.

The writer recently removed a second deciduous lower molar in which the dentin had been entirely removed from the crown and a considerable portion of the inner surface of the enamel had been dissolved. He also has in his collection the crown of a replanted third lower molar, dissolved in the same manner, which had been replanted three years before. (The tooth had been affected with pyorrhœa alveolaris; treatment by extracting, scraping the root, replanting, and banding it to another tooth was done as an experiment.) In this case the dentin has all been removed from the crown except a thin lamina in the centre, which is very much "honeycombed." In the first instance the process is physiologic, in the other pathologic, yet the results were identically the same.

Tomes says, "That part of the dentin which immediately surrounds the pulp—in the deciduous teeth—appears to have more power of resistance than any other part of the tooth, and thus often persists for a time as a sort of hollow column." The pulp retains its vitality to the last, and seems to be necessary to the completion of the resorptive process.

The alveolar walls immediately surrounding the roots of the deciduous teeth are also removed by the same resorptive process, and new alveoli are formed about the roots of the permanent teeth as they come into place.

Fig. 223 illustrates a peculiar case of exuviation of a tooth in the jaw of a kitten, from the private collection of Dr. Vida Latham. The tooth was either formed without a root, which is most probable, or the root has been removed by resorption, and the base of the pulp canal filled with secondary dentin. The permanent tooth lies beneath in its bony crypt.

The resorptive process seems to be dependent upon some form of vital chemic change taking place at various portions of the surface of the root, which induces a molecular dissolution of the tooth-structures and the surrounding bone, and the resolved elements are returned to the general circulation by the absorbent and lymphatic vessels.

The agencies which set this process in operation and the *modus operandi* by which the process is accomplished are still subjects of discussion.

The view formerly taught in reference to the cause of the resorption of the deciduous teeth was that it was induced by the pressure of the advancing permanent teeth.

Various objections can be maintained in opposition to this view. For instance, in some of the lower animals, and particularly in snakes and certain fishes, conditions exist during the evolution of successive sets of teeth that prove conclusively that resorption takes place similar to that in man, and entirely independent of pressure. "In the frog and the crocodile the growing tooth-sac passes bodily into the excavation made for it in the base of the tooth, which has preceded it, while if pressure had any share in the matter, the cells of its enamel-organ must have inevitably been crushed and destroyed." (Tomes.)

In the snake, whose succession of teeth are endless, the new teeth are developed at the inner side of those already in position, and when a tooth is about to be shed the process of resorption attacks the bone at its base, removing the inner side before the outer side is at all affected.

The new tooth gradually moves forward and occupies the position made vacant by the resorption and exuviation of the preceding one. But at no time during this process do the exuviating and the new teeth come in contact with each other.

Again, instances are numerous in which it can be shown that the resorptive process frequently begins, as already mentioned, at points remote from the surface of the advancing permanent tooth, where pressure from this cause could not possibly occur.

Another reason for doubting the correctness of this view is the fact that frequently the permanent teeth are still enclosed in their bony crypts at the commencement of the process of resorption, and the process is not infrequently completed and the tooth exuviated before the permanent tooth is ready to leave its follicle.

The presence even of the permanent tooth is not necessary to establish the resorption of the root of the deciduous tooth, "for it has been successfully accomplished in the absence of its successor." (Pierce.)

Mechanical pressure, however, is capable of producing resorption of tissue, instances of which are common in the practice of orthodontia. In moving a tooth from an abnormal to a normal position the orthodontist depends upon his power to produce resorption of the alveolar process by applying mechanical pressure in a certain direction.

Resorption of bone is often brought about by the pressure of an enlarging aneurism or of the accumulations of fluid or of pus, as, for instance, in the maxillary sinus, where it sometimes results in the rupture of one of the walls of the sinus.

The *active agent*, apparently, which produces the resorption of the roots of the deciduous teeth is a soft, highly vascular papilla,—the "absorbent organ,"—which is found in close contact with the root of the tooth.

The surface of the papilla is composed of very large multiform cells,—giant cells,—each cell being composed of several smaller ones, the number varying from two or three to twelve or fifteen. The prevailing forms of the cells are ovoid and spherical, although some of them have the appearance of the myeloid cells of Kölliker (Fig. 224). The excavated surface of the tooth lying next to the absorbent organ, if examined microscopically, is seen to be covered with numerous very small cup-shaped indentations,—the lacunæ of Howship,—in which a giant cell has evidently been lodged.

The *modus operandi* by which these giant cells affect a dissolution of the dental tissues is not definitely known. Giant cells, however, are always present wherever the resorption of hard tissues like bone is going on, or foreign substances located in the body that are capable of being dissolved. The giant cells which compose the "absorbent organ" are no doubt modified osteoclasts derived from the pericemental membrane of the deciduous teeth, and perform the same office for the teeth that the osteoclasts do for the bone, and are known as "odontoclasts."

Several theories have been advanced in explanation of the process of resorption of the deciduous teeth.

It was thought, until quite a recent period, to be due to the formation or secretion of an acid by the "absorbent organ," which attacked the dental tissues and dissolved them, and that these elements were then removed by the absorbents and carried into the general circulation.

Abbott advanced the theory that the absorbent organ was not the active agent in the resorption of the temporary teeth, but rather the result of it. The process of resorption, he believed, was brought about through the *living matter*, the organic basis substance of the dental tissues, by a retrograde metamorphosis, or a change to embryonal tissue, and that the process is closely allied to that of inflammation. That the lime-salts are first dissolved and the basis substance or organic material is afterwards liquefied. Medullary elements then arise out of the liquefied material and proliferate, resulting in a new formation of medullary tissue, the so-called "absorbent organ."

Black has suggested the most rational explanation of the process, one which is in entire harmony with the latest developments in physiology,—namely, that the absorbent organ secretes or elaborates a digestive fluid or soluble ferment which dissolves or digests the dental tissues and alveolar walls, and prepares them to be resorbed, just as under certain circumstances

FIG. 223.—Vertical section of a peculiar case of exuviation of a tooth in the jaw of a kitten. × 35.

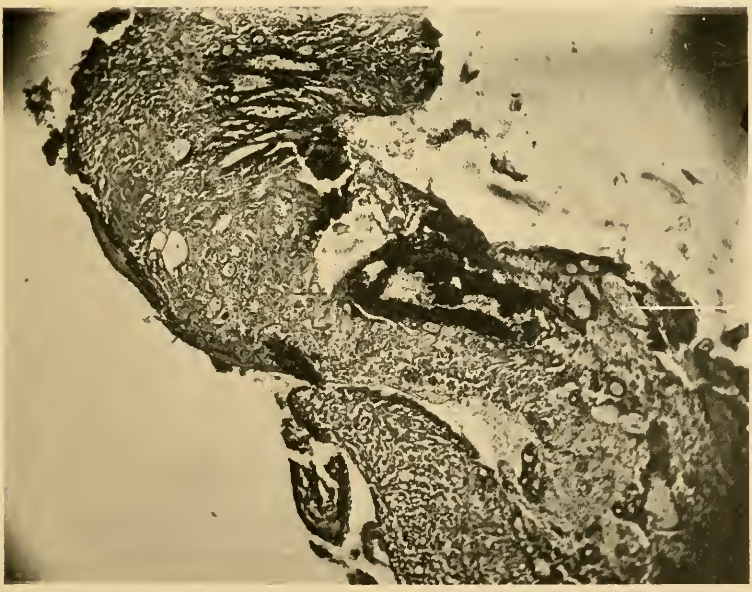


FIG. 224.—Absorbent organ and portion of dentin *in situ*. *A*, giant cells. (V. A. Latham.) × 65.

bone is resorbed, or ivory pegs which have been driven into the tissues, or catgut sutures, silk ligatures, decalcified chicken-bone, drainage-tubes, or even sponges are dissolved and removed by the process of resorption.

Devitalized temporary teeth are not resorbed; hence it would seem that the vital pulp must play an important part in the resorptive process. Pierce says the very moment vitality of the pulp ceases that instant this retrograde metamorphosis, designated "physiologic absorption," terminates.

Vital permanent teeth sometimes undergo a process of resorption at various points upon the surface of their roots as a result of pericemental irritation or inflammation, and after the subsidence of the morbid condition new bone or cement formation takes place at those points by the calcification of the absorbent cells.

Tomes says, "The process of absorption once commenced does not necessarily proceed without intermission, but may give place for a time to actual deposition of osseous tissue on the very eroded surface; probably by the agency of the absorbent cells themselves, which are capable of being calcified in the excavations they have individually made."

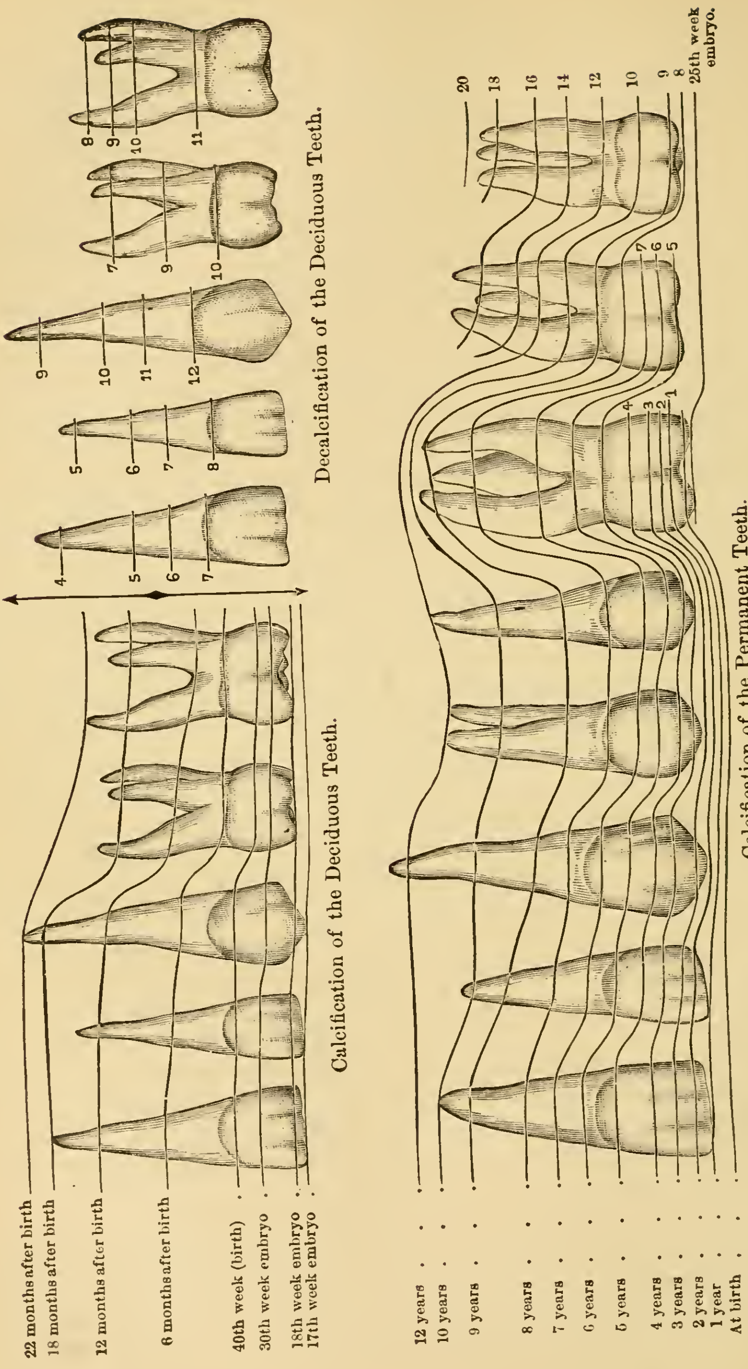
Replanted, transplanted, and implanted teeth are often attacked by a process of resorption which in many respects is quite similar to the resorptive process which removes the roots of the deciduous teeth. This difference, however, is to be noted, that while in the deciduous teeth and vital permanent teeth the process leaves a comparatively smooth excavation, in devitalized teeth the cementum and dentin become more or less roughened and honeycombed. The latter process is also attended with considerable soreness, due to the pericemental inflammation, and pus not infrequently forms, which may escape around the cervix of the tooth or point through the gum, while in the process as seen in the exuviation of the deciduous teeth no inflammatory symptoms are present.

The former is a *pathologic* process established to remove an organ which has become a source of irritation and acts as a foreign body. The latter is a *physiologic* process established to remove an organ which has served the purpose of its creation, but which is to gradually give place to a stronger and more enduring counterpart of itself. Pathology, we are taught to believe, is perverted physiology; but just where normal function ceases and morbid conditions begin science has not as yet been able to demonstrate. The accompanying diagram (Fig. 225, page 78), drawn by Professor C. N. Peirce, most admirably illustrates the periods at which calcification takes place in the deciduous and the permanent teeth, and also the decalcification or resorption of the roots of the deciduous teeth.

ERUPTION OF THE PERMANENT TEETH.

Normal *secondary* or *permanent* dentition begins at about the sixth year by the eruption of the first molars, which take position directly behind the second deciduous molars, the growth of the jaws having made this possible by increasing the distance between the second deciduous molar and the ascending ramus in the lower jaw, and between the same tooth and the tuberosity in the upper jaw.

Fig. 225.



Calcification of the Deciduous Teeth.

Calcification of the Permanent Teeth.

(After Peirce.)

The growth of the jaws, which keeps pace with the eruption of the permanent teeth, is mainly confined to an elongation of the horizontal ramus between the second deciduous molar and the angle. There is, however, a certain amount of growth taking place at the symphysis menti and at the median and intermaxillary sutures, and also in the interstitial substance of the jaws.

This statement is corroborated by the fact that as the period of second dentition approaches, spaces appear between the deciduous teeth which gradually widen until the primary teeth are exuviated. The widest space in the lower jaw is between the central incisors, while in the upper jaw it is between the central incisors and between the lateral incisors and cuspids. Nature thus beautifully provides for the increase in the number and of the size of the succeeding teeth by arranging the growth of the jaws in harmony with the space required for a normal arrangement of the individual permanent dental organs.

There is often a considerable variation in the time and order of the eruption of the permanent teeth, even in healthy individuals, but the following table gives approximately the date and the order in which they may be expected to appear in the dental arch :

First molars	5 to 7 years of age.
Central incisors	6½ to 8 years of age.
Lateral incisors	7 to 9 years of age.
First bicuspids	9 to 11 years of age.
Second bicuspids	10 to 12 years of age.
Cuspids	11 to 14 years of age.
Second molars	11½ to 13 years of age.
Third molars	16 to 21 years of age, or at any period later.

The third molars not infrequently fail to appear at all. They are usually developed, but remain in the jaws for lack of space in the arch to accommodate them, or are so malposed that their eruption is difficult or impossible.

Symptoms.—The *symptoms* which accompany second dentition are usually so mild as not to attract special attention. There is slight salivation and a little tenderness of the gums over the erupting teeth. Occasionally, however, marked symptoms may be present, profuse salivation, great tenderness and tumefaction of the gums, sometimes accompanied with ulcerative stomatitis, neuralgia of the trifacial nerves, and epileptic seizures.

The eruption of the third molars, particularly the inferior ones, is often productive of great suffering from inflammation of the gums and surrounding tissues. Suppuration not infrequently supervenes, which may extend to the jaw, causing large abscesses and infection of the lymphatic glands. Abscesses of this character in the lower jaw often burrow downward into the tissues of the neck, involving the important vessels of this region, the accumulation of pus being sometimes very considerable. The writer once opened such an abscess from which more than a pint of pus was extracted, and has frequently in his hospital practice treated cases in which half that quantity has been withdrawn from the abscess.

Septicæmia and necrosis of the jaw sometimes complicate the affection. The presence of septicæmia adds greatly to the dangers surrounding the case, and may cause a fatal termination.

Necrosis of the jaw may be of slight or considerable extent. It may involve only a portion of the alveolar process or extend to the body of the bone, destroying large portions of it, or even the entire half of the jaw.

The process of eruption of the permanent teeth is so nearly analogous to that of the temporary dentition that no special description seems necessary.

Irregularities in the Position of the Permanent Teeth.—In the eruption of the *succedaneous teeth*—those which succeed the deciduous set—rapid resorption of bone takes place upon the labial and buccal aspects of their crypts, resulting in an opening very much larger than the crown of the tooth. The fact will therefore be recognized that any slight mechanical obstruction situated in the path of its progression would be sufficient to deflect it from its normal course and result in an irregularity in position. The muscular action of the lips and tongue, the habits of tongue-sucking and thumb-sucking, are all potent factors in modifying the arrangement of the teeth when applied at this period of their evolution. Certain developmental conditions of the bones of the face are very common causes of irregular arrangement of the permanent teeth, and by some authorities thought to be the most prolific causes,—namely, excessive development and arrested or retarded development of the maxillary bones. These conditions may be the result of many and varied causes, some *hereditary*, others *acquired*. These may again be divided into *constitutional* and *local*.

Among the constitutional conditions which may be classed as *direct inherited* causes are, *first*, constitutional taints, like syphilis, tuberculosis, and neurotic conditions, *peculiarities* in the formation of the jaws and of the teeth, peculiarities in the arrangement of the teeth in the arch, and tendencies to the suppression of certain teeth, or to the presence of supernumerary teeth; *second*, conditions which may be classed as *indirect inherited causes*, as, for instance, when one peculiarity is inherited from the father and another from the mother, which combined form an irregularity, like the inheritance of large teeth from one parent and a small jaw from the other. The deformity is not directly inherited from either parent, but indirectly from both.

Miscegenation of nations and distinct races is often a prolific source of malformations of the jaws and of irregularities of the teeth, which operates by mixing national and race peculiarities which are more or less antagonistic to each other. *Third*, *acquired constitutional defects*. These result from *diseases* or *traumatisms* which interfere with nutrition, and thus prevent a normal development of the maxillary bones and the teeth, or cause an abnormal arrangement of the teeth in the alveolar arches.

The *local conditions* which may act as factors in producing an abnormal arrangement of the teeth are:

1. Undue retention of the deciduous teeth or parts of a tooth.
2. The presence of supernumerary teeth.
3. The too early extraction of the deciduous teeth.
4. Injudicious extraction of permanent teeth.

5. Delayed eruption of a permanent tooth.

6. Mouth-breathing due to enlarged tonsils and adenoid growths in the nasopharynx.

7. The habits of tongue-sucking and thumb-sucking.

The *retention of a deciduous tooth beyond the normal period of its exuviation* is often productive of a malposition of the succeeding teeth. Nature provides for the resorption of the roots of deciduous teeth. Death of the pulp prevents physiologic resorption, therefore the unabsorbed root of the retarded tooth may cause the permanent tooth to be deflected from the normal position.

The *presence of a supernumerary tooth* may also operate in a like manner to deflect the permanent tooth from a proper position in the arch, or so crowd the arch by its presence as to destroy the occlusion.

The *too early extraction of the deciduous teeth* tends to retard the interstitial growth of the jaw; permits the teeth upon either side of the space made by the extraction of the deciduous tooth to move or tilt towards each other, thus robbing the permanent tooth of its required space, and forcing it into an abnormal position, while the extraction of the second deciduous molar before the first permanent molar is erupted permits this tooth when erupted to move forward and occupy the space needed by the second bicuspid. This procedure also induces, as graphically shown by Talbot, a shortening of the arch of the jaw upon that side, thus crowding the cuspid and bicuspids out of line, and causing a deformity difficult to remedy except by the extraction of one of the bicuspids.

The *injudicious extraction of permanent teeth* often entails a serious inconvenience to the individual by permitting a tilting of the crowns of the proximate teeth and forming large inverted V-shaped spaces which are difficult to cleanse, and therefore invite caries. This condition frequently follows the extraction of the first permanent molar if delayed until after the eruption of the second molar.

The extraction of the permanent superior lateral incisors, to make room for prominent cuspids, also causes a deformity in the arrangement of the teeth which cannot, except in rare instances, be corrected, and should be condemned in the severest terms.

The extraction of the cuspids is also to be condemned if performed for any other reason than a diseased condition involving contiguous parts. The loss of the superior cuspids is productive of a narrowing of the anterior portion of the arch, and depression at the corners of the mouth and alæ of the nose.

Delayed eruption of a permanent tooth, particularly the superior lateral incisors and the first or second bicuspids, are often productive of troublesome irregularities. Delayed eruptions of the lateral incisor permits the cuspid to take an abnormal forward position, often approximating the distal surface of the central incisor, and making it impossible for the lateral to occupy a normal position; while the non-eruption of a bicuspid permits the approximation of the contiguous teeth, and often destroys the occlusion upon that side.

Mouth-breathing, due to enlarged tonsils and adenoid growths in the naso-

pharynx, is also productive of a narrowing of the superior alveolar arch in the region of the bicuspids and protrusion of the anterior teeth. The writer is aware that in making this statement he places himself in opposition to some of the very best authorities upon the etiology of dental irregularities, but nevertheless he believes that the position of the upper lip and of the cheeks, when the mouth is open sufficiently to permit these subjects to breathe with comfort, is such that steady and continuous pressure is brought to bear upon the teeth and alveolar process in the bicuspid region. This force acting upon the crowns of the erupting permanent teeth, which as yet have their roots but partially formed, and have no bony support except the crypt in which they have been developed, and in this resorption of the walls has been so considerable that the opening in it is much larger than the size of the crown, while, furthermore, the alveolar process is not formed around these teeth until after the crown is erupted, cannot but exert a moulding influence upon the position of these teeth and their alveolar process, narrowing the arch at this portion and protruding the teeth in the incisive region. It seems to the writer that if these facts in relation to the evolution of the teeth and alveolar process are given their full weight in the argument, it must be acknowledged that mouth-breathing is as potent a factor in the production of this class of irregularities as that they are produced by an arrested or retarded development of the jaws, caused by the obstruction of nasal breathing.

The *habits of tongue-sucking and thumb-sucking* may also be regarded as factors in the production of protrusion of the anterior teeth. Sucking of the tongue may, by the pressure upon the lingual surfaces of the superior and inferior incisors, cause a protrusion of the teeth of both jaws. While sucking of the thumb may cause a protrusion of the superior incisors by the pressure upon their lingual surfaces, and, when the thumb also presses upon the labial surfaces and morsal edges of the inferior incisors, it may cause an intrusion of these teeth. These habits do not, as a rule, cause irregularities of the deciduous teeth. This fact has been used as an argument against the possibility of their causing a malposition of the permanent teeth. At first the argument seems good, but upon a careful study of the facts and conditions it will be discovered that these habits are rarely confirmed in the child until about the time that it is weaned from the breast or the bottle, which generally occurs when the child is from one and one-half to two years of age.

The roots of the deciduous incisors are at this time nearly or fully formed, and the development of the alveolar processes is completed, thus rendering the teeth fairly stable and not easily moved from their position by such a form of intermittent pressure, while, upon the other hand, when the habits are continued to the period of the eruption of the permanent incisors, it can be readily understood how, during the passage of the crowns of these teeth through the gums, and during the development of their roots and of the alveolar processes, a very slight amount of pressure, even though of an intermittent character, would be sufficient to divert them from their normal position to an abnormal protrusion of greater or less obliquity.

CHAPTER V.

BACTERIOLOGY OF THE MOUTH.

THE discoveries which the science of bacteriology has made and is still making in reference to the causation of disease render it imperative that a knowledge of the bacteriology of the mouth should be possessed by the student and the practitioner who would approach a scientific study of dental and oral diseases, or who would be successful in their treatment.

Bacteriology is one of the most exact of the medical sciences, and is governed by the most rigid laws, the slightest deviation from which often vitiating the results of long and laboriously conducted experiments.

The student, therefore, who would hope to do original work in this line will need to cultivate exactness in methods and the most scrupulous obedience to those laws which have been found to govern the various phenomena of their natural and artificial growth, and the methods by which their various functions may be proved.

No treatise on operative dentistry written at the present day can be considered as at all complete which does not deal, to some extent at least, with the subject of oral bacteriology; yet in a treatise of this size it will not be possible to give more than a simple outline of the subject in general, and this of necessity must be more or less elementary in character.

Definition.—The term *bacteriology* is derived from the Greek βακτήριον, a little stick, and λόγος, science.

Bacteriology is that department of biology which deals with the origin, development, and functions of living micro-organisms.

With the development of the science of bacteriology, or rather out of it, has grown the germ theory of disease. This theory, when first promulgated, had for its foundation the demonstrable facts that a certain few diseases were caused by specific germs, micro-organisms, or parasites. These statements of fact stimulated further research into the causation of other diseases, many of which, both medical and surgical, were found to be dependent upon specific micro-organisms which had gained access to the tissues of the body.

These discoveries have revolutionized the practice of medicine and surgery in all their departments, but the greatest revolution has been in the practice of surgery.

Without the discovery of the pyogenic bacteria and of the other pathogenic forms now known to science, and without a knowledge of the principles of modern antiseptics which grew out of these discoveries, much of the success which has been achieved in modern surgery during the last two decades would still be an impossibility.

The achievements in modern dental surgery in the prevention and treatment of oral diseases have been due to the discoveries made in oral bacteriology and to the application of the same general principles of antiseptics.

PARASITES.

Definition.—Parasites are plants or animals which live upon other plants or animals.

In the early history of bacteriology scientists found great difficulty in classifying some of the parasitic forms, from the fact that it was almost impossible to determine whether they belonged to the animal or vegetable kingdom. Nearly all of the parasites which enter the animal organism are microscopic in size, hence they have been designated as micro-organisms, microbes, or bacteria. Scientists are now generally agreed in classifying the bacterial forms as belonging to the vegetable kingdom. Bacteria belong to the fission plants, known as *Schizophyta* or *Schizophytes*, a division of the *Thallophyta*, including those varieties which multiply by *fission* or *division*. These are divided into two sub-classes, those which possess chlorophyll—namely, the *Cyanophyceæ* (usually referred to as *Algæ*)—and those having no chlorophyll, or the *Schizomycetes* (usually referred to as *Fungi*).

"Many of the bacterial forms are so small as to approach the limits of visibility, even when the highest powers of the microscope are employed." When located in the animal tissues, they are often demonstrated with the greatest difficulty, special staining reagents being necessary—sometimes double and triple staining being required—to differentiate them from the cellular elements of the tissues; even then the demonstration may be unsatisfactory, and it becomes necessary to institute a series of experimental cultivations of the products of tissue disintegration in the case, and the inoculation of lower animals with the products of the artificial cultivations before a positive diagnosis can be reached.

Miller, in his "Micro-organisms of the Human Mouth" (1882), arranged those fungi which have a bearing upon the hygienic conditions of the body into four groups:

1. Fission fungi (bacteria) .... *Schizomycetes.*
2. Mould or thread fungi.................................. *Hyphomycetes.*
3. Bud fungi (yeast fungi) .... *Blastomycetes.*
4. Animal fungi (Pilzthiere) .... *Mycetozoa.*

The first of the four groups, the *Fission fungi*, are the most important from the stand-point of health and disease, as they are the chief agents in the production of fermentations and putrefactions, and although through these processes they conserve the life and health of the vegetable and of the animal kingdom, by preventing the accumulation upon the earth's surface of dead vegetable and animal matter, reducing them to their original elements and returning them again to the air, the water, and the earth, they unfortunately have the power of attacking living organisms and exerting most baneful influences upon health and life, and are now recognized as being the active or exciting cause of a very large number of the diseases which attack the human body.

The *mould fungi* (Fig. 226), although widely distributed in nature, have much less importance from the hygienic stand-point. They produce de-

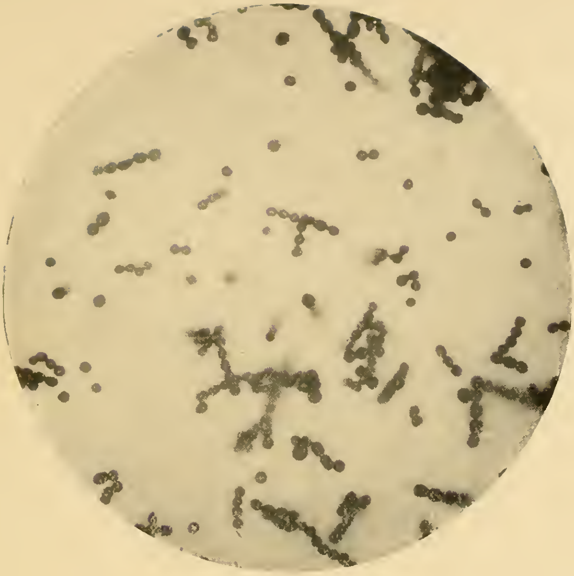


Fig. 226.—Fruit mould. (Shearer.) × 130.

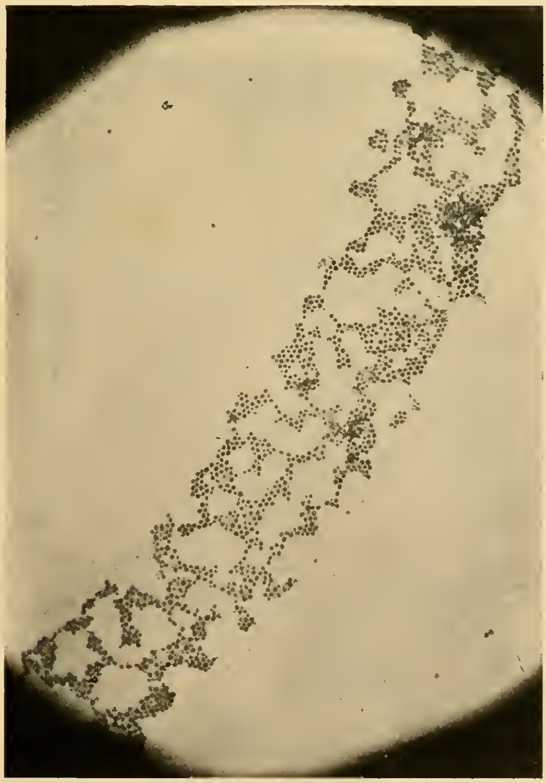
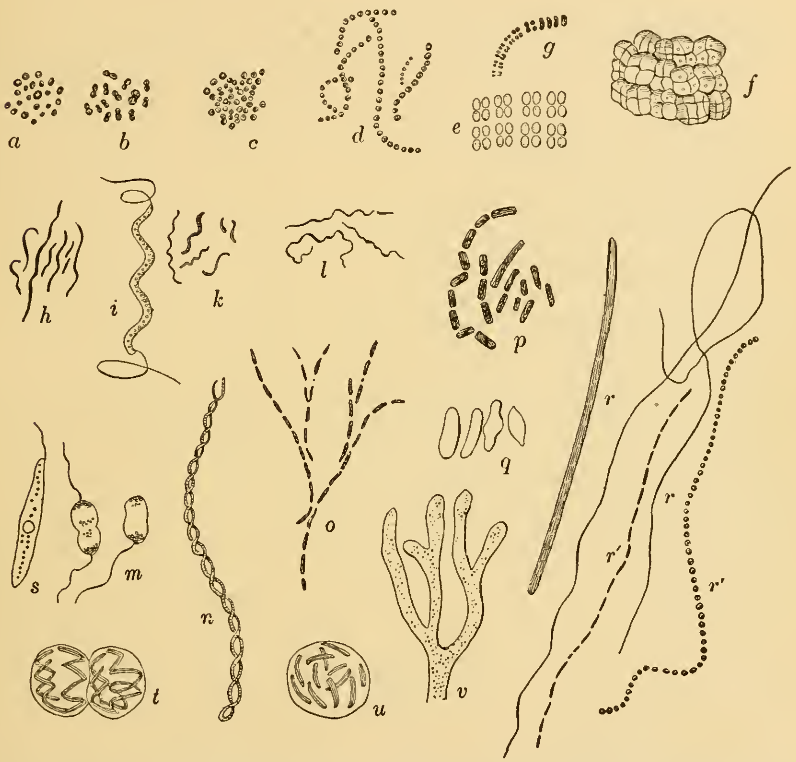


Fig. 229.—Torula, or yeast fungi.

compositions of organic substances, but with less intensity, and with the exception of certain cutaneous diseases, thrush and ringworm, do not cause such profound disturbances in the human body as do the fission fungi, although abscesses and seropurulent peritonitis have been known to occur from inoculation.

The *bud fungi* are even less important as disease-producers than the mould fungi. About the only diseases known to be produced by them are blastomycetic dermatitis and certain catarrhal changes.

FIG. 227.



Forms of bacteria. (In part after Flügge and Zopf.) *a*, cocci; *b*, diplococci; *c*, cluster-cocci (staphylococci); *d*, coccus chains (streptococci, torula); *e*, surface-shaped colonies (merismopedia); *f*, packet-shaped colonies (sarcina); *g*, a double coccus chain produced by a single fissation of each member in a direction at right angles to the long axis of the chain; *h*, vibriones; *i*, *k*, spirilla; *l*, spirochætes; *m*, spiromonades; *n*, spirulina; *o*, cladothrix; *p*, rods (bacilli); *q*, clostridium; *r*, leptothrix (threads); *r′*, articulated threads; *s*, rhabdomonas; *t*, *u*, *v*, zooglœa.

The *animal fungi*, or *mycetozoa*, are a group of fungus-like saprophytic organisms, the *slime fungi* or *slime moulds*. Most naturalists and bacteriologists class them as *fungi* or as plant-growths of low type. E. R. Lankester and his followers, however, group them with the *protozoa*, or lowest animal forms, while others have classed them as *protists*, or living organisms not decisively classifiable as either plants or animals.

Of the *animal fungi*, mycetozoa, or slime moulds, very little is known. These organisms resemble huge masses of protoplasm, which are found upon decaying vegetable matter. They are the supposed origin of certain plant diseases, such as the "finger and toe" of cabbage roots.

Bacteria are divided into three general classes according to their form,—viz., spherical cells, rod forms, and screw forms. Those which are rod-shaped are termed *bacilli;* those which are spherical are designated as *cocci* or *sphero-bacteria;* while those with screw forms are called *spirilla.*

Fig. 227 represents some of the common forms of bacteria.

ZOPF'S CLASSIFICATION (MODIFIED).

GROUP I. Coccaceæ. Spherical forms only.

Genus I. Micrococcus (Staphylococcus) Division in one direction only, but irregular, so that the cocci after division form irregular clusters.

Genus II. (Streptococcus) Division in one plane, but regular, so that the cocci form chains.

Genus III. Division in three directions at right angles to each other, and in two planes, so cubes are formed.

GROUP II. Rods, straight or curved. At some period of life history, though cocci and other forms may occur.

Genus I. Bacterium. Straight rods; endospore formation does not occur.

Genus II. Bacillus. Straight rods; endospore formation occurs.

Genus III. Spirillum. Spiral rods; spore formation does not occur.

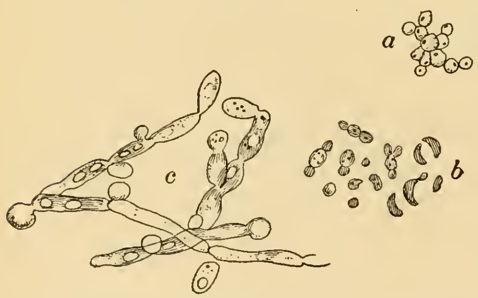
Genus IV. Vibrio. Spiral rods; spore formation occurs.

GROUP III. Leptotrichæ. These are all thread forms.

This is a practical and convenient classification.

Pasteur classified all bacteria under two general divisions, from their relations to oxygen; one division he termed *Aërobes,* the other *Anaërobes.*

FIG. 228.



Various forms of yeast fungi. *a*, colonies of round cells (saccharomyces conglomeratus?); *b*, single cells of different forms partly forming daughter-cells; *c*, cylindrical cells of the pellicle fungus (saccharomyces mycoderma).

The aërobic bacteria require the oxygen of the atmosphere in order to maintain existence, and therefore live upon the surfaces of substances.

The *yeast fungi* are examples of aërobic bacteria (Fig. 228).

Fig. 229 shows one of the forms of yeast fungi—the torula.

The anaërobic bacteria do not require oxygen to maintain existence, hence they live beneath the surfaces of liquids and within the tissues of living bodies. The *Bacterium tetani* is an example of the anaërobic bacteria; oxygen retards its growth or completely arrests its development.

A very large proportion of all the bacteria are aërobic. Some of them are so dependent upon oxygen that even the slightest diminution in the amount is sufficient to retard or completely arrest their development. These are termed *obligate* aërobic bacteria. Others will develop equally well in a medium rich in oxygen, or where there is no oxygen, or rather, independent of the atmosphere. These are called *facultative* aërobic bacteria. Nearly all the disease-producing forms of bacteria belong to the facultative variety. The fluids and tissues of the body contain a certain amount of oxygen, but this is soon consumed by the rapid growth and multiplication of the bacteria; consequently their development would be arrested or their existence terminated did they not possess the faculty of living under certain conditions without the presence of oxygen.

"The capability of certain bacteria to proliferate and to manifest their specific action without access of air may explain *the progress of tooth caries under air-tight fillings* in cases where the softened dentin was not thoroughly removed before inserting the filling." (Miller.)

Long exposure of certain forms of pathogenic bacteria to oxygen diminishes their virulence. Pasteur discovered that if artificial cultures were made of the bacterium of chicken-cholera and the cultures exposed to oxygen for a period ranging from three to eight months, the virus became very much attenuated. Cultures of the anthrax bacillus when treated in a like manner gave the same results.

He found that if a chicken was inoculated with this weakened or attenuated culture of the chicken-cholera bacillus, it was rendered immune to the action of the virulent virus, and that the attenuated culture of the anthrax bacillus prepared in the same manner rendered sheep immune to inoculations with anthrax, or if the disease was contracted after inoculation with the attenuated virus, it appeared in only a very mild form.

Paul Bert has discovered that if the anthrax bacillus is exposed to oxygen under a pressure of twenty to forty centimetres, its vitality is completely destroyed.

Functions of Bacteria.—Bacteria are often classified according to their particular function; for instance, certain species are disease-producing; these are termed *pathogenic*. Other varieties produce color,—yellow, white, green, etc.; these are designated as *chromogenic*. Another species causes fermentation, and are called *zymogenic*. Another produces gas; these are termed *aërogenic*. Others are endowed with intense putrefactive properties and are known as *saprogenic*, while many others have not yet had their special functions discovered.

A very large proportion of the bacterial forms are saprogenic.

When classifying bacteria according to their relations to disease, it is customary to arrange them under two general divisions:

1. *Non-pathogenic*, or those which do not as a direct cause produce disease.

2. *Pathogenic*, or those which are the direct cause of disease.

Fermentation and putrefaction are the results of the growth and multiplication of certain forms of bacteria within the substances which ferment or putrefy.

Among the non-pathogenic micro-organisms are included the *saprophytic germs*. These are sometimes spoken of as "nature's scavengers," from the fact that they prey upon dead and decomposing vegetable and animal matter. These organisms may become *indirect* causes of disease when they gain access to wounds in which there are pent-up discharges and dying tissues. Under such circumstances they propagate with great rapidity, and produce certain poisonous and irritating substances called *ptomaines*, which when absorbed by the system give rise to symptoms which are denominated as *septic intoxication*, *ptomaine fever*, or *septicæmia*.

Such conditions may follow the death of a tooth-pulp, the extraction of a tooth, the wounding of the tissues of the mouth, or a compound fracture of the jaw.

Pathogenic micro-organisms grow and flourish in the dead and dying matter, and invade the living tissues and destroy them. They also enter the circulation by direct inoculation through wounds and abrasions, and are carried to all parts of the body, and wherever deposited increase in numbers with amazing rapidity, forming fresh foci for the production of poisonous and irritating substances. The chief difference, therefore, between the *saprophytes* and the *pathogenic* germs is, that the former act as *indirect* causes of disease by the production of poisonous substances, which are absorbed by the system; but they have no power to penetrate the tissues or to enter the circulation, while the latter possess this power and act as *direct* disease-producing agents.

The pathogenic bacteria may be divided again into two general classes:

First. Micrococci.

Second. Bacilli.

Each of these classes has been divided and subdivided by the bacteriologist into an almost endless variety. This division and subdivision has been made necessary by the discoveries which have grown out of the more thorough and careful study instituted as to their size, form, and length; their growth, grouping, and manner of propagation; their action upon the various culture-media; their chemical reaction; the color imparted to the culture-media; their susceptibility to the various staining reagents, and their action upon fermentable substances and living organisms.

Investigation is constantly going on, and almost daily discoveries are being made of new forms of bacteria, or "further research into the life and habits of old forms develops new features and modes of action, which a little while before had not been dreamed of, while the etiology of certain diseases which were before considered as obscure are one by one being cleared up by the discovery of a specific micro-organism, which, when introduced into the system in sufficient quantities, will produce the disease."

The evidence which has been deduced in regard to the specific nature of the micro-organisms found in anthrax, typhoid (Fig. 230), tuberculosis, tetanus, diphtheria, glanders, leprosy, cholera, bubonic plague (Fig. 231), pneumonia (Fig. 232), erysipelas, actinomycosis, gonorrhœa, and suppurative inflammation is beyond dispute, while in many other diseases the evidence strongly points to the presence of a specific germ as the active cause of their development.

The *Micrococcus* is an individual bacterium, the smallest of all the bac-

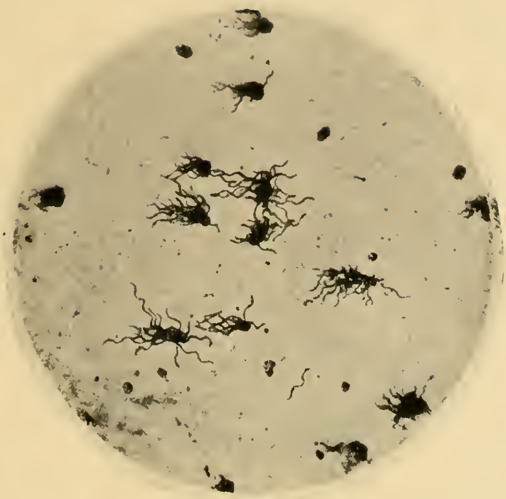


FIG. 230.—Bacterium typhosus. × 1000.

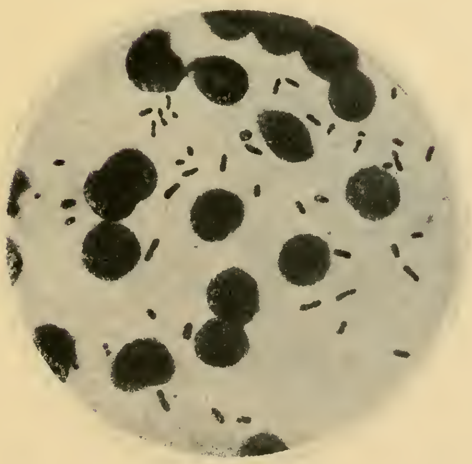


FIG. 231.—Bacillus pestis, and blood-cells of rat. × 1000.

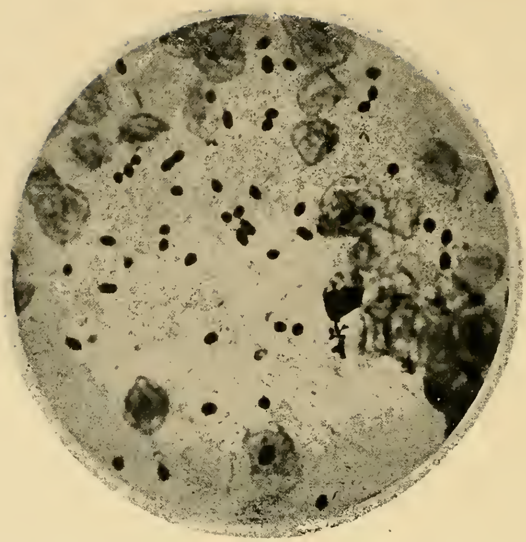


Fig. 232.—Pneumococcus, showing capsule form. (V. A. Latham.) × 1200.

Fig. 233.—Diplococcus pneumoniæ. (Fränkel.) × 1000.

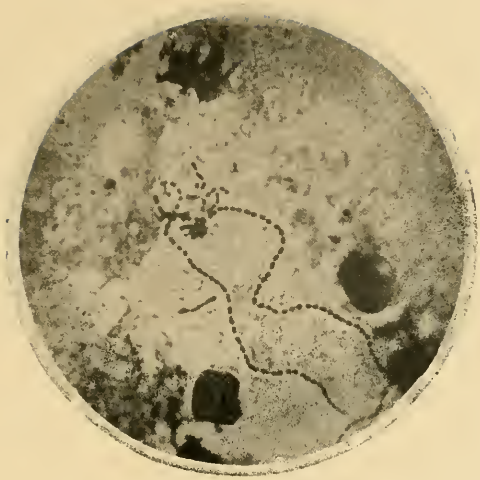


FIG. 234.—Streptococcus pyogenes. (V. A. Latham.) × 1000.

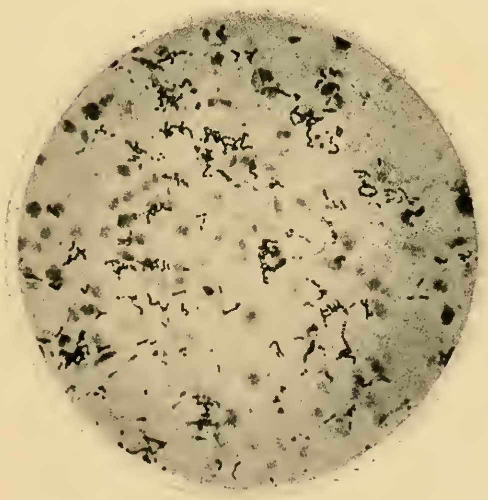


FIG. 235.—Streptococcus in pyæmia after erysipelas. (V. A. Latham.) × 660.

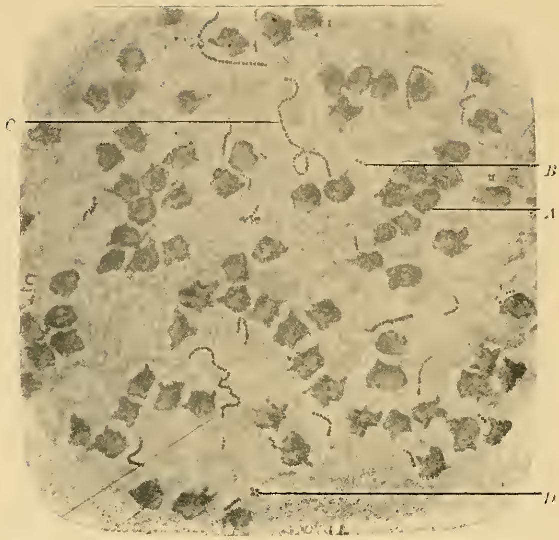


FIG. 236.—Forms of bacteria in pus from an abscess. × 700. *A*, pus-cells; *B*, micrococci and diplococci; *C*, streptococci; *D*, tetracocci.

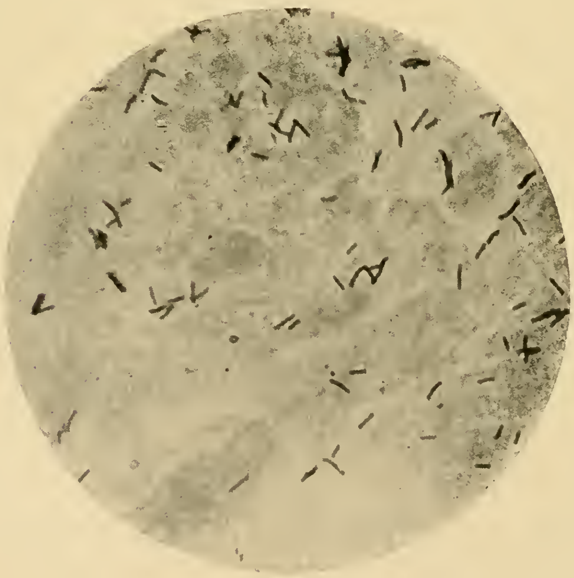


FIG. 237.—Bacillus tuberculosis. × 1000.

terial forms, spherical, or nearly so, tiny, globe-like masses of matter, in some instances isolated, in others united in pairs, in fours, or in larger numbers, or arranged in chains or chaplets, or deposited in masses of zooglea or gelatinous matrix secreted by the bacteria themselves.

When the micrococci are united in pairs they are termed *Diplococci* (Fig. 227, *B*), when in fours, *Tetracocci* (Fig. 227, *D*). When grouped in clusters they are called *Staphylococci*. When arranged in chains or chaplets they are known as *Streptococci* (Fig. 227, *C*).

The *pneumococcus* or diplococcus of pneumonia (Fig. 233) is a good representation of the diplococci.

Among the numerous difficulties which have to be met by the bacteriologist and the pathologist is the seeming identity of certain forms of bacteria found in diseases presenting dissimilar characteristics; for instance, the *Streptococcus pyogenes* (Fig. 234) seems to be identical with the *Streptococcus erysipelatus* (Fig. 235), the only discoverable difference being one of size, the coccus of erysipelas being the larger.

The cocci multiply or propagate only by fission. The cell elongates prior to its segmentation, when a constriction appears in the centre, which becomes deeper and deeper until complete division of the cell into two equal parts takes place. These new cells soon attain the size of the parent cell, when they divide in the same manner, and so on *ad infinitum*.

The diplococci, staphylococci, and streptococci are generally found associated with broken-down tissue and discharges which result from inflammatory action, particularly in the pus-formations of acute abscesses and suppurating wounds (Fig. 236). These are termed the *pyogenic cocci*, or *pus-microbes*.

The *bacillus* is an individual bacterium of rod-like form. The *bacilli* include all of the elongated forms of bacteria, except the screw forms, and such as have a gyratory motion; these are classed with the genus *Spirillum*. The bacillus tuberculosis (Fig. 237) is a good example of the short rod-like bacilli.

A *spirillum* is an individual bacterium whose elements are curved, often forming a spiral of several turns. *Koch's comma bacillus*, which is found in the alvine discharges of patients suffering from Asiatic cholera, is a spirillum, and represents a simple curved variety, while *Miller's* spirillum, which is found in carious teeth, represents the screw or spiral form. Some of the spirilla have flagella attached to their extremities (Fig. 238.) The bacillus of hog cholera is an excellent illustration of a flagellated bacillus (Fig. 239).

Some bacilli are rigid, others flexible; some are motile, others non-motile, and they propagate either by direct fission or by endogenous spore-formation,—the formation of a cell within the body of the parent cell.

Multiplication of Bacteria.—The process of reproduction in bacteria is a very rapid one. Flügge observed the process of segmentation in a coccus to be completed in twenty minutes. Cohn has made the calculation that if it should take one hour to complete the process of segmentation and for the new cell to attain the size of the parent-cell, one coccus, multiplying by this process, would in a single day produce 16,000,000 progeny; at the end of two days 281,000,000,000; while at the end of the third day it would have reached the enormous number of 46,000,000,000,000. Such figures are at first thought very startling, and if this multiplication could go on unhindered, the earth might soon be dominated by micro-organisms. There are, however, many circumstances which constantly oppose them; one of the chief of these is their own delicate susceptibility to change of environment, the slightest difference in the soil, amount of oxygen, temperature, or moisture being sufficient in many instances to arrest their growth or completely destroy them.

Various species are found growing together, but the struggle for existence and of natural selection is as active here as elsewhere; the stronger and more vigorous soon destroy the weaker. When they enter healthy living bodies they are attacked by the phagocytes and destroyed, or they do not find a congenial soil in which to grow, and either die or are swept out of the body by the excretory organs.

The *spore* possesses an exceedingly dense enveloping membrane, which protects it from harmful external influences until such time as it finds a soil and environment suitable for its growth and propagation.

The parent cell is usually enlarged at the middle or at one end by the growth of the spore, and when it reaches its full development gelatinous softening of the cell-membrane takes place, the cell breaks up, and the spore is set free. The spore loses its tough enveloping membrane during its process of development, and is therefore more readily destroyed.

The struggle for existence between certain species of bacteria found growing together suggested a therapeutic principle, the overcoming of one pathogenic species by the introduction of another, which many investigators have been trying to utilize for the benefit of mankind, though as yet with only partial success. Blood-serum therapy, however, is making rapid advances, and gives promise of being the most successful method of preventing or curing those diseases which are due to the introduction of micro-organisms into the system, or of their poisonous products.

The growth of bacteria is also influenced by the presence of their own excretory or waste products; for instance, the yeast plant ceases to grow after a certain amount of alcohol has been formed.

The ammoniac fermentation of urine ceases when the ammonium carbonate reaches thirteen per cent. (Flügge.)

In lactic acid fermentation the process ceases when the acidity has reached 0.75 to 0.80 per cent., and the micro-organism is often destroyed by the action of the acid which has been produced.

Lactic acid fermentation of the carbohydrates takes place spontaneously in milk, in the juice of the sugar-beet, in the accumulations in the oral cavity, etc., and may be artificially induced by a large number of different bacteria in saccharine solutions. (Miller.)

Acids and alkalies possess a certain amount of controlling influence in the growth of bacteria, especially the former. Acids in very dilute solution retard the development of bacteria. There are, however, important exceptions to this rule, as, for instance, the *Mycoderma aceti*—acetic acid

FIG. 238.—Flagellated spirillæ and vibrio. × 2100.

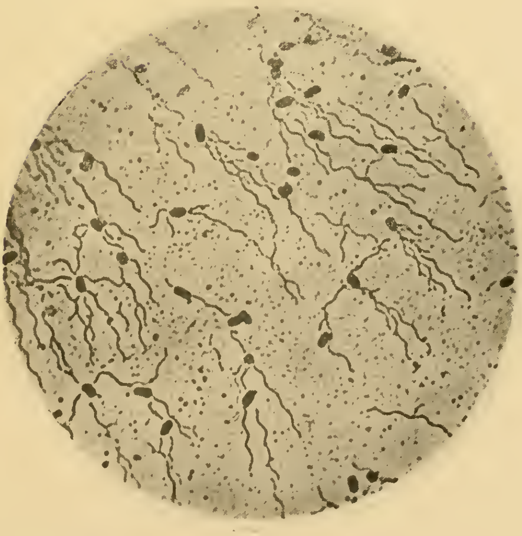


FIG. 239.—Bacillus of hog cholera. (V. A. Latham.) × 1000.

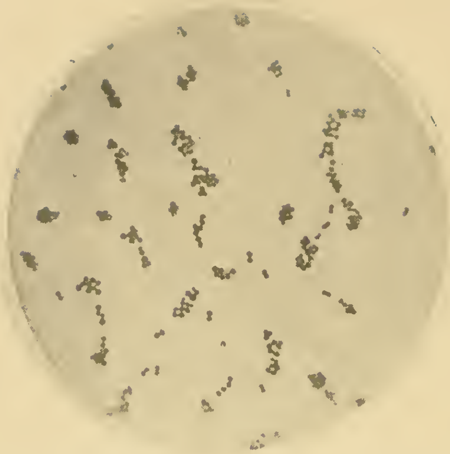


FIG. 240.—Staphylococcus pyogenes. (V A. Latham.) $\times$ 1000.

FIG. 241.—Streptococcus pyogenes. $\times$ 1000.

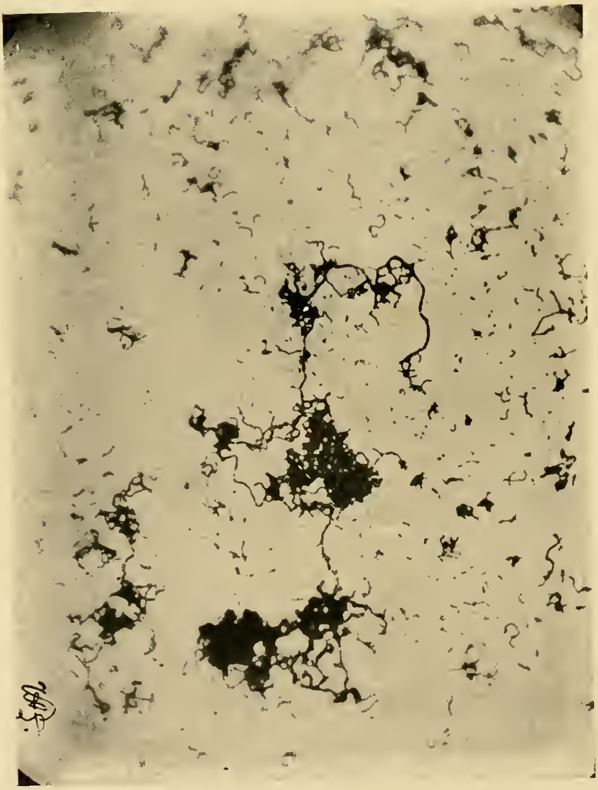


FIG. 242.—Streptococcus hominis. (V. A. Latham.) $\times$ 218.75.

bacterium—thrives best in a solution containing an excess of from one to two per cent. of acetic acid. Ten per cent. of acetic acid prevents the continuation of the acetic acid fermentation, while the *Micrococcus urea* thrives best in a high degree of alkalinity. With few exceptions, however, a neutral medium is best adapted for the growth and propagation of micro-organisms.

Heat and Moisture.—Two conditions are absolutely necessary for the germination and development of bacteria,—viz., a certain amount of heat and moisture. Both must be present, and in suitable amount; the requisite amount of heat minus the moisture, or the moisture minus the heat, is in neither case favorable to their development.

This is eminently true in the treatment of dental caries and devitalized teeth; with thorough desiccation of the properly prepared cavity of decay, or of the root-canal, and the prevention of the ingress of moisture by tight plugs, caries will be arrested in one case and suppuration prevented in the other. In no department of surgery is thorough antisepsis more important than in operations upon the teeth.

The temperature necessary for the growth of the majority of bacteria is 37° C. (98° F.). Mature bacteria cannot resist a temperature of 77° C. (170° F.). Most of them are destroyed when exposed to a temperature of 55° C. (131 F.), while spores have been known to resist 100° to 120° C. (212° to 236° F.). A temperature of 100° C. (212° F.), if maintained for ten to fifteen minutes, will effectually destroy the most persistent of spores.

Spores resist the action of germicidal agents to a much greater degree than the bacilli which produced them, doubtless on account of the tough membrane which envelops them.

Spores which have gained access to the tissues of the body may remain dormant for years, and give rise to no untoward symptoms until aroused to activity by the presence of conditions—environment—which favor their development and multiplication.

Fütterer reports having found the typhoid bacillus in the gall-bladder years after the initial attack of typhoid fever.

Pyogenic or Pus Bacteria.—The pathogenic micro-organisms with with which the surgeon and the dentist has most frequently to contend are those which cause suppuration.

The pyogenic bacteria by a specific action convert the inflammatory exudates, leucocytes, and the cellular elements of the tissues into pus. They are, therefore, termed pyogenic or pus bacteria. Of these there are several varieties, most of them of the globular or coccus form (Figs. 240, 241, and 242). The number of bacterial forms which have been fully identified as the exciting cause of surgical diseases is not large, yet the statement may be safely made upon the basis of our present knowledge, that all traumatic infective diseases can be traced to the specific action of certain micro-organisms which have gained access to the tissues of the body.

Koch laid down certain laws which he thinks should be used as the crucial test in establishing the specific disease-producing power of any given organism: 1, it must be found in all cases of that disease; 2, it must be found in no other disease; 3, it must appear in such quantity and be so distributed that all symptoms may be accounted for by its presence; 4, the organism must be capable of being isolated from the diseased tissues and be grown upon some artificial culture-media; 5, when injected into an animal it must be capable of reproducing the disease. In many instances all of these conditions cannot be fulfilled, yet when a certain form or variety of micro-organism is constantly present in a particular disease, it is fairly good evidence that it is the specific cause of that disease, although we may not be able to cultivate it artificially.

Pathogenic Mouth Bacteria.—To Professor Miller of the University of Berlin science is indebted more than to any other bacteriologist for our knowledge of the mouth bacteria.

This author has shown in his most valuable work, the "Micro-organisms of the Human Mouth," that nearly all of the pathogenic and many of the non-pathogenic micro-organisms have been found in the human mouth. He has isolated and cultivated more than a hundred different species obtained from the human mouth, thus establishing the fact that this cavity is the receptacle and often the breeding-ground of a considerable number of specific micro-organisms, as well as the source through which infection of many serious and sometimes fatal diseases may take place.

Among the more important forms of pathogenic micro-organisms which he found in the mouth may be mentioned the *Micrococcus of sputum septicæmia*, *Bacillus crassus sputigenus*, *Staphylococcus aureus* and *albus*, *Streptococcus pyogenes*, *Micrococcus tetragenus*, the *Pneumococcus* of pneumonia, and many others.

MOUTH BACTERIA PROPER.

Miller described six forms of micro-organisms, which are common to almost every mouth, and which he termed "mouth bacteria proper"; but none of these was he able to successfully cultivate on any then-known culture-medium, although he experimented in hundreds of different ways.

These are the *Leptothrix innominata*, *Bacillus buccalis maximus*, *Leptothrix buccalis maxima*, *Jodococcus vaginatus*, *Spirillum sputigenum*, *Spirochæte dentium* (denticola).

To this classification may be added the *Leptothrix racemosa* of Vincentini, and the Streptothrix buccalis of Goadby.

Of the six forms in Miller's classification, Goadby, of London, has succeeded in obtaining pure cultures of two of them, namely: the *Bacillus maximus* and the *Spirillum sputugenum*.

The term *Leptothrix buccalis* was first used by Robin, and has been applied to almost every living organism that has been found growing in the mouth. Miller thinks it should be banished from all bacteriologic writings on account of the confusion which it creates. He objects, also, to the term *Bacterium termo*, as it has so often been misapplied, some authors classing every organism showing a slight contraction in the middle as *Bacterium termo*.

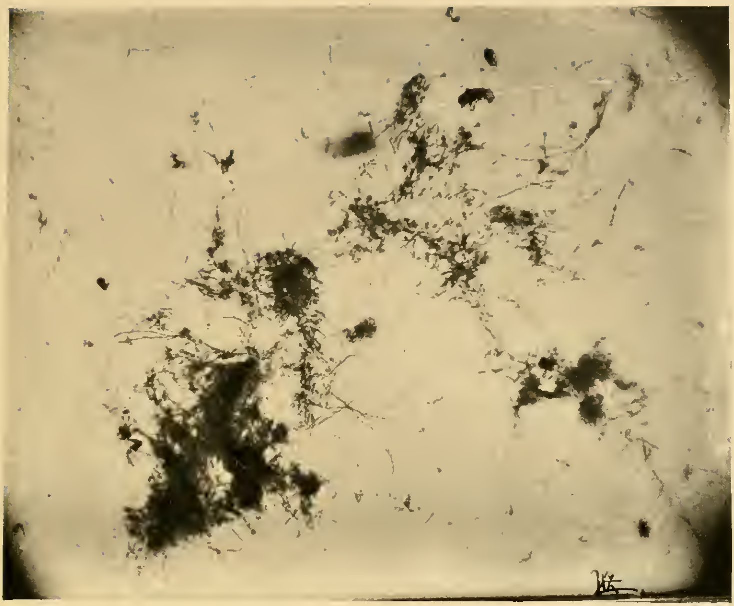


FIG. 243.—Leptothrix buccalis. (V. A. Latham.) × 193.75.

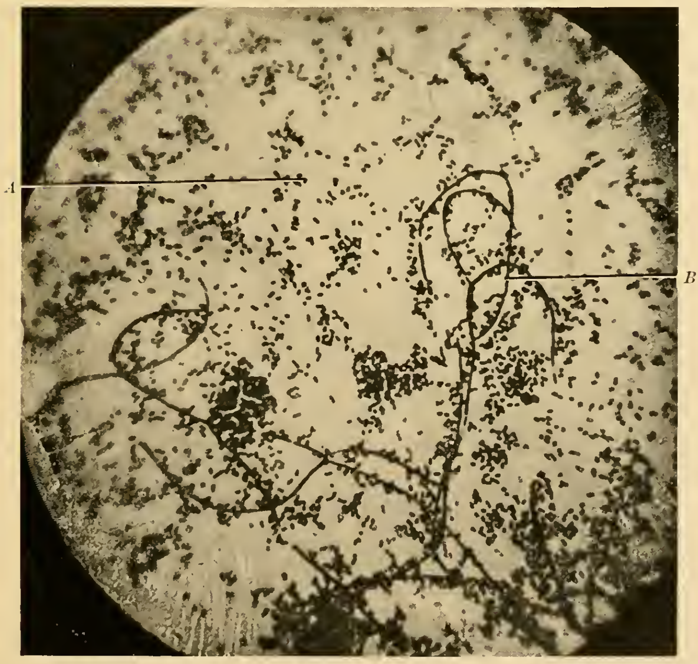


FIG. 244.—Mouth bacteria. (R. R. Andrews.) *A*, diplococci; *B*, leptothrix buccalis.

Leptothrix Innominata.—This term has been proposed by Miller for those bacteria growing in threads, whose biology is too little known to define their relation to other mouth bacteria, or to form a separate group with distinct characteristics.

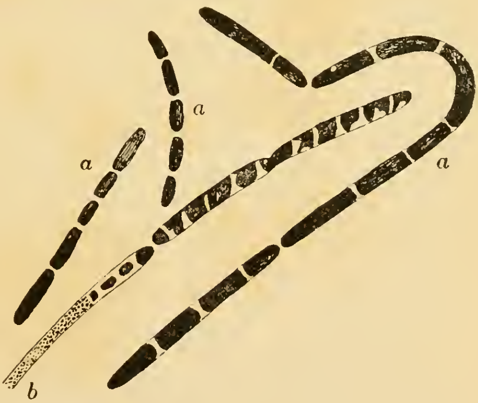
This organism is found in every mouth, but in varying quantities, depending largely upon the personal habits of the individual. It occurs in the soft white deposits which accumulate on the teeth; sometimes it appears in masses, at other times it will be sparingly found (Fig. 243). These masses, according to Miller, vary in size, and consist apparently of small round granules, from whose margins thin, more or less zigzagged threads project.

These granular masses form the so-called "matrix of *Leptothrix buccalis*," and were formerly looked upon as its spores, but are in reality partly micrococci and partly only crossings of the threads themselves.

The threads vary considerably in length, and are from 0.5 μ to 0.8 μ broad; they are twisted, tortuous, immotile, and inarticulated, and take a faint yellow stain with iodine. They often appear degenerated or even lifeless. Shorter threads or rods are also found which may be either fragments of the threads or young cells (Fig. 244).

Bacillus Buccalis Maximus.—This organism is the largest occurring in the mouth. The threads measure from 30 to 150 μ long, the separate rods are from 2 to 10 μ long and from 1 to 1.3 μ broad. Miller found it in isolated threads, but most often in tufts, the threads having a parallel direction, separate bundles sometimes crossing each other.

FIG. 245.



Bacillus buccalis maximus. After treatment with iodine solution. 1800 : 1.

The rods have a very regular contour, and are usually of the same thickness throughout (*b*, Fig. 245, is an exception). Iodine stains the majority of the threads brown-violet, either throughout or in isolated sections. Miller has never found them in the dentinal tubuli; their size would not permit their entrance. Its size, the distinct and regular articulation of the rods, the absence of the zigzag windings, and its reaction to iodine, Miller thinks should preclude it from being classed with the *Leptothrix innominata*.

Goadby found ("Mycology of the Mouth," p. 192), under favorable circumstances, that he was able to obtain this organism in pure culture by making an emulsion in broth of the material containing the bacillus and other mouth bacteria; the emulsion is then plated on a series of (1) maltose-agar or (2) potato-gelatin plates, and the colonies carefully examined for the organism. The bacillus is slow in becoming acclimated to the new environment of artificial media, but when it has developed its "laboratory habit" it grows freely.

He describes the organism as thick-jointed threads, 0.5 to 1.5 μ broad, 10 to 20 μ long; some threads may be much longer, and occasionally twisted, especially upon old potato cultures. The individual elements are 1 to 4 μ long, but may be much longer.

There is considerable irregularity of the protoplasm, both in the organism from the mouth direct and in the cultures of the bacillus, which is brought out by staining. When stained with çarbol-fuchsin or carbol-methylene-blue the bacilli present a "spotted" appearance, due to a fragmentation or breaking up of the cytoplasm. When stained with hot carbol-fuchsin, spores are shown situated at the ends of the threads, while large, clear, unstained areas may be found, which appear to be spaces recently occupied by the extruded spores, and to the effects of plasmolysis.

The organism stains by the Gram method and by the ordinary anilin dyes. Red granules often appear in the older threads when stained with carbol-methylene-blue. When MacConkey's capsule stain is employed isolated masses of deep staining are seen in the interior of the threads. Well-marked dark-red spores are discovered upon using Möller's method. Staining with Pitfield's method shows a few lateral flagella, in the proportion of about six lateral to one terminal. A few of the threads give the granulose reaction. Large oval involution forms appear in old cultures.

Biologically, the organism is aërobic, facultative anaërobic, and a liquefying, motile bacillus, forming spores, while its pathogenic function is undetermined.

Leptothrix Buccalis Maxima.—Miller has given this name to a form of Leptothrix threads which he found in the mucous deposits upon the teeth. He describes the organism as having long, thick, straight or curved filaments, which show a marked resemblance in form to the *Bacillus buccalis maximus* just described, except that the joints are somewhat shorter in the latter. It does not give the iodine reaction. For these reasons he does not feel sure whether it is a different variety or the immature cells of the same variety in which the substance which takes the blue color is not yet formed.

Jodococcus Vaginatus.—This organism is found almost universally in unclean mouths. Miller has never failed to find it except in two instances of children, aged respectively five and six years. He describes it as appearing singly or in chains of from four to ten cells, longer chains rarely being seen.

They are of coccus form; the cells appear sometimes as flat disks, or rounded or even square-shaped bodies, being enclosed in a sheath. The chains have a diameter of 0.73 μ. He occasionally found chains from which one or more cells were missing, others whose sheaths had burst, but from which the cells had not as yet escaped. The sheaths do not show the iodine reaction, but remain colorless, or after continued action of the reagent become yellow. The cell contents always take the stain, the shade varying from dark blue to violet.

Spirillum Sputigenum.—This bacterium is present in all mouths, but in varying quantity. In cleanly mouths the numbers will be small, in those which are foul from neglect they often exist in prodigious numbers. They are found in the soft deposits at the margins of the gums. In neglected mouths with inflammation of the gums Miller sometimes found an almost pure culture of the organism. It is comma-shaped in form and has very active spiral movements, and when grouped together it forms short spirals or S-shapes. It is sometimes found in the dentinal tubules. It was for a time thought to be identical with the comma bacillus of Koch,—the cholera bacillus,—but Miller claimed it was an entirely different species, from the fact that it could not be artificially cultivated upon any then known culture medium, while the Koch bacillus can be readily cultivated. Klein, however, has stated that the *Spirillum sputigenum* can be cultivated in acid gelatin.

Goadby, however, has succeeded in obtaining pure cultures after two years of experimentation with forty different species of culture media. In many cases the organism would grow for a short period, but immediately died upon being transferred to another medium.

He says, "the mouth spirillum generally grows for a short time upon blood serum, and may also be observed upon several fluid media, but only in small numbers. Thus, on beer wort, mucin broth (made from snails), saliva filtered and 1 per cent. peptone added, maltose broth with 0.5 per cent. of potassium sulphocyanide, egg broth and alkali albumin broth, all will occasionally show a limited development.

"The two media which I found to give the best results are saliva set with agar and potato gelatin; the latter medium is not a favorable one for the mouth streptococcus, which otherwise grows to the exclusion of most other forms."

His method of obtaining the spirilla is as follows: "Successive streaks are made upon a number of tubes of the potato medium, and in three or four days a second series of tubes is streaked with any minute pin's-point colonies which show spirilla. The second series may often require to be treated as the first, and even then the organisms have a great tendency to die out.

"When a culture is obtained it requires subculturing every few days or two or three weeks, after which it gradually becomes accustomed to the altered conditions and develops fairly well. The early cultures do not form typical spirilla; under the hanging drop, however, the characteristic movements are seen."

The organism is described as occurring in young cultures "in the form of comma-shaped rods 0.1 to 0.3 μ in breadth, 1 to 2.5 μ long, with round or pointed ends. In old cultures well-marked spirilla are formed, some composed of commas united in series, others of spirilla with three or four turns without a break. Very long threads are also met with; these are often thinner and irregular (spirochæte). Spiral forms best marked on both cultures in forty-eight hours. No endogenous spores were found, but irregular spherical bodies are found attached to the older threads as well as independently."

The organism does not stain by the Gram method.

The best results are obtained with "carbol fuchsin or carbol gentian violet or aniline gentian violet. It stains but faintly with carbol methylene blue. In old cultures the threads stain unequally, and give the appearance of chains of bacilli with unstained intervals. With Pitfield's method single terminal flagella are seen."

Biologically the organism is aërobic, facultative anaërobic, and is a liquefying motile spirillum, but does not form endogenous spores. Arthrospores formed(?).

Its pathogenic function is not fully determined. Agar culture-emulsion in doses of 1 c.c. proved fatal in three days when injected into the peritoneal cavity of guinea-pigs. Four only were inoculated.

Miller discovered and describes two other forms of curved rods or comma bacilli which he found in the human mouth. The *first* is not difficult to cultivate, and occurs in short, plump, tapering rods, slightly curved and generally united in pairs. It is motile and multiplies by fission.

The *second* occurs in the form of delicate rods of varying length, sometimes straight, at others so curved as to form the arc of a circle, and when joined together at their ends forming a circle or letter O; occasionally they are so joined as to form a letter S. They are non-motile, and multiply by fission, and during this process they form chains of cocci. This organism possesses many of the characteristics of the Finkler-Prior bacillus, but whether it is identical has never been definitely determined.

Spirochæte Dentium (denticola).—Miller found this organism (Fig. 246) almost universally present, not, however, in decaying dentin, but in the same locations as the *Spirillum sputigenum*,—namely, at the margins of the gums, in the deposits found there, especially when the gingival borders are in an inflamed condition. This organism is of spiral form, from 8 to 25 μ long, of unequal thickness, very irregular windings, and with marked differences in their susceptibility to staining reagents.

Miller is not sure whether they are two separate organisms, or only different stages in the development of the *Spirillum sputigenum*.

In Fig. 247 it will be noticed that the same spiral or comma-shaped bacilli have flagellæ.

Leptothrix Gigantea.—This very remarkable organism (Fig. 248) was found by Miller in the mouth of a dog suffering from pyorrhœa alveolaris, and to which he has given the above name, suggested by its enormous dimensions. It grows in tufts or fascicles whose threads diverge from a common point of adhesion (Fig. 249). It forms cocci, rods, and threads, and therefore belongs to that group of bacteria known as *pleomorphic*, having more than one form. The threads of the individual tufts vary considerably as to their thickness; some are very thin, others very thick. They sometimes appear straight (Fig. 250), at others irregularly curved or twisted into spirals.

He did not determine its etiologic relations to the disease. In examining the mouths of other animals—sheep, cattle, pigs, horses, dogs, cats, rabbits, etc.—he frequently found leptothrix-like fungi.

FIG. 246.—Spirochæta dentium (denticola) and leptothrix threads. × 1000.

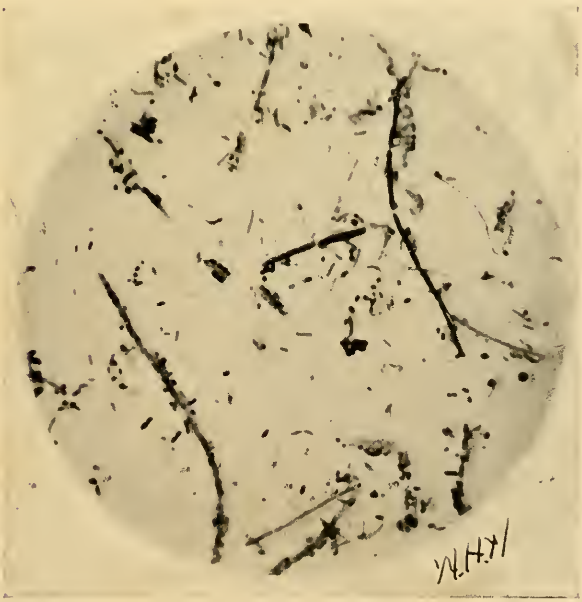


FIG. 247.—Spirochæta dentium (denticola), showing their flagella. 1000.

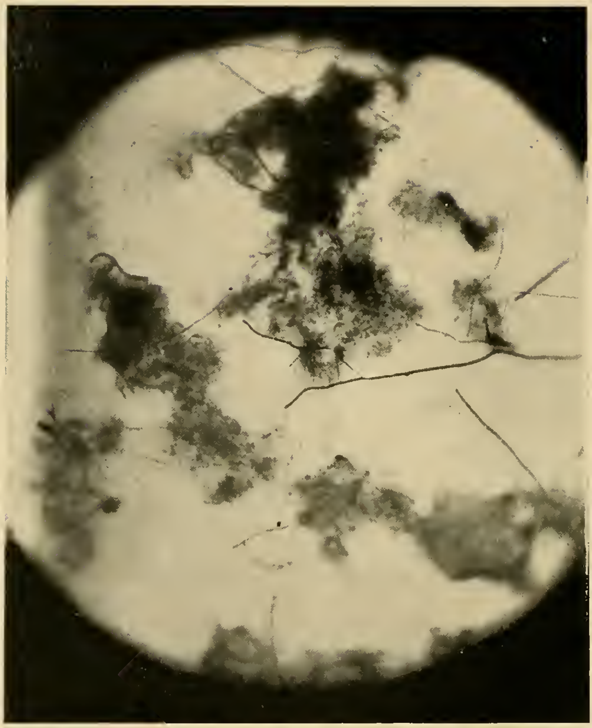


FIG. 248.—Leptothrix gigantea, from dog. × 750.

FIG. 249.—Leptothrix gigantea. (V. A. Latham.) 1000.

FIG. 250.—Leptothrix gigantea. (Miller.) 1000.

Besides these micro-organisms, there are a very great number of others that are found at different times in the human mouth, many of which are pathogenic. Miller has made the estimate that in a certain very unclean mouth there were not less than 1,140,000,000 of micro-organisms.

With such conditions as these it is not surprising that the human saliva is poisonous and sometimes possessing *very virulent toxic properties*, which may endanger the life of the operator who should be so unfortunate as to become inoculated with it through some wound or abrasion upon his hands.

Biondi isolated from the human saliva five different forms of pathogenic micro-organisms, to which he gave the following names: *Bacillus salivarius septicus*, *Coccus salivarius septicus*, *Micrococcus tetragenus*, *Streptococcus septo-pyæmicus*, and *Staphylococcus salivarius pyogenes*. Cultures of all of these organisms were found to be more or less virulent, causing death in mice and guinea-pigs in from twenty-four hours to fifteen days when injected subcutaneously.

Miller has also found within the mouth a considerable number of other bacterial forms possessing pathogenic properties, four of which he examined in dètail and named as follows: *Micrococcus gingivæ pyogenes*, *Bacterium gingivæ pyogenes*, *Bacillus dentalis viridans*, and *Bacillus pulpæ pyogenes*.

The first and second were found in the pus from pyorrhœa alveolaris; the third was found in decaying dentin, and the last in gangrenous pulps.

Cultures made from the first two and the last were found to be extremely virulent, causing death, when injected into the abdominal cavity of white mice, in from ten to twenty-five hours.

The *Bacillus dentalis viridans* was not quite so virulent as cultures from this organism. When injected into the abdominal cavity of mice and guinea-pigs it produced death from peritonitis in from twenty-two hours to six days.

Black, in his investigations of the mouth bacteria, found that the pyogenic or pus-producing organisms were almost constant in this location, and says, "We must take into consideration the fact that the pyogenic bacteria are generally present in the oral cavity, and endanger every wound we make in it."

Miller, in giving emphasis to the fact that the mouth, loaded as it is with so many forms of pathogenic micro-organisms, is a prolific source of infection, says, "The diseases caused by the pathogenic bacteria of the mouth may be considered under six heads, according to the point of entrance of the infection:

"1. Infections caused by a breach in the continuity of the mucous membrane, brought about by mechanical injuries (wounds, extractions, etc.). These lead either to local or general disturbances.

"2. Infections through the medium of gangrenous tooth-pulps. These usually lead to the formation of abscesses at the point of infection (abscessus apicalis), but also sometimes to secondary septicæmia and pyæmia, with fatal terminations.

"3. Disturbances conditioned by the resorption of poisonous waste products formed by bacteria.

"4. Pulmonary disease caused by the inspiration of particles of mucus, small pieces of salivary calculus, etc., containing bacteria.

"5. Excessive fermentative processes and other complaints of the digestive tract, caused by the continued swallowing of microbes and their poisonous products.

"6. Infections of the intact soft tissues of the oral and pharyngeal cavities, whose power of resistance has been impaired by debilitating diseases, mechanical irritants, etc."

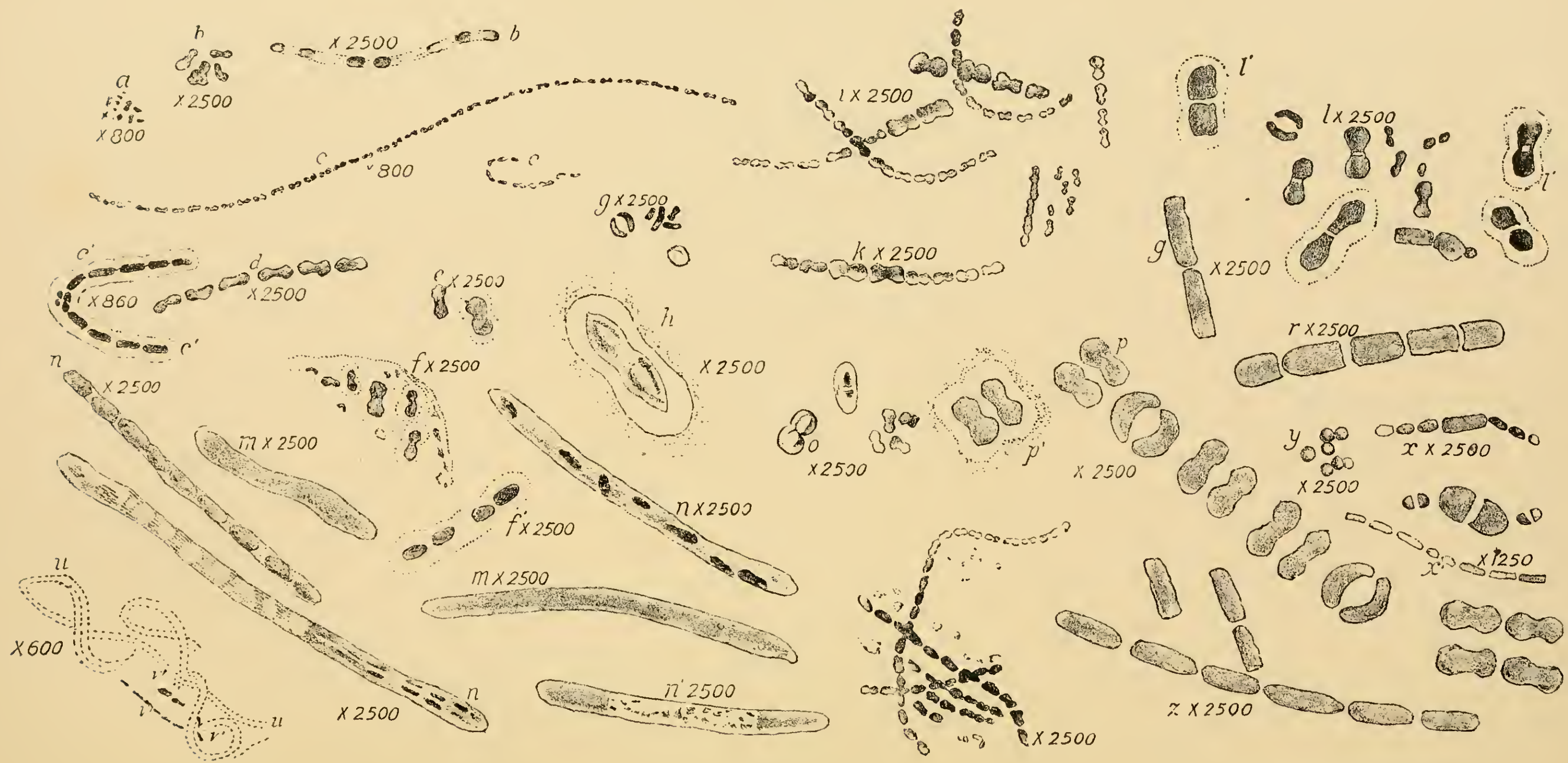
Leptothrix Racemosa.—Dr. Filandro Vicentini, in a series of articles published in the *International Journal of Microscopy and Natural Science* (1894–1895), upon the "Bacteria of the Sputa and the Cryptogamic Flora of the Mouth," announces the discovery of a thread-like organism or Leptothrix, which he terms *Leptothrix racemosa.* This organism he first found in the sputa of pertussis, and afterwards traced to the mouth as its natural habitat, and which could always be found in the *patina dentaria,*—plaques of deposit,—located in the interdental spaces, if the material were gathered in the morning before the fast was broken, or some hours after a meal. This organism differed from the various forms of Leptothrix which had been recognized and described, in that the stems or filaments present a beaded appearance, and that these stems terminated in enlargements or heads which contained six or more rows of spores, as shown in Plate VI., Fig. 24.

This micro-organism, he claims, passes through *four phases* of development and is therefore pleomorphic. The *first phase* being common to all the other species of bacteria, but which does not, however, represent its whole cycle of life, but only its primordial stage of immersed vegetation, or a vegetation destined to propagate in a liquid or semi-solid media.

In the *second phase* of the life history of the organism many degrees of transition may be observed. These are represented "by chains, bundles, and masses of intertwined filaments, isolated filaments, large dumb-bell bacteria of the type *p*, *p*, and *p′*, Plate V., and masses of diplococci; the large dumb-bell bacteria being derived from the diplococci, the two original cocci linking together. The chains are often surrounded by masses of diplococci, while in the same chain small diplococci may alternate with elliptical bacteria and medium-sized dumb-bells, all perfectly equal, which form the largest number."

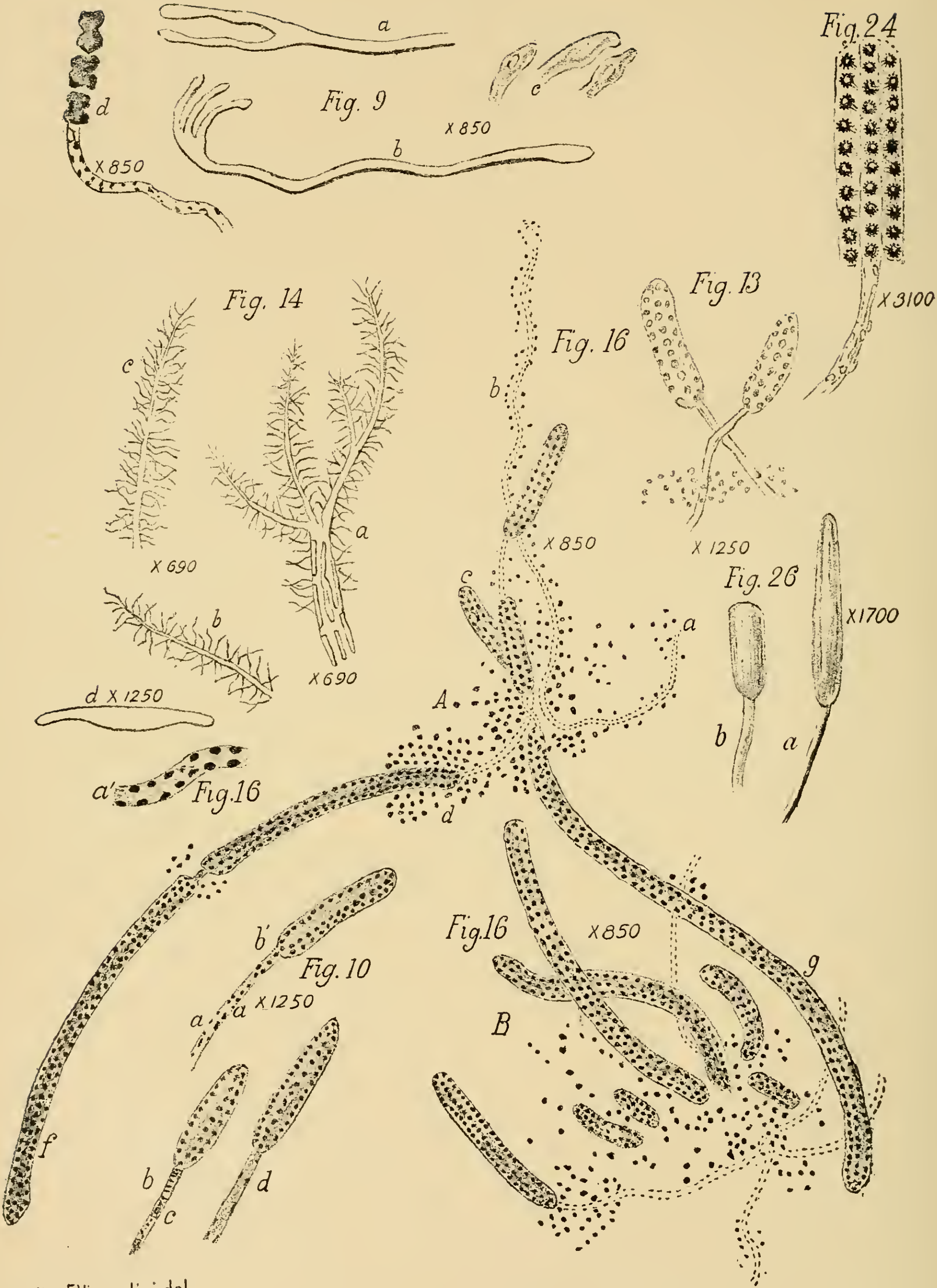
The *third phase* is generally met with in the salivary calculus of the teeth. Its predominant elements are large filaments, often long, bent, and reunited in bundles, and stumps. Two notable features are observed in the large filaments, which have not been described by any previous author. The first of these is the division of the radial extremity of the filament into two or three branches (Plate VI., Fig. 9). "In *a* the filament is broken towards the top and exhibits two long roots; in *b* there are three hood-shaped roots, both appearing to be swollen at their ends (*c*) like *haustoria.*" The author raises the query of the use of these barbs or roots,

PLATE V.



after F. Vincentini. del.

PLATE VI.



after E.Vincentini.del.

if they are not to obtain a firm foundation in the soil. And to what purpose a firm foundation, if not to support higher forms of vegetation?

The second feature is that of the enlargement or "swelling of the terminal ends of the filaments, as shown in *b* and *c*, Fig. 9, and these are of varied form, at times containing a kind of nucleus. Plate VI., Fig. 26, *a* and *b*, show further development into *heads* or *ears*. There are other enlargements found along the filament, which might be styled knotty.

"Intermixed with the other element—the stumps—are almost all the forms of bacteria, bacilli, spirilla, etc., besides a large number of very varied small chains, after the types shown in Plate V., *c*, *d*, *k*, *i*, *x*, and *x'*."

The large size of the stumps he thinks may be accounted for by the fact that "the points of the filaments are removed by friction or other mechanical means, and this seems to impart a greater development to the remaining stems in the sense of greater thickness, as happens in the pruning of trees, through the retrocession of the ascending sap." This he thinks explains "the appearances of the stumps and their fragments, which are so various, and which led Miller to make of residual filaments two distinct species,—viz., *Leptothrix buccalis maxima* and *Bacillus buccalis maximus*, while the fertile filaments which he had discovered constitute Miller's third species, the *Leptothrix innominata*."

"From the tiny islands of the stumps in question spring at last the fructifications. The larger filaments gradually become thinner and pale, showing in their interior countless granules or parietal gemmules. These are the fertile filaments. They may spring either from the proper filaments with continuous contour or from the little chains, *d*, Plate VI., Fig. 9, which are seen occasionally on the top of those filaments; and in this last case, instead of a gradual thinning, may abruptly pass from the chain to the fertile filament," as shown in the figure. This phase the author terms *incomplete aërial vegetation*.

The *fourth phase* he terms *complete aërial vegetation* or *fructification*. In this stage the fructification *heads* or *ears* have reached a developmental stage, which shows the formation of spores arranged in three rows (Plate VI., Figs. 10 and 13).

"The fertile filaments are sometimes straight, at others bent or curved; occasionally they are entirely wanting, because the fructifications have been carried away by mechanical force."

In Plate VI., Fig. 10, at *a*, *a*, "gemmules of reserve" are seen adhering to the walls of the stem; at *b* the little spores are properly lodged; at *b'* only five are seen, the others having dropped; at *c* the penultimate articulations of the stalk appear older and woody; the last is granular, like the two articulations on the apex of the younger filament, *d*.

The sporules, which are very small and round, are arranged in three vertical rows; this is the appearance, almost without exception, in all the specimens observed, hence it is inferred by Vicentini that they are arranged in six longitudinal lines. In several specimens stained with picric acid the prolongations of the stem into the interior of the fructification head could be distinctly traced. Staining with aniline colors rendered the viscid substance in which the sporules are suspended opaque; but if glycerol was substituted for water in the preparation of the slide, the stalk after a long time reappears distinctly in all its length. The stalk and the ear form a continuous whole, and he likens a tuft of the organism with its vibrating ears to "a field of wheat."

The length of the ears is frequently considerable, as shown in Plate VI., Fig. 16, the more conspicuous specimens being found in pulmonary sputum, "the largest being one-sixth of a millimetre."

Bacteria in general are reproduced by two methods,—viz., by *fission* or cell divisions, and by the formation of spores within the parent cell, termed *endogenous spore formation.* Another method of reproduction is known as *arthrosporous* reproduction. By this process spores are formed out of portions of the cell-body, or some of the individual cells of the latter set free from the parent organism, the opposite of endogenous spore formation. Very little is known of this process at the present time.

Still another method of reproduction may be mentioned: this is termed *acrogenous abjunction,* a process by which spores are formed at the apices of certain cryptograms. In this process the terminal cell becomes enlarged and transformed into what is known as a *basidium,*—a diminutive base,—from which external sprouts or *sterigmata,* bearing spores or *spermatia* upon their terminal ends, arise.

Vicentini believes from his study of the *Leptothrix racemosa* that it propagates by two distinct methods, the first by "*internal gemmulation,*"—endogenous spore formation,—which he terms the "*inferior* or first cycle," and the other by "*conjugated fructification,*"—acrogenous abjunction,—which he terms the "*superior* cycle." He claims that "the organism possesses real organs of reproduction by which it would resemble fungi and *diœcious algæ,* with distinct sexes upon different filaments or individuals.

Its fertile filaments are at times engrafted, with two or three roots, upon clods or firm substrata, and end in fructification. The ears are linked together and fastened to a stalk, as shown in Plate VI., Fig. 16. Other filaments, however, less numerous than these, at times multiply, and lastly, branching off, bear certain productions by *points,* the male elements (Plate VI., Fig. 14) or pseudo-inflorescences or blossoms formed of spindle-like (*d,* Fig. 14), snake-like, or comma bacilli (*Spirillum sputigenum*), destined from all appearance, through their lively activity, to the function of conjugation.

This investigator was able to observe the complete process of fructification of the organism in sputa impregnated with its elements. The process is completed upon the fourth day by keeping it well sheltered in the dark.

Vicentini makes the bold statement that he believes, from a study of the various phases through which the *Leptothrix racemosa* passes in its life history, that it is with perhaps one exception the mother organism of all the bacteria and bacilli found in the sputum. He says, "Of the six primary species of fungi of the mouth, described by Miller, there would, in fact, exist only one, the *Leptothrix buccalis* of Robin (*Leptothrix innominata* of Miller), or at most a second one, the Spirillum (*Spirochæte dentium* of

Miller). The other four types would represent, if we are not mistaken, only phases, or disintegrated particles of the microphyte,—viz., *Bacillus buccalis maximus* and *Leptothrix buccalis maxima*, fragments of the stumps that form the inferior layer of vegetation : the *Jodococcus vaginatus* series of special sheaths of bacteria proceeding from certain 'gemmules of reserve,' enclosed in the filaments; the *Spirillum sputigenum* (comma bacilli) with our spindle-like and serpentine appendages detached from the pseudo-inflorescences (blossoms), and probably male organs.

"All these particles or articulations cut from the mother plant (except the last,—viz., the copulative filaments) multiply by themselves, in various ways, according to the condition of the nutrient substratum, in the liquid menstrua or on firm soil."

He further suggests, as have some other investigators, that the pathogenic or virulent properties of bacteria are in all probability acquired as a result of their environment, and that it is not necessarily a permanent quality.

This may explain the periods of activity and of immunity which are observed in relation to the progress of dental caries.

Dr. J. Leon Williams, in an article in the *Dental Cosmos* (April, 1899) upon the "Bacteriology of the Human Mouth," states that he, without knowing of the discovery of Vicentini, had some two or three years later made an identical discovery of the fructification of Leptothrix threads. He says, "While studying mouth bacteria I came across very regular arrangements of coccus forms about the ends of Leptothrix threads. At first I regarded these as purely accidental. But the persistence and regularity of these forms in nearly every one of the preparations I was then making led me to examine them more closely, and I was astonished to find what appeared to be a thorn-like connection between the spore or coccus form and the leptothrix-like thread."

After reading the work of Vicentini, which was brought to his attention by a friend to whom he had mentioned his own discovery, Williams went forward with his work. His method of procedure is as follows: "A stream of sterilized water is thrown from a powerful syringe into the interdental space between the first and second upper molars. With a sharp, sickle-shaped instrument, previously sterilized, a gelatinous microbic plaque is removed, which appears upon the instrument as small, grayish-white material, which possesses considerable tenacity. This is placed upon a clean watch-glass and covered with twenty or thirty drops of a thin, watery solution of methyl violet aniline, the mass being allowed to remain in the solution for twelve hours, but in the mean time occasionally teasing it apart to obtain a better penetration of the staining fluid. The fluid is then drained off and the mass washed first with sterilized water and then with a mixture of equal parts of glycerol, spirit, and water. A drop of the same mixture is then placed upon a cover-glass, the stained mass dropped into it, and teased apart as much as possible, and then carefully inverted on a slide, care being taken to make as little pressure as possible upon the cover-glass. The preparation will now show fields similar to Figs. 251 and 252 if examined with a one-sixth-inch objective.

Under a one-tenth- or one-twelfth-inch objective in fortunate specimens, fields like Fig. 253 will be observed. Such a view very clearly resembles a grass-plot, from which arise the blossom, fruit, or seed-heads of the plant. These are the fruit or spore-heads of a thread-like micro-organism, which I have found to be as constant as any form of bacteria in the human mouth." The *Leptothrix racemosa* of Vicentini (Fig. 254) shows such a field under high magnification.

This organism Vicentini describes as having ears or fruit-heads made up of six regularly arranged rows of spores or seeds. Williams has secured a few lucky views of the heads in cross-section, which show them to be composed of twelve rows or even more.

The attachment of the spores to the central stalk by the thorn-like processes, sterigmata, or peduncles, and which constitutes the final and irrefutable proof of the correctness of Vicentini's claim of the fructification of the *Leptothrix racemosa*, is most beautifully shown in Figs. 255 and 256, while in Fig. 257 the spore attachment in both longitudinal and transverse section is likewise finely shown. Fig. 258 shows a transverse section under a magnification of about nine thousand diameters.

Williams believes with Vicentini that the organism is one of very rapid growth and common to all mouths, and the forms which must result from the breaking up of the spore heads and stem of the organism are *long* and *short rods*, various sizes of *micrococci*, various sizes of *diplococci*, and various sizes of *curved* and *club-shaped bacilli*. He further says, "I have no disposition to indulge in speculation over these discoveries, but here are the facts which must be reckoned with in all future considerations of the bacteria of the human mouth and body. It would be folly to deny that these facts are big with possibilities. . . . However much we may be disposed to reticence, it is impossible to avoid asking what becomes of the enormous number of micro-organisms of different forms and sizes which are being constantly shed into the human mouth by this parent organism, and how many of them have been classified as permanent species."

Upon this point Vicentini says, "According to my calculations not less than from two to three hundred trillions of germs or separated elements are generally present in the mouth and nose, liable to disseminate the species at every minute into other parts."

There is a question, however, whether these organisms are not placed in the mouth by nature for a beneficent purpose. Fabulous numbers of them are constantly passing into the digestive tract, where they may, as suggested by Hallier, take an active part in the transformation of the ingested food by the transmutation of the starchy elements into glucose, both in the mouth and the stomach. Miller and others have recognized in the buccal bacteria a peptonizing action equal to pepsin itself, even without the action of acids.

Streptothrix Buccalis.—This organism was discovered by Goadby, and first described by him in a paper published in the *Trans. Odont. Soc.*, London, June 18, 1899. It was found in the thick viscid pus, sometimes emanating from the gum pockets around teeth affected by pyorrhea alveolaris. He later found it in the white deposits around the necks of the

FIG. 251.—The material from which this photograph was made, and all of those which follow, was obtained by scraping the approximal surfaces of teeth after thoroughly syringing with sterilized water, and, in some instances, also after rubbing the surface of the tooth with a wad of sterilized cotton-wool. The gelatinous mass of micro-organisms adheres to the surface of the enamel with considerable tenacity. The scrapings were stained with watery solution of gentian-violet-anilin water and mounted in diluted glycerol. Under a power of four or five hundred diameters places will be found presenting such appearances as are shown above. (J. Leon Williams.)

FIG. 252.—Fructification heads of *leptothrix racemosa.* Zeiss objective 3 mm., projection ocular 3. (J. Leon Williams.)

FIG. 253.—Fructification heads of *leptothrix racemosa*. (J. Leon Williams.)

FIG. 254.—Thick growth of *leptothrix racemosa* fructification heads from approximal surface of tooth, under high magnifying power. (J. Leon Williams.)

Fig. 255.—Fructification heads of *leptothrix racemosa*.

Fig. 256.—Fructification heads of *leptothrix racemosa*.

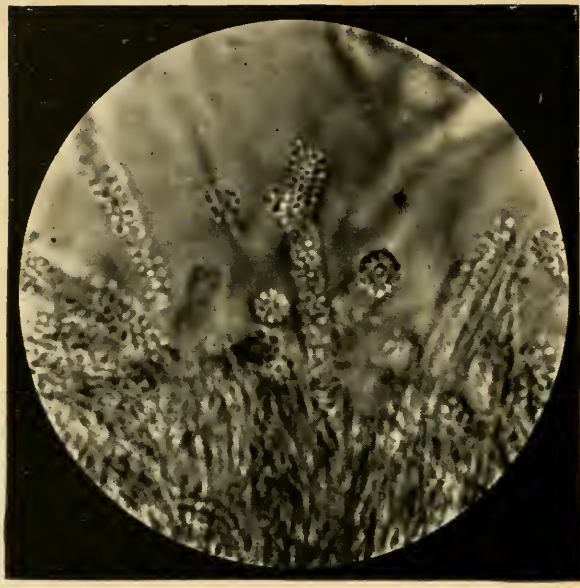


FIG. 257.—Showing attachment of spores to central stem in both longitudinal and transverse section. (J. Leon Williams.)

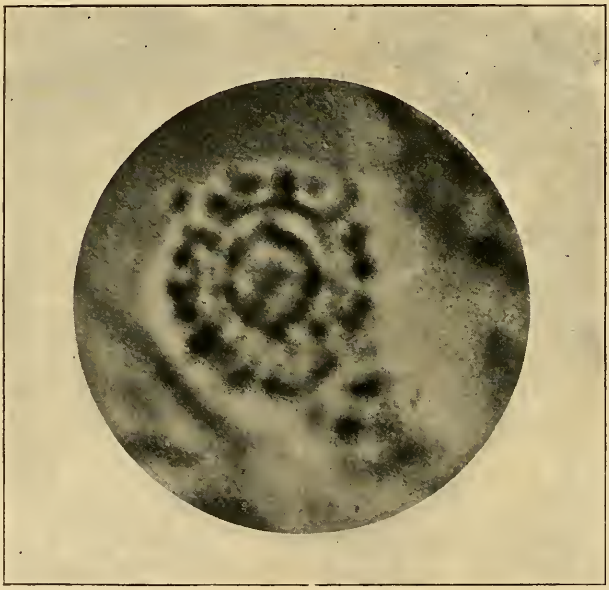


FIG. 258.—This photograph is from an enlarged negative made from an original photograph of transverse section of fructification head of *leptothrix racemosa*. The original negative was magnified to 2000 diameters. The enlarged negative and the above print represent an amplification of about 9000 diameters. It shows the cell wall and the shrinkage of the protoplasm caused by the action of the glycerol and spirit. The spore-stems, or sterigmata, are seen to arise from the central protoplasm and to pass through the cell wall. (J. Leon Williams.)

teeth, and in gingival inflammations. He classifies the organism as belonging to the genus Streptothrix, and thinks it should be placed in the same category as the Actinomyces bovis, because it conforms to the generic description of Streptothrix—namely: "delicate-threaded organisms free of chlorophyl, showing a true branching mycelium; portions of the threads show club-shaped endings and gonidia which may also be developed in the mycelium. Fragmentation of the mycelium occurs with the production of various morphological forms not to be differentiated from the various forms of Schizomycetes. The mycelium may be developed from the gonidia or from the fragmented threads." He therefore named the organism "*Streptothrix buccalis.*"

The organism is described as follows: "Filamentous forms; in young cultures a tangled mycelium is produced, the threads of which show well-marked lateral branches; the ends of these threads are frequently club-shaped.

Dichotomous branching, or branching by longitudinal fission of terminal filaments not observed.

The lateral branches are unequally distributed upon the thread and often present a constriction at their junction with the main stem. The terminal portions of the threads may taper to a point or show distinct enlargements. Somewhat later the threads and clubbed extremities undergo changes resulting in the thread staining unequally, especially with gentian violet or Gram's method; at the same time segmentation transverse to the long axis results in the production of bodies which may be termed gonidia. Fragmentation now occurs, the mycelium splitting up into a series of forms morphologically simulating various bacteria, and as some of the threads are slightly spiral, comma shapes and spirilla are also found.

The gonidia set free, germinate, and produce threads by lateral extension, and thus the cycle is complete. On solid media particularly the colonies become covered with a white powder consisting of the gonidia, which, if transferred to another tube, grow into colonies."

The organism stains readily by the Gram method and by the ordinary aniline dyes. The clubbed ends stain most deeply.

Biologically the organism is an aërobic, liquefying streptothrix. Not motile. Endogenous spores not observed.

Pathologically the organism seems to bear an interesting relationship to pyorrhea alveolaris, from the fact that it does not seem to be present in normal mouths, and has been found only in connection with the above-mentioned disease, the emanations or secretions found at the margins of the gums around the necks of the teeth, and in gingival inflammation.

BACTERIA WHICH AFFECT THE INTEGRITY OF THE DENTAL TISSUES.

The *zymogenic* and the *saprogenic* micro-organisms have also a distinct interest for the dental surgeon from the fact that certain species of the zymogenic bacteria have for their special function the formation of acids within the mouth by the fermentation of the carbohydrates which are lodged there as alimentary *débris*, and also that certain other species of the saprogenic bacteria have the power of liquefying albuminoid substances or digesting them by the production of a soluble ferment.

According to the now generally accepted theory of dental caries, these micro-organisms are the prime factors in the production of this disease.

The fermentation of the carbohydrates within the mouth is produced by certain species of bacteria, the results of which are the formation of various compounds, lactic acid, mannite, dextrin, etc. According to Miller, butyric acid is never found in the mouth except as a *by-product* in lactic acid fermentation.

The fermentation of the carbohydrates is chiefly productive of the formation of lactic acid; this is brought about by certain species of bacteria acting upon these fermentable compounds and converting them into lactose and lactic acid, with or without the evolution of carbon dioxide. (Miller.)

A considerable number of micro-organisms are capable of affecting this transformation.

Miller, experimenting with twenty different species of mouth bacteria upon the carbohydrates, obtained in sixteen of them an acid resultant, while in one of the others, which was found in a putrid pulp, the evolution of gas was so copious as to tear the gelatin into shreds.

Vignal found, in his researches upon the mouth bacteria, that out of seventeen different varieties, seven of them liquefied coagulated albumin, five others caused it to swell and become transparent, ten dissolved fibrin, nine dissolved gelatin, seven coagulated milk, six dissolved casein, three transformed starch, and nine converted lactose into lactic acid; the majority, it will be seen, had a peptonizing effect, and some of them grew independent of free oxygen.

The principal organism, however, in the production of lactic acid, and one which is constantly found in the human mouth, is the *Bacterium acidi lactici* of Hueppe.

Among the carbohydrates which are most highly fermentable and readily acted upon by the lactic acid bacterium are the sugars, dextrin, starch, cellulose, etc., and these are always found in the mouth, in greater or less quantities, as alimentary *débris*, ready to be acted upon by zymogenic bacteria. The mouth presents at all times the necessary degree of heat and of moisture for the rapid growth of these organisms. Lactic acid in very dilute solutions readily acts upon the inorganic substances of enamel structure and disintegrates it, and thus opens the way for caries to attack the dentin. The organisms which produce lactic acid enter the dentinal tubuli, where they continue to generate acid, which removes the calcium salts, while the liquefying or peptonizing action of other forms of bacteria dissolve the decalcified dentin matrix.

Several other fermentations of carbohydrates take place within the mouth, by which mannite, dextrin, etc., are formed.

Mannite is the product of a fermentation induced by an exceedingly small coccus—*Micrococcus viscosus*—which grows in chains in various saccharine beverages, in wine, beer, etc., and in saccharine juices (Miller), and forms a gummy product known as mannite. Black believes that this substance is the cause of sordes which accumulate upon the teeth in the continued fevers, and that it may be the cause of thick, ropy saliva.

Dextrin is formed as the result of fermentation caused by the action of a micrococcus—*Leuconostoc mesenterioides*—upon beet-juice and molasses, and can be induced artificially in saccharine solutions. (Miller.)

Action of Pathogenic Bacteria.—The question of *how the pathogenic bacteria produce their effects upon the living tissues of the body* is one upon which there is still a wide difference of belief. Some observers are of the opinion that the symptoms of infectious diseases are the result of the formation by the micro-organisms of chemical substances of an irritating or poisonous nature, a sort of specific excretia.

Others believe the phenomena, both local and constitutional, to be due to changes wrought within the tissues by the organisms themselves during their development, and that it is not necessary to assume the formation of a specific poison or virus to account for these phenomena.

The action of the pyogenic or pus-producing bacteria is to produce local irritation or inflammation, while the chemical substances elaborated in the focus of infection are disseminated throughout the body, which, by virtue ot a peculiar action, thought to be ferment-like, augments tissue metamorphosis, stimulates the "thermic centres" and thereby increases the body temperature, producing fever or systemic disturbance. This condition is known as *septic infection.*

The absorption of ptomaines without the presence of pathogenic bacteria will produce grave systemic disturbances. This condition is termed *septic intoxication*, or *toxic infection.*

Ptomaines are powerful animal poisons developed by the process of decomposition of animal tissue in the presence of saprophytic bacteria. In their physiologic action they resemble the alkaloids, and when received into the circulation by the process of absorption they produce more or less severe constitutional symptoms. The "toxines" probably belong to this class of substances.

The development of the ptomaines seems to exert a controlling or inhibitory effect upon the growth of the micro-organisms. Many of the artificial cultures of bacteria, after a period of growth, cease to develop, and it is partly by virtue of the formation of these substances that this controlling effect is brought about.

Leucomaines are animal alkaloids which are produced within the living tissues by metabolism—tissue changes—independent of micro-organisms. The pathologic significance of these products is as yet not well defined.

Immunity.—The effects of the virus of certain bacteria upon the vital fluids and the tissues of the body in certain diseases is to give protection against future attacks; in other words, to render the organism *immune.*

Pasteur believed this protection or immunity to be due to the exhaustion of the chemical substances supposedly necessary to maintain the life and development of the specific bacteria.

Fraenckel was of the opinion that the first invasion of the bacteria left behind certain substances which were inimical to the further development of the same species of micro-organisms, which might at some other time gain an entrance to the system.

From the foregoing pages it will be readily appreciated that the difficulties to be surmounted in securing an aseptic condition of the mouth are so great as to make it an impossibility.

Much can be attained, however, by a scrupulous attention to certain hygienic rules,—viz., brushing the teeth after each meal, followed by the use of floss-silk passed between the approximating surfaces, and the assiduous use of antiseptic mouth-washes.

Boric acid in fifty per cent. solution, cinnamon water, formal (one per cent.), listerine, pasteurine, and borolyptol are all valuable antiseptics for this purpose.

Too much care cannot be exercised by the dentist and the surgeon in thoroughly cleansing the mouth and the teeth before commencing any operation which involves a breaking of the continuity of the soft tissues. and the thorough sterilization of all instruments and dressings used in the operation. A no less important precaution is that of thoroughly cleansing the hands and finger-nails of the operator, and washing them in antiseptic solutions. Failure to do this often results in the introduction of pyogenic bacteria and establishing suppurative processes, which with proper care might have been avoided.

STERILIZATION OF HANDS AND INSTRUMENTS.

Absolute cleanliness in all operations within the mouth is of such great importance from the surgical stand-point that too much stress cannot be laid upon its strict observance in every detail. This comprehends the sterilization of the hands of the operator, of the mouth and teeth of the patient, of the instruments used in the operation, of the rubber dam, and of other materials employed for the exclusion of moisture.

The student who would be successful in the treatment of the diseases and injuries to which the teeth and the mouth are subject must be taught to appreciate the value of antisepsis and the technique of its employment.

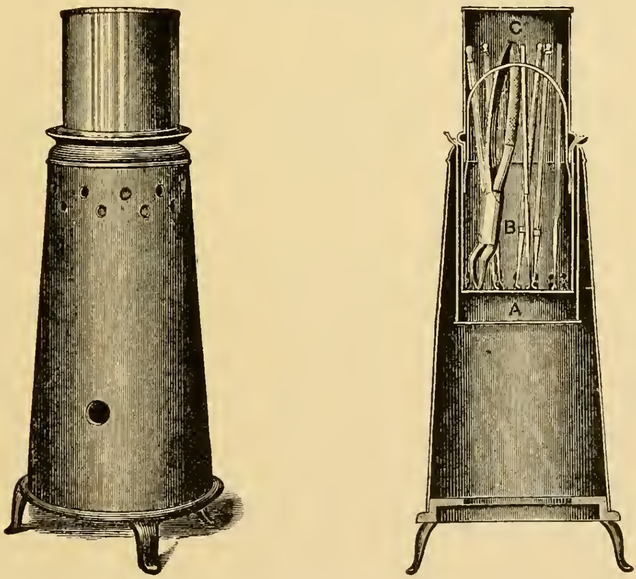
Carelessness upon the part of the operator in not observing the ordinary precautions of aseptic methods may not always result in spreading infection; but this is due to the resistance of the tissues which have been thus endangered, rather than to a lack of transmitting infectious material. Cases are on record in considerable numbers in which serious consequences have followed the employment of unclean or septic instruments in operations like lancing an alveolar abscess, extracting a tooth, etc., some of which have resulted fatally.

Among the most common infectious diseases which may be transmitted from one patient to another by the hands of the dentist and of his instruments are tonsillitis, diphtheria, suppurative inflammation, certain forms of stomatitis, malignant œdema, tuberculosis, and syphilis. In view of these facts, the operator should exercise the greatest circumspection in the cleansing and sterilizing of his hands and instruments when passing from one patient to another. The operator should never under any circumstances permit himself to come in contact with his patient without first washing his hands, and this should be done in the presence of the patient, that there may be no lingering doubt about the question of cleanliness; while the instruments which he is about to use should be taken fresh from the instrument-case, where they have been placed after being sterilized. Instruments should never be permitted to remain upon the operating-table after the patient has been dismissed, but should be immediately cleared away and placed in the sterilizing apparatus before the next patient takes the chair. Such attention to the appearances of cleanliness is very gratifying to the scruples of patients, and increases their confidence in their dental adviser that no effort will be lacking upon his part to insure them against the spread of disease by infection.

TECHNIQUE OF STERILIZATION.

Sterilization of the Hands of the Operator.—This may be accomplished by thorough washing and scrubbing with hot water and antiseptic soap; green soap containing two per cent. of carbolic acid is the best for this purpose. The finger-nails should then be carefully cleansed and the hands again washed in hot water. In cases of operation in which the soft tissues are to be involved the hands should receive a bath in a five per cent. solution of carbolic acid, or a 1 to 1000 solution of mercuric bichloride.

FIG. 259.



Instrument sterilizer.

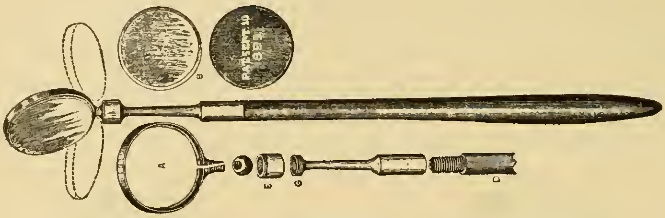
The operator should also guard against his own infection by covering even the slightest abrasion of the cuticle of his hands with a film of flexible collodion.

Sterilization of the Mouth and the Teeth of the Patient.—This comprehends the thorough removal of all calcareous and other deposits upon the teeth; the filling of all carious cavities, either permanently or temporarily; the treatment or removal of all suppurating teeth and roots, and a liberal use of antiseptic mouth-washes, like a saturated solution of boric acid; two to three per cent. solutions of carbolic acid; the Thiersch solution (salicylic acid 4 parts, boric acid 12 parts, water 1000), or solutions of listerine, borolyptol, pasteurine, or formol 1 to 100 of the forty per cent. solutions.

Complete sterilization of the mouth and teeth, however, can never be attained by even the most rigid technique, but it may be so nearly approximated as to greatly reduce the dangers from infection in those cases where the continuity of the soft tissues of the patient has to be broken.

Sterilization of Instruments.—Instruments of every kind should be thoroughly sterilized before being used upon a patient. This may be most efficiently done by boiling in water. All instruments which have been used about the mouth of a patient should first be thoroughly scrubbed with warm water and soap, rinsed, and placed in a sterilizer and boiled for at

Fig. 260.



Dental mirror.

least five to ten minutes. Fig. 259 shows a very neat and efficient sterilizer, manufactured by the S. S. White Dental Manufacturing Company, which is sold at so moderate a price that every dentist can afford to possess one.

When the instruments are removed from the sterilizer they should be wiped dry with a clean, sterile towel while they are still hot. By this method the instruments will not rust or tarnish. Mouth-mirrors are sometimes injured by the boiling process, but the best German makes stand the ordeal very well, and will often last for months. Ash & Son and the S. S. White Dental Manufacturing Company supply a mirror (Fig. 260) which can be taken out of the frame, which makes it possible to sterilize this part of the instrument by placing it in strong solutions of carbolic acid, while the frame may be boiled. The safer method, however, is to boil these instruments like all others, and when the glass gives out replace it by a new one, which can now be done at trifling expense.

Rubber dam may be kept in a sterilized condition ready for use by cutting it into squares of suitable size and placing it in a covered glass jar containing a 1 to 3000 solution of mercuric bichloride and washed in sterilized water before using. To guard against the possibility of carrying infection by the rubber dam from one patient to another it is best never to use the dam a second time, except upon the same patient.

Gauze and cotton rolls are now prepared for the use of the dentist, which have been rendered sterile by prolonged heat. These should be kept in boxes with tight-fitting covers, and may be resterilized at any time by placing them in a sterilizing oven heated to 250° to 300° F.

CHAPTER VI.

EXAMINATION OF THE TEETH AND MOUTH.

THE importance of frequent examinations of the teeth and oral cavity as a prophylactic measure against the development of disease and its early discovery cannot be too strongly urged upon the public or upon the practitioner. The old adage "that an ounce of prevention is worth a pound of cure" was never of more value than when applied to the prevention of diseases of the teeth and mouth.

It has been said that "*the highest aim of the healing art is not to cure disease, but to prevent it.*" It should be, therefore, the highest duty of the dental surgeon to strive to prevent the development of disease within the oral cavity, and to check its ravages at the earliest possible moment, so that the attendant dangers may be reduced to the minimum. In order to accomplish this much-to-be-desired result frequent examinations at stated periods, with instruction in the various means which may be adopted to keep the teeth and mouth in an hygienic condition, will be absolutely necessary.

This system of frequent periodical examinations, to be most effective, should be instituted in early life, commencing with the little children as soon as the deciduous teeth are erupted.

These examinations should be made as often as every three months in the case of little children.

At these sittings the child should be taught by the dentist how to cleanse the teeth. This first instruction in the art may be rendered the more effective by the operator giving the child an object-lesson, by brushing his own teeth in its presence. The little patient should then be given a brush and induced to imitate the brushing process by watching the operator as he applies the brush to the teeth and makes the necessary movements in order to cleanse all the surfaces that can be reached by this method. The nurse or the mother of the child should be present, and instructed to follow up the teaching each day, adopting the same methods of instruction. By the frequent examinations indicated the dentist has opportunity to learn whether or not his instructions are being followed and the child keeping its teeth and mouth clean, and if not, it gives repeated opportunities to correct the habit of neglect and impress upon the child and those who are responsible for its care the importance of a hygienic condition of the mouth in preventing the development of disease.

In the light of the prevailing theory of disease, and of the constant presence within the mouth of so many forms of zymogenic and pathogenic micro-organisms, the practitioner would be remiss, indeed, who did not impress upon his *clientèle* the great value of a hygienic condition of the oral cavity as a prophylactic measure.

At each periodical visit the teeth should be thoroughly cleansed and polished, and a critical examination made in reference to the presence of caries, diseased conditions of the gums, or other abnormal manifestations, appropriate treatment being instituted for the relief of the individual ailment.

This system can be followed with older children, young people, and adults, the intervals between the examinations being longer or shorter according to the exigencies of each individual.

Children and youths during the period of rapid growth, chlorotic girls, and pregnant women have usually an increased predisposition to dental and oral diseases; consequently it is the duty of the dentist to acquaint them with the fact that they should give increased attention to the care of their teeth and mouth if they would maintain these organs in a healthful condition.

The writer has found in his own practice that his clients were very appreciative of this thoughtful attention to their physical welfare, and, as a rule, gladly co-operate with him in these endeavors.

In order that no case requiring especial attention may be overlooked, it is his custom at the sitting given for the examination to record an engagement upon the appointment-book for the next examination, informing the patient that a notice of the engagement will be mailed a few days in advance of the time when it becomes due.

These engagements, it is pleasant to say, are usually kept with great punctuality and evident appreciation.

POSITION OF PATIENT AND OPERATOR.

In examinations of the oral cavity good light is a *sine qua non.* An examination conducted with inadequate light is of little value, and a diagnosis made under such conditions would be unreliable.

The *patient* should therefore be seated in a suitable chair provided with a head-rest capable of being raised and lowered and moved backward and forward. The head of the patient should be so positioned that when the mouth is opened the light will fall directly within it.

The *operator* should stand upon the right of the patient, with his feet firmly planted, the body erect, and the shoulders thrown back. The chair should be so elevated that the operator can maintain this position during examinations, and as far as possible in all operations. The stooping position so often assumed by many operators is not conducive to full and regular breathing, and sooner or later will result in stooping shoulders, contracted chest, and pulmonary complaints.

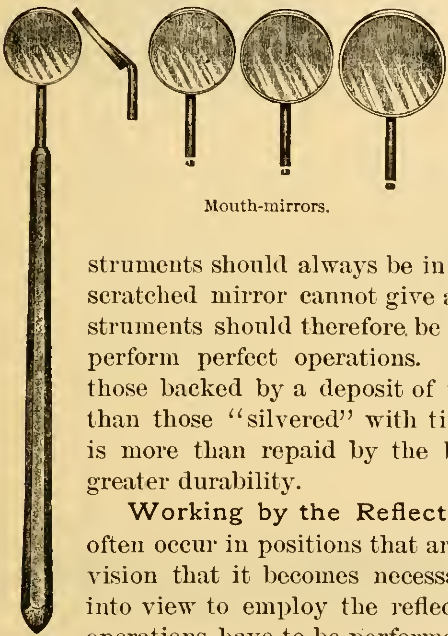
The operator should always be careful to breathe through the nose. Habits which produce a bad breath should never be indulged in. The contact of the operator with the patient should be at as few points as possible. People of refinement and culture appreciate the efforts of the dentist to guard them against any unnecessary contact of person. The dental chairs as made to-day are capable of such changes that the position of the patient can be suited to any requirement, so that the only contact that is necessary to *support* and *guard* the hands of the operator is that of resting the ends of the ring and fourth fingers upon some portion of the patient's face, while the fingers of the left hand control and guard the lips.

INSTRUMENTS USED IN EXAMINATIONS.

The instruments and appliances which are necessary to a thorough examination of every portion of the crown of each individual tooth are of several kinds,—viz., mirrors, magnifying-glasses, explorers, electric mouth-lamp, floss-silk, separators, and wedges.

Mirrors.—Plane and concave mirrors are both necessary in a critical examination of the tissues and organs of the oral cavity. The plane mirror gives the best and sharpest image, and is therefore the most important means of obtaining a view of the defects upon those surfaces of the teeth which are not in a direct line of vision.

Fig. 261.



Mouth-mirrors.

The concave mirror gives an enlarged but less distinct image; its greatest value lies in its power of concentrating the rays of light and illuminating the obscure portions of the mouth. These instruments should always be in the very best condition. A dull or scratched mirror cannot give a clear and distinct image; such instruments should therefore be discarded if the operator desires to perform perfect operations. The most satisfactory mirrors are those backed by a deposit of pure silver; they cost a little more than those "silvered" with tin and mercury, but the added cost is more than repaid by the brilliancy of the surface and their greater durability.

Working by the Reflected Image.—Defects in the teeth so often occur in positions that are entirely out of the range of direct vision that it becomes necessary in order to bring such defects into view to employ the reflecting surface of the mirror. Many operations have to be performed upon the teeth in which the only view of the field of operation is obtained from the reflected image in the mouth-mirror.

The novice will at first find such operations exceedingly difficult from the fact that the image is reversed, and that each movement must be made in a direction opposite to that which appears to be correct. Continued practice, however, eventually overcomes these difficulties, and the operator is able to pass from a *direct* movement to a *reverse* one with apparently no effort of the will. It requires years of practice, however, and a high order of skill to make perfect operations under such circumstances.

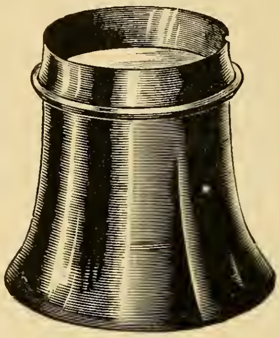
Magnifying Lenses.—These instruments are of very great value in detecting minute defects in the structure of the enamel, for observing the condition of fillings previously made, or the progress of an operation, and in the examination of the finished filling.

The most useful lenses are those which give a magnifying power of about four diameters. They may be either the watchmaker's glass (Figs. 262 and 263), held in position before the eye by the muscles surrounding the orbit, or the lens mounted with a long handle, as shown in Fig. 264.

Fig. 262.

Pointed eye-glass.

Fig. 263.

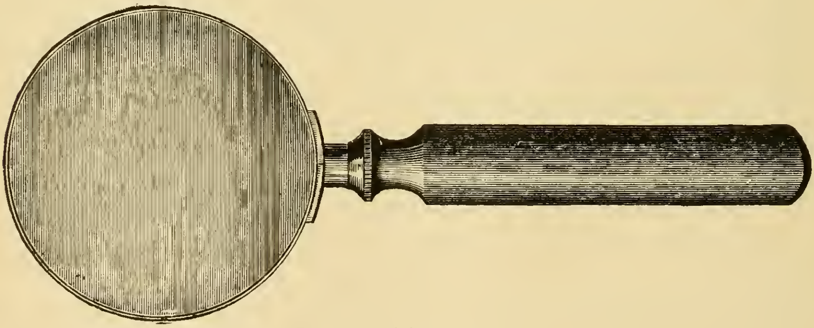


Eye-glass.

Such aids to the critical examination of the teeth are indispensable to the careful operator.

The magnifying lens may be employed in two ways, either to directly magnify the parts which are in the direct line of vision, or by magnifying the image obtained of obscure parts by reflection upon the surface of the plane mirror. The enlarged image obtained in this manner is more sharply defined than that obtained by the concave mirror. The clouding of the mirrors and lenses may be obviated by coating the surfaces with pure glycerol.

Fig. 264.



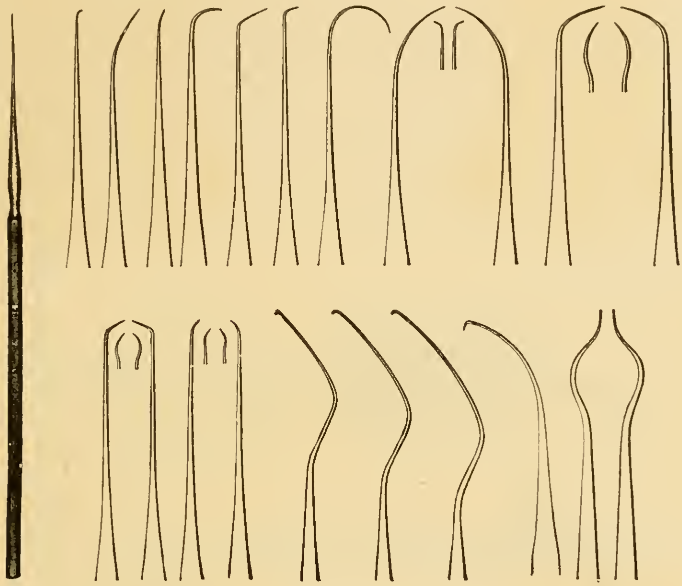
Magnifying lens.

Explorers.—These instruments are absolutely necessary for the detection of surface defects in the enamel and at the margins of fillings. They are "essentially prolongations of the fingers, and convey impressions by their vibrations to the tactile nerves." (Jack.) They are principally used to search out defects in the sulci, fissures and grooves formed by the union of the developmental lobes of the enamel, and to explore those surfaces which cannot be brought into view either by direct or reflected light.

Several different forms are necessary to reach all parts of the crown of the tooth, some straight, others of various curves or angles. Fig. 265 represents some of the common forms. These may be made by the practitioner himself, or he can obtain them from the supply houses.

No. 18 (American gauge) piano wire is the most suitable material from which to construct the points. The temper of this steel wire permits it to

Fig. 265.

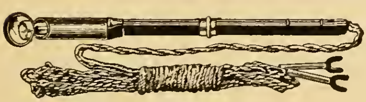


Explorers.

be bent into any desired shape necessary for this purpose, and is not so hard but that it can be filed to any degree of fineness compatible with the required strength and rigidity of such an instrument. These points may be mounted in wood or metal handles, to suit the taste and ideas of the operator.

Electric Mouth-Lamp.—The electric mouth-lamp, or *stomatoscope* (Fig. 266), is a great aid in the detection of defects upon the proximal surfaces of the teeth. The lamp should be placed within the mouth, at the lingual surfaces of the teeth, and the current switched on. The light passing through the teeth renders them in a measure translucent, and defects upon their surfaces or fillings appear as dark shadows. Transillumination is also a valuable means of detecting the non-vitality of the pulp. Devitalized teeth do not transmit the light as readily as those having vital pulps. This is quite easily demonstrated with the electric stomatoscope, even in obscure cases.

Fig. 266.



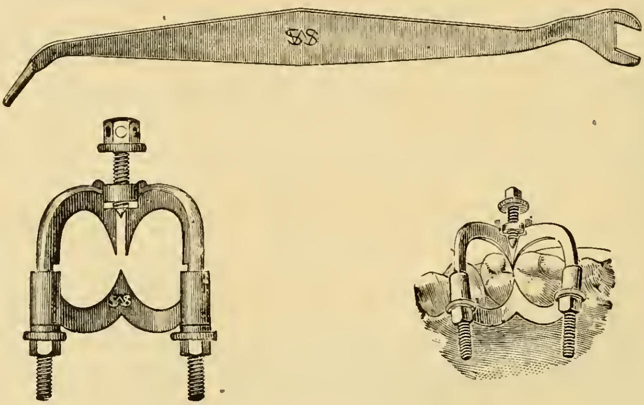
Electric mouth-lamp (reduced).

In detecting diseases of the antrum it is indispensable.

To obtain the best results by transillumination a dark room is necessary, especially for examinations of the antrum. Fluid or solid material (tumors of various structure) within the antrum obstruct the transmission of light and produce an opacity which can be detected by comparison with the normal opposite side and with the surrounding tissues.

Floss-Silk.—Floss-silk which has been just sufficiently waxed to bind the fibres together is a very valuable adjunct to the explorer in the detection of proximal surface defects of the enamel and in determining the condition of fillings. In a normally arranged denture, and in a crowded condition of the teeth, the finest explorers will not reach the approximating surfaces; the floss-silk then becomes indispensable as an added means of detecting superficial lesions of the enamel, which is indicated by the character of the friction produced by moving it back and forth upon these surfaces, or by the fraying of its fibres. Very slight defects, however, will sometimes remain undetected; consequently implicit reliance must not be placed upon its negative evidence, and other means, when doubt exists, must be used to establish the conditions of these surfaces beyond peradventure.

Fig. 267.



Parr's universal separator.

Separators and Wedges.—Separation of the teeth for the purposes of examination or in preparation for filling may be accomplished in several ways. Immediate separation may be obtained by the use of the Parr, Perry, or other screw or wedge separators (Figs. 267, 268), or by driving a wooden wedge between the teeth, or it may be accomplished more slowly by the use of waxed linen tape or india-rubber strips forced between them.

THE EXAMINATION.

A critical examination of the oral cavity should usually be preceded by a thorough cleansing and polishing of the teeth, as few mouths are so scrupulously clean that this procedure will not make the after-examination more sure and thorough.

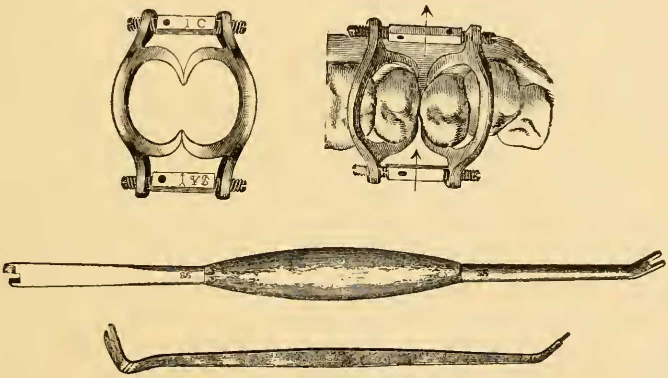
Certain parts of the teeth are more liable to be attacked by caries than others; these are in locations which give ready lodgement and retention to food *débris* and sedimentary deposits, and in which fluids are retained or suspended by capillary attraction.—viz., the *proximal surfaces*, the *sulci* and *fissures*, and the *labial* and *buccal surfaces;* the relative liability to caries being in the order named.

In conducting an examination of the mouth it is best to proceed in an orderly manner, that no part may be overlooked, and that every part should receive due attention.

First. Notice the appearance of the patient as to the state of health.

Secondly. A general view should be taken of the whole oral cavity, including the gums, the mucous membrane of the cheeks, lips, palate, and fauces; the tongue and the character of the oral secretions, and any deviation from the normal carefully noted, as these all have a more or less direct bearing upon the hygienic condition of the teeth. They are also indicative of various constitutional states and tendencies that influence the course and character of the dental diseases, the consideration of which

Fig. 268.



Perry's two-bar separators.

should enter largely into the question which must always be decided, as to whether the best interests of the patient will be conserved by the introduction of temporary or permanent fillings.

Thirdly. Beginning at the median line of each denture, a critical inspection of every portion of each tooth should be instituted by the aid of the various appliances just described, and each defect carefully noted. Particular attention should be given to those locations in which caries is most liable to be developed. The condition of all previous operations should be ascertained, and if imperfections exist they should be recorded, as should also the presence of salivary calculus, exposed pulps, devitalized teeth, pyorrhœa alveolaris, dento-alveolar abscess, the location of supernumerary teeth, irregularities, and teeth which have been lost.

For the purpose of preserving the results of these examinations various forms of charts have been devised, with special signs adapted to simplify the work of making the record, any one of which will adequately serve the purpose. The operator can, however, use any of the diagrams which are found in the dental registers, inventing or adopting such signs as seem best to him as a means of making a rapid, expressive, and reliable record.

These temporary records should be preserved until the required operations and treatment have been completed, and the record of each transferred to the permanent register.

The careful registration of all operations of whatever character cannot be too strongly urged upon the student and young practitioner, for as time goes on they become invaluable as a means of reference.

No one can remember the exact condition of each and every denture upon which he has been called to operate in the past, nor the circumstances or difficulties which surrounded the performance of a certain operation, the condition of the pulp, or of the root-canals, etc., but many times such information would be of incalculable benefit to the patient and operator in the future treatment of the case.

CHAPTER VII.

DENTAL CARIES.

Definition.—Caries (Latin, *caries*, rotten).

Synonymes.—Caries dentes; Caries dentium; Dental decay; Dental gangrene.

DENTAL caries may be defined pathologically as a progressive molecular disintegration of the structural elements of the tooth, beginning with the solution of the inorganic substances by the action of lactic acid formed within the mouth by fermentation, and terminating with the dissolution of the organic matrix through the solvent action of the saprophytic micro-organisms.

Magitot defined dental caries from its clinical aspects as "a progressive softening and continuous destruction of the hard structures of the teeth, advancing constantly from the exterior to the interior, and causing a gradual disappearance of a more or less extensive portion, or even the whole of the organ."

Introduction.—Dental caries is, without doubt, the most common of all the diseases to which the human body is heir, and from which very few persons among civilized nations entirely escape. It seems to be pre-eminently a disease of higher civilization, as it is most common among those nations which are recognized as having the highest civilization, and yet no race or tribe of men yet discovered, whether savage, barbarous, semi-civilized or civilized, ancient or modern, have ever wholly escaped it. Archæology, history, and anthropology all prove the correctness of the statement. Evidences are not lacking that the prehistoric man suffered from dental caries, alveolar abscesses, and other dental diseases. Many of the Egyptian mummies found in our great museums show well-marked evidences of caries and other diseases of the teeth.

Herodotus tells us that the Egyptians had doctors for the eyes, doctors for the ears, and doctors for the teeth, etc., showing that they had need of specialists in these directions. Lancets and forceps for the extraction of teeth are to be found in museum collections of Egyptian antiquities. Artificial teeth have been found in the mouths of mummies, and statements have been made, though not very well authenticated, that gold fillings had likewise been discovered in the teeth. They evidently possessed some knowledge of dental therapeutics, for they applied the juice of the poppy, pepper, spices, etc., to relieve the pain of toothache, and in the later stages of this disease and in the early stage of alveolar abscess applied the actual cautery and counter-irritation. One mummy in the British Museum, dating back to a period about 2800 B.C., or more than four thousand five hundred years, shows undisputed evidence of dental caries and other dental lesions.

That dental caries and the lesions which result therefrom were common among the Greeks in the earlier and later periods of their history there is abundant proof. The early Greek physician gave considerable attention to the diseases of the teeth. During the latter part of the Greek epoch the fop or dude gave great attention to the care of his teeth, and was very proud of having them look fine and white. His more stalwart brethren ignored such attention to their personal appearance, considering it effeminate and only suited to women and fools. Their physicians treated odontalgia after the manner of the Egyptians. Cicero credits the third Æsculapius with inventing an instrument for extracting the teeth. Diocles opposed extraction and treated toothache by medication. Strabo mentions formulæ for the relief of odontalgia and cosmetics for the care of the teeth. Dr. Schliemann, the great Greek archæologist, has reported that in his excavations at the site of ancient Troy several of the crania found there exhibited teeth with carious cavities, some of which had been filled with metals, lead particularly.

Coming next to the old Roman civilization, the historical proof is abundant that dental caries and other dental diseases must have been common among them, and that they practised the art of filling carious teeth and of inserting artificial teeth carved from bone and ivory.

Celsus gives formulæ for the treatment of toothache resulting from caries. These were compounded from resinous and aromatic substances combined with the juice of the poppy, saffron, sulphur, etc., and were to be applied to the carious cavity in the painful tooth. He also advised the use of blisters and poultices for the cure of alveolar abscess, and insisted upon general medication in conjunction with the local treatment. Celsus has been given the credit of inventing the art of filling teeth with gold and other substances 150 to 180 A.D. Archæologic proof of the fact, however, that the art of filling teeth was practised by the ancient Romans is entirely lacking. Whether this is due to the quite general custom of burning the dead, and thus destroying the evidence, or that it had no real foundation in fact, is a question that may never be settled.

RESULTS OF THE EXAMINATION OF ANCIENT CRANIA.

Mummery has examined and tabulated a very large number of ancient crania in relation to the prevalence of dental caries with the following results: Ancient Britons of dolichocephalic type, 2.94 per cent.; of brachycephalic type, 21.87 per cent.; Romano-Britons, 28.67 per cent.; Anglo-Saxons, 15.78 per cent.; ancient Egyptians, 41.66 per cent. It will thus be seen that the prevalence of caries bears a very close relationship to the degree of civilization and the luxurious habits indulged in by these ancient nations.

Professor Broca examined a large number of crania of the ancient peoples of Europe, and discovered that caries of the teeth was much less frequent than at the present time, and that they were also very much worn down from attrition.

Dr. Patrick instituted an examination of all the prehistoric crania to be found in the various important museums in America, composing Peabody Museum of Harvard University, the Army Medical Museum, Washington, D. C., the collection of Dr. Samuel G. Morton in the Academy of Natural Sciences, Philadelphia, the collection in the Davenport Academy of Science, Iowa, the collection in the Museum of the Chicago Medical College, Illinois, and a collection obtained from an ancient burial mound near the great Cohokia Temple Mound in St. Clair County, Illinois, now in the Museum of the Missouri Historical Society at St. Louis.

These examinations cover a wide range of subjects, including every evidence of the diseases and anomalies of the teeth and jaws, and form a wonderful mine of information, the importance of which can hardly be over-estimated, "for there is not a question that may arise in morphology, histology, or physiology on which the facts revealed in this investigation will not shed some light." (Patrick.)

The crania examined included South Americans, Central Americans, North Americans, Europeans, Pacific and Sandwich Islanders, Egyptians, and Asiatics. Dental caries was found to be prevalent in all, but in a varying percentage, which seemingly is governed by the habits of life and the state of civilization.

The *South Americans* included Peruvians, Chilians, Tierra del Fuegians, and Guanches. In this group 6719 teeth were examined; 2462 were diseased, or 36.75 per cent. Number of carious teeth, 390, or 5.804 per cent.

The *Central Americans* were composed of Mexicans, Guatemalans, and Nicaraguans. The teeth examined numbered 930, and of this number 250 were diseased, or 26.8 per cent. Caries was present in 44, or 4.872 per cent.

The *North Americans* included Esquimaux, Alaskans, and various tribes from nearly every section of the United States. In this very large group 27,362 teeth were examined: 3811 showed evidences of disease, or 21.4 per cent. Of this number, 1394 were carious, or 5.093 per cent.

The *Europeans* included Germans, French, English, Swedes, Irish, Greeks, Italians, Anglo-Americans, and a few modern soldiers. The number of teeth examined was 3422. Of this number, 1373 were found to be diseased, or 40.4 per cent. The number of carious teeth was 242, or 7.079 per cent.

The *Pacific Islanders* included Sandwich Islanders, Australians, New Zealanders, and Tchoolabees. In this group 2738 teeth were examined, and 417 were found diseased, or 15.25 per cent.; 118 showed caries, or 4.309 per cent.

The *Egyptians* included Africans. The number of teeth examined was 3306; of these, 689 were found diseased, or 20.8 per cent. Of this number, 113 were carious, or 3.418 per cent.

The *Asiatics* included Malays, Chinese, Japanese, Armenians, Hindoos, and Burmese. In this group 2180 teeth were examined, and 336 showed evidences of disease, or 15.4 per cent. Number of carious teeth, 45, or 2.064 per cent.

Miller maintains that in the meat-eating races caries is far less prevalent than in those which subsist largely upon mixed foods, and presents as evidence the fact that the dolichocephalic ancient Britons, who subsisted in all probability almost exclusively upon a meat diet, presented in the crania examined only about three per cent. of dental caries, while in the brachycephalic ancient Briton, Romano-Briton, Anglo-Saxon, and Egyptian, all of whom subsisted upon a mixed diet, the percentage of caries ranged from fifteen to forty-one per cent. Among the modern aboriginal flesh-eating races he cites the Esquimaux, North American (coast) Indians, North American (interior) Indians, South Americans, Feejee Islanders, New Zealanders, and Lapps. These have all a low percentage of dental caries. The Esquimaux, who live almost exclusively upon meat and fish, have but 2.46 per cent. of caries, while the North American (interior) Indians, whose diet is mostly meat, but using some vegetables, have an average of 9.09 per cent, this being the highest percentage in this group of aboriginal meat-eating races.

Magitot could find in the anthropologic series of the museums of Paris no examples of dental caries among the crania of the Mexicans, Peruvians, or Patagonians, none among the aborigines of Australia, Madagascar, New Caledonia, etc., nor among the Malay and Javanese crania of Professor Wrolik. He also states that the African and Arab races are remarkable for the soundness of their teeth, the Caucasian race being the opposite of this, while the Mongolian race seems to hold a middle position. The Icelanders, according to recent investigations, seem to be nearly exempt from the disease.

The investigations of Barrett, conducted for the same purpose, also lead to the same conclusions.

Prevalence.—Statistics upon the prevalence of dental caries among the nations of the present civilization are by no means numerous, and nearly all of those which have been taken deal more with the question of the frequency of caries in individual teeth and groups of teeth than with the subject of the percentage of people who are sufferers from the disease. That the percentage is very large and apparently upon the increase there is not the shadow of a doubt in the minds of those best qualified to judge, and yet without statistics carefully prepared from many sources, at stated periods and under varying conditions of life, any statement that might be made must be taken as one of personal opinion only.

It is generally conceded, however, that females are distinctly more liable to dental caries than are males.

Magitot expressed the relative frequency of caries in the female by the ratio of three to two as compared with the male. Harris places the ratio much higher, claiming that it occurs in the female three times as often as it does in the male. Married women are considerably more liable to the disease than the unmarried, as the period of pregnancy and lactation are especially favorable to the development and progress of the disease.

In reference to the relative frequency of caries among the men of France who were subject to military duty, Magitot introduces the statistics of the war office. These statistics deal only with young men of twenty years of age, but they may be fairly considered as showing the regular percentage of badly defective dentures for the whole mass of the adult male population.

The French law gave exemption from military service, *first*, when there was loss or caries of the incisors or canines of one of the jaws, and *secondly*, when there was loss or caries or a bad condition of the majority or of a large number of the other teeth.

The exemptions from military service from 1837 to 1849, inclusive,—thirteen years,—by reason of imperfect dentures, was 25,918 out of 3,295,202, which is equivalent to an annual average of 785 in every 100,000 examined. The annual maximum was 895 in 1837; the minimum, 643 in 1847, or an average percentage of 7.85. If there be added to this the increased percentage of caries in females, using Magitot's figures of a ratio of three to two, and taking an equal number of males and females, the percentage for the entire population would be 9.15. This, however, does not fairly represent the average percentage of persons afflicted with caries; in fact, it falls far short of the actual condition, as all of those who were received were not free from dental defects, but simply were not sufficiently defective under the law to give exemption.

Statistics which more clearly represent the true condition of the prevalence of dental caries among civilized nations is to be found in the report of the School Committee of the British Dental Association (Tomes), following the examination of the mouths of 3368 boys and girls at the Hanwell and Sutton schools, and at the Exmouth training ship. Out of this number only twenty-three per cent. had sound dentures, or, in other words, seventy-seven per cent. were afflicted with caries. The number of permanent teeth found to be carious was 4543, while about an equal number of temporary teeth were found in the same condition. These boys and girls ranged from three and a half to seventeen years of age, but the majority were from five to fourteen.

The number of boys upon the Exmouth training ship was 480, largely recruited from these schools, the average age being fourteen years; twenty-four per cent. had perfect dentures, or, seventy-six per cent. had carious teeth; 44.9 per cent. had from one to four carious permanent teeth, 22.9 per cent. had from five to eight, and 5.25 per cent. had more than eight carious permanent teeth. At the Hanwell schools, out of 903 children examined at the age of eight years, 83 furnished 127 carious permanent teeth, all first molars; at the age of twelve years 90 children had 244 carious permanent teeth; the percentage of unsound permanent teeth in this number of children at the age of six is 53, at the age of twelve, 271, and at the age of fourteen, 300.

The Association Committee made an attempt to compare the condition of the teeth of the children in the *poor* and *high-class* schools, but the numbers in the latter were not sufficiently numerous to give conclusive results, as only 205 children of this class were examined, and these did not compare favorably with those less fortunately placed.

Another interesting fact in reference to the prevalence of caries is the wide difference existing in the relative frequency of the disease in the upper and the lower jaw, and between individual classes and groups of teeth.

The differences between the right and left sides are so small as to be of no particular moment; hence in the following tables this difference will only be noted in the footings.

Ottofy computed from an examination of 14,644 teeth of American public-school children that caries was present in 27.33 per cent. in males and 32.67 per cent. in females.

The teeth examined comprised 5100 deciduous and 9544 permanent teeth.

Of the 5100 deciduous teeth examined the following percentage were found carious:

Lower central incisors	0.03
Lower lateral incisors	0.09
Upper central incisors	1.32
Upper lateral incisors	1.42
Lower cuspids	1.99
Upper cuspids	2.78
Lower first molars	6.52
Upper first molars	6.72
Lower second molars	7.80
Upper second molars	9.77

Of the 9544 permanent teeth examined the following percentage were found carious:

Lower cuspids	0.01
Lower lateral incisors	0.04
Lower central incisors	0.05
Upper cuspids	0.05
Lower first bicuspids	0.10
Upper second bicuspids	0.28
Lower second bicuspids	0.30
Upper first bicuspids	0.38
Upper lateral incisors	0.55
Upper central incisors	0.85
Upper second molars	1.25
Lower second molars	1.57
Upper first molars	7.20
Lower first molars	7.70

This table gives a better showing for the American public-school children than that furnished by the committee of the British Dental Association of the condition of the teeth of the children found in the Hanwell and Sutton schools. This difference is explained by the fact that the children in the Hanwell and Sutton schools were from the poorest class of English society, while the American public schools are patronized by all classes of society.

The Schleswig-Holstein Dental Association, in a recent investigation* into the prevalence of dental caries among school-children in Northern Germany, conducted by Dr. Greve, of Lubeck, presents an extended report upon the subject, of which the following table is a summary:

* Cor. Blatt. für Zahn, July, 1899.

Age.	Number Examined.	Perfect Teeth.		Carious Teeth.	
		Number.	*Per cent.*	*Number.*	*Per cent.*
Six to eight years	6060	407	6.8	5653	93.2
Nine to ten years	4990	268	3.4	4732	96.5
Ten to twelve years	3518	149	4.3	3369	95.7
Twelve to fifteen years	5157	172	5.5	4985	94.5

Of the 19,725 children examined, ninety-five per cent. showed dental caries.

It was also noted that there were 372 anomalies of various characters, including harelip, cleft palate, irregularities, V-shaped jaws, and, singular as it may seem, only one case of congenital syphilis was found.

The investigation covered the children of nineteen towns.

The boys were found to have somewhat better teeth than the girls, the difference being about three per cent. in favor of the boys.

Magitot places the relative frequency of caries in the upper and lower jaw respectively in the proportion of three to two.

This author presented the following analysis of ten thousand cases, from which the above conclusion is drawn :

Central incisors	642	612 upper. 30 lower.
Lateral incisors	777	747 upper. 30 lower.
Canines	515	445 upper. 70 lower.
First bicuspids	1,310	940 upper. 370 lower.
Second bicuspids	1,310	810 upper. 500 lower.
First molars	3,350	1,540 upper. 1,810 lower.
Second molars	1,736	690 upper. 1,046 lower.
Third molars	360	220 upper. 140 lower.
Total	10,000	10,000

Upper	6,004	10,000	Right side	4,791	10,000
Lower	3,996		Left side	5,209	

Hitchcock, in Wedl's "Pathology of the Teeth," presents the following table of twenty thousand cases prepared from records of fillings and extractions in which the ratio of frequency of caries in the upper teeth is placed at 1.9 to 1 in the lower, or nearly two to one :

Central incisors	2,189	2,101 upper. 88 lower.
Lateral incisors	1,954	1,827 upper. 127 lower.
Canines	1,261	1,058 upper. 203 lower.
First bicuspids	2,073	1,588 upper. 485 lower.

Second bicuspids	2,585	1,715 upper. 870 lower.
First molars	4,399	2,273 upper. 2,126 lower.
Second molars	3,615	1,675 upper. 1,940 lower.
Third molars	1,924	899 upper. 1,025 lower
Total	20,000	20,000

Upper	13,136	20,000	Right side	10,151	20,000
Lower	6,864		Left side	9,849	

Tomes presents a table of 2638 cases of extractions on account of caries or its consequences, as follows:

Central incisors	25
Lateral incisors	62
Canines	36
First bicuspids	227
Second bicuspids	393
First molars	1090
Second molars	575
Third molars	230
Total	2638

A table prepared by Pare and Wallis from the records of 30,012 cases of extractions at Guy's Hospital gives the following results in percentage:

First molars	10,891, or 36.30 per cent.
Second molars	5,904, or 19.68 per cent.
Second bicuspids	4,179, or 13.93 per cent.
First bicuspids	3,212, or 10.70 per cent.
Third molars	2,639, or 8.76 per cent.
Lateral incisors	1,202, or 4.00 per cent.
Canines	1,098, or 3.66 per cent.
Central incisors	884, or 2.94 per cent.

Separating the upper from the lower teeth in this table of cases, Pare and Wallis have given us the following percentage for the individual teeth:

Lower first molars	5632, or 18.7 per cent.
Upper first molars	5259, or 17.4 per cent.
Lower second molars	3489, or 11.62 per cent.
Upper second bicuspids	2503, or 8.33 per cent.
Upper second molars	2415, or 8.04 per cent.
Upper first bicuspids	2288, or 7.623 per cent.
Lower second bicuspids	1676, or 5.58 per cent.
Lower third molars	1322, or 4.4 per cent.
Upper third molars	1317, or 4.38 per cent.
Upper lateral incisors	1013, or 3.37 per cent.
Lower first bicuspids	924, or 3.07 per cent.
Upper canines	861, or 2.86 per cent.
Upper central incisors	754, or 2.51 per cent.
Lower canines	237, or 0.78 per cent.
Lower lateral incisors	189, or 0.62 per cent.
Lower central incisors	133, or 0.443 per cent.

The following table of dental caries of individual teeth is compiled from the Surgeon General's Reports, U. S. Army, for the years 1901, 1902, and 1903, which shows that during these years 70,256 teeth were treated by the dental surgeons by filling or extraction. This is the largest number of cases upon which the relative liability of the individual teeth to dental caries has ever been computed, and for that reason would seem to be most reliable. On the other hand, however, it should be remembered that the men composing the U. S. Army have been selected for service by reason of their comparative physical perfection, and therefore these statistics would represent the liability to dental caries in the individual teeth of persons who were otherwise in the most perfect state of health when they entered the service :

	No.	Percentage.
Central incisors, upper, right side	3115	4.43
" " " left side	3022	4.30
" " lower, right side	273	.38
" " " left side	297	.42
Lateral incisors, upper, right side	2422	3.44
" " " left side	2583	3.67
" " lower, right side	338	.98
" " " left side	340	.48
Cuspids, upper, right side	1171	1.66
" " left side	1269	1.80
" lower, right side	449	.63
" " left side	392	.55
Bicuspids, first, upper, right side	2787	3.96
" " " left side	2755	3.92
" " lower, right side	815	1.16
" " " left side	704	1.00
" second, upper, right side	3010	4.28
" " " left side	2984	4.24
" " lower, right side	1630	2.32
" " " left side	1586	2.25
Molars, first, upper, right side	4960	7.06
" " " left side	4821	6.86
" " lower, right side	4366	6.21
" " " left side	4235	6.02
" second, upper, right side	3269	4.65
" " " left side	3412	4.85
" " lower, right side	3868	5.50
" " " left side	4168	5.93
" third, upper, right side	1065	1.51
" " " left side	1059	1.50
" " lower, right side	1462	2.80
" " " left side	1632	2.32
Total	70,259	

	No.			Percentage.
Upper	43,704	= 70,259	Upper	62.20
Lower	26,555		Lower	37.80
Right side	35,000	= 70,259	Right side	49.81
Left side	35,259		Left side	50.19

In the later table it will be noticed the permanent first molars are most susceptible to those influences which produce decay, and that the lower molars are slightly less susceptible (12.23 per cent.) than the upper (13.92 per cent.), the difference being 1.69 per cent. The lower second molars stand next in susceptibility; these are followed by the upper second bicuspids and the upper second molars, and so on down the list until the lower canines, laterals, and centrals are reached, in which the percentage of decay is so small as to almost constitute immunity.

The agency which gives this protection or immunity is thought by some authorities to be the secretion of the submaxillary glands, by others the presence of fluid in the floor of the mouth, which is kept in constant motion by the movements of the tongue, and thus retarding the process of fermentation; but whatever it is, the protective effect is not efficacious in the posterior part of the mouth, and it will be noticed that the agency grows less and less efficacious from the incisors backward.

From the foregoing pages it will be readily seen that all of the investigations in reference to the prevalence of dental caries among ancient and modern races conclusively proves that the disease has always been present, at least as far back as evidence can be obtained from written history and archæologic research; that it was comparatively rare among aboriginal tribes and nations who *per force* lived a simple life; while among those ancient and modern races and nations who had attained to a high state of civilization, with its attendant luxuries and enervating habits, it has been very common, while at the present time, as proved by the statistics recently gathered, it is increasing in a most alarming manner.

ETIOLOGY.

The causes which are responsible for the universal prevalence of this disease are many and varied. These are divided into two general groups, —viz.:

Indirect or *predisposing*, and direct or *exciting causes.* The former deals with certain conditions which have been established beforehand, through inheritance of constitutional tendencies or special dyscrasia and local developmental defects or anomalies; while the latter treats of those phenomena which are the active agents in establishing and maintaining the progress of the disease.

Predisposing Causes.—The conditions which are here enumerated as predisposing causes of dental caries may be divided into two groups,—viz., *constitutional* and *local.*

The constitutional predisposing causes are:

Environment.

Climatic influences.

Miscegenation.

Excessive mental strain in growing children.

Hereditary influence.

Influence of inherited disease.

Exanthematous disease.

Continued fevers.

The local predisposing causes are:

Structural defects of the teeth.

Traumatic injuries.

Irregularities in the arrangement of the teeth.

Abnormal oral secretions.

These causes are all more or less important factors in the predisposition and susceptibility of the teeth to caries, by reason of their influence upon nutrition and vital resistance, or of their local surroundings or environment.

Upon a proper appreciation of the depressing influences of these constitutional conditions upon the function of nutrition and of vital resistance to disease, and the effort to correct or prevent these evil influences in the future, will depend in no small degree the perfection in structural development and the integrity of the teeth of the generations yet unborn.

CONSTITUTIONAL PREDISPOSING CAUSES.

Environment.—The term environment as here used is intended to include all those conditions of life which are the results of civilization,—viz., the physical, mental, and social conditions, and the food habit.

It has already been stated that dental caries is most prevalent among those races and nations which have attained to the highest degree of civilization, and there can be no doubt that a deterioration of the teeth is a constant accompaniment of the progress of civilization. Why civilization should produce such effects is not a very difficult question to answer. The civilization of a race or a nation is a gradual process, and one which affects both the intellectual and physical development. The evolution of a savage or barbarous race to the plane of a civilized people is the work of centuries. The whole trend of thought and of moral obligation and responsibility to others has to undergo a radical change. With these changes come higher aspirations, an enlargement of intellectuality, and a desire for more knowledge. Knowledge is only attained by study and intellectual pursuits, which of necessity greatly change the habits and mode of life. A savage, nomadic people, constantly warring with their neighbors, begin the process of evolution by forming confederations against a greater enemy; they next intermarry, and later, because their common interests demand it, settle in communities and establish permanent homes. As their intellectuality increases, the older and wiser ones teach the younger the value of greater knowledge than they themselves have possessed, as this would give them an advantage over their enemies. Finally some one of their number arises whom they look upon as having more wisdom than the rest, and he becomes a leader, and perhaps a teacher of the tribe. Their language is developed, and characters are invented by which to express the language in writing. Later, schools are formed, in which the more ambitious are taught in the knowledge possessed by the wise men. As a result, larger communities are formed, industries spring up, cities are builded, the confederated tribes become a nation, and a ruler is chosen. Contact with other nations broadens the intellectual horizon and increases the ambition of the people to be equal to their neighbors. These ambitions stimulate a desire for wealth, and riches result in the introduction of new and more luxurious habits of life and greater devotion to intellectual attainments and pursuits, as well as the capacity to enjoy them.

The nation has now reached the plane of civilization. With this evolution has come higher mental and nervous endowments and greater capacity to enjoy and to suffer; but this mental and nervous development has been very largely evolved at the expense of the physical system. The powers of physical endurance and of resistance to disease have been greatly lowered by the change in environment. War and the chase have given place to the counting-house and the shop; the tent and the "dug-out" are now represented by the cottage and the mansion; the simple diet of meat and a few vegetables, often uncooked, has been replaced by an endless variety of foods, containing large quantities of fermentable substances, and so prepared by the culinary art that the teeth and jaws get very little of the exercise which is so necessary to maintain them in a healthful condition; while the use of food containing large quantities of such fermentable substances as starch and sugar present the necessary elements from which the acids are formed which act upon the teeth, thus inducing dental caries and many other diseases as sequelæ.

Those nations of the present day which suffer most from dental caries are the Anglo-Saxons of America and Great Britain and the great European nations. The growth of modern dental science and the perfection of the art among these peoples has been a work of necessity, and one which from its surgical aspects has kept pace in its development with the demands which have been laid upon it.

But viewed from the more important aspect of *prophylaxis*, it has not yet attained nor kept pace with the ever-increasing needs in this direction. When one stops to consider how wide-spread and universal dental caries has become, and the increasing number of teeth that are destroyed by the disease every year, we are appalled by the problem, and wonder if the human race is not destined to become endentulous.

The teeth of the present generation seem to be inferior to those of their immediate ancestors, while the children of to-day have, as a rule, a greater predisposition to dental caries than their parents. In other words, there seems to be a gradual deterioration in the structural development—perfection of development—of the teeth, and a lowering of the resistive powers or the vital energy of the system against the encroachment of disease.

Perfection in the structural development of the teeth of city-bred children of the middle and better classes of society is the exception, defective teeth the rule. Little children between the age of three and six years are frequent sufferers from dental caries, odontalgia, and alveolar abscess, while very many have defective first molars which require attention as soon as they are erupted.

This is the age of steam and electricity, of the lightning express train and the ocean greyhound, of the electric telegraph and the telephone.

Men, and women too, have seemingly partaken of the energy and speed of these forces. It is an age of rush and of whirl. Men and women vie with each other and with their sex for place and power. In business and social life, in educational matters, in their pleasures and vices, they go at high-pressure speed, and as a result often break down at a period of life when under more favorable circumstances they would still be in their prime. These conditions are manifest everywhere in the civilized world, but are most noticeable in the great cities, where the intensity of the struggle of the poor for existence and of the well-to-do and the rich for supremacy over their fellows in business, social pleasures, education, and display are the greatest. Children born under such circumstances have generally constitutions which are far from equal to those inherited by their parents, and as a consequence they are handicapped in their struggle for existence either by the direct inheritance of disease, or of tendencies and predispositions to disease which are the result many times of the terrible deprivations of poverty, or of overwork or over-indulgence in the luxuries and the pleasures of life, or of the indiscretions or the vices of their parents or earlier progenitors.

Such an environment can only result in enervation, depression of vital forces, malnutrition, and defects in the mental, the nervous, and the physical development.

Climatic Influences.—The influences of climate as a predisposing cause of caries in these days of immigration, colonization, and international trade has come to be an important factor, and it should receive that recognition from the scientific men of the profession which its importance deserves.

It has often been remarked, especially in India and other tropical climates, that the white man was physically often very profoundly affected by the radical changes in the climate and environments. This is particularly noticed in the increased susceptibility to disease and in a lowered vitality or resistive power, so that it has become a recognized fact that these people must, as a rule, return to their own country every seven to ten years in order to recuperate their lowered vitality and physical stamina. The depressing effects of the climate are so severe to some individuals that a residence of one or two years under its influences is sufficient to completely break their health.

It can therefore be readily understood how such depressing and enervating influences acting upon the general system may lead to malnutrition, loss of nervous energy, vitiation of the secretions, particularly of the oral cavity and the alimentary tract, and thus act as predisposing causes of dental caries. That the teeth of the average Briton who takes up his residence in India for a period of years decay more rapidly than they did when at home seems to be the general opinion among them. The same opinion prevails among the American missionaries who have spent a number of years in India and other tropical climates. These opinions have been substantiated by the experiences of the British troops in South Africa, and the United States troops in Cuba and the Philippine Islands.

The Report of the Surgeon General U. S. A. for 1903 shows that the percentage of dental diseases for troops who served in the United States was 42.85. For those serving in the Philippine Islands it was 61.12, or 18.27 per cent. higher than for the troops who served in the United States, while for those who served in Cuba and Porto Rico it was 64.02, or 21.17 per cent. higher than for those who served in the United States.

These statistics, however, do not show the actual conditions in relation to the prevalence of dental diseases, among the troops of the United States Army as a whole, for the reason that these figures are based upon the conditions presented of the officers and enlisted men only who applied for treatment.

The increased percentage of dental diseases among the troops who served in Cuba and Porto Rico over those serving in the Philippine Islands is due to the fact that these diseases are generally more prevalent among the *native* troops of Porto Rico than among the white troops. For the purpose of securing more exact data as to the condition of the teeth of the white troops who had served for two years or longer in the Philippine Islands, the writer instituted a careful and systematic examination, with the aid of two of his assistants, of two infantry regiments recently returned from the Islands with the following results: In the first regiment examined it was found that 89.17 per cent. of the enlisted men were in need of immediate dental treatment; while the examination of the second regiment revealed the fact that 97.25 per cent. of this command were in a like condition.

The statistics are as follows:

Total number of enlisted men in the first-mentioned regiment		738
Number absent from command for various reasons		27
Number of enlisted men examined		711
Number not needing dental treatment		77
Number needing dental treatment		634
Percentage of command needing treatment	89.17	

Classification of Diseases.

Whole number of teeth with dental caries	2280
Number of teeth so badly diseased as to require extraction	321
Number of teeth that can be saved with appropriate treatment	1959
Number of men needing immediate treatment for pulpitis and dento-alveolar abscess	277
Number of cases of salivary deposits	182
Number of cases of gingivitis	42
Number of cases of pyorrhea alveolaris	4
Number of cases needing artificial dentures	14

Total number of enlisted men in second-mentioned regiment		780
Number absent from command for various reasons		15
Total number of enlisted men examined		765
Number not needing dental treatment		21
Number needing dental treatment		744
Percentage of command needing treatment	97.25	

Classification of Diseases.

Whole number of teeth with dental caries	3565
Number of teeth so badly diseased as to require extraction	197
Number of teeth that can be saved by appropriate treatment	3221
Number of men needing immediate treatment for pulpitis and dento-alveolar abscess	97
Number of cases of salivary deposits	196
Number of cases of gingivitis	60
Number of cases of pyorrhea alveolaris	10
Number of cases needing artificial dentures	18

Of the number in both regiments who did not need dental treatment, several had been fortunate enough to receive treatment by the army dental surgeons just before sailing for the United States. The conditions as found in these two regiments, it is believed, is a fair sample of the conditions to be found in all United States troops who have served in the tropics for two or more years.

It is a notable fact that in this country, which receives every year large additions to its population from foreign nations, principally from Europe, these people, after a few years of residence, often suffer greatly from the ravages of dental caries. This the writer has observed to be the case more particularly among the Irish and Scandinavians. This tendency has been ascribed to various causes; some authorities have maintained that it was due as much to a change in the food and social surroundings as to climatic influences.

Wedl, in writing upon this point, says, "If it be true that geologic and climatic conditions, and the means of subsistence which are connected with the same, have such a preponderating influence in respect to the frequency of caries, then it is impossible to explain the fact that foreigners belonging to different races, who are exposed to the same conditions as the native inhabitants, still retain the typical structure of their teeth, as well as that of their bodies, and continue to furnish the proportion of dental caries peculiar to their race. This is found to be the case with the isolated Slavonic races of Austria and the descendants of the Celtic race in France."

To this remark Hitchcock appends the following: "As geologic, climatic, and social conditions exercise a predominant influence upon the growth and development of the various races, mentally as well as physically, it is evident that the development of the dental organs cannot fail to be controlled by the same causes. In this country, which is annually receiving large numbers of foreigners by immigration, the typical traces of race are usually effaced after the lapse of a generation or two, the descendants possessing all the peculiarities, and their teeth apparently being as liable to caries as the teeth of Americans generally."

The personal observation of the writer leads him to the opinion that the children of immigrants born in this country are not, as a rule, as robust as their parents, and that they suffer more from dental diseases.

Miscegenation.—The intermarriage of individuals representing distinct nations and races has come to be a very common occurrence all over the civilized world. The railway trains, the steamships, the telegraph, and the submarine cable have broken down the barriers that once existed between nations, and have stimulated the individual to seek knowledge, wealth, and home in other climates than his own, while the enlightenment which has followed in the path of these great inventions has swept away in large measure the religious and race prejudice which beforetime had prevented such alliances; as a result, the human family is entering upon a course which is destined sooner or later to bring about an amalgamation of those contiguous nations and races which belong to the higher class of civilization.

The crossing of distinct races, like the Anglo-Saxon and the negro, or the Mongolian and the Malay, produces a progeny which is in no way the equal, physically, of either of the races from which they sprang. The difference is principally noticed in a lowered state of vital resistance to disease and in the powers of endurance under physical strain.

Miscegenation exercises a depressing influence upon the integrity of all of the structures of the body, tooth-structures included. The crossing of races and nations is not generally productive of benefit, especially when so widely separated as are those of the human species. "Human hybrids are notably deficient in physical completeness and vital power, nutrition is more or less impaired, and the physiologic processes are weakened, so that the entire economy is depressed and abnormal." (Thompson.)

These facts were so generally recognized in this country during the days of slavery, that the slave-dealer never made the mistake of buying mulattoes to fill an order for slaves to work in the rice-fields and sugar plantations of the far South, as these people did not possess the two great prerequisites for this kind of labor,—viz., resistance to disease and superior powers of physical endurance.

The mulattoes on this account were generally employed as house servants, while the blacks were in demand as field-hands, because they possessed in a much greater degree the necessary qualifications for hard labor and resistance to those diseases which are so common in the lowlands of the South.

The half-breeds of the Malay Archipelago and the Eurasians of India are also examples of the degenerating physical effects of miscegenation.

The effects of the amalgamation of nations is particularly seen in the American people, who are receiving a continuous stream of foreign and heterogeneous blood into their veins. "The depression that has ensued to the physique of the people of the United States as a natural result of these intermarriages may have contributed somewhat to the existing extra defectiveness of the teeth of Americans over those of nations who have been less subject to the effects of miscegenation." (Thompson.)

Excessive Mental Strain in the Growing Child.—Excessive mental strain coming at that period in the history of the child when the developmental changes are most active and when the nervous system is in a very exalted state and responds most acutely to all forms of stimulation and depression, is often productive of conditions which lower the general tone of the system and disturb the functions of digestion, assimilation, and nutrition, and thus lay the foundation for a train of physical ailments from which the child may never fully recover, while the nerve-centres may be so impressed as to produce nervous prostration, chorea, epilepsy, paralysis, and kindred complaints. This lowering of the general tone of the system, the disturbance to the nutritive functions, and the nervous phenomena which may develop as a result of mental strain in growing children play an important part in the greater predisposition to dental caries so generally noticed at this period of life, by producing developmental defects in the structures of the teeth, vitiated oral secretions, and rendering the child less able to successfully cope with disease-producing germs.

The tendency of the age is to force children in their school work to the limit of what they are mentally and physically able to endure. This system applied to ambitious children often operates to their disadvantage, as they are inclined to go beyond their strength, and sooner or later the health is undermined, the teeth break down from caries, and, unless the strain is removed and the child given a complete rest, change of air, and surroundings, physical and nervous prostration are the result.

The author has often found it necessary to advise parents and guardians to remove a child from school to save the health from being wrecked. In many of these cases the rapid decay of the teeth was the prominent symptom which attracted his attention and led to an investigation of the general health and surroundings of the child.

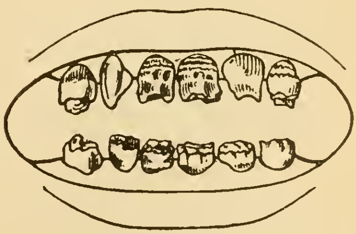
Hereditary Influence.—Inherited tendencies or predisposition to caries of the teeth is often well marked in certain families. This predisposition is doubtless established by the transmission of some abnormality in the form of the teeth or by a direct structural malformation of the enamel or the dentin. The children of parents whose teeth have been lost early in life from dental caries are unquestionably very prone to be affected with like conditions. So well has this hereditary influence been established that it is not an infrequent experience to find special teeth in members of the same family attacked by the disease, and at relatively the same period of life.

Influence of Inherited Disease.—Hereditary tendencies and predispositions to certain diseases like tuberculosis, rheumatism, gout, various nervous affections, and insanity are often well marked; but *syphilis* is the only disease that has been positively demonstrated to be directly transmitted from parent to child.

The syphilitic virus predisposes to dental caries through its depressing influence upon nutrition and its tendency to attack epithelial structures, thus producing atrophy of the ameloblasts in those teeth in which the process of calcification is about to begin, and forming faults or imperfections in the enamel which later become the starting-point of caries.

If the student will refer to the chart showing the progress of calcification of the permanent teeth (Fig. 225, page 78), he will notice that the only teeth in which calcification is progressing up to the end of the second year of existence are the first molars and the central and lateral incisors, and these are the teeth which are always the most profoundly affected by the action of the virus in inherited syphilis. This will be readily understood when it is remembered that the most active stage of the disease in these unfortunate children is during the first and second years after birth. When this stage is prolonged to the third year the cuspids are also affected.

Fig. 269.



Syphilitic teeth. (After Hutchinson.)

Jonathan Hutchinson first called attention to the peculiar effects of inherited syphilis upon the permanent teeth, and offered the only adequate explanation of their malformation,—viz., interrupted nutrition. These malformations consist of an atrophied condition or lack of development of the enamel upon the morsal surfaces of the first molars and the morsal edge of the incisors, with a notched condition of the morsal edge of the central incisors, *semilunar in outline* (Fig. 269). The incisors, both upper and lower, have often a stunted appearance, and are narrower at the morsal edge than at the cervix. The upper lateral incisors are sometimes very much dwarfed, resembling pegs or inverted cones. Hutchinson regarded the semilunar notch in the central incisor teeth as diagnostic of inherited syphilis. This view has, however, been called in question, as the same condition has been noted in children to whom mercury had been administered in infancy until the system was profoundly impressed, but who had not inherited syphilis. And inasmuch as mercury is usually administered in inherited syphilis, the question has been raised as to whether the peculiar malformation is due to the effects of the virus or to the drug. On the other hand, the malformation is common in children with inherited syphilis who have received no treatment of any kind. It therefore seems probable that both the virus and the drug, by their depressing effects upon the functions of nutrition, are capable of producing these peculiar malformations.

Teeth of this character are very prone to caries at those points where the enamel is defective or entirely lacking, and yet certain cases will resist the inroads of the disease for many years.

Exanthematous Diseases and the Continued Fevers.—The exanthems and the continued fevers occurring at the time of dental development retard or arrest this process for a shorter or longer period, according to the severity of the disease and the recuperative powers of the child. This interference with nutrition is indelibly impressed upon the developing teeth by *pits* and *grooves* which encircle the crowns of the teeth at that particular part of the enamel which was undergoing calcification at the time, or the enamel may be imperfectly developed at the morsal edge of the incisors and the cuspids, or at the cusps of the molars. Sometimes the enamel is entirely absent over a considerable portion of the crown.

The teeth which are most liable to be affected in this manner are the first permanent molars, the incisors, and the cuspids.

Various other diseases, like diphtheria, convulsions, and the gastric and intestinal affections, so common among children during the period of dental development, may produce like developmental defects.

Cases of this character are of frequent occurrence. One of the most marked instances of this kind which ever came under the observation of the writer was a little boy ten years old, who was at this age in apparently good health, but rather small and slender for one of his years, and of strumous diathesis and nervous temperament. His teeth up to this age had erupted at the normal period. The deciduous teeth had all been well formed, but very frail, and nearly all of them had been treated for caries. The permanent teeth which had so far erupted were the superior and inferior first molars, and the central and lateral incisors and first bicuspids. All of these teeth except the bicuspids were devoid of enamel over the whole extent of the crowns, except a narrow band at the cervical margin. The denuded surfaces were quite sensitive to the touch of instruments, or the action of acids, sweets, or thermal changes. The bicuspids were normally developed. The child was born of a highly cultured but extremely nervous mother, with tubercular tendencies. For the first three years of his life the child was continually ill, suffering from gastric troubles and convulsions whenever there was any slight irritation to the nervous system. If his milk were ever so little changed by lactic acid fermentation, or he were ever so slightly overfed, convulsions usually followed, and it was only by the most careful nursing that he was carried through the critical period of first dentition.

There is also a rapid increase in the progress of caries, as well as a greater predisposition or susceptibility to the disease in pregnancy, tuberculosis, typhoid fever, diabetes, and other wasting diseases. Similar conditions prevail in anæmic and leukæmic states. It is a noticeable fact that in young girls who are suffering from chlorosis the teeth often exhibit an increased tendency to caries and exceptionally rapid progress of the disease.

Certain occupations have been thought by some authorities to predispose to caries; for instance, millers, bakers, and candy-makers show an especial liability to caries, as do also workers in alkali, phosphorus, arsenic, chlorine, and sulphuric acid manufactories.

LOCAL PREDISPOSING CAUSES.

Structural Defects of the Teeth.—Structural defects in the enamel, the result of constitutional conditions which have impaired nutrition and thus prevented the proper development of this tissue, are a most important factor in predisposing the teeth to caries. The most observable of these defects have just been referred to,—viz., pits or honey-combed conditions, grooves, and the absence of enamel upon certain portions of the crowns. The less noticeable but more important defects are those which may be found in almost all teeth, even of the most perfect development,—viz., the sulci, fissures, and pits formed by the union of the developmental lobes. Fig. 270 shows such a condition. At these points the enamel-rods many times seem to have been imperfectly cemented together, or the sulci and fissures are so deep as to give ready lodgement for food *débris*. These conditions invite the establishment of caries by making it possible for the micro-organisms of the disease to find a lodgement where, undisturbed, they may propagate and flourish.

Many of the enamel defects are so infinitesimal in size as to require the aid of high-power objectives for their discovery, and yet they are sufficiently large to give lodgement to masses of micro-organisms.

Structural defects of the enamel which leave the dentin exposed to the action of the micro-organisms favor rapid disintegration of this tissue; but if the exposed surface of the dentin is of such shape or in such a location that the lodgement of bacteria can be prevented, caries will be no more likely to occur at these points than upon the enamel itself.

The rapidity with which caries progresses in the dentin will depend in large measure upon the character of the structure of this tissue. Dentin in which the interglobular spaces are numerous does not seem to possess the same degree of resistance to the invasion of the micro-organisms of decay as those teeth which are more perfectly organized.

Black has shown very conclusively that the chemical constituents of the teeth do not exhibit a sufficient variation to account for the differences observed in the rapidity with which structural disintegration takes place in caries, and that the variations in the amount of lime-salts in the dentin are not enough to explain their variation in hardness.

It must be conceded, however, that alterations in the structural organization and chemical constituents of the dentin modify to a greater or less extent the progress of the disease. "The forces of attack being equal, a poorly organized and badly formed tooth will succumb sooner than one perfectly formed and of completely organized tissues; this law is constant in all biology." (Burchard.)

Another structural defect which predisposes to caries is the deviations from the normal in the external forms of the teeth. Teeth of the most perfect form are broader at their morsal surfaces than at the cervix; in other words, are bell-crowned. This form of tooth in a normal dental arch permits approximal contact with each of its neighbors at one point only,—viz., near the morsal margin of the approximal surface of the bicuspids and molars and the morsal edge of the incisors and cuspids, thus separating each tooth from its fellow by V-shaped interspaces, which are generally kept clean by the passage through them of the fluids of the mouth. If, on the other hand, the labio-lingual diameter of the crowns is much greater than the mesio-distal, and the approximal surfaces are flattened, these surfaces of the teeth lie closer together, nearly if not quite obliterating the proximate interspaces, thus making it difficult or impossible to keep them free from alimentary *débris*, and favoring the lodgement and growth of the bacteria of fermentation.

Traumatic Injuries.—Defects in the enamel caused by traumatic injuries are not nearly so common as the developmental defects, and are not, as a rule, so liable to become the starting-point of caries. Injuries which fracture the enamel, leaving the dentin exposed, if occurring at points which are subject to the friction of mastication, or of such shape as to be self-cleansing, rarely develop caries; but when the reverse is the case, caries will often be established in a very short time. Injuries which cause crushing or splitting of the enamel without dislocation of the fragments are much more liable to become the starting-point of caries than those fractures which cause loss of tissue, from the fact that they offer much more favorable conditions for the entrance of bacteria and their undisturbed propagation. Fig. 271 shows caries following a crack in the enamel.

Irregularities in the Arrangement of the Teeth.—Teeth which are irregular in their arrangement in the arch, no matter how perfect they may be in structure and form, have a much greater predisposition to caries than those which have a normal arrangement.

Nature in constructing the typical dental organs of man and arranging them in the perfect arch, placed them in the best possible condition to withstand the action of those destructive agencies which continually surround them. Any deviation from this perfection of form and arrangement must, therefore, necessarily predispose the teeth to be acted upon by these agencies, while the degree of predisposition will be largely controlled by the character and degree of the irregularity in form and position.

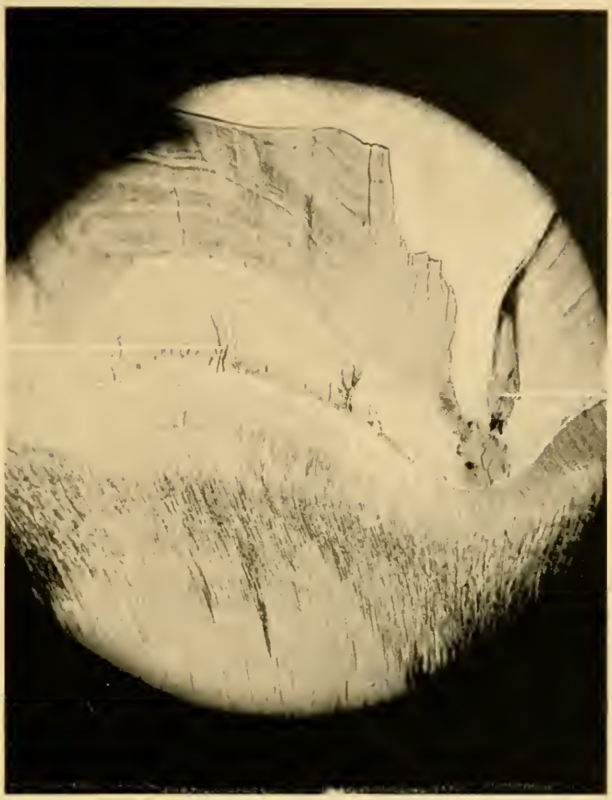


Fig. 270.—Section of human molar, showing caries of enamel following a fissure. × 95.

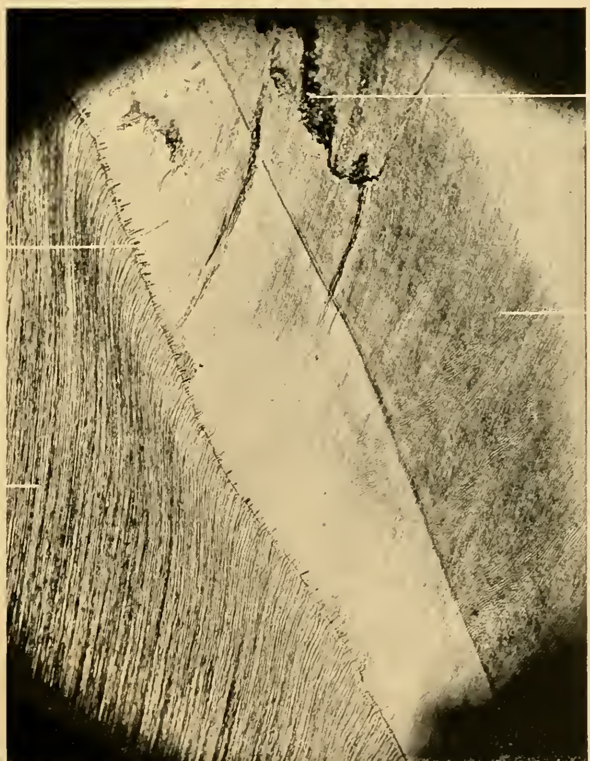


Fig. 271.—Caries following crack in enamel. × 95.

By mal-arrangement of the teeth certain of their surfaces are rendered very difficult or well-nigh impossible to cleanse by natural or artificial means, and thus the active agencies of caries are furnished with the best possible conditions for the establishment of their destructive work.

Injuries, extractions, or the necessary loss of a tooth often cause mal-position of adjoining teeth, and render the approximal surfaces more difficult to be cleansed by the natural agencies of the mouth, and by that much establish a greater predisposition to caries. The injudicious use of the file is also a predisposing cause of caries, and secondary caries is often invited by failure to restore the normal contour of the teeth when inserting approximal fillings. Broad contacts upon the approximating surfaces of the teeth are grave deviations from the normal condition of a perfect dental arch, and should never be allowed to obtain as the result of operation, as all such conditions invite a recurrence of the disease.

Abnormal Oral Secretions.—Normal mixed saliva is generally alkaline in its reaction, and it contains a special ferment, ptyalin, in the proportion of seven parts per thousand. Parotid saliva is faintly alkaline, while the secretion from the submaxillary glands is more strongly alkaline, as is that from the sublingual glands. The secretion from the parotid is a clear, watery fluid, while that from the submaxillary glands, though a limpid liquid, is quite viscous, a quality which under the influences of cold gives it an almost gelatinous consistence.

The secretion from the sublinguals is a limpid viscid fluid, but rich in ptyalin, which gives it a ropy consistency. The secretion from the buccal mucous glands is also a viscid fluid, rich in mucin, and has an acid reaction.

Changes in the character of these secretions often take place as a result of certain morbid conditions of the mouth or of the general system.

The morbid oral conditions which may induce alterations in the character of the saliva are stomatitis in its various forms, gingivitis, tonsillitis, pharyngitis, and diphtheria. These inflammatory conditions greatly augment the secretion of buccal mucus, and as a consequence there is a marked increase in the acidity of the oral fluids. This is made evident by the use of litmus paper, and "by the solution and consequent disappearance at such times of deposits of tartar." (Magitot.)

The morbid conditions of the general system which may induce alterations in the character of the oral secretions are certain *acute* and *chronic diseases.*

Among the *general acute affections* which may produce these effects are the eruptive fevers, typhoid and malarial fevers, pneumonia, bronchitis, pleurisy, gastritis, enteritis, tuberculosis, diabetes, albuminuria, syphilis, and the constitutional effects of such drugs as mercury, potassium iodide, etc.

In all of these conditions it has been observed by various writers, from Donne (who called attention to these facts in 1835) to the present time, that the oral secretions presented an acid reaction, and that accompanying this condition there was hypersensitiveness of the teeth, with an increased predisposition to caries.

The *general chronic affections* in which these changes are most often noticed in the oral secretions are rheumatism, gout, dyspepsia, chronic enteritis, dysentery, gastralgia, and pulmonary tuberculosis. "Their effect is to exaggerate the production of ptyalin, the agent of viscidity, and to excite a hypersecretion of mucin, two phenomena caused either by the direct influence of intestinal alteration or by reflex action of the general condition upon the conditions of the mouth." (Magitot.)

Like conditions are frequently observable in certain physiologic states, as in pregnancy and lactation. Acid reaction of the saliva and hyper sensitiveness of the teeth, with an increased predisposition to caries, is so common among women during these states that the tendency among them at these times to lose their teeth has been crystallized into the terse adage, "for every child a tooth."

In mouths which show an acid reaction of the saliva it is common to find an increased quantity of ptyalin and mucin, which give an albuminous, ropy appearance to the secretion.

These substances, being capable of coagulation, give a tenacious character to the saliva and cause it to cling to the surfaces of the teeth, thus forming a convenient medium for the growth and destructive action of the bacteria of decay and the retention and fermentation of food *débris*.

Chemical analysis, both quantitative and qualitative, of the secretions and excretions of the body, especially of the blood and the urine, has long been recognized as a valuable means of diagnosis in numerous abnormal conditions of special organs and of the general system.

It remained, however, for Michaels,* of Paris, in a paper "On the Rôle of Systemic Hyperacidity," to emphasize the great value of chemical and polariscopic examination of the saliva and its constituents in health and disease, as a means of diagnosing various abnormal conditions of the body.

Michaels found the saliva contained as constant normal elements ptyalin, mucin, chlorides of sodium and potassium in varying amounts, sulphates of sodium and potassium, earthy phosphates and carbonates, phosphate of iron, fatty matters, and derivatives of acid urates. In certain abnormal conditions he found urea, glucose, biliary pigment, lactic acid and leucin, and these substances, except urea, were found only in pathologic conditions. He further expresses the conviction that "the functional activity of the salivary glands dialyzes all of these chemical elements out of the blood plasma. Dissolved in water these chemical elements are easily recognized, if not by direct analysis, then after dehydration, by the microscope, or by the polariscope with transmitted light. Certain crystals are volatile, or change in form, or lose their color on drying; but it is possible to fix them and cover them in time with Canada balsam."

Certain crystalline organic substances when in solution will crystallize out in varied forms, branched, stellate, coral-like, or in amorphous and atypical shapes; and no treatment is necessary to produce these crystals except evaporation of the fluid, and they are often beautiful and characteristic. This fact appears important and interesting. "Profound micropolariscopic study of the chemical composition of the saliva," he is of the

* International Dental Journal, 1900.

opinion, "would enable the physician to recognize initial steps in a developing disease, and urinary analysis would confirm such results."

Michaels was led to the investigation of the salivary secretions by reason of the fact that in patients of a gouty or rheumatic diathesis, in whom there is always an hyperacid condition of the fluids of the body, he frequently observed, as an accompaniment to the usual morbid conditions of these affections, certain secondary effects which were manifested in the dental and oral tissues. Among these he mentioned rheumatic inflammation of the gums, alveolar neuralgia, acidity of the mouth, looseness of the teeth, nervous palatal constriction, alveolo-dental abscess, expulsive gingivitis, chemical abrasion of the teeth, dental tartar and deposits of sordes, and dental caries of constitutional origin.

He says, "the characteristic features of the rheumatic diathesis are diminished urine and diminution of all normal urinary constituents together, and the appearance in the saliva of uric-acid derivatives, sulphocyanates, and oxalic acid, varying from two to seven times the normal; namely, the series of sulphocyanides of sodium, ammonium, and potassium, and the series of acid and basic oxalates."

Among patients with diminished acidity he found the "creatin group," and as a consequence of their presence, he believes, special effects are produced on dental caries, as he found in these cases that the process of caries was very rapid, the teeth being lost in spite of all the efforts of the dental specialists.

Acidity of the saliva, he contends, is but a local expression of a constitutional condition, and by precipitating mucin tends to form deposits of sordes upon the teeth; this produces a peculiar and characteristic form of caries at the necks of the teeth.

In the gouty diathesis there is prevelant certain affections of the gums, gouty deposits in the jaw bones (arthritic), alveolo-dental abscess, degeneration of ligaments, and painless loss of the teeth.

In the rheumatic diathesis the salivary acidity is dependent upon the sulphocyanides of sodium and ammonium, the local oral manifestations being "alveolar neuralgia, nervous constriction of the palate, diminished saliva, 'the teeth set on edge,' pain in the maxillary joints, penetrating caries, and chemical erosion of the teeth."

In diabetes, which is also a hyperacid diathesis, the changes in the condition of the oral tissues is due to glucose in the saliva and general nutritional changes in the system. The principal manifestations in the oral cavity are "softened and bleeding gums, stale and fetid breath, denuded teeth, and loss of the teeth in the initial stage of the disease."

Chemical erosion of the teeth, he believes, is due to the presence of potassium sulphocyanate (K C N S), which appears in the saliva as one of the uric-acid derivatives and associated with the rheumatic diathesis. He is also of the opinion that this chemical agent is the product of the labial glands, and that the erosion takes place from the constant contact of the secretion of these glands with the labial surfaces of the teeth. From the foregoing he comes to the conclusion that a more complete knowledge of the conditions of the saliva in diathesis would put the dental surgeon in the possession of facts which would materially aid him in devising more radical methods for the cure of dental diseases.

He contends it is readily demonstrable that the sáliva more nearly represents the condition of the blood plasma than does the urine or any other excretion ; *first*, for the reason that the secretion of the salivary glands is not modified in any particularly important feature by the action of these glands, which separate it from the blood plasma, while the urine contains large quantities of excrementitious matter ; *second*, although the saliva contains excrementitious substances it is also a digestive fluid, which passes into the stomach as soon as it is secreted by the salivary glands, and thus passes through endless nutritional cycles, abstracting from the blood plasma certain soluble crystallizable compounds which have been formed as end-products or by-products of metabolism, and which are dialyzed from the blood by the glandular apparatus of the mouth.

He found also that the chemical components of the saliva varied with the nutritional condition and diathetic state of the individual, that the composition of the saliva in any given diathesis is fairly constant, and that there was very little difference during any given period of the same diathesis.

Dr. E. C. Kirk,* who has carefully reviewed the clinical and laboratory investigations of Michaels', says : "Accepting these promises as trustworthy, Michaels' deduction that the composition of the saliva varies with the nutritional state, is a necessary corollary, and the theoretical deduction has been amply borne out by laboratory and clinical investigation.

Two important generalizations are the outgrowth of the basal principle just stated, first, that the composition of the saliva is fairly constant for a given diathetic state ; second, that it is also fairly constant for any period in a given diathetic state. We are, therefore, able from an examination of the saliva to determine with reasonable accuracy not only the general diathetic condition, but the period of the diathesis—*i. e.*, whether it be weak or advanced in its pathologic intensity."

Kirk looks upon the variations which occur in the constituents of the saliva in health and disease as of great diagnostic importance in determining the causes of certain abnormal states of the system or diatheses, and also as positive factors in some instances, and in others as probable factors in the production of various oral lesions, as, for instance, dental erosion and phagedenic pericementitis, and probably dental caries and various neoplasms and morbid growths of the soft tissues of the mouth.

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* Proceedings Chicago Odontographic Society, 1903.

CHAPTER VIII.

DENTAL CARIES (CONTINUED).

THE agents which are immediately responsible for the production and maintenance of a disease are termed its *direct, exciting*, or *active causes.* These causes are often obscure, and many times entirely hidden from observation.

Dental caries was thought by many of the older writers to be analogous to *caries of bone*, but this cannot be the case, for the physical phenomena of disintegration of these tissues are so very different. Caries of the bone is an inflammatory molecular disintegration of tissue, a retrograde metamorphosis. The organic and inorganic substances or elements are dissolved or break down together, and are carried away in the sanies or pus which is formed as a result of the inflammation.

In *caries of dental tissue* there are no inflammatory symptoms except that of increased sensitivity. Modern research has demonstrated that caries is caused by zymogenic organisms. The inorganic elements of the tissue are first removed by chemical solution produced by the acid-forming bacteria of the mouth, while the organic material or basis substance becomes gangrenous and is afterwards dissolved by the liquefying action of the saprophytic micro-organisms and is washed away.

For more than two thousand three hundred years dental caries has formed an interesting subject for medical writers and theorists.

The etiology of the disease has always furnished a most interesting field for original investigation and research, while the peculiarities of the physical phenomena presented by the disease and the obscurity of the causes which produced them have led to many and divers opinions. As a result, several theories have from time to time been advanced to explain the phenomena which are manifest in the dissolution of these tissues.

The ancient physicians and dentists who made any attempt to inquire into the causes of the affection seemingly contented themselves with offering hypotheses more or less ingenious, but based in part upon experience and clinical observation, to account for the physical phenomena of the disease. No real investigation, however, that could be called scientific was at all possible until the invention of the microscope opened the way for the study of the histologic structure of the dental tissues, both normal and pathologic, and the minute bacterial forms which we now know to be the cause of so many diseases.

History.—It will be interesting to the student to briefly review the following theories and trace the evolutionary steps by which the *direct causes* of the disease were finally discovered :

1. The Humoral Theory.
2. The Vital or Inflammatory Theory.
3. The Worm Theory.
4. The Putrefaction Theory.
5. The Chemical Theory.
6. The Electro-Chemical Theory.
7. The Germ Theory.

The Humoral Theory of Caries.—Hippocrates (B.C. 456) and his pupils were humoral pathologists. Hippocrates taught that the body contained four fluid humors,—viz., blood, phlegm, yellow bile, and black bile; that a proper or due proportion of each of these humors constituted health, while a disturbance of the proportions resulted in illness. He ascribed all diseases to this cause; hence he and his followers ascribed dental caries to a bad condition of the humors,—viz., to the stagnation of depraved juices in the teeth.

This view was generally maintained by physicians for more than a thousand years, and is still prevalent in the traditions of the common people.

Bourdet (1757) still maintained the humoral theory of Hippocrates, while most of his contemporaries accepted the vital theory. He claimed that when the fluids contained in the vessels of the tooth are too thick they coagulate, and since they are confined, putrefy and act directly upon the structures of the tooth, producing caries. He also called attention to the fact that when a tooth decays, its fellow upon the opposite side of the jaw is sooner or later similarly and symmetrically affected, and explains this predisposition by the fact that as corresponding teeth are usually calcified at the same period and pursue the same order of development, so the same morbid processes are commonly manifested in the same locations of corresponding teeth.

The Vital or Inflammatory Theory of Caries.—Galen (A.D. 131) looked upon dental decay as being caused by a disturbance in the functions of nutrition. He said, "The lack of nutrition makes the teeth weak, thin, and brittle, while an excess of nutrition excites an inflammation very similar to that of the soft parts."

Ambroise Paré (1579), the noted French surgeon, held to the theory of the inflammatory nature of dental caries. He says, in discussing the subject of toothache, "These organs, after the manner of other bones, suffer from inflammation, quickly suppurate, and become rotten."

Fauchard believed with Galen that caries was caused by vital or inflammatory action, and described seven forms of the disease,—viz., scorbutic, variolous, scrofulous, moist or putrid, dry, superficial, and deep; the latter form giving rise to severe pain. He assumed that there must be two causes for caries, as for all other diseases of the teeth, one of internal origin, producing *internal caries;* the other *external* in origin, and producing *external caries.*

The internal causes, he stated, were referable "generally to the quantity and quality of faulty, acrid, or corrosive lymph, which acts upon their roots, attacking their external and internal surfaces." The latter doubtless referring to the root-canal and pulp-chamber. This variety, he stated, was difficult to recognize, from the fact that it is concealed from view by the gums and the alveolus. The external causes he does not explain, but said these attack the outer portions of the tooth,—viz., the enamel, occasionally the neck, and the roots.

The prevailing opinion of the medical men of this period was that caries of the teeth was due to inflammation, or, in other words, to vital action; that it was a true disease of dentin, the term "Odontitis" being given to it. Upon this supposition the researches of Fauchard, Bourdet, Jourdain, Hunter, Fox, Bell, Cuvier, Duval, Linderer, Meckel, etc., were conducted.

This theory was revived by Newmann (1862), while Hertz and Abbott later attempted to confirm it, but with indifferent success.

Jourdain (1766) believed with Fauchard in the exclusively vital or organic nature of the affection, which was at times inflammatory.

Hunter (1778) maintained that the disease was a *vital process*, characterized by inflammation and gangrene, and somewhat analogous to caries of bone. He said, "It does not arise from internal injury or from menstrua, which have the power of dissolving part of a tooth, but we may reasonably suppose that it is a disease arising originally within the tooth itself."

He does not, however, seem satisfied with the idea of the analogy between the carious process as observed in bone-tissue and in tooth-substance, as it does not satisfactorily explain the phenomena of gradual decomposition and loss of tissue with the formation of cavities. Upon this point he says, "The most common disease to which the teeth are exposed is such a decay as would appear to deserve the name of mortification. But there is something more; for the simple death of the part would produce but little effect, as we find that the teeth are not subject to putrefaction after death, and therefore I am apt to suspect that during life there is some operation going on that produces a change in the diseased part. It almost always begins externally (*external caries*) in the small part of the body of the tooth, and commonly appears first as an opaque white spot. This is owing to the enamel losing its regular crystalline texture and being reduced to a state of powder from the attraction of cohesion being destroyed, which produces similar effects to those of powdered crystal. When this has crumbled away the bony part of the tooth is exposed, and when the disease has attacked this part it generally appears as a brown speck."

He also claimed that occasionally the disease originated in the dentin (*internal caries*), and that in this case the tooth assumed a shining blackness from the dark color being seen through the remaining external shell of the tooth, which upon opening is found leading to the pulp-canal.

Fox (1806) expresses the belief that "the diseases to which the teeth are subject have their origin in inflammation." In writing of the proximate or *direct* cause of caries, he considered it to be "an inflammation in the bone of the crown of the tooth, which on account of its peculiar structure terminates in mortification." This process, he believed, was established through inflammation of the dental pulp and lining membrane of the pulp-chamber (membrana eboris). He evidently considered the pulp-membrane as analogous to the periosteum, and confounded necrosis with caries; for he stated that if the inflammation was severe in the pulp-membrane, nutrition would be arrested in circumscribed areas, as in periostitis, thus causing death of portions of the dentin, which would afterwards decompose and form cavities of decay.

Bell (1831) maintained that dental caries was a species of gangrene, and that "the true proximate cause of dental gangrene was inflammation." He did not believe that caries was ever caused by *external agencies* which acted upon the enamel, but was due to *internal causes* which produced death of portions of the dentin. He defines dental gangrene as "mortification of any part of a tooth, producing gradual decomposition of its substance." Further he says, "The situation in which gangrene (caries) invariably makes its first appearance is immediately under the enamel, upon the surface of the bone (dentin)." This, he thought, was explained by the structure of the teeth and the nature of the disease. "As the vessels and nerves which supply the bone of the teeth are principally derived from the internal membrane (pulp), it is natural to conclude that in so dense a structure the organization would be less perfect in those parts which are farthest removed from its source, and that in the same portion they would be less capable of resisting the progress of mortification." With regard to the progressive character of the disease, he thought this could only be explained by following the same reasoning. "When a portion of any of the other bones loses its vitality it acts as an extraneous body, *producing irritation in the surrounding parts*, and a process of absorption is set up in a line of living bone in contact with it in order to effect its separation. A similar effort appears to me to be made in gangrene of the teeth, but with a very different result, in accordance with the difference in the structure of the two seats of the disease. When a portion of the tooth is killed by inflammation it excites, as in the other case, an increased action in the vessels of the surrounding portion of bone; but that very action, which in such bones as possess greater vital power becomes remedial by promoting the removal of the cause of irritation, produces in the present case the continued extension of the disease; for the irritation thus excited, instead of effecting the removal of the part by absorption, as in other necrosed bones, at once destroys its vitality and renders it only an additional portion of dead matter to that which had already existed. This, in its turn, becomes an extraneous and irritating body to the surrounding bone, in which the same action is set up and the same mortification produced, and thus portion after portion is successively irritated and killed, until the whole crown of the tooth is destroyed."

Fitch (1829–35), in both editions of his work, expresses substantially the same view as did Neumann, Hertz, Koecker, and others.

Koecker says, "Caries of the teeth must be considered as similar to gangrene in other parts of the system. And when we speak of caries as a disease we mean that diseased action in the bony structure of the living tooth produced by chemical irritation of its dead and rotten parts.

"Hence it is indispensable that we should make a due distinction between caries considered as a disease in the tooth and the effect of that disease,—viz., mortification and putrefaction of its whole structure. Caries, in fact, is that state of the tooth in which mortification has taken place in one part, and inflammation in the part contiguous to it, the former originally produced by the latter, and the latter continually kept up by the former."

Koecker, however, maintained that there were two forms of caries, one beginning upon the external surface of the tooth, and the other having its origin within. The latter variety he looked upon as analogous to an abscess of the bone, for he says, "It (the disease) never proceeds so far towards the cavity containing the nerves as to render this membrane altogether unprotected by the bony structure before it has penetrated through the external osseous parts, including the enamel, and has thus formed a natural outlet for the bony abscess."

Abbott (1879), Heitzmann, and Boedecker (1886 and 1888) made the attempt to revive the vital theory of caries. Abbott describes caries occurring in a vital tooth as "an inflammatory process, which, beginning as a chemical process, in turn reduces the tissues of the tooth into embryonic or medullary elements, evidently the same as, during the development of the tooth, have shared in its formation; and its development and intensity are in direct proportion to the amount of living matter which they contain, as compared with other tissues."

He opposed the idea that micro-organisms in any sense produced caries; that these organisms did not penetrate the basis-substance of the tooth, "but appeared only as secondary formations, owing to the decay of the medullary elements."

These authors maintained with the most positive assertions that "there occurs a primary inflammation in dentin, independent of pulpitis or pericementitis, *running its course in the middle of the dental tissue*, and leading, as all inflammatory processes do, either to a new formation or to destruction by suppuration."

They explained the process as follows: "Inflammation causes first a solution of the lime-salts, and afterwards a liquefaction of the basis-substance, both in bone and dentinal tissue. The result will be the appearance of globular spaces or bay-like excavations, which exhibit medullary corpuscles, or sometimes clear protoplasmic masses corresponding to the embryonal stage of the inflamed tissue. . . . By the breaking apart of these medullary corpuscles pus may be formed in the middle of the dentin, thus representing an abscess independently of the pulp-tissue; or, on the other hand, a healing process may take place through the redeposition of lime-salts." These views were never adopted by the profession in general, as they were based upon alleged facts which were entirely foreign to the teaching of the best authorities in morphology, histology, and pathology, and, furthermore, others were not able to demonstrate them.

The Worm Theory of Caries.—Just when or by whom the theory that worms were an essential factor in the origin and development of caries is not known, but it is certain that for many centuries they were regarded as the cause of the disease, and various remedies were employed to destroy them or drive them out. Scribonius used fumigations, Ebu-Sina employed the seeds of henbane, leek, and onions. Musetanus (1114), Kräutermann (1732), Ruyleman (1824), Kremler, and many others recommended similar measures. (Miller.)

Whether this theory arose as the result of imperfect observation or from a deliberate intention to deceive, history does not enlighten us. The chances are, however, that it was invented by some charlatan who desired to defraud the public and thereby fill his purse. This theory is commonly believed in China at the present day, and their dentists pretend to remove such parasites from the teeth. The worms, which are artificial, are dexterously placed in the mouth of the patient by the dentist during his manipulations, and then extracted and held up to the gaze of the wondering but satisfied victim.

Fauchard (1728) took infinite pains to discover the worms which were supposed to be the cause of the disease, and the odontalgia which was a frequent accompaniment of the disintegration of the tooth, but failed to discover them either in the carious dentin or in the salivary calculus.

Pfaff (1756) discovered worms in the mouths of persons who ate decaying cheese, but he was "not able to observe that these worms had produced toothache by gnawing." (Miller.)

The Putrefaction Theory of Caries.—Pfaff (1756) was the first to advance the theory that dental caries was caused by putrefaction. He says, "Remains of food which undergo putrefaction between the teeth occasion decay of the teeth."

Ficinus (1847) attributed dental caries to a putrefaction induced by certain minute infusorial animalcules which live in the mouth, and to which he gave the name *Denticola*. He believed these organisms produced a kind of putrefaction which first attacked the enamel cuticle, then proceeded to destroy the enamel, and afterwards the dentin. The process of putrefaction requires an alkaline reaction, but he does not explain the disappearance of the calcium salts, which require acids for their solution. (Leber and Rottenstein.)

Klencke (1850) maintained the theory of putrefaction as the cause of caries, but divided caries into two distinct varieties,—*central caries* and *peripheric caries*. The former, he stated, has its origin in the pulp-cavity, the latter in the external portions of the teeth.

Peripheric caries he divided into three different forms:

1. Soft caries (caries acuta), caused by the agencies of putrefaction, dental animalcula, *denticole hominis*.

2. A soft caries (caries acuta), due to the proliferation of a vegetable parasite called *Protococcus dentalis*.

3. The so-called dry caries (caries chronica), in which the parasites have no part; this form being caused by the chemical action of acids upon the dental tissues.

The Chemical Theory of Caries.—For many years, and up to a very recent period, the acid theory of decay received the support of a large majority of the profession. In fact, it was the prevailing theory until the researches of Miller proved the disease to be caused by the zymogenic bacteria.

Many of the advocates of the "acid theory" taught that the teeth when once formed were not susceptible to change in structure, and that consequently they were passive in the hands of the disease; that the cause of caries was a purely chemical one, based upon the known fact of the affinity of acids for calcium salts.

Although the chemical theory may be said to be of modern origin, it nevertheless received its first suggestions from some of the older writers. According to Miller, Paul, of Ægina (636), first suggested the idea that acids might cause caries. He says, "In order to preserve the teeth precautions should be taken against the spoiling of food in the stomach, since the frequent vomiting resulting from it is very injurious to the teeth."

Carabelli is authority for the statement that the first experiments in regard to the action of acids upon the teeth were made by Berdmore (1771) with nitric and sulphuric acids. Pasch (1767), Bücking (1782), Becker (1808), and Ringelmann (1824) all attributed injurious effects to some foods and acids. (Miller.)

Harris (1830) was the first writer to announce his belief that caries was caused by a purely chemical process, the result of the action of acids within the mouth acting upon the calcareous material of the tissues of the tooth.

Robertson (1835) combated the vital or inflammatory theory of the disease, and stated that caries was caused by a chemical decomposition of the dental tissues by the means of acids, the acids being formed in the mouth by the dissolution of food particles.

Linderer (1837) considered caries to be due to a purely chemical process induced by the oral fluids, and combated the inflammation theory, for, "since dentin contains no blood-vessels, inflammation in this tissue is not conceivable." He also denied the existence of the so-called internal caries.

Regnaud (1838) upheld the pure chemical theory of caries, considering the disease to be the result of the destruction of the dental tissues by acids formed within the mouth. He further stated that silk ligatures wound around the teeth, when left for a considerable period, cause the destruction of the enamel, while caps covering the teeth, whether made of wax or some metallic substance, promote their destruction, and human teeth, artificial sets, and individual teeth made from ivory also undergo destruction.

Westcott (1843) proved conclusively by a long series of experiments that acids, both vegetable and mineral, act more or less vigorously upon the calcified structures of the teeth.

Allport, a few years later, conducted a similar series of experiments with the vegetable and mineral acids, and arrived at substantially the same conclusions.

Desirabode (1846) recognized two forms of caries, one *external*, which is caused by a chemical destruction acting from without inward, and the other *internal*, arising from some injury to the pulp or from a congenital defect in the dentin and developed spontaneously from within outward.

Tomes (1837) was contemporary with Robertson, and in his earlier writings his views were quite similar to those of Klencke. In his later work (1873) he concluded that caries was the effect of external causes in which the so-called vital forces play *no* part; that it is due to the solvent action of acids which have been generated by fermentation going on in the mouth, the buccal mucus probably playing no small part in the matter; and when once the disintegration is established in some congenitally defective point, the accumulation of food and secretions in the oral cavity will intensify the mischief by furnishing new supplies of acids. In his third edition he states that the buccal organisms have no small share in the matter of causing the disease.

Tomes was the first to accurately describe the histologic alterations which take place at the seat of caries. These changes in the enamel he thought were caused in the majority of cases by imperfect development, with a greater porosity of the tissues, the porosity increasing with the progress of the disease. The most remarkable changes were found in the canaliculi of the dentin. In cross-section they were seen to be surrounded by a thickened sheath, having a tobacco-pipe-stemmed appearance. In completely decalcified dentin the canaliculi with their enclosed soft fibrils —Tomes's fibrils—remain free in the softened mass. In the more advanced stage of the disease he found these elements losing the sharpness of their contour and assuming a finely granular appearance. When the progress of the disease was very rapid, the dentinal sheaths presented varicosities and globular swellings.

These pathologic changes proceed along the canaliculi towards the pulp, giving usually to the carious or infected portion of the dentin the form of a brownish cone with its base turned towards the enamel. In those cases in which a more extended surface of the enamel was involved, and where the destructive process was rapid, the cone existed only incompletely or was entirely wanting. Around the cone of discolored dentin a zone of relative transparency existed in which the canaliculi contained calcified dentinal fibrils.

These changes were attributed by Tomes to organic or vital reaction of the dentin against the pathologic irritation induced by the caries, and he believed retarded or arrested the progress of the disease.

Oudet (1862) described two distinct forms of caries,—viz., *external* and *internal*. The former he believed to be caused by the action of acids upon the inorganic elements of the tooth, while the latter was the result of inflammatory action occurring within the substance of the dentin, which secondarily involved the contiguous portion of enamel.

Watt was perhaps the most conspicuous and aggressive advocate of the purely chemical theory of dental caries. He maintained that caries was caused by mineral acids principally, though he did not exclude the action of the organic acids, and insisted that the different colors seen in caries was the result of the action of these mineral acids,—viz., nitric, producing white decay; sulphuric, black decay; and chlorohydric, the intermediate colors.

Taft in his earlier writings favored the chemical theory of caries. In his opinion, "acid mucus and saliva, vitiated secretions, products of decomposition of animal and vegetable matter in the mouth, galvanic action, and mineral and vegetable acids, were the chief causes of dental decay."

Schenckler believed most strenuously that acids produced caries, for he says, "Be it repeated, where there is no acid no caries is possible."

Baume stoutly maintained the correctness of the chemical theory, and as strongly opposed the parasitic theory. He said, "*The fungi are the result of the caries.*"

Magitot (1867), in his "Treatise upon Dental Caries," advocated the purely chemical theory of caries, claiming that the disease was caused by the acids contained in the saliva, or formed in the mouth by fermentation. He states as his conclusions, reached after a long series of observations and experiments upon natural teeth and those carved from ivory, under both natural and artificial conditions: 1. That dental caries is a purely, chemical alteration of the enamel and dentin. 2. That the disease always progresses from the external surface of the organ inward, attacking first the enamel, second the dentin, and third the pulp, and that the existence of internal caries cannot be fairly proved. 3. Disorganization of the enamel is a purely passive chemical process. 4. That in vital teeth there is developed between the caries of the dentin and the pulp a "cone or white zone formed by a mass of canaliculi obliterated in consequence of a formation of secondary dentin." This he terms the *cone of resistance*, and looks upon it as an effort of nature to resist or retard the progress of the disease. 5. That artificially produced caries presents the same phenomena as natural caries, with the exception of the evidences of *organic* or *vital resistance.*

The Electro-Chemical Theory.—This theory was promulgated by Bridgman (1861–63), and endorsed by the Odontological Society of London.

The discovery by Faraday of the simple galvanic battery—viz., that a copper or zinc rod, with one end immersed in a dilute solution of sulphuric acid in water and the other exposed to the atmosphere, soon became polarized, and that at a point on the rod corresponding to the surface of the liquid the metal was gradually eroded and the material carried up the rod and deposited upon the portion exposed to the atmosphere, the acid forming one element of the battery, and the oxygen of the atmosphere the other—suggested to the mind of Bridgman that here, perhaps, was the solution of the vexed question of the cause of dental caries. He thereupon instituted a series of experiments upon teeth out of the mouth under conditions as nearly like those obtaining within the mouth as he could compass, with the result of producing caries artificially, which in appearance was identical with that produced out of the mouth by acids, and in general features corresponded to the microscopic appearance of natural caries.

He argued from this, applying the principles involved in the discovery of Faraday, that a tooth in the living body was always polarized, and had well-established electric currents, that the root of the tooth when invested with the gum and alveolus, like the end of the rod immersed in the dilute sulphuric acid, possessed electro-positive qualities, while the crown of the tooth, like the free end of the rod, being exposed to the atmosphere, had electro-negative qualities, consequently each tooth was a miniature galvanic battery, and whenever fluid or moist pulpy material was permitted to remain undisturbed in one position, as in the sulci and approximal spaces, for a few hours, the electric currents, which are constant, decompose them, and as a result acids are formed which attack the lime-salts of the tooth, and caries is established.

He further claimed that the insertion of metal plugs within the teeth increased the galvanic action and also accounted for *secondary caries.*

Palmer, Chase, and Flagg endorsed the views of Bridgman in reference to the production of secondary caries, and became the sponsors of what is known as the *New Departure Theory* in relation to the relative values of the various filling-materials as conservers of tooth-structure. These gentlemen instituted a long line of experiments to establish the position, in the electro-chemical series, of dentin with the various filling-materials. These experiments resulted in the demonstration of the following scale: Electro-negative: gold; amalgam, tin, gutta-percha, dentin, oxychloride of zinc + electro-positive.

The strongest electro-motive force or electric action is therefore generated by a combination of gold and dentin, and in a decreasing ratio amalgam and dentin, tin and dentin, gutta-percha and dentin. Palmer claimed that these materials in the order named above possessed a compatibility with tooth-structure in an increasing ratio,—viz., gold being the least compatible, and the ratio increasing to the bottom of the list.

These authors and their followers have claimed further that the variability in the structure of the teeth plays an important part in the liability to secondary caries; teeth of low organization—"of greater porosity"—furnishing the most favorable conditions for a recurrence of the disease after the tooth had been filled, and those of the highest organization offering the least favorable conditions. Moisture is necessary in order to establish galvanic action between the filling-material and the dentin. This moisture is furnished by the fluids of the mouth which act at the margins of the filling, but it has been claimed that the tooth itself also furnishes moisture through its tubuli which in teeth of low organization would be sufficient to establish galvanic currents between the tooth and the filling-material, followed by decomposition of the fluid, the formation or liberation of acids, and decalcification of tooth-structure.

The Germ Theory.—In discussing the various relations of micro-organisms to the process of fermentation, it has been frequently suggested that caries of the teeth might be, in part at least, caused by the action of micro-organisms.

Erdl (1845) was the first to definitely state that dental caries was caused by parasites. These, he claimed, formed upon the crown as a delicate, colorless membrane, composed of cells, which later became more irregular and their nuclei more distinct. Miller thinks that inasmuch as Erdl employed muriatic acid to isolate the "caries matter," that it is quite probable that the delicate membrane which he obtained was nothing more than Nasmyth's membrane. Erdl applied creosote and nitric acid to destroy the parasites and prevent the progress of the disease. His method was first to apply creosote until the "caries matter" was impregnated with it, then nitric acid, the latter immediately producing a violent and complete decomposition of the creosote and of the parasites saturated with it.

Ficinus, in 1847, suggested, as we have already seen, that the organisms of putrefaction—his *denticolæ*—were the active agencies which produced the disease. These, he claimed, proliferated in Nasmyth's membrane, which they destroyed; they next attacked the material between the enamel prisms, thus decomposing this structure and penetrating the dentin, which they destroyed in the same manner.

Klencke (1850) discovered another parasite in the human mouth, which he denominated *protococcus dentalis*, and claimed that this fungus possessed the power of liquefying enamel and dentin. He says of it that it "softens and destroys dental substances, and is nourished by their chemical elements."

The first extended study of the organisms which are found in the mouth was undertaken by Leber and Rottenstein, and the results of their labors were published in 1867. These authors believed that there were two forms of caries, one which they denominated *central caries*, having its origin in the cavity of the pulp, but an exceedingly rare form, and another to which is applied the term *external caries*, having its origin in the enamel, and caused by external influences.

In reference to central caries, they presented a single case in illustration, in which three teeth (two superior and one inferior incisor) in the mouth of a lady twenty-one years of age had lost their vitality from a traumatism,—a fall in early childhood. The teeth were blue in color, but there was no evidence of caries having penetrated from the surface. "In piercing the posterior face of one of these teeth it was found completely softened, even to the enamel, and the tissues had a brown color. The root itself was hollowed to a considerable extent. The same was found to be the case with one of the other teeth. The third, whose color was not so marked, and which caused no unpleasant sensation, was let alone."

Microscopic examination was not possible, hence doubt must exist in relation to the supposition that caries did not originate from some microscopic defect in the enamel.

These authors do not attempt to explain the cause which produced the *central caries* (?), but say, "We believe that there exist cases where the dental tissues are attacked and destroyed from the cavity of the pulp; but these cases are extremely rare, and the conditions of their production are not yet well understood, except, perhaps, the previously necessary death of the tooth."

With regard to *external caries*, they were of the opinion that the disease commences as a purely chemical process, but that as soon as the enamel is dissolved and the surface of the dentin exposed the elements of the *leptothrix buccalis* enter and penetrate the dental canaliculi, enlarging them, and thus increasing the facilities for the penetration of the acids which dissolve the lime-salts.

Weil (1880), writing in support of Leber and Rottenstein's view of caries, says, "Decay generally begins from without, and must, therefore, first make its way through the enamel-cuticle.

"It is highly probable that the fungus (*leptothrix buccalis*) bores directly through it. The fungi now proceed farther into the enamel, and force its prisms apart, gradually disorganizing its structure. From the enamel they penetrate into the tubules of the dentin, which are often enlarged by them to two or three times their original size, at the same time dissolving the calcium salts."

Arkövy stated the disease was "brought about by chemical action, in which the invasion of nosogenous fungi play an essential part."

Milles and Underwood, in a paper presented to the International Medical Congress, held in London in 1881, gave new interest to the germ theory of dental caries, and marked the most important advance made in the discovery of the causes of the disease up to this time.

The work of Leber and Rottenstein had found but few advocates, and had only stirred a passing interest in the subject, as the profession in general seemed satisfied with the acid theory of the disease.

The marked success, however, of Lister (1865–69) in the treatment of wounds, which was based upon the discoveries of Pasteur in relation to the organisms of the various ferments, added new interest, and stimulated investigation into the theory advanced by Leber and Rottenstein of the etiology of dental caries.

Koch (1881) added greatly to the facilities for observing these micro-organisms by the introduction of his improved methods of staining, and made it possible for later investigators to escape the errors into which their predecessors had fallen.

Milles and Underwood, noticing the constant presence of micro-organisms in decaying dentin, and the equally constant enlargement of the dentinal tubuli, came to the conclusion that in the process of dental decay "two factors were always in operation,—*first*, the action of acids, and *second*, the action of germs.

This theory, which, for the sake of distinction, may be called the *septic*, is rather an amplification of the chemical theory than a contradiction of it.

They say, "Most probably the work of decalcification is entirely performed by the action of acids, but these acids are, we think, secreted by the germs themselves, and the organic fibrils upon which the organisms feed, and in which they multiply, are the scene of the manufacture of their characteristic acids, which in turn decalcify the matrix and discolor the whole mass."

In reference to caries of cementum they say, "From our observations on cementum to which caries has extended, we conclude that the process is very similar; the bioplasmic contents of the lacunæ and canaliculi afford food and lodging for the organisms, which multiply, and when sufficiently numerous decalcify the surrounding bone so that each lacuna loses its outline and extends in all directions."

Miller (1882) announced the results of a series of experiments which he had conducted in relation to the active causes of dental caries, that it was his opinion that the first stage of the disease consisted of a decalcification of the tissues of the teeth by acids which are, for the greater part, generated in the mouth by fermentation. In this he agrees with Leber and Rottenstein, and partially with Milles and Underwood.

In his later studies, which were published in the *Independent Practitioner*, 1884 and 1885, he carried the subject much farther, and arrived at conclusions which have been generally accepted, and now form the basis of the present teaching upon this subject.

He says, in summarizing his work (1884),—

"1. I convinced myself by the examination of some thousands of slides of carious dentin that micro-organisms were always present, and that they, without any doubt, were the cause of various anatomical changes which were found to take place in the structure of the dentin during caries. (Here, of course, the question of priority does not suggest itself; Leber and Rottenstein, as is well known, were the first to give definite expression to this fact.)

"2. I proved, at the same time, that the invasion of micro-organisms was not, in the large majority of cases, simultaneous with the softening of the dentin, but that large areas of softened dentin could be found that contained no fungi.

"Of all those who examined my preparations in America, no one, whatever his theory, ever once denied this fact. I concluded from this that the softening of the dentin went in advance of the invasion of the organisms.

"3. I determined, by analysis of masses of carious dentin sufficiently large to give reliable results, that the softening of the dentin is of the nature of a true decalcification; that the decalcification of the outer layers is almost complete and diminishes in degree as we advance towards the normal dentin; furthermore, that the same relations maintain in dentin softened in a mixture of saliva and bread, or in weak organic acids; also, that in a mass of carious dentin the lime-salts had been removed to a much greater extent than the organic matter.

"4. I maintained from the first that the softening of the dentin was produced by acids for the most part, generated in the mouth by fermentation. I had, however, no proof of this.

"5. I *proved* that fungi exist in great numbers in the human saliva and in carious dentin, which have the power to produce acid under conditions which are constantly present in the human mouth. I determined this acid —for one of the fungi at least—*to be the ordinary ferment, lactic acid.*

"6. I produced caries artificially, which under the microscope cannot be distinguished from natural caries, by subjecting sound dentin to the action of these fungi in these fermentable solutions.

"7. I determined the influence of various antiseptics and filling-materials upon the fungi of caries.

"8. I isolated various forms of these fungi, and determined, *in part*, the conditions most favorable to their development, their characteristic reaction upon gelatin, their physiologic action, their effect when inoculated into the system of lower animals, and their possible connection with certain obscure diseases generally attributed to the carelessness of the dentist."

J. Sim Wallace* (1899) contends that caries is in no wise an inherited affection, nor is heredity a predisposing factor, but that certain inherited peculiarities of the teeth might favor the lodgement of food and micro-organisms and thus predispose to caries; and that the environment of the teeth and consequent liability to caries is similar in certain families and races, on account of the similarity in diet and other customs.

An important factor in the predisposition to caries lies in the relative lodgeability of the various food-stuffs. He believes the fibrous food-stuffs have a detergent action upon caries, in that these foods are less liable to acid fermentation. Comparing the conditions of the mouth following a meal made from flesh of any kind and that following a meal made from starchy foods, a marked difference is noticed in their relative cleanliness. In the former the mouth is comparatively clean, only a few fibres remaining between the teeth, and these easily removed, while in the latter the inter-approximal spaces and the fissures of the teeth are packed full of fermentable material, which is difficult to thoroughly remove, and thus are established all the conditions which are most favorable for the production of lactic acid fermentation and the decay of the teeth.

Mouth-Bacteria and Carbohydrates.—The chief source of nourishment for micro-organisms in the human mouth, according to Miller, is furnished by two groups of substances, the carbohydrates and the albuminoid substances. These are almost constantly found in the human mouth, either in the sulci and fissures of the teeth, in the approximal spaces, or upon their free surfaces. These substances are readily acted upon by the zymogenic and saprogenic bacteria. In all forms of fermentation there is a limit under ordinary circumstances to the quantity of the waste products produced by zymogenic bacteria.

Black states: "It is an established law that the waste products of an organism become poisonous to that organism when they have collected in a certain quantity. This is true of urea in the animal, it is true of alcohol in the vinous fermentation, and Miller found it to be true of the organism causing caries. When lactic acid has accumulated in certain quantity (this amount not yet definitely determined) the further development of the organism is interfered with. Their power to go on producing lactic acid in the depths of the dentin is accounted for by the formation, from the lime-salts of the tooth, of the lactate of lime, which does not interfere with the further development, and, in fact, is equivalent to a removal of the waste product. Long before the existence of a special organism in lactic fermentation was known, it had been found that by adding chalk or other form of lime the fermentation could be continued and much more lactic acid produced. Following up these facts, Miller has analyzed carious dentin and found it to contain calcium lactate."

From the foregoing facts the student will readily understand why, as a

* The Cause and Prevention of Decay in Teeth.

rule, dental caries when once established steadily progresses—more or less rapidly—until the tooth is completely destroyed.

Were it not for the presence of the calcium in the structures of the tooth with which the lactic acid combines, forming lactate of calcium, the waste product of the organism—lactic acid—would soon destroy the bacterium, and the progress of the disease would be arrested.

The carbohydrates in undergoing fermentation produce an acid reaction, while the decomposition or putrefaction of the albuminoid substances present an alkaline reaction. When these substances are mixed they are, as a rule, accompanied by an acid reaction. Consequently the reaction from the fermentation of food *débris*—which is usually composed of carbohydrates and albuminoids—will be found most often to give an acid reaction. This, however, is not an invariable rule, for Miller found that the reaction depended partly upon the nature of the food found in a particular part of the mouth at the time and partly upon the particular kind of bacterium which was acting upon it.

In the case of one bacterium which he examined in reference to this question, he found that when it was cultivated in a three per cent. solution of beef extract, in the presence of one-tenth per cent. of sugar, it gave a neutral reaction, but upon increasing the amount of sugar the reaction became acid, and upon diminishing it the reaction became alkaline.

Miller, in another series of experiments instituted to determine the action of the mouth bacteria upon the carbohydrates, found that out of twenty-two varieties, sixteen in a very short time produced an acid reaction when cultivated in beef-extract, peptone-sugar solutions ; four under the same conditions gave an alkaline reaction, while in only two did the reaction remain neutral.

Following this with another series of experiments with twenty-five mouth-bacteria, thirteen stomach-bacteria, and fourteen intestinal bacteria, instituted for the same purpose, sixteen of the mouth-bacteria gave an acid reaction, four alkaline, and five inconstant results ; of the thirteen stomach-bacteria, nine produced an acid reaction, two alkaline, and two inconstant results ; of the fourteen intestinal bacteria, six gave an acid reaction, five alkaline, and three inconstant results. Miller, in his next series of experiments, undertook the task of demonstrating by qualitative analysis the character of the acids formed by the acid producing mouth-bacteria. It was generally believed up to this time that the lactic acid fermentation could not be brought about except in the presence of one specific micro-organism,—viz., the *bacterium acidi lactici*. Miller had discovered, however, some time previously, that *several forms of bacteria* found in the human mouth were capable of forming lactic acid out of sugar. This discovery has since been verified and established by various investigators, as well as the fact that a large number of bacteria are possessed of inverting and peptonizing properties.

Out of eighteen different forms of acid producing bacteria, Miller found as a result of his labors that *ten of them produced lactic acid.* Among the other products of fermentation of these bacteria were formic, acetic, and butyric acids, "the latter, however, in very small quantities."

Lactic acid, however, requires for its production in the mouth,—

1. Substances which are capable of being converted into glucose, $C_3H_{12}O_6$,—viz., the three groups of carbohydrates,—glucoses, $C_6H_{12}O_6$; saccharoses, $C_{12}H_{22}O_{11}$; and amyloses, $C_6H_{10}O_5$.

The carbohydrates of the glucose group which are most common in the food of human beings are grape-sugar (dextrose) and fruit-sugar (levulose), cane-sugar of the saccharose group, and starch, cellulose, and gum in the amylose group.

Hydration converts grape-sugar into two fermentable substances, *levulose* and *dextrose*, their chemical composition being the same, $C_6H_{12}O_6$. This change is brought about by the action of such organized ferments as ptyalin and amylopsin. The conversion of starch into glucose is represented by the following formula: $\underset{\text{Starch.}}{C_6H_{10}O_5} + H_2O = \underset{\text{Glucose.}}{C_6H_{12}O_6}$.

2. The fermentable carbohydrates must be acted upon by ferments capable of converting these substances into lactic acid. These ferments are constantly found in the human mouth in the form of various zymogenic bacteria, while the necessary conditions for their growth and development—heat and moisture—are ever present.

The fungi have the power to cause the sugar to split up without the formation of carbon dioxide, a molecule of glucose, $C_6H_{12}O_6$, forming two molecules of lactic acid, $2C_3H_6O_3$.

It is noticeable, however, that caries does not always progress with the same rapidity in the same individual or in different individuals; that the character of the disease is not always the same; that certain teeth are attacked, to the exclusion of others, while there is a marked difference in the extent of the disease between individuals and in the same individual at different periods of life, and under varying conditions of health.

The question very naturally arises as to the cause or causes for these differences. Are they *due to the degree of vital resistance possessed by the individual at the time, or by individual teeth?* Or are there conditions *operative within the mouth which favor the growth of the lactic acid producing ferments at one time and retarding them at another?* It is not at all improbable that in the multitude of mouth-bacteria some form inimical to the growth of lactic acid forming organisms may under certain conditions gain the ascendency for a time, and thus in a measure control the production of the lactic acid ferment. The further study of these organisms may yet discover such a bacterium which, introduced into the mouth, will retard or prevent the growth of lactic ferments, and thus solve the problem of the prophylaxis of dental caries.

The tendency to caries is always augmented in certain forms of disease, like the continued fevers, tuberculosis, anæmia, and all wasting affections. These abnormal conditions of health not only reduce the vital resistance of the general system and lower the *vis naturæ* of individual tissue, but they produce abnormal conditions of the buccal secretions which favor the growth of the zymogenic mouth-bacteria. It is therefore possible that both of these factors act together under the conditions indicated, not only to increase the tendency to caries, but also the extent of the disease and the rapidity of its progress.

Mouth-Bacteria and Albuminoids.—It is generally recognized at the present time that a great number of the bacterial forms possess the power of liquefying, digesting, or peptonizing coagulated albumin and collagen, which forms the basis substance of dentin and bone.

Miller says, "By far the majority of mouth bacteria, in fact, of all bacteria, possess an action similar to pepsin, in converting coagulated albumin into soluble modifications." The bacteria possess the power of peptonizing these substances in either an acid, alkaline, or neutral medium, while pepsin acts only in the presence of acids, preferably hydrochloric. Albuminoid substances are, therefore, excellent media upon which to cultivate bacteria.

Miller found the products of mouth bacteria cultivated upon albuminoid substances to be the same as those developed from the putrefaction of organic substances in general.

These are principally malodorous and noxious gases—sulphuretted hydrogen (H_2S), ammonia (NH_3), carbon dioxide (CO_2)—and numerous substances, such as formic, acetic, butyric, valeric, and other acids.

He also found that four of the mouth bacteria which he examined would not grow upon coagulated albumin; six had but a limited growth, while all the others "developed comparatively well, in some cases completely liquefying the albumin."

It will thus be seen that the mouth bacteria are capable of producing dental caries, that certain of them possess the necessary properties for forming acids, which, acting upon the lime-salts of the enamel, disintegrate this tissue and thus permit the entrance of these organisms into the dentinal tubuli, where they continue the process by dissolving or abstracting the lime-salts from the dentin, and that afterwards certain other forms liquefy, peptonize, or digest the basis substance, thus removing the organic tissue and forming a cavity of decay.

Bastyr (1885), in commenting upon the active causes of dental caries, says, "As long as it cannot be shown that the appearances observed in the decay of living teeth, decay of dead (pulpless) teeth in the mouth, and artificial caries show any appreciable differences, so long will every attempt to explain decay as a vital process be very difficult."

Black (1886), in discussing the germ theory of caries as promulgated by Miller, says, "The fungus has no power of attacking anything, or growing into anything, except it be a thing that offers spaces filled with soft tissue, or openings into which it may grow as the vine grows through spaces in a lattice-work.

"It is not the organism that makes the attack, but the products of the organism, the lactic acid.

"When the dental tubules are once exposed, they form a protection to those filaments of the fungus which strike into them in the process of growth, and development occurs in that direction. Hence the continuous progress of caries when it has once fairly begun in the dentin. Then the growth will continue in any direction in which space is offered for the development of filaments. In this way the tubules become packed full of the organisms, and the surrounding dentin is always decalcified in advance of the growth of the fungus by the lactic acid produced. That this is the true explanation of the etiology of dental caries there is no longer a reasonable doubt."

Gysi (1887), in writing upon the chemico-parasitic theory of caries, remarks, "As all my experiments and investigations upon this subject have presented facts which are consistent with it, I accept it as a satisfactory explanation of the etiology of the disease."

Pierce (1888) endorsed this theory in the following words: "I am a firm believer in the fact that dental caries cannot progress without these low forms of life."

Sudduth (1888) says, "Dr. Miller's theory of the formation of cavities by the action of a digestive ferment upon the basis substance of dentin has been the only theory ever advanced that explained the formation of cavities."

Allan (1889) maintains that "the germ theory is the only one so far presented that clearly and satisfactorily accounts for the acid," and, further, that "the 'germ theory' fully explains the distended tubules and the broken-down basis substance."

Caries of the Enamel.—Up to a very recent period our knowledge of the phenomena of caries of the enamel has been very meagre.

Miller, in his earlier descriptions of the phenomena, etiology, and morbid anatomy of dental caries, did not give a very clear and distinct idea of the *modus operandi* of caries in the enamel, but his later suggestions and observations, correctly interpreted, led the way to the more definite discoveries of Williams in the morphology and histologic anatomy of the enamel, described in Chapter III., Histology of the Dental Tissues, to which the student is referred.

Williams (1898) found, in studying enamel structures, that in decalcifying sections of fully formed enamel the acid attacks the interprismatic substance first, and the rods fall apart, proving conclusively that the substance is one which is acted upon by acids.—viz., *calcareous material, and not an organic basis substance composed of animal matter, but more readily acted upon than the enamel-rods themselves.* If the process of decalcification was continued, the enamel-rods were attacked and the whole structure destroyed, leaving behind no evidence whatever of an organic matrix.

Sections of enamel treated by a one per cent. solution of chromic acid —which does not destroy organic substances—left no trace of organic material; hence it can be positively stated that fully developed enamel contains not the slightest evidence of an organic matrix.

Williams, in his studies of caries of enamel, found zooglœa masses of micro-organisms adherent to the surface of the enamel, probably attached to the remains of the enamel cuticle and lining the surfaces of the cavities of decay. He says, "Lining the cavities or covering the surface where decay has commenced, there is always to be seen a thick, felt-like mass of acid-forming micro-organisms. This mass of fungi is so dense and adhesive as to make it highly improbable that the enamel is affected, except in rare or special instances, by any acid other than that which is being excreted (lactic) by the bacteria at the very point where they are attached to the enamel. This thick, glutinous-like mass of fungi also prevents the excreted acid from being washed away, so that it exerts its full chemical power upon calcified tissue." This idea was first suggested by Ficinus as far back as 1847.

Dilute lactic acid produced appearances upon sections of fully formed enamel that were identical with those produced upon this tissue in the progress of natural caries.

Decalcification of the enamel proceeds most rapidly along the line of the enamel-rods when the process has once been established. The bacteria growing into the spaces formed by the solution of the interprismatic cement substance cause fracture and dislodgement of masses of partially decalcified enamel-rods, and thus hasten the process of cavity formation.

In cases of rapid caries, Williams found streptococci almost always present, while in caries of slow progress ("backward decay") the large cocci and diplococci were always found. In the direct caries of enamel the cavities are lined with leptothrix and thread-like forms.

The leptothrix Buccalis maxima and the bacillus Buccalis maximus of Miller are nearly always found, the latter more sparingly.

Beneath the felt-like masses of thread-forms, and lying in contact with the decomposing enamel in direct decay, and also in deep cracks and fissures in backward decay, there is invariably found a short, thick bacillus, usually constricted in the centre.

Williams suggests that possibly the variety of the organism found in these forms of enamel decay may be the governing factors in the rapidity of the progress with which dissolution of the enamel takes place.

In the light of these discoveries it may be stated with certainty that the first stage of dental decay is characterized by a softening of the enamel, which is brought about as a direct result of the presence of carbohydrates which undergo fermentation through the action of certain zymogenic bacteria, and that these organisms are retained in protected positions through the formation of a gelatin-like substance secreted by themselves or certain other organisms present in the mouth, thus forming zooglœa masses which adhere to or become glued to the surfaces of the teeth.

By this means the acid formed by the zymogenic organisms are kept in contact with the enamel and prevented from being washed away, as would undoubtedly be the case were it not for the presence of this protecting envelope, thus permitting the full chemical action of the acid upon the enamel to go on undisturbed.

Caries of Dentin.—In studying the etiology of dental caries we have found that the same acid-producing ferments or micro-organisms were accountable for the production, initiation, and progress of the disease in all of the calcified tissues of the teeth, and that the saprogenic bacteria, or possibly the same zymogenic organisms, liquefied the basis substance and removed it, thus causing a gradual dissolution of these tissues until the entire organ is destroyed.

The lactic-acid-producing organisms belong to the *facultative* variety of bacteria. This has been proved by the fact that they grow and develop equally well upon the surface of the enamel wherever lodgement can be found, in the presence of the oxygen of the atmosphere, and in the tubuli of the dentin in which the oxygen of the atmosphere would be excluded by the presence of the fluids of the mouth.

This fact explains the progress of caries which occasionally occurs under fillings having perfect margins, in which, for reasons that have seemed good to the operator, portions of decalcified dentin have been permitted to remain in the bottom of the cavity, but have not been thoroughly sterilized by dehydration and antiseptics.

For the growth of micro-organisms three conditions are absolutely necessary,—*heat*, *moisture*, and *a proper soil* or food-supply; cut off any one of these and the organism will cease to develop.

The permanent arrest of caries, therefore, from the therapeutic standpoint, sums itself up into, *first*, so preparing a carious cavity that the food-supply of the micro-organisms and the decalcified tissue is thoroughly removed, and, *secondly*, in so inserting a plug or filling as to hermetically seal it.

Without the ingress of moisture, or the presence of the elements from which the bacteria elaborate lactic acid, the progress of the disease must be arrested.

Susceptibility and Immunity.—Susceptibility to caries has generally been considered to be one of local environment, dependent upon the structural defects of the enamel and dentin and conditions which favored the development of the lactic-acid-producing micro-organisms. While immunity has been thought to be the result of perfectly developed dental tissues and conditions which retarded or prevented the formation of lactic acid, the degree of susceptibility, it was thought, was governed by the extent of the structural defects and the numbers and rapidity of development of the micro-organisms of decay.

The investigations of Black (*Dental Cosmos*, May, 1895) and of Williams (*Dental Cosmos*, March and April, 1897) have conclusively shown that dental caries is not dependent upon the structural defects or imperfections of the dental tissues nor to their degree of calcification.

Black determined by laborious and painstaking laboratory experimentation that human teeth show wide differences in physical structure of both the dentin and the enamel, ranging from that in which the enamel is practically perfect in all of its parts to those which present grave imperfections of its physical structure, such as imperfectly closed developmental grooves, which leave fissures, pits, and openings of various sizes and shapes.

The dentin also presents marked deviations from a physical perfection of structure. In some instances the dentin is very perfect, in others the interglobular spaces are exceedingly numerous and the granular areas present many physical imperfections.

These investigators have both shown that these physical imperfections are in no wise a cause of dental caries, for among persons wholly immune to caries these imperfections are relatively as frequent as in those persons who suffer from caries, and that even when the imperfections of the enamel are such as to expose the dentin, no decay has occurred in a lifetime, as, for instance, in the imperfections of structure due to inherited syphilis and arrests of development caused by the exanthematous disease of early childhood, etc.

Black * thinks these facts prove beyond a doubt that structural imperfections, at most, only give greater opportunity for the active agents of caries to do their work, and have no further relation to that cause. In other words, physical imperfections of the enamel and dentin are simply local predisposing causes of the disease.

Teeth, therefore, which present the most faulty structure may not decay, and will not decay in persons who are immune to caries, while teeth of the most perfect physical structure will succumb to caries in persons who are at the time susceptible to the disease.

The active agents of caries are to be found in every mouth, and in sufficient quantities to produce the disease, and yet in certain individuals there is a complete immunity through a lifetime, while in others there may be various periods of susceptibility and immunity which seem to have no discovered relation to the local environment or condition of the health.

The formation of the gelatinous plaques or zooglea masses by the caries fungus, as shown by Williams to be necessary to start the process of caries in the enamel, are not found in all mouths, though the organisms may be there and growing. The power of the organism to form gelatin, according to Black, seems to depend upon something in the saliva, the nature of which has not been discovered. These facts seem to throw some light upon the subject by indicating the direction in which future investigation should proceed.

At the risk of being considered over-sanguine, the writer suggests that a means of preventing caries will yet be discovered, and that it will be in the nature of an antagonist to those organisms which have the power of forming gelatin in the oral fluids.

Black is of the opinion that susceptibility is influenced by an inherited predisposition to the loss of the teeth, or of especial teeth at certain ages; by changes of environment, either of climate or mode of life; by the age of the individual, the young being most susceptible, while immunity usually comes with adult age; and by the fluctuations of bodily conditions which change the character of the oral secretions.

It should be remembered that dental caries occurs in a cavity of the body that is constantly bathed by a secretion containing vital cells, which are subject to very considerable physiologic and pathologic variation, dependent upon the state of health of the individual.

It is a well-known fact that the organisms of diphtheria and pneumonia are not infrequently found in the mouths of individuals who are in a normal state of health, with no manifestations of local infection, which proves conclusively that the power of many pathogenic bacteria to produce

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* Dental Cosmos, September, 1899.

specific disease depends upon the local environment and the state of health or the resistive power of the general system.

Phenomena of Caries of Dentin.—The invasion of the dental tissues by caries begins by the decalcification of the enamel, either in some fissure, pit, or crack, which may be only microscopic in size, or upon roughened surfaces which have given lodgement and protection to the zymogenic organisms, most commonly the approximal, labial, and buccal surfaces, as shown in Fig. 272.

The margins of the cavity usually present more or less discoloration or opacity, while the enamel will be found softened by decalcification and broken down. Sections of teeth cut through a cavity of decay in the enamel show immediately beneath an exposure of the dentin with softening and discoloration. Closer inspection reveals, lying between the floor of the cavity and the pulp-chamber, several peculiarities in the color, the degree of decalcification, the transmission of light, and certain changes in the size and form of the tubuli.

Pigmentation.—The color in ordinary caries at the surface of the cavity is yellowish brown, but it shades off as it reaches towards the pulp into the normal color of the dentin. In caries of rapid progress the color is white or yellowish white, while in caries of slow progress, or in arrested caries, the color is dark brown or black. *The more rapid the progress of caries the lighter the pigmentation.* It was thought at one time that the color was produced by the carious process or by the micro-organisms. The fact, however, that the discoloration can be easily and perfectly reproduced out of the mouth, with teeth which have been acted upon to any considerable extent by acids, proves conclusively that it is not due to the process of caries nor to bacteria. To accomplish this, place such teeth in water holding in solution a small quantity of sulphuretted hydrogen, fill the vessel, and place it in a dark closet to prevent decomposition of the solution, and the tissues of the teeth, to a point as deep as that affected by the acid, will gradually assume a dark color. (Black.)

Decalcification.—The degree of decalcification grows less and less from the surface of a carious cavity until normal dentin is reached. (See Fig. 273.)

The outermost layers of the dentin will generally be found completely decalcified, the basis substance being soft and leathery, and having an odor like that of gangrenous lung-tissue.

Beyond the line of partial decalcification is a transparent zone known as the *zone of Tomes* (Fig. 274), which its discoverer and Magitot have maintained was caused by vital action, or resistance of the tissue to the encroachment of the disease, and produced by the filling up of the dentinal tubuli with calcific material, and thus making it more easily penetrated by rays of light. It is in appearance very similar, both macroscopically and microscopically, to the senile dentin, the dentin of the crowns of teeth worn down by mechanical abrasion, and the roots of teeth which have remained long in the mouth without dental decay.

Miller, by quantitative analysis, has shown that it contains more calcium salts than the surrounding normal dentin. Walkhoff thinks that

FIG. 272.—Vertical section of deciduous molar, showing caries of enamel which started in a fissure, and of the dentin which had its origin in an approximal cavity of decay. × 8.

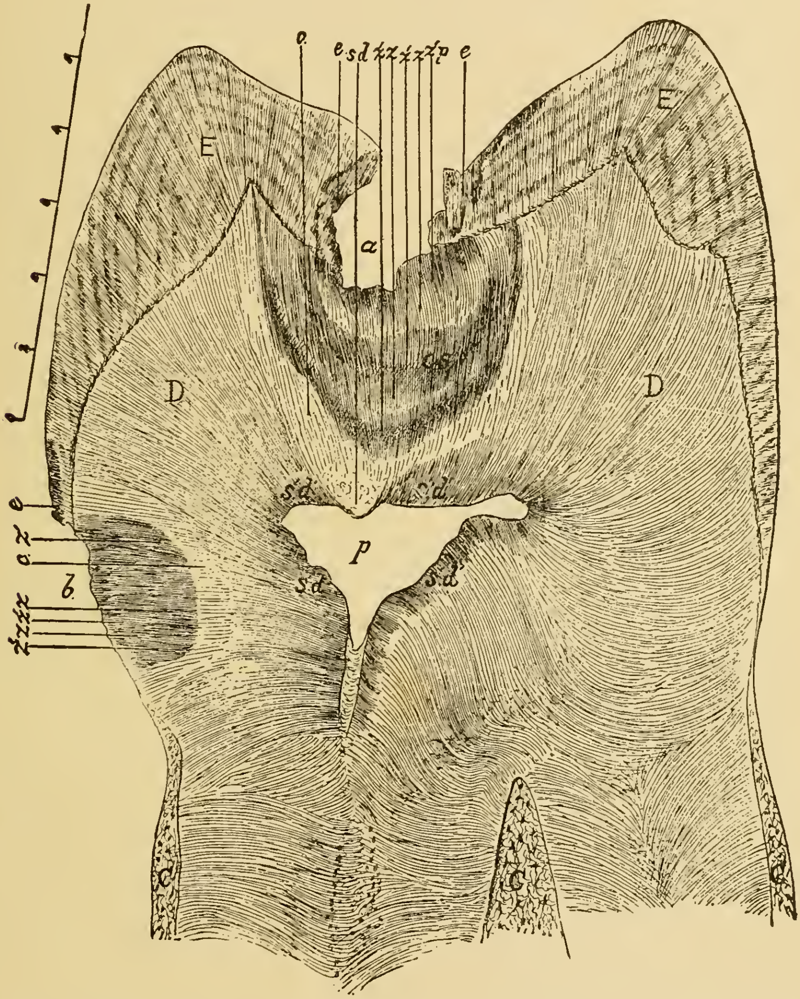
FIG. 273.—Carious dentin from base of cavity. (V. A. Latham.) × 46.66. *A*, infected tubules; *B*, enlarged tubules; *C*, infected interglobular spaces.

FIG. 274.—Undermining caries of enamel, showing transparent zone of Tomes at A. (R. R. Andrews.)

FIG. 276.—Dentinal tubules from infected dentin, showing enlargement of the tubules and the presence of micro-organisms within them. (Tomes.)

it is an evidence of vital or formative activity induced by the stimulation of irritation, causing the production of an intercellular substance at the surface of the cells and primarily of their offshoots.

Fig. 275.



Longitudinal ground-section of crown of an inferior molar of a negro. This figure is drawn from a ground and polished section mounted in Canada balsam. (Gysi.) E, enamel; D, dentin; C, cement; *p*, pulp-chamber; *a*, large decay, from the grinding surface; *b*, small decay, from the mesial surface; *cs*, zone of septic invasion and discoloration; *e*, partially decalcified and discolored enamel around the carious cavity; *z*, dark zones; *z'*, clearer zones; *z'p*, oldest zones, where putrefaction of the tooth-cartilage begins; *c*, outer transparent zone, or zone of Tomes; *sd*, secondary dentin, caused by irritation; *s'd'*, secondary dentin deposited by normal physiological process, recession of the pulp.

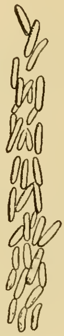
It will be noticed, also, as pointed out by Gysi, that the transparent zone which lies between the carious dentin and the pulp is continuous with a new formation of dentin—secondary dentin—upon the wall of the pulp-chamber (Fig. 275).

Burchard thinks "these evidences point to the truth of Walkhoff's explanation of the process, and indicate that the transparent appearance is the result of vital reaction."

Fig. 277.

Single tubule filled with cocci. (Miller.) 1100:1.

Fig. 278.



Single tubule filled with rods. (Miller.) 1100:1.

Fig. 279.

Single tubule showing a mixed infection with a pleomorphous bacterium. (Miller.) 1100:1.

Fig. 280.

Decayed dentin, showing a mixed infection with cocci and bacilli. (Miller.) 400:1.

Fig. 281.

Longitudinal section of decayed dentin, showing infection with rod- and thread-forms. (Miller.) *a*, tubule distended, but walls still comparatively intact; *b*, *d*, tubular walls broken through and the dentin in a state of complete dissolution; *c*, tubules out of focus. Circa 500:1.

It is still, however, an open question as to whether the transparent

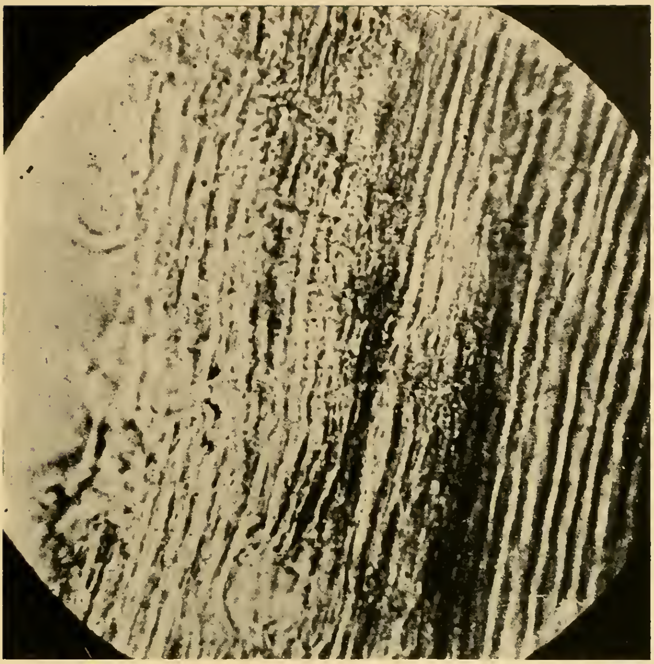


Fig. 282.—Vertical section of infected human dentin, showing the presence of micro-organisms and enlargement of the tubules. (R. R. Andrews.)

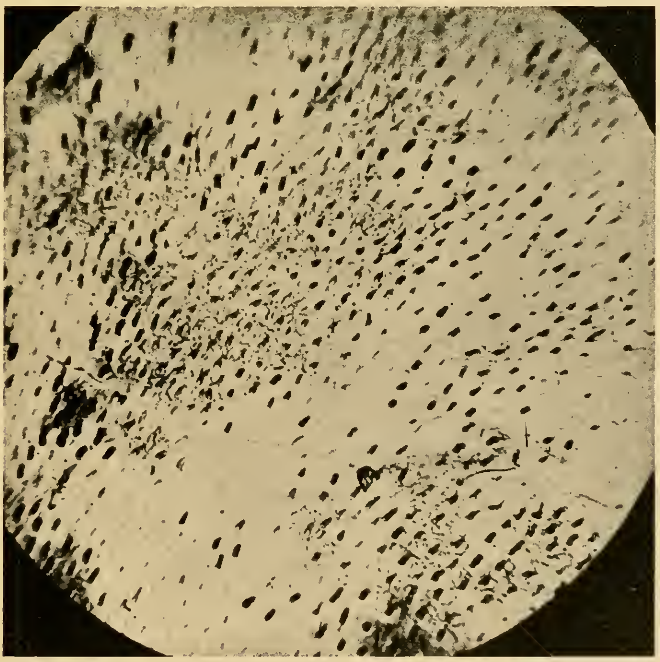


Fig. 283.—Transverse section of infected human dentin, showing the presence of micro-organisms and various enlargements of the tubules. (R. R. Andrews.)

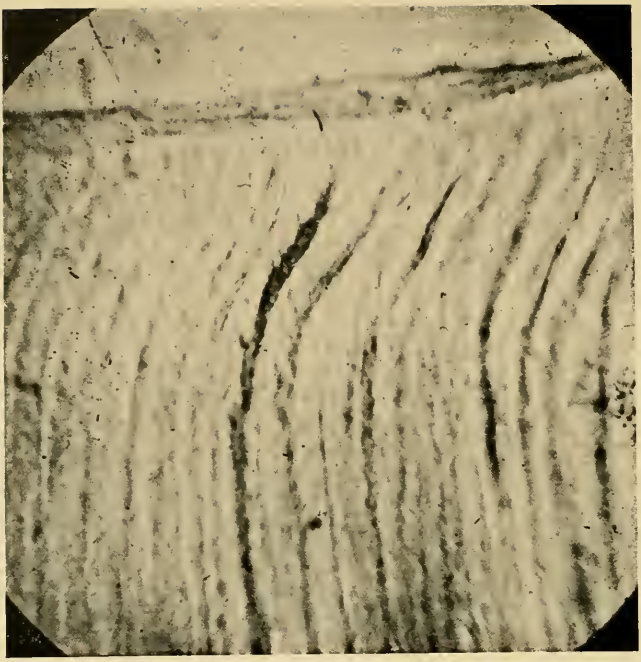


Fig. 284.—Vertical section of infected human dentin, showing tubules greatly enlarged and filled with micro-organisms. (R. R. Andrews.)

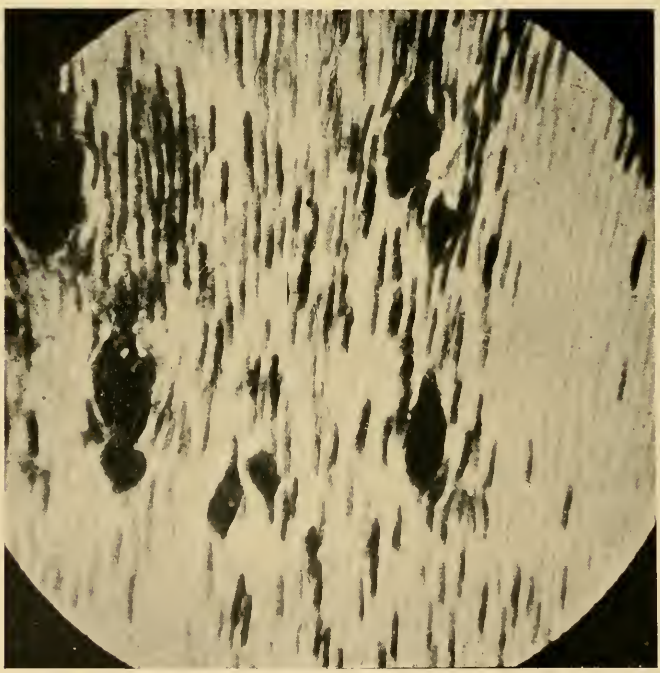


Fig. 285.—Infected human dentin, showing confluence of enlarged tubules forming cavities which are filled with micro-organisms. (R. R. Andrews.)

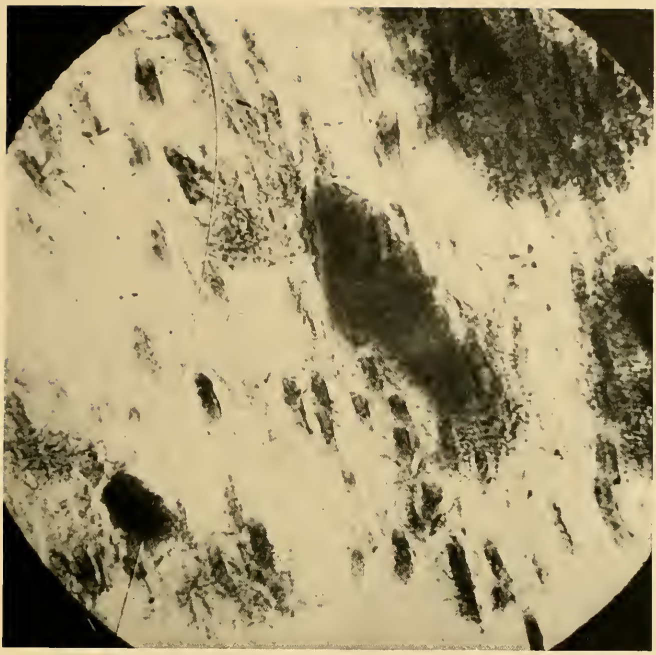


FIG. 286.—Oblique section of infected human dentin, showing confluence of tubules forming larger cavities. (R. R. Andrews.)

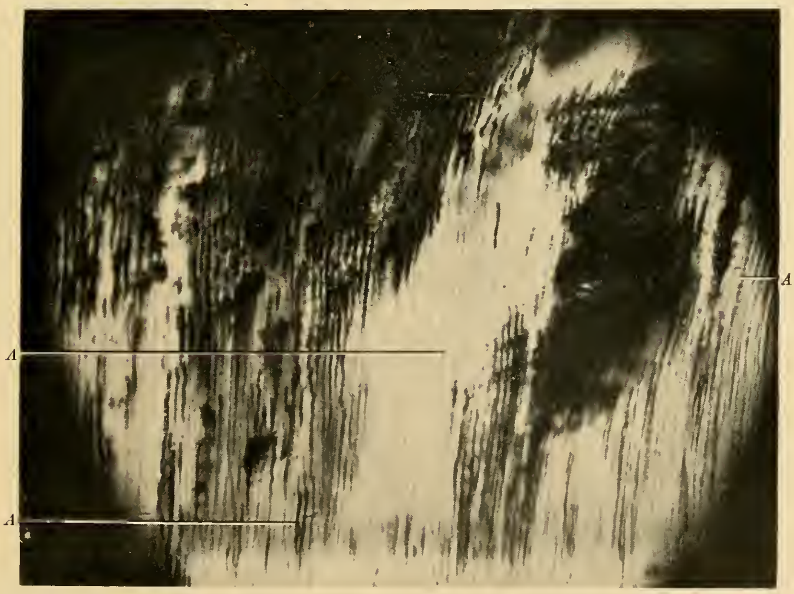


FIG. 287.—Infected human dentin, showing advanced state of infection. (V. A. Latham.) × 100. A, A, A, micro-organisms in the tubuli. The dark portion shows decalcified and discolored areas of dentin.

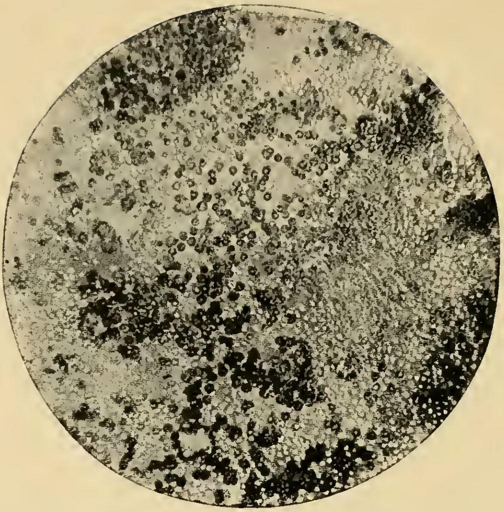


FIG. 288.—Transverse section of human dentin, showing pipe-stem appearance of infected dentinal tubules. (Tomes.)

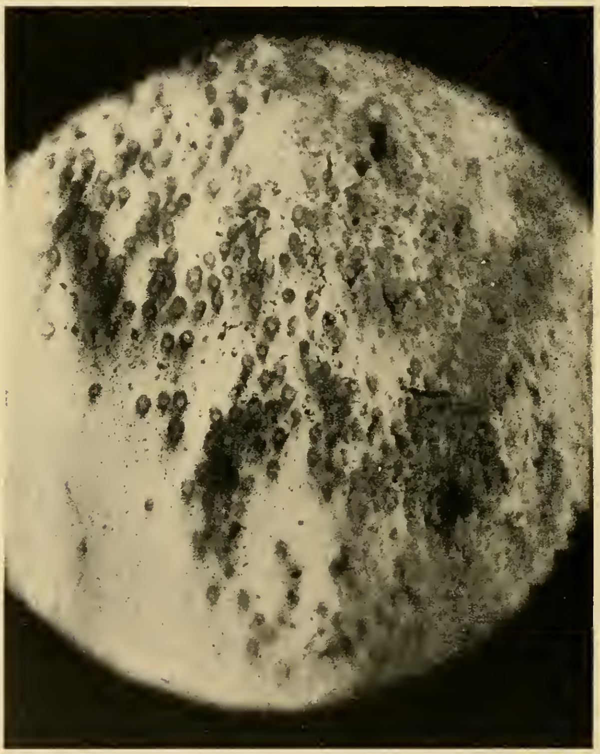


FIG. 289.—Transverse section of dentinal tubules. (V. A. Latham.) × 162.5. The dark tubules show infection with micro-organisms and the pipe-stem appearance described by Tomes.

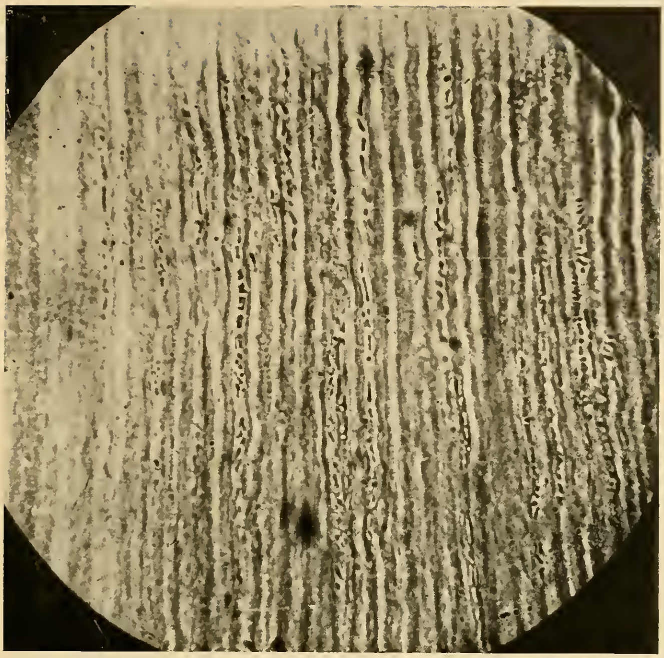


FIG. 290.—Longitudinal section of infected human dentin, showing the pipe-stem appearance of the tubules described by Tomes. (R. R. Andrews.)

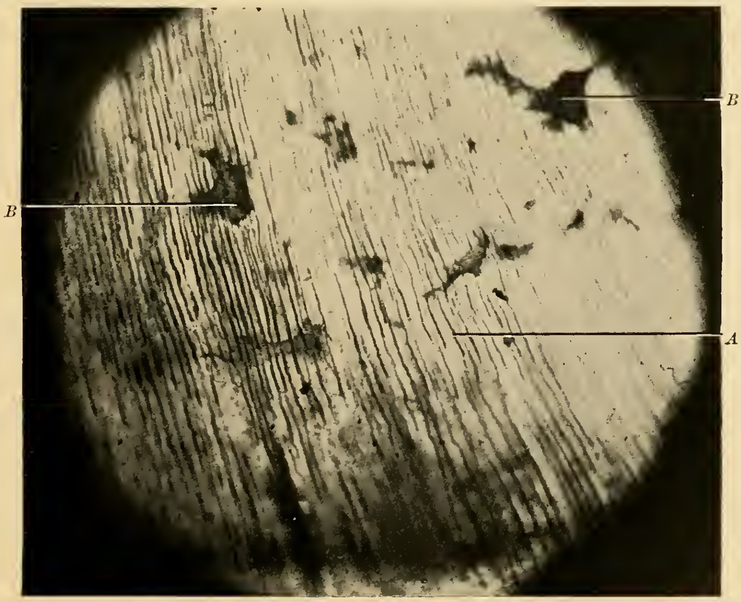


FIG. 291.—Infected human dentin. (V. A. Latham.) × 162.5. *A*, micro-organisms in the tubuli; *B*, *B*, micro-organisms in the interglobular spaces.

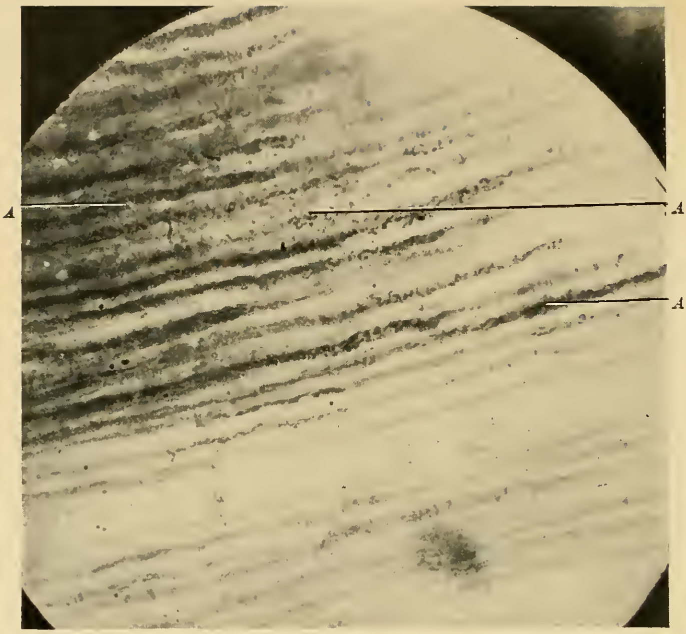


FIG. 292.—Infected human dentin. (R. R. Andrews.) *A*, *A*, *A*, showing penetration of micro-organisms in the tubuli.

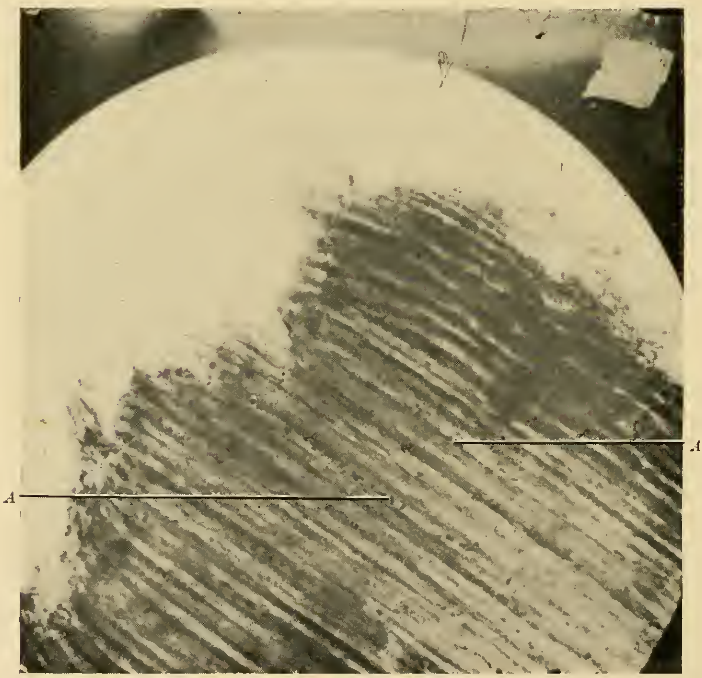


FIG. 293.—Infected human dentin. (R. R. Andrews.) *A*, *A*, showing penetration of micro-organisms in the tubuli.

zone is or is not a real zone of resistance to the encroachment of the disease and effective in retarding its progress. Clinical observation and experience would seem to indicate that it has an effect upon the dentin which renders it more resistant to the progress of the disease.

Expansion of the Tubuli.—Sections of carious dentin cut parallel with the long axis of the tubuli, which have been stained with fuchsin or gentian violet, show these tubules to be considerably enlarged, with swellings or molecular expansions upon individual tubes (Fig. 276).

There is, however, no uniformity in the enlargement of the tubules or of the nodular expansions. Some tubules will be very much enlarged, while others will seem to be only slightly affected. Walkhoff declares the dentinal tubuli are regularly enlarged, and that the varicosities appearing at irregular intervals are occasioned by the drying of the specimen.

Upon further examination with higher powers of the microscope it will be discovered that the tubuli in the superficial, softened, and decalcified dentin are filled with bacterial forms, cocci, rods, and threads, the coccus forms predominating.

Fig. 277 shows a single tubule filled with cocci; Fig. 278, one filled with rods. Fig. 279 shows a mixed infection of cocci, diplococci, short and long rods, or infection with a pleomorphous bacterium (polymorphous). Fig. 280 shows several tubules in decaying dentin filled with a mixed infection of cocci and bacilli, while Fig. 281 shows a longitudinal section of decayed dentin which is infected with rod- and thread-forms. Figs. 282, 283, 284, 285, 286, and 287 show the micro-organisms as they appear in slides made from decaying dentin.

In the deeper layers of decalcified dentin the bacteria become less and less in numbers, until they finally disappear. Beyond this non-infected point, however, there is a zone of partially decalcified dentin, the removal of the lime-salts being caused by the solvent action of the lactic acid produced by the bacteria lodged within the tubules.

Cross-sections of decaying dentin exhibit a very peculiar appearance of the dentinal tubuli, or rather of the sheaths of Neumann (Fig. 288), which are, according to Tomes, greatly thickened, and the lumen partially obliterated, giving the section the appearance of having been built up of a multitude of tobacco-pipe-stems (Fig. 289). Such is the condition at a certain stage of their disorganization.

In longitudinal sections examined at a later period the sheaths appear to break up into short lengths or sections, and are found twisted; and, finally, the whole tissue undergoes disorganization into minute granules, which are by degrees washed away by the fluids of the mouth.

Disorganization of the Dentinal Fibres.—The contents of the tubuli—Tomes fibres—also appear to undergo disorganization and break up into pipe-stem sections or short rods (Fig. 290). This was first noticed by Tomes.

This peculiar appearance has not been satisfactorily explained. Tomes says, "These rods may be portions of consolidated fibrils, or they may be bits of the sheaths of Neumann, or they may be mere casts of the enlarged tubules."

Wedl, however, thinks the statement that they are consolidated fibrils is not proved. Miller is of the opinion that they are calcified fibrils, as he has observed their rapid disappearance while viewing them under the microscope when the specimen was treated with dilute sulphuric acid.

Another peculiarity is also observed in the dentinal tubuli in the form of shining or glistening granules. These are seen occurring in the early stage of caries, and sometimes in the zone just in advance of the carious process. Some observers, Tomes, Magitot, and others, have thought them to be lime formations thrown out by the odontoblasts for the purpose of resisting the advance of the disease. Wedl, Black, and others looked upon them as fat-globules. Baume has shown conclusively, however, that these globules are not particles of fat, since they do not disappear when treated with sulphuric ether.

Miller thinks these granular bodies cannot be lime formations thrown out by the pulp, for they are found in caries of pulpless as well as living teeth, but regards it as not improbable that they have the same origin as the rod-shaped (pipe-stem) formations found in the tubuli.

PENETRATION OF CARIES.

Generally speaking, the line of progress or penetration of caries may be stated to be in the direction of the tubuli, or, in other words, from the surface towards the pulp. This, however, is not universally the case, for occasionally cavities will be found which have been formed in a direction transverse to the tubuli. The conditions which favor the formation of such cavities are usually, if not always, due to faulty formation of the dentin, interglobular spaces, thick granular layer, or other imperfections in the deposition of the calcoglobulin and its calcification. Such spaces offer admirable facilities for the penetration and growth of the micro-organisms and the lateral extension of the disease. Fig. 291 shows interglobular spaces filled with micro-organisms. In the ordinary form of caries the disease travels along the tubules by the penetration of the fungi into these open spaces (Figs. 292 and 293), and exposure of the pulp takes place before lateral spreading has progressed to any great extent. This is especially true of teeth of the best development, for observation proves that exposure of the pulp will occur in this class of teeth with the least destruction of tissue. "The more perfect the development the more completely will the penetration be confined to the direction of the tubules." (Black.)

CARIES OF CEMENTUM.

The etiology of caries of cementum is so nearly like that of decay of dentin that it hardly needs a special description, except that which grows out of the difference in the histologic structure. Decalcification is caused by the same micro-organisms that produce caries of dentin. The fungi first attack the calcified rods known as Sharpey's fibres, and penetrate to the cement-corpuscles and their canaliculi, decalcifying the surrounding tissue as in decay of dentin. The organic substance is then liquefied by the saprophytic bacteria and washed away.

CHAPTER IX.

DENTAL CARIES (CONTINUED).

Varieties of Caries.—The older writers were in the habit of dividing caries into several varieties, according to the physical signs presented by the disease, believing that these signs represented distinct forms of the affection, which they classified as follows: *caries humida*, moist caries; *caries acuta*, acute or rapid caries; *caries chronica*, chronic or slow caries; and *caries sicca;* dry caries or arrested caries. This classification of the disease is no longer used, as the affection is now known to be one and the same from beginning to end, the differences in the physical signs being due to the differences in the character or perfection of the structure of the teeth, the conditions of the general health, the character of the oral secretions, and the hygienic conditions which prevail in the mouth. All of these factors have an influence upon the extent and the rapidity in the progress of the disease, and are responsible for the differences in the physical signs.

Stages of Caries.—It is customary with most writers in describing dental caries to divide the disease into various natural periods or stages. Magitot divided the affection into three periods,—*first*, *second*, and *third.*

The *first period* he confined to the dissolution of the enamel. The *second period* to the destruction of the dentin. The *third period* to the involvement of the pulp-chamber.

A more exact division of the stages of the disease recognizes four distinct periods or degrees of progression:

First, superficial or incipient.

Second, progressive.

Third, deep-seated.

Fourth, complicated.

In the *first*, or *superficial or incipient*, *stage* (Fig. 294, *A*) the disease involves only the enamel or the cementum. This may be confined to the surface of these tissues or involve their whole thickness, forming a perceptible cavity, which may be more or less sensitive to sweets, acids, or thermal changes.

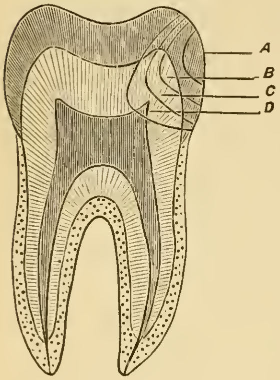
In the *second*, or *progressive*, *stage* (Fig. 294, *B*) the enamel or the cementum has been penetrated and the disease is extending into the dentin, forming a deeper cavity.

The *third*, or *deep-seated*, *stage* (Fig. 294, *C*) represents a more serious involvement of the dentin, reaching almost to the pulp-chamber; not, however, exposing the pulp, but causing irritation and making it necessary to protect it by some form of capping before inserting a filling.

In the *fourth*, or *complicated*, *stage* (Fig. 294, *D*) the disease has extended to the pulp-chamber, causing inflammation or death of the pulp.

The rapidity with which caries sometimes progresses often makes it impossible to distinguish the various stages one from another, while in such cases especially there is a lack of pigmentation. This form of the disease, which is sometimes termed *white decay* (caries humida), not infrequently in the course of a few weeks destroys one-half or more of the tooth and exposes the pulp. In the ordinary form of caries (caries acuta), sometimes designated as *brown decay*, the time required for the disease to penetrate from the enamel to the pulp-chamber is from six to eighteen months, while in that form known as *black decay* (caries chronica) the process is so slow that several years are required for the disease to penetrate to the pulp.

Fig. 294.



Vertical section of a lower molar tooth showing stages of caries.

Symptoms.—The symptoms of caries in its earlier stages vary from a mild drawing or gnawing sensation to that of acute pain. These symptoms are induced by the exposure of the dentinal fibrils to the irritating effects of sweets, acids, salt, changes of the temperature, and instrumentation.

The character and severity of the symptoms vary with different individuals, and in the same individual at different times and under varying circumstances.

Temperament has much to do with the character and severity of the pain experienced by people suffering from dental caries. Individuals possessed of exalted nervous irritability suffer much more than others, while in the same individuals certain conditions of health, like anæmia, dyspepsia, nervous prostration, mental worry, or other causes which depress the vital forces, as chlorosis and pregnancy, often greatly increase the susceptibility to pain and render the symptoms of caries very acute.

It is also a notable fact that many times in the *first* and *second stages* of the disease there will be great sensitiveness of the dental tissues, but as the process advances the sensitiveness diminishes until the pulp becomes involved.

Under ordinary circumstances the superficial layers of carious dentin are much more sensitive than those which lie deeper. This is also true of normal dentin. The peripheral extremities of the dentinal fibrillæ, or that portion of them which lies directly beneath the enamel and cementum, assuming that the fibrillæ carry sensation, are much more sensitive than at their deeper parts. This is true of peripheral nerves everywhere. The irritation attendant upon the carious process greatly increases the sensitiveness of the fibrillæ, and produces what is termed *hypersensitive dentin*. In certain individuals, however, the sensitiveness of their teeth is so slight that carious cavities can be excavated with little or no pain so long as the pulp is not invaded, the character or rapidity of the carious process seemingly making no difference.

And yet some of these individuals would be classed as possessing the temperament known as *nervous*, while others would be classed as *sanguine*, *bilious*, and *lymphatic*. Does this lack of irritability to stimuli, applied to the dentinal fibrillæ, lie in the fibrillæ themselves or in the general nervous system of the individual? Or is there some difference in the character of the micro-organisms which produce the disease, or in the irritating quality of the acid produced by them?

These are the questions which the writer has often propounded to himself, but has never been able to satisfactorily answer.

In the *third*, or *deep-seated*, *stage* of caries, severe pain is often experienced from the entrance of irritating substances or their application to the diseased dentin. When decalcification of the dentin has progressed to a point that reaches the pulp, but not exposing it, irritating substances having gained access to the cavity of decay, often cause hyperæmia of the pulp, and produce paroxysms of pain of a more or less severe character, lasting for a few minutes, or it may be for a much longer period. The irritation of the pulp may be so severe as to produce inflammation and death of the organ.

The *fourth*, or *complicated*, *stage* is usually ushered in by pain of a severe and prolonged character, from the invasion of the pulp-chamber, which, permitting septic infection, causes inflammation and death of the pulp.

It often happens, however, that the vitality of the pulp has been destroyed by the irritating and septic conditions accompanying the deep-seated stage of the disease, and the pulp-chamber will be found to be occupied by the remains of a gangrenous pulp; or the exposure of the pulp may have resulted in a low grade of suppurative inflammation which has become chronic; or inflammation of a chronic type may have resulted in hypertrophy of the pulp, which has more or less completely filled the cavity of decay.

Sensitiveness and pain, however, do not always accompany the progress of caries, even in the latter stages of the disease, and it is not uncommon with certain individuals to find the pulp-chamber invaded and the pulp in a gangrenous condition without pain being experienced at any period of the carious process.

Diagnosis.—The diagnosis of caries can usually be made without much trouble, and yet in some cases it becomes a matter of considerable difficulty. The disease is to be sought for in those locations which experience has taught the operator are the most vulnerable, and therefore the most likely to furnish evidences of tissue disintegration. These locations have already been indicated as found in the enamel in the natural fissures, sulci, and pits, upon the approximal, buccal, and labial surfaces, and not infrequently in cracks caused by traumatic injuries, and the expansion and contraction of the tissue incident to the great and rapid changes in temperature to which they are often subjected in going from a warm room to a cold outside atmosphere, often many degrees below zero; or in immediately following a mouthful of some hot fluid with another one of ice-water, a custom very common among Americans. These imperfections in the initial stage of the disease are frequently microscopic in size, but are, nevertheless, sufficiently large to give access to the organisms of caries.

The approximal surfaces of the teeth are the locations which are most often the seat of caries, from the fact that the inter-approximal spaces give constant lodgement for alimentary *débris*, and fluids are held by capillary attraction, thus favoring the processes of fermentation.

The lingual, labial, and buccal surfaces are most free from the carious process, and in the order named, while their most vulnerable points are the developmental furrows and pits and the cervical margins at the free edge of the gums.

Parreidt has ascertained that on an average one hundred carious teeth would be composed of twenty-six incisors and cuspids, twenty-eight bicuspids, and forty-six molars. Of the incisors and cuspids, ninety-eight per cent., on an average, decay on the approximal surfaces, and only four per cent. on the incisive, lingual, and labial surfaces. The bicuspids decay most frequently upon the approximal surfaces, the percentage being ninety-two; while the molars decay most often upon the morsal surfaces, the percentage being seventy-two; the approximal surfaces, twenty-eight; the labial and lingual, two. He says, further, "According to my observation, the first appearances of caries occur in sixty-four cases out of one hundred on the approximal surfaces of the teeth." These surfaces are often so close together that it is with extreme difficulty that the eye can detect the disease in its incipient stage without resorting to mechanical appliances for separation or the use of reflected artificial light.

The most difficult cases to diagnosticate, however, are those which give no evidence to the eye of disintegration of the enamel, but are so far progressed as to cause acute and severe pain. These most often begin in some tiny pit or fissure upon the morsal surface of the molars and bicuspids, or the buccal surfaces of the molars, in which the process of decay has been so rapid and the point of entrance of the micro-organisms so small that there has been no change in the color of the affected tissue. The discovery of such cases calls for a high degree of skill and unlimited patience.

Many such cases have been entirely overlooked by practitioners of consummate skill and large experience, and diagnosticated as neuralgia or as imaginary pains.

Too much care cannot be exercised in the examination and diagnosis of these cases, as a failure to find the cause often entails great suffering upon the patient and loss of reputation to the consultant.

The means which are used in examinations of the mouth have been fully described in Chapter VI., to which the reader is referred.

Prognosis.—The prognosis of dental caries, if no therapeutical or surgical means are introduced for its arrest or control, is, as a rule, extremely bad, for nearly every tooth so attacked will be sooner or later entirely destroyed.

The prognosis for those teeth which are operated upon according to the most approved methods of conservation will depend in large measure upon the thoroughness with which these methods have been applied, and the care which is afterwards given by the patient to the hygienic conditions of the mouth.

Recurrence of the disease at the margins of the filling after a few years will invariably occur if the operation has been faulty, or the patient has been neglectful of the ordinary means of cleansing the teeth and preserving the mouth in a healthful condition.

The disease in individual teeth may be arrested at any stage of its progress, and recurrence prevented, provided the therapeutic measures above indicated are faithfully followed, but the tendency to the affection cannot be eradicated except by the removal *in toto* of the predisposing and exciting causes.

Much, however, may be accomplished by the institution of certain prophylactic measures, which will be discussed in the following chapter.

CHAPTER X.

TREATMENT OF CARIES. PROPHYLAXIS.

Definition.—Prophylaxis (from the Greek προφυλαξις, caution; προ, beforehand; φυλασσω, to guard, to prevent). The prevention of disease; preventive measures; preventive medicines: hygiene.

The treatment of dental caries resolves itself into the application of those measures which aim at the prevention of the disease,—*prophylaxis,*—and those which are instituted to arrest the progress of the affection and remedy the defects and injuries which have been caused by it,—*therapeutics.*

Prophylactic treatment comprehends all of those measures which are instituted for the purpose of removing the exciting causes of the disease, and, as far as possible, rendering inoperative those causes which are predisposing factors.

The removal of the exciting causes of dental caries should, from the importance of the subject, receive our first and most earnest attention. As already indicated in a previous chapter, the science of dental surgery has not yet come up to the demands upon it in the prophylactic treatment of dental caries, and until such time as it does, the profession will not be fulfilling its highest obligations to its clientele.

Cleanliness of the mouth and teeth is the greatest of all prophylactic measures which can be instituted against dental caries. This statement needs no verification, for it should be patent to every one whose observation and operative experience have extended over even a limited period of time, as they must have noticed how exceedingly rare it is for caries to occur upon *smooth* surfaces of the teeth which are fully exposed to the friction of foods in mastication and the cleansing action of the tongue, lips, or cheeks, and the oral secretions.

The prevention of caries, therefore, should aim at securing perfect cleanliness of the mouth, for this implies the destruction of the zymogenic micro-organisms of decay, and the removal of their acid products and all fermentable material, as well as the correction, so far as possible, of those constitutional conditions which lower the vitality and tend to vitiate the oral secretions.

The value of perfect oral cleanliness is not generally understood by the public. Most people brush their teeth for purely cosmetic reasons, and not to prevent disease. It therefore becomes the duty of every dentist to so instruct his clients in the need of oral hygiene as a preventive measure against disease, and the means by which they may secure this condition, that they will fully appreciate its value, and intelligently strive to carry out the instruction in all of its details. These measures should consist of:

1. Instruction to parents in the care of their children in relation to general measures of hygiene,—food, clothing, exercise, pure air, bathing, etc.,—that the best possible development of the whole body, and consequently of the dental organs, may be secured.

2. In such a regular and systematic mechanical cleansing of the teeth and the mouth that the acid-producing bacteria and the fermentable substances upon which they grow may be thoroughly removed or reduced to the minimum.

3. By prohibiting or so limiting the consumption of such foods and confections as furnish the material for acid formation that the chief source of lactic acid may be eliminated or greatly reduced.

4. In such a systematic and intelligent use of antiseptics that the zymogenic bacteria may be destroyed, or their number and action so limited as to render them practically harmless.

Miller, in his experiments with the zymogenic bacteria of the mouth and the influence of certain prophylactic measures upon them, has rendered a service to humanity which is beyond calculation.

The great value of mechanically cleansing the mouth with the brush, toothpick, floss-silk, etc., he demonstrated by taking ten cubic centimetres of saliva from the mouth before cleansing it, and adding half a gramme of starch, and placing the mixture in the incubator. After cleansing the mouth an equal amount of saliva and starch were mixed, and, as before, placed in the incubator. The first mixture not only showed earlier signs of fermentation than the second, but also formed more acid in a given time. In later experiments he determined the amount of acid produced in two equal infections from the same individuals before and after a careful cleansing of the mouth and teeth, and found the amount of acid produced by the latter sometimes as low as one-fourth that of the former, while after the use of strong antiseptic mouth-washes the amount was reduced to *nil*. "There is no known solution, alkaline or antiseptic, applicable in the human mouth, which will penetrate between the teeth, or to the bottom of fissures and cavities,—when these are filled with food,—in sufficient quantity to have any appreciable effect. Therefore before all antiseptics or alkaline washes come the tooth-brush, toothpick, and floss-silk."

Thorough mechanical cleansing of the teeth can only be accomplished by the use of all these means. The brush alone, even when used with the greatest intelligence, will not thoroughly remove the food *débris* from the inter-approximal spaces, and it becomes necessary to follow its use with the toothpick, and afterwards with waxed floss-silk drawn between the teeth, in order to free the proximate surfaces of all fermentable substances. To insure a perfect hygienic condition of the mouth this cleansing process should be repeated after every meal, and the mouth sterilized with an antiseptic solution after each cleansing, on retiring at night and upon rising in the morning.

The importance of this statement cannot be over-estimated nor too strongly impressed upon those seeking the services of the dental specialist, for therein lies the salvation of the teeth. Too many people imagine that antiseptic mouth-washes are sufficient to correct the tendency to fermentation, regardless of the fact that when food *débris* is retained between the teeth and in the sulci and fissures the antiseptics do not penetrate these substances, and therefore the action of the zymogenic bacteria is only retarded upon the surfaces, while in the deeper portions it still goes on with unhindered rapidity.

Dentifrices of various composition are used as adjuncts to the mechanical action of the tooth-brush ; these are made in the form of powders, pastes, and soaps.

Miller places no particular value on tooth-powder as a means of cleansing the teeth. He admits that the external surfaces, particularly of the front teeth, may be kept whiter by the use of tooth-powder, but thinks the centres of decay are more liable to become stopped up than to be cleansed by tooth-powder, particularly when they contain insoluble substances.

He would recommend tooth-soaps, in so far as they dissolve fatty substances without attacking the teeth, and, furthermore, possibly make the penetration of the bristles of the tooth-brush into the centre of decay somewhat more easy. He thinks the dentifrice should be made of neutral soap and have a neutral or slightly alkaline reaction, and finally says, "Under all conditions, however, the chief thing is the thorough mechanical cleansing of the teeth."

Tomes says, "In many respects tooth-soaps are to be preferred to powders."

The writer, however, has never been able to appreciate the advantages of the tooth-soaps over tooth-powders or tooth-pastes, for there are few mouths in which the teeth can be kept bright and clean without the polishing effect of some form of tooth-powder containing calcium carbonate or magnesium carbonate.

All good tooth-powders and pastes should contain a sufficient amount of the best castile soap to gain the advantage of its dissolving action upon fatty substances. The following formulæ will be found useful.

Tooth-powder.

℞ Precipitated chalk............ ℥ viii ;
Pulv. orris root............... ℥ iv ;
Pulv. cinchona bark........... ℥ iv ;
Pulv. cinnamon.............. ℥ v ;
Pulv. castile soap............. ℥ ii ;
Pulv. white sugar............. ℥ iv ;
Oil of lemon..................gtt. xx ;
Oil of rose....................gtt. ii.
Mix, pulverize, and sift through a fine hair sieve.

Tooth-paste.

℞ Precipitated chalk.............. ℥ viii ;
Pulv. orris root................. ℥ iv ;
Pulv. cinchona bark............. ℥ iv ;
Pulv. castile soap............. ℥ ii ;
Bicarbonate of soda .... ℥ i ;
Oil of gaultheria................ f ʒ ss ;
Glycerol, q. s. to make a thick paste.
Mix, pulverize, and sift the dry ingredients before adding the oil of gaultheria and the glycerol.

It is not necessary to give more than one or two formulæ for dentifrices, as a large variety of good powders, pastes, and soaps have been placed upon the market by the dental dealers, most of which are entirely reliable, and the dentist may place them in the hands of his clients with confidence that they are what they are represented to be.

Miller, in his experiments with regard to the effects of various antiseptics upon the zymogenic function of the mouth-bacteria, found great difficulty in selecting substances to which serious objections could not be raised, either from their injurious effects upon the teeth or the mucous membrane, their general toxic effects, or from their disagreeable taste or smell.

The following substances, in solutions admissible for use in the mouth, were tested by him as to the time necessary to devitalize bacteria. Several of them were found to accomplish this result inside of one minute.

Antiseptic.	Concentration.	Time necessary for devitalization.
Salicylic acid*	1 to 100	¼ minute.
Benzoic acid*	1 to 100	¼ minute.
Listerine	....	¼ to ½ minute.
Salicylic acid	1 to 200	½ minute.
Bichloride of mercury	1 to 2500	½ to ¾ minute.
Benzoic acid	1 to 200	1 to 2 minutes.
Borobenzoic acid	1 to 175	1 to 2 minutes.
Thymol	1 to 1500	2 to 4 minutes.
Bichloride of mercury	1 to 5000	2 to 5 minutes.
Peroxide of hydrogen	10 per cent.	10 to 15 minutes.
Carbolic acid	1 to 100	10 to 15 minutes.
Oil of peppermint in agreeable strength	....	5 to 10 minutes.
Permanganate of potash	1 to 4000	More than 15 minutes.
Boric acid	1 to 50	More than 15 minutes.
Oil of wintergreen	....	More than 15 minutes.
Tincture of cinchona	1 to 18	More than 15 minutes.
Lime-water	....	No action.

It will appear that only a very few of these substances are really serviceable for the purpose of disinfecting the mouth, for the reason that the time necessary to destroy the vitality of the bacteria is too long. Solutions which will not sterilize the oral cavity in from one to two minutes would possess little value as antiseptic mouth-washes, for usually such solutions do not remain in the mouth for more than a few seconds, or at most for a minute.

According to Miller, "The bichloride of mercury is the most active, not only because it has the highest antiseptic power, but because its action continues for a longer time."

Lister, who used it very extensively in his surgical practice at one time, has gone back to carbolic acid, for the reason that a five to ten per cent. solution penetrates the tissues to a greater depth than a 1 to 500 solution of bichloride of mercury. Strong bichloride solutions coagulate the albumin upon the surface, and thus form a barrier against the penetrating effect of the drug.

Listerine was found by Miller to be a very efficacious preparation for sterilizing the mouth. It produced devitalization of mouth-bacteria in from one-fourth to one-half a minute. It should be applied to the tooth-brush or diluted one-half as a mouth-wash.

* Salicylic and benzoic acids may be applied in this concentration only on the brush.

Pasteurine, borolyptol, thymozone, and other similar preparations which are combinations of benzoic acid, thymol, formalin, etc., are efficacious in sterilizing the mouth, have a favorable tonic action upon the soft tissues, and reduce inflammation.

Miller found that the oil of wintergreen and other similar aromatic substances, which usually form an important constituent of mouth-washes, have, in an adaptable concentration for use in the mouth, very little antiseptic action. He, however, excepts oil of peppermint from this category.

Black extols the antiseptic qualities of oil of cassia, oil of cinnamon, and oil of cloves, and thinks they have a much higher antiseptic power than oil of peppermint.

Koch, on the other hand, found oil of peppermint to have an antiseptic action nearly seven times as strong as oil of cloves. Miller thinks this difference between these astute observers may be accounted for in the difference of the bacteria experimented upon.

Thiersch's antiseptic solution the writer has found to be a most valuable sterilizing mouth-wash. It is slightly bitter to the taste, but this may be disguised by the addition of a few drops of oil of cassia, oil of peppermint, or oil of wintergreen.

The formula is as follows : Salicylic acid, four parts ; boric acid, twelve parts ; water, one thousand parts. Flavor to suit the taste. It may be used *ad libitum*.

The most effective method of using antiseptic mouth-lotions is that suggested by Ottolengui, to force the solution between the teeth and over the surfaces by means of an atomizer.

CHAPTER XI.

TREATMENT OF CARIES (CONTINUED). MEDICATION. EXCISION.

Definition.—Therapeutics (from the Greek θεραπευτική, curative). That branch of medical science which considers the application of remedies as a means of cure.

The therapeutic treatment of dental caries consists in the application of certain surgical principles and mechanical procedures which are adapted to the peculiar nature and causation of the disease, the character of the tissue affected, the extent and the rapidity of the progress of the affection, its complications, the environment, and the liability of the disease to recurrence.

The surgical procedures which are applicable to the cure of dental caries are *Medication*, *Excision*, and *Obturation* or *Filling.*

MEDICATION.

Treatment by medication consists of impregnating the softened surface of enamel or dentin with nitrate of silver or some other salt which will destroy the bacteria which have penetrated these tissues, and so change the character of the impregnated tissues that they no longer offer a favorable field for the growth and development of the lactic-acid-producing fungi.

The idea of arresting dental caries by the application of the nitrate of silver was presented more than fifty years ago. It, however, never came into general use except in the treatment of superficial caries in the posterior part of the mouth. The great objection which has been raised against its employment is the fact that it stains the eroded enamel and the exposed dentin jet-black, thus giving a very unsightly appearance to a tooth so treated. If the treatment, however, has been successful, the black stain gradually disappears, leaving a polished mahogany-brown surface, which is immune to caries.

Stebbins (1891) revived interest in this method of treatment by advocating its use for the arrest of caries in the temporary teeth. The blackening of the decayed surface in these cases is not so objectionable as in the permanent teeth, while it often renders the preservation of the deciduous teeth a much easier task than by the more difficult, laborious, and painful operation of inserting a filling.

Stebbins advocated the application of a solution of silver nitrate to the carious cavity by means of a small pointed stick inserted in a socket instrument or porte-carrier made for the purpose.

He found that many cases needed no further treatment, as the carious process was completely arrested, while in others, after a few months, a second application was necessary. In many cases he thought it advisable to fill the cavities with gutta-percha after the application of the silver nitrate.

Peirce recommends that application be made by means of pieces of blotting-paper of suitable size, saturated in a forty per cent. solution of the drug, and kept ready for use.

Kirk objects to the use of blotting-paper or cotton as a means of applying the solution, for the reason that "the contact of silver nitrate with vegetable fibre of any sort involves not only a destruction of the fibre, but also of the silver nitrate, so that the preparation in a short time loses its desirable qualities." He advises instead the use of asbestos felt which has been heated before the blow-pipe to eliminate all vegetable matter previous to saturation with the solution.

Holmes suggests, in the treatment of proximal cavities, that the walls be "cut away to a V shape, and with a piece of gutta-percha softened by heat, of the proper size of the space, bring the surface to come in contact with the diseased part of the teeth in contact with the powdered crystals of silver nitrate, and carry it into place in the tooth or teeth prepared for its reception, packing it firmly, and leaving it there to be worn away by use in mastication. When that takes place the surface of the teeth will be found black and hard, with no sensitiveness to the touch or to changes in temperature, and they will remain so indefinitely. In case the child is so timid as to prevent this course, dry the cavity, take out as much softened dentin as the patient will permit, carry the crystals on softened gutta-percha into the cavity, and pack it there, leaving it until such time as desirable to make a more thorough operation."

Goddard deprecates the practice of making V-shaped separations in these cases, and believes it better to open proximal cavities from the morsal surface, "as the full diameter of the teeth is necessary to preserve the fulness of the arch."

The writer maintains the same opinion, but would add another reason, —viz., that the preservation, when possible, of the full size of the morsal surface of the teeth is important from the fact that if they are cut away the power of thoroughly grinding the food is by that much curtailed, and the child forms the habit of swallowing its food before it is properly masticated.

EXCISION.

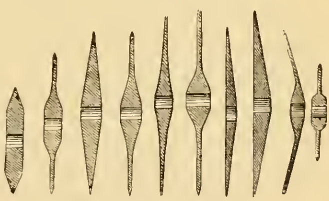
In the *operation of excision* the diseased part is cut away with files, or with disks revolved by the dental engine, and the surface thoroughly polished. This operation is only admissible in the superficial stage of the disease. The advisability of the operation has been seriously questioned, however, by some of the best operators in the profession; and in the light of the recent discoveries made by Williams in the *modus operandi* of enamel decay it would seem that the operation can be of very little benefit as a therapeutic measure. It may possibly retard the progress of the disease for a time by removing the roughened surface of the enamel, and thus making it a somewhat less favorable surface for the attachment of the zymogenic fungi, but as a permanent cure it is not to be relied upon, although every operator of experience has, no doubt, seen cases in which the operation has proved permanently curative.

Many of the older operators, fifty years ago, practised the operation very extensively, and they were often quite successful in arresting the progress of the disease, but they did it at a great sacrifice of tooth-structure. Approximal cavities in bicuspids and molars were often treated in this way, the method being to cut large V-shaped spaces, the apex of the V at the cervices of the teeth, the base being so broad that the surfaces thus formed would be kept clean by the friction of mastication.

Arthur at a later period (1871) introduced and extensively practised a modified form of the operation as a prophylactic as well as a curative method.

He argued that the great majority of individuals suffered from proximate caries of their teeth ; also that it was possible for the dentist by intelligent observation to determine in advance those cases in which caries would occur. Observation had also taught that when the teeth were so arranged naturally that they were well separated from each other, immunity from caries was the general rule ; further, that the separation by filing, practised by the older dentists, often arrested the disease and gave immunity to such surfaces from further destruction ; that accidental injuries to the teeth which exposed the dentin, when in locations that were kept clean by the friction of mastication, and the practice of many aboriginal races of filing their teeth for various purposes without injury to the dentin, led him to believe that the enamel might be removed without harm to the teeth, provided the surfaces and spaces thus made were of such shape that they could be readily cleansed. The friction of mastication and ordinary care on the part of the patient, he believed, would be sufficient to prevent the occurrence of the disease. The method which he advised and practised was to separate the bicuspids and molars by means of thin corundum disks (Fig. 295), but as far as possible retaining the natural contour of the proximate surfaces. The six anterior teeth were separated by the same means, but in this case the separation consisted in forming V-shaped spaces upon the lingual surfaces, the apex of the V being directed towards the lip and the base towards the tongue.

Fig. 295.



Corundum disks.

For a time this practice was followed by a considerable number of practitioners, but it gradually fell into disrepute from the fact that the claims of its advocate could not be realized by those who adopted it, except in a few isolated cases.

CHAPTER XII.

TREATMENT OF CARIES (CONTINUED).

THE separation of contiguous or adjoining teeth, the proximate surfaces of which may be the seat of caries, is an important and an essential procedure, preliminary to the operation of removing diseased tissue and restoring the tooth to its original form by the introduction of some suitable filling-material.

The enlarging of the interproximate space for a brief period is not only necessary, that a direct view of the cavity may be obtained, and facilitate the operation of cavity preparation, but that it may give opportunity for restoring the original contour of the teeth with the filling material, so that when they return to their normal positions their relations to each other will be the same as before they were attacked by the carious process.

Separation by filing is to be deprecated, and in these days it is rarely practised, as the restoration of contour is not possible by this method of separation.

The resulting consequences from failure to restore the normal contour and mutual relationship of such teeth, particularly the bicuspids and molars, is often very serious. When permanent separations are made, either by filing or failure to restore the contour so that the approximal surfaces do not "knuckle up" to each other, food is driven into the interproximate space, to the great annoyance of the patient and often painful and serious injury to the gum, inducing pericementitis, recession of the gum, and sometimes loss of the affected tooth.

In dealing with the anterior teeth the restoration of contour is also important from the æsthetic stand-point. Teeth which have been permanently separated by filing present mutilations which in themselves constitute a deformity, while they often move out of their normal position by tilting towards each other, or assuming other positions out of harmony with the natural arrangement of the arch.

The separation of the teeth is a procedure which calls for considerable care to avoid injury to the pericemental membrane and gum and to render the process as nearly painless as possible. There is considerable difference in individuals as to the amount of soreness and pain produced by separating the teeth. In children and young people the necessary space is gained much more quickly and with less irritation than when the alveolar walls have become firm and compact, or when the arch is full and the teeth are in close proximity. In the former the bone yields readily and permits an expansion of the arch, while in the latter the resistance to force is much greater and the process of expansion considerably slower.

A certain amount of space is always gained, even in a full arch, by the closing of the slight spaces which often exist between the teeth. It is therefore important that the force applied and the materials or appliances used should be adapted to the conditions presented in each individual case. Constant and sustained pressure, if the force used is not too great, will separate the teeth more quickly and with less irritation than if applied intermittingly. With such precautions as would be suggested by good judgment no harm can come from the process, even when the tissues are irritable or the structures are of the firmest character. There is no difficulty in obtaining sufficient space for any operation if proper care is exercised and the force is steadily and mildly applied.

Methods of Separation.—Separations may be obtained by the employment of various means, the selection of which should be governed by the conditions and requirements of the case in hand,—viz., the amount of space required, the time in which it must be accomplished, the firmness and irritability of the structures, and the location of the teeth to be separated.

Two methods are employed to gain space by wedging, one termed *immediate* or *direct*, the other *gradual* or *indirect.*

Immediate or *direct wedging* is most applicable to the anterior teeth, where usually only a limited amount of space is required. Its greatest advantage, however, lies in its use as a method of obtaining space for the examination of the proximate surfaces, and to permit the introduction of polishing strips, for the removal of superficial softening of the enamel, stains and discolorations, and for the purpose of repolishing fillings.

Immediate separation may be accomplished by forcing properly shaped wooden wedges between the teeth, either by steady pressure or by driving with the mallet. The wedges should be made of hard, close-grained wood, orange-wood being the best. The wedges should be inserted between the teeth, one near the morsal edge, the other at the cervix, care being taken not to impinge upon the gum in such a manner as to bruise or otherwise injure it. These are then alternately forced farther and farther until the desired space is obtained.

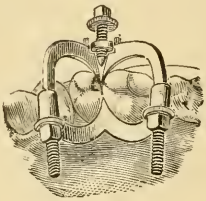
The angular form of the interproximate space sometimes makes it impossible to use a wooden wedge, as the wedge travels towards the gum as soon as force is applied, instead of producing lateral pressure upon the approximal surfaces and insuring fixation of the teeth.

Mechanical Separation.—Various mechanical appliances have been invented for the immediate separation of the teeth. The best for separating the anterior teeth is, no doubt, the one invented by Woodward, while those best adapted for gaining space between the bicuspids and molars are the Parr and the Perry forms (Figs. 296 and 297).

Separations made by the aid of these instruments for the examination of the approximal surfaces or to gain space for operations are far less painful than those obtained by driving the wooden wedge. They are also valuable for increasing the space gained by other methods, and for fixing the teeth which have been separated by the gradual method, and in which there still remains a little pericemental irritation and soreness. When the patient is pressed for time it often becomes necessary to operate before the irritation has entirely subsided, but without some such support as this it would be impossible to operate, on account of the discomfort which would be caused to the patient, and which would be increased at every stroke of the mallet.

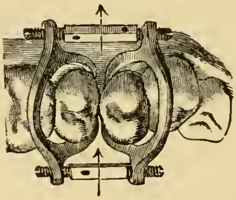
Mechanical separators, however, have the disadvantage that they cannot be used in all locations, even if one possess a half-dozen or more different

Fig. 296.



Parr separator.

Fig. 297.



Perry separator.

forms, while with the Perry instrument there is a constant tendency for it to slip towards the gums. This can, nevertheless, be overcome by placing beneath the bows small pieces of gutta-percha or india-rubber.

Parr's instrument is more universal, but it is decidedly more clumsy.

Gradual or *indirect wedging* may be accomplished by the introduction between the teeth of *thin wooden wedges*, which should be changed to thicker ones each day, depending upon the swelling of the fibres under moisture to produce the separation.

Linen tape, either waxed or unwaxed, is an admirable material with which to separate the teeth.

Waxed tape will pass more readily between teeth that stand close together than will the unwaxed, but it does not move the teeth so quickly as the unwaxed, the wax preventing the rapid absorption of moisture and swelling of the fibres. It becomes necessary sometimes, however, to begin the separation by the immediate method,—either with a wedge of wood or the separator,—as it is impossible to get anything between the teeth without the application of considerable force. As soon as sufficient space is gained, the tape may be inserted and the separating appliance removed. The tape should be removed each day and a thicker one inserted, until such time as the required space is obtained, when gutta-percha may be packed between the teeth and allowed to remain until all soreness has disappeared. In fact, this or similar means of retaining the teeth in their separated position should always follow the removal of the material used for gradually separating the teeth, as it is always best to wait for soreness to disappear before beginning the operation of filling.

Pledgets of cotton may also be used as a means of separating the teeth, especially in the posterior teeth when the cavity has been broken through the morsal surface. The pledgets should be packed as tightly as possible when the cavity is not so deep as to involve a vital pulp. The cotton may then be saturated with sandarach varnish to bind the fibres together.

The front teeth may be separated with the same material by twisting it into a strand, drawing this between the teeth, and cutting the ends short.

The cotton will act more rapidly, however, without the sandarach varnish, as this retards the absorption of water, and consequently the swelling of the fibres is more gradual.

India-rubber—caoutchouc—in strips of various widths is perhaps, on account of its effectiveness, more frequently used than any other means of producing gradual separation. When a strip of india-rubber is drawn between two teeth the middle portion is pressed to great thinness, the ends acting as two opposing wedges, the elasticity or resilience of the material constantly drawing the ends or wedges together until a space is obtained equal to the thickness of the strip. Great caution, however, should be exercised in using this material, as its power is very great, and serious pericemental inflammation may be induced by the use of strips which are too thick.

Separations of almost any desired width may be obtained with this material, with little or no irritation, if only the strips used are thin enough and are changed every day.

Red base-plate gutta-percha has been recommended by Bonwill as a desirable material with which to gradually separate the teeth. It should be packed firmly into the open cavities and existing space between the teeth, depending upon the force of mastication to produce expansion by driving the material towards the gum.

This material is also valuable for exposing the cervical margins of the cavities which are covered by overlapping gum-tissue, by packing it into the cavity and interproximate space. It is much better than cotton for this purpose, as it does not absorb septic material.

EXCLUSION OF MOISTURE.

The exclusion of moisture during all operations upon the teeth is of the greatest importance. The presence of the oral secretions is often a serious obstacle to the performance of many operations, and when the flow is excessive it becomes a matter of considerable annoyance to the patient. All operations upon the teeth are more successfully performed by the exclusion of moisture than when the mouth is flooded with its secretions; but for the introduction of gold as a filling-material, and in the treatment of devitalized teeth, it becomes an absolute necessity.

In the earlier days of modern dentistry the question of the exclusion of moisture during a long and tedious operation with cohesive gold caused the dentist many anxious thoughts, and added not a little to the nervous strain incident to his professional life; a strain which the younger members of the profession can hardly realize or appreciate, since they are furnished with a material—the rubber dam—which removes entirely all anxiety upon the part of the operator that his operation may be completely ruined by the entrance of moisture and his labor come to naught.

Various methods and appliances have been introduced for the purpose of securing and maintaining dryness in the field of operation, including the napkin, bibulous paper, cotton pads, gauze, saliva ejectors, and the rubber dam.

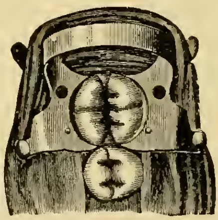
Napkins.—The use of napkins as a means of excluding moisture is the oldest, and was for many years the only one, with which the older practitioners daily fought the battle of maintaining a dry field for their operations. It is still a valuable method, and is often resorted to in those cases in which the rubber dam cannot be employed, as, for instance, in the treatment of molars which are only partially erupted, or in those persons to whom the dam is so disagreeable or nauseating that they will not permit its use.

Napkins for this purpose should be made of the best diaper or bird's-eye linen of various sizes, six inches, nine inches, and twelve inches square being the most useful sizes. The smallest ones folded in pads the full length of the napkin are admirable for use in the lower part of the mouth, and are applied by placing one end of it opposite the incisor teeth, between the tongue and the lingual surfaces of the teeth, carrying the middle of the napkin to the angle of the jaw, folding it upon itself, and laying the other half between the cheek and the buccal surfaces of the teeth, and holding it in place with the thumb and index-finger of the left hand. If the tongue is raised before the napkin is applied upon the lingual side of the teeth, the tongue will hold this end of the napkin in place, and at the same time press it down upon the orifices of the sublingual and submaxillary glands. A better means of holding the napkin in position is to apply the Ivory napkin clamp. (See Figs. 298 and 299).

Fig. 298.

Bicuspid napkin clamp.

Fig. 299.



Molar napkin clamp.

The larger napkins are folded by taking hold of one corner with the thumb and index-finger of the left hand and the lateral corners rolled or folded in. It is applied, for instance, to the upper left side by passing the corner held by the left thumb and finger under the lip at the left oral commissure, holding it there with the index-finger of the left hand, and with the index-finger of the right hand or a pair of dressing forceps carry the thicker part of the napkin backward to the tuberosity of the jaw; then folding it upon itself, it is brought forward along the lingual surfaces of the teeth and maintained in its position with the left index-finger. The free end of the napkin is then spread out so as to cover the lower lip. The procedure for the right side is the same, with the exception that the hands are reversed.

Bibulous paper, *prepared gauze*, and *cotton pads* are now used by some operators to the exclusion of napkins. Their application is similar to that of napkins folded into pads.

The moisture which appears around the necks of teeth, coming from the glands at the margin of the gums, is often quite troublesome when only the napkin or similar means are used to exclude the moisture. This may be controlled by packing small pieces of bibulous paper between the teeth at the cervix.

Saliva Ejectors.—These instruments are exceedingly useful in conjunction with napkins, bibulous paper, etc., or with the rubber dam, for removing the secretions that accumulate during the operation. In many operations the necessary position of the jaws is such as to make it impossible for the patient to swallow, hence the accumulation of saliva is often very troublesome to both the patient and the operator, especially so when the secretions are normally excessive. or are greatly increased by the stimulation of operative procedures. These instruments act upon the principle of the siphon, and are made for attachment to the water-supply and used in connection with the fountain cuspidors.

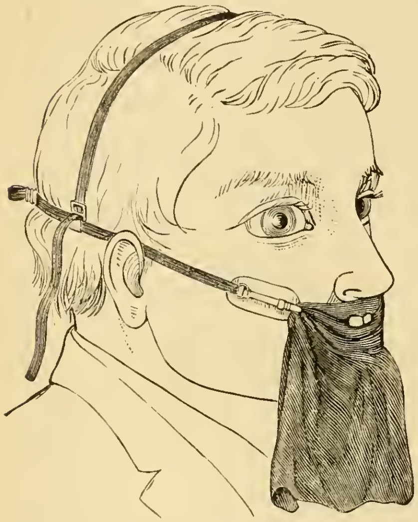
Rubber Dam.—Barnum conferred a great boon upon suffering humanity and greatly lightened the labors of the dentist by his invention of applying sheet-rubber or rubber dam as a means of excluding moisture from the field of dental operations, thus making it possible to save many teeth which before were condemned to the forceps. It has universal application in all parts of the mouth wherever a tooth or root has sufficiently emerged from the gum for the dam to be passed over it.

It is of greatest value, however, in the preparation and filling of proximal cavities where the disease has extended beneath the gum, and in which the exclusion of the secretions and of blood is a difficult matter with any other means at our command. For the exclusion of moisture and septic secretions, and the protection of the soft tissues from medicaments in the treatment of devitalized teeth, alveolar abscesses, etc., it is indispensable.

Rubber dam is made in three thicknesses, known as *thin*, *medium*, and *thick*, and usually sold in strips varying in width from five to seven inches. The preference for general use lies with the medium thickness, although it is well to have all three thicknesses on hand. The quality of the rubber is a matter of first importance ; it should be strong, elastic, extensible, and free from odor. Exposure to the atmosphere and the high temperatures of summer weather cause deterioration in these qualities and soon render it worthless. To protect it as much as possible from these deteriorating influences it is usually sealed in tin cans or boxed. It should be cut for use into squares and triangular pieces, the squares from five to seven inches, the triangular pieces being made by folding the squares corner-wise and dividing them. A form of rubber dam has lately been introduced which is coated with a metallic aluminum powder, which gives it a very light appearance and adds greatly to its usefulness by making it luminous. The application of the rubber dam is to the student in his first attempt to adjust it a somewhat difficult procedure ; to the older practitioner who has become expert by long practice it is usually a simple matter, requiring but a moment of time; and yet occasionally a case will present in which its application will require all his ingenuity and patience.

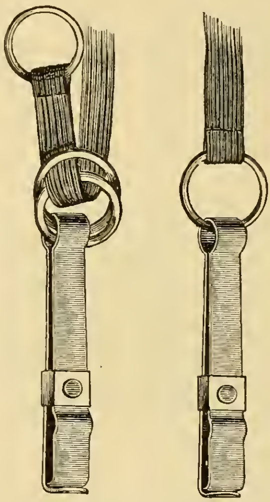
In adjusting the dam to a tooth with a simple cavity upon the morsal surface, a hole should be pinched or cut at such a location as will permit the dam to lie smoothly over the mouth after its adjustment to its position. The dam may be adjusted by grasping the two upper corners with the thumb and index-finger of both hands, and with the middle finger of each hand placed on opposite sides of the hole through which the tooth is to pass, the rubber is put on the stretch. This enlarges the hole in the rubber, and it is forced over the tooth by passing first one edge and then the other of the opening between the mesial and distal proximal spaces, and carrying it well up to the cervix. Fig. 300 shows the rubber dam in position upon the upper incisor teeth, the upper corners of the dam being

Fig. 300.



Rubber dam applied.

Fig. 301.

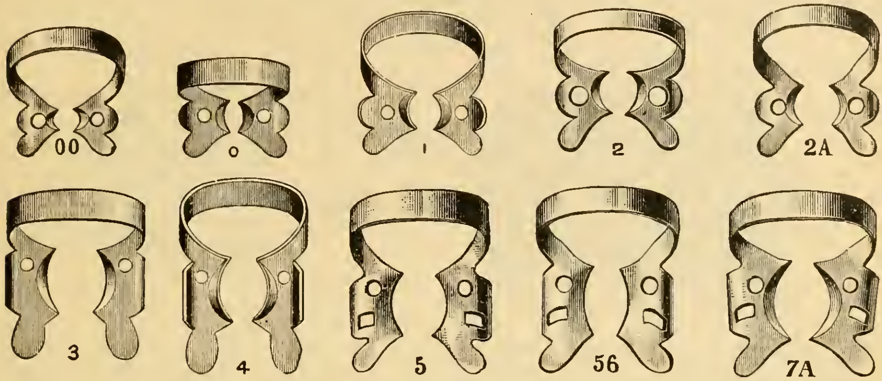


Rubber-dam holder.

secured with a rubber-dam holder (Fig. 301) Various other forms of holders are also for sale by the dealers, and the operator may suit himself with almost any desired form. The rubber dam may be held smooth by attaching weights to the lower corners.

If two or more teeth are to be isolated, it then becomes necessary to punch the same number of holes in the dam, so locating them that when the dam is placed in position the straits between the holes will be just a trifle wider than the spaces between the teeth; the edges of the dam around the cervices of the teeth should then be *turned under*, using the point of any straight-pointed instrument of suitable size. The dam thus grasping the cervix of the tooth acts as a valve, and effectually excludes all moisture from the teeth so enclosed. To secure the dam in position, a ligature may be passed around each tooth and tied with the surgeon's knot, or clamps of various forms (Fig. 302) are used alone for the same purpose, or in conjunction with the ligatures. Properly constructed clamps are so shaped that they materially assist in holding the dam away from the crown of the tooth, thus causing less obstruction to the entrance of light

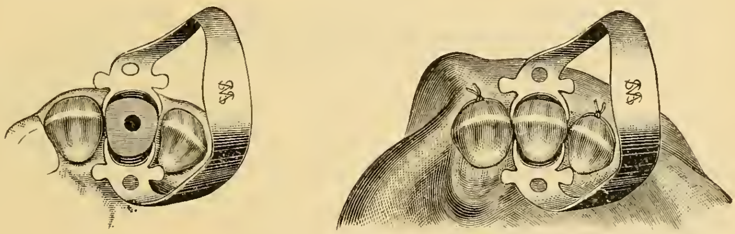
FIG. 302.



Ivory's clamps.

and giving a better view of the field of operation. The Ivory clamps possess these very desirable features to a greater extent than any others at present known to the writer.

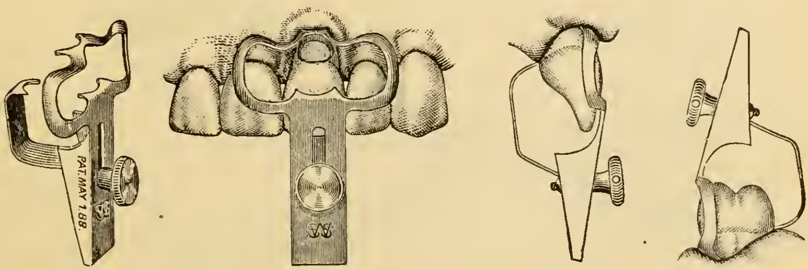
FIG. 303.



The Ottolengui clamp applied.

The Ottolengui clamp (Fig. 303) also possesses many of the desirable features.

FIG. 304.



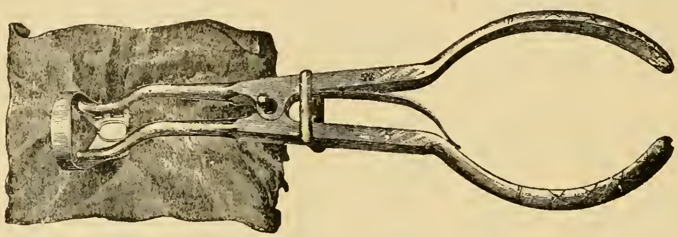
Dr. How's cervix screw clamp.

The How cervix screw clamp (Fig. 304) is an admirable instrument for securing the dam and exposing the cervical margin in cervical cavities. Its application is shown in the illustration.

Specially constructed forceps are necessary in the adjustment of all forms of spring clamps like those shown in the preceding illustrations.

Fig. 305 shows a method of adjusting the clamp and the rubber dam at the same time. The clamp in the illustration is known as the Elliot molar clamp, and is a favorite appliance with many operators.

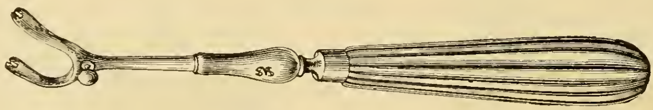
FIG. 305.



Elliot's clamp and forceps.

When the teeth are very close together and the alveolar walls are very firm, it is sometimes a difficult matter to pass the dam between the teeth without some special preparation of the contiguous surfaces. The rubber-dam applier, shown in Fig. 306, duplicates the fingers and materially

FIG. 306.

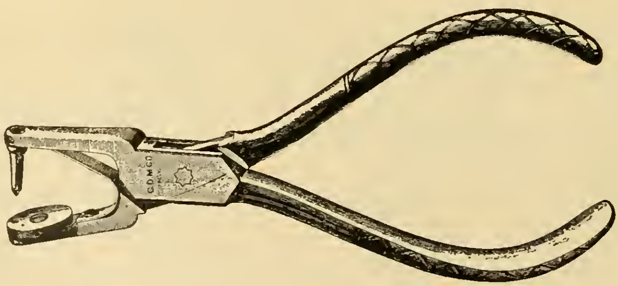


Rubber-dam applier.

assists in forcing the dam between the teeth. In all such cases the passage of the dam may be facilitated by first lubricating the surfaces by passing floss-silk between them which has been charged with vaseline, cosmoline, or toilet soap.

The holes in the dam may be made either with the punch (Fig. 307), the scissors, or by stretching the dam over the end of a small, round.

FIG. 307.



Ainsworth's rubber-dam punch.

tapering instrument,—the reverse end of a mallet-plugger will answer the purpose,—and nicking the rubber near the point with a sharp knife; the result is a perfectly round hole. Any desired size may thus be obtained;

the lower down upon the instrument the nick is made the larger the hole; the tighter the dam is drawn the smaller the hole will be.

The writer has used this method many years, to the exclusion of all others, and with perfect satisfaction.

Fig. 308 shows the relative size of holes adapted to (1) incisors and cuspids, (2) bicuspids, (3) molars. The depressed rubber dam (Fig. 309)

Fig. 308.

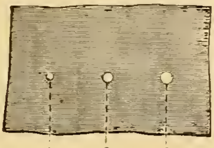
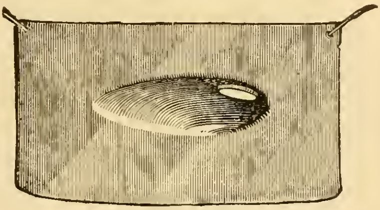


Fig. 309.



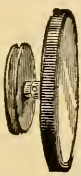
Depressed rubber dam.

and the Denham coffer-dam shield (Fig. 310) are often found useful in operations for children and in preliminary treatments, or when remedies are to be used which it is desirable should not come in contact with the surrounding tissues of the mouth. Fig. 311 shows the Denham coffer-dam shield adjusted and secured with a clamp. A small mirror (Fig. 312) may be inserted in the depressed rubber dam for the purpose of greater illumination.

Fig. 310.

Denham coffer-dam shield.

Fig. 312.



Mirror.

Fig. 311.

Denham coffer-dam shield adjusted.

Nausea and other unpleasant symptoms are often occasioned by the contact of the rubber dam with the tongue and palate, and from the unpleasant odor. The nausea may be relieved by spraying the mouth and throat with a two per cent. solution of cocaine in water, while the unpleasant odor may be overcome by dipping the dam in rose-water or other toilet-water. Jack recommends painting the parts with tincture of camphor, while the nervous conditions which sometimes appear on adjusting the dam and covering the mouth may be overcome by requesting the patient to breathe freely through the nose.

CHAPTER XIII.

HYPERSENSITIVE DENTIN.

Dentin is a fibro-calcareous structure, tubular in character, the tubuli passing from the pulp-chamber to the periphery of the dentin, branching in their course, and terminating in minute tubules, which unite to form an intricate plexus. These tubuli are each of them traversed by a minute fibril or filament, which is generally thought to be a prolongation of an odontoblastic cell, and that through these fibrils sensation is conveyed to the dental pulp. There is some evidence, however, as already pointed out in Chapter III., that a portion of the tubuli are occupied by certain fibres, which appear to be prolongations of the nerve-filaments of the pulp, or that the nerve-filaments of the pulp enter the odontoblasts, and thus furnish the necessary elements which fit the fibrillæ to carry sensation.

It has never been demonstrated, however, that the fibrillæ of the dentin were composed of nerve-tissue, and yet there can hardly be a doubt that such is their composition, for they perform the functions and present all the phenomena of nerve-tissue under stimulation and under irritation.

Dentin in its normal state is only slightly sensitive, but when subjected to irritation from external agencies it may become most excruciatingly *hyper*sensitive. The degree of hypersensitiveness will depend upon the character of the irritant, the point of attack, its duration, the condition of the oral secretions, the character of the structural development of the teeth, the age, and the physical condition of the patient.

Irritation from caries is the most common cause of hypersensitive dentin, the degree of abnormal sensitiveness depending largely upon the character of the carious process. In the *white* or rapid form of caries the hypersensitive condition is usually the most exalted. In the *brown* or less rapid form the sensitiveness is much less, while in the *black* or slow form it is but little above that of normal dentin.

The most sensitive part of a carious tooth is just beneath the protecting enamel or cementum, on the periphery of the dentin at the terminal ends of the fibrillæ, just as the most sensitive part of the external surface of the body lies immediately beneath the horny layer of the cutis at the terminations or end organs of the nerves. It therefore becomes evident that caries in the superficial stage will present the highest degree of hypersensitiveness to be found in each of the three forms of caries. In other respects the zone of greatest sensitiveness is directly beneath the softened portion of dentin, the sensitiveness becoming less and less as the sound tissue is approached.

Another cause of hypersensitive dentin is irritation from *attrition* or *mechanical abrasion.* This cause, however, operates so slowly that certain changes may take place in the dentin within the tubuli by the deposition of calcific deposits,—*eburnation*,—which after a time diminishes or entirely destroys their capacity to convey sensation. The same process of eburnation sometimes takes place in chemical abrasion and denudation, thereby lessening and sometimes entirely obliterating sensation.

Exposure of the cementum from recession of the gums is another very common cause of hypersensitive dentin, but here again nature is prone to mitigate the conditions by the same calcific changes in the dentinal tubuli. But caries often supervenes in these cases from lack of attention upon the part of the patient, who, because of the pain induced by the use of the brush, fails to keep these surfaces properly clean. There is also very often the added influence of acid mucous or salivary secretions, which by their irritating effect tend to augment the hypersensitive condition, while the reverse is true when the oral secretions are alkaline or neutral.

Excessive sensibility of the teeth is often an accompaniment of the catamenia, of dyspepsia, neuralgia, pregnancy, pulmonary tuberculosis, especially in its later stages, typhoid fever, acute rheumatism, and the convalescent stage of fevers in general. The condition under these circumstances is due to the changed or vitiated character of the oral secretions, which have almost invariably a strongly acid reaction.

Imperfect calcification of the teeth is another factor in the etiology of hypersensitive dentin. The teeth of children and of rapidly growing young people are, as a rule, much more sensitive than those of adults. This is thought to be due to the fact that the teeth during childhood and youth are still undergoing changes of development, and that they are not all fully formed, in the sense of being perfectly calcified, until adult age; but that as each group of teeth are perfected they become less susceptible to external irritants, and consequently less sensitive. Females, however, as a general rule, are more often sufferers from hypersensitive dentin than are males.

Nervous irritability is greater in some persons than in others, females usually possessing a larger share than males, and this in a measure accounts for the intense suffering which some of these individuals endure from hypersensitive dentin. This exalted irritability of the nervous system in some instances is only a passing condition which has developed as the result of illness, mental or physical shock, overwork of mind or body, over-indulgence in social pleasures, or of debauchery; while in other instances it is an established condition or dyscrasia peculiar to the individual; or it may be a family peculiarity which has been transmitted as an inheritance. In any event the suffering is so great in some of these cases of hypersensitive dentin as to call for the greatest sympathy, consideration, and forbearance upon the part of the operator during the preparation of the cavity. The dentist who cannot rise to such an occasion, and by tenderness and sympathy endeavor to carry the patient through the trying moments of the ordeal without losing his patience, should change his occupation, as he lacks or has lost the most important qualification for a successful dental practitioner.

TREATMENT OF HYPERSENSITIVE DENTIN.

The treatment of hypersensitive dentin is one of the most perplexing problems with which the dentist has to deal, and consequently the remedies which have been suggested and introduced from time to time for obtunding the sensation of dentin have been *legion.* Each new remedy has generally been extolled as a specific; but each of them, after a few trials, has been laid aside, with the hopes that were from the beginning doomed to disappointment. Specific medication succeeds no better in the treatment of dental diseases than it does in general medicine. Certain remedies which may cure in one case often prove only an aggravation in another, and remedy after remedy may be tried with no appreciable beneficial effect; while, upon the other hand, certain drugs have been found which will upon their application to the dentin positively destroy its sensation, but will also destroy or jeopardize the vitality of the pulp.

The treatment of hypersensitive dentin is therefore limited to those remedies and procedures which will temporarily relieve or mitigate the suffering incident to the preparation of cavities, or to give permanent relief in the various other forms of irritation to which the vital dental tissues are subjected.

Treatment of Moderate Hypersensitiveness.—In the treatment of moderate hypersensitiveness due to caries the excavation of the cavity should be approached in a manner to engender confidence upon the part of the patient that the operator will endeavor to perform his task with the least possible pain and in the most expeditious manner that the nature of the case will permit, assuring the patient that, if the pain is unbearable, palliative means shall be employed for its relief. With such assurances, accompanied with a calm, cheerful, and sympathetic manner upon the part of the operator, the courage of the patient can usually be stimulated to such a degree that the operation may be completed without resort to obtunding agents.

By a display of harshness in the methods of operation, or an exhibition of irritability of temper, or an unsympathetic mood upon the part of the operator, apprehension, dread, and nervous excitement are increased, and the difficulties of controlling the patient by just that much augmented.

It is often advisable in dealing with nervous individuals, either adults or children, to select for the first operation something that will cause little or no pain, that they may become acquainted with the various surroundings and procedures incident to dental operations. This will relieve their dread and apprehension for the time, and thus make it possible to advance by degrees from the simpler and comparatively painless operations to the more complicated and severer ones.

In excavating the simpler cases of moderately hypersensitive dentin, SHARP instruments only should be used, but these should never be sharpened in the presence of the patient, for reasons which are obvious. The cutting should be done by quick, light, and sure movements, as such cutting is decidedly less painful than slow, heavy, scraping movements of the instrument. The *direction* of the cutting should, for the same reason, always be from the centre of the cavity towards the periphery, and never towards the pulp. If burs driven by the dental engine are used, these should be sharp and clean-cutting, as dull burs, or those which clog and do not cut freely, engender heat by friction, and thus increase the pain incident to the operation.

If the bur be revolved at a high rate of speed, and the contact with the sensitive dentin made by light, quick touches, this tissue may be removed with so little pain as to be quite tolerable. The dread, however, of the dental engine has been induced by the reverse of this method of operating.

If the operator prefers to prepare the cavity in the moist state, it will be found that if a continuous stream of hot water be thrown into the cavity while excavating with the bur, the pain will be greatly mitigated. On the other hand, if the dry method be adopted, it will be found that the more nearly complete desiccation is obtained the less will be the pain experienced.

In those cases in which the hypersensitive condition is so great as to render the operation of cavity preparation by the foregoing methods intolerable, treatment, either local or constitutional, must be instituted to temporarily mitigate or palliate the suffering. This treatment may consist of the exhibition of certain therapeutic remedies, chemical agents, or anæsthetics, either local or general.

PALLIATIVE TREATMENT.

The treatment of the hypersensitive dentin by palliating remedies applied locally is sometimes beneficial in relieving the pain of excavation. The available drugs for this purpose are morphia, veratria, atropia, cocaine, cannabis indica, and chloretone. As neither of these remedies produces any immediate effect, it is customary to seal them in the cavity —after the thin enamel edges have been removed and the softest portions of the decayed dentin have been lifted out—with gutta-percha or zinc oxyphosphate for two or three days or longer, when on removing the temporary filling it will be found that the hypersensitive condition has been materially lessened.

Morphia sulphas and *morphia acetas* are both used for this purpose, but the writer prefers the acetas, as it seems to give the best results.

To prepare the morphia for this purpose it should be rubbed up in glycerol, an eighth of a grain of morphia to a drop of glycerol. The cavity should first be neutralized by irrigating it with an alkaline solution, preferably sodium bicarbonate. The rubber dam should then be adjusted, the cavity dried, and the morphia paste carried into the cavity and spread over its walls, after which the temporary filling should be introduced. The writer prefers the zinc oxyphosphate, for the reason that by mixing it soft it can be introduced without pressure, and this is an important advantage in those cases in which the dentin is exceedingly sensitive.

Veratria is prepared in the same manner,—one-twentieth of a grain in sufficient glycerol to make a thin paste,—spread over the surface of the cavity, and sealed in with cement. The veratria acts by producing paralysis of sensation in the dentinal fibrillæ.

Atropia sulphas, one-sixteenth of a grain, may be prepared and introduced in the same manner and often with good results. Atropia applied locally relieves pain and sensitiveness by its paralyzing effect upon the peripheral nerves, and doubtless acts in the same manner upon the dentinal fibrillæ.

Cocaine citras and *hydrochloras*, one-eighth of a grain in glycerol, applied as above, sometimes prove efficacious in overcoming the sensitiveness by producing local anæsthesia of the dentin.

Cannabis Indica—fluid extract—applied upon cotton and sealed into the cavity will also sometimes give relief.

Chloretone is perhaps the most efficient remedy for this purpose that has as yet been introduced to the profession. It is employed in solution as a local application to hypersensitive dentin. The solution is made by mixing equal parts by weight of sulphuric ether and the crystals of chloretone.

The chief objection to the use of these remedies is the great length of time which is required for them to act. This is explained by the exceedingly small amount of organic material in the dentin and the low absorptive powers possessed by this tissue.

Constitutional palliative treatment consists in the exhibition of such drugs as, by their sedative and analgesic action, will measurably obtund general sensation for a short period of time. These are morphia, chloral hydrate, potassium bromide, and whiskey combined with some of them for its stimulating effect.

The following formulæ have been found by the writer to be very useful for this purpose:

℞ Morphia sulph., gr. ¼;
Bourbon whiskey, f℥i.
Sig.—Twenty minutes before operation.
For an adult.

℞ Croton chloral hydrate, gr. x;
Bourbon whiskey, f℥i.
Sig.—Thirty minutes before operation.
For an adult.

℞ Potassium bromide, gr. xx to xxx;
Cinnamon-water, f℥i.
Sig.—Thirty minutes before operation.
For an adult.

℞ Potassium bromide, gr. xv to xx;
Croton chloral hydrate, gr. x;
Cinnamon-water, f℥i.
Sig.—Thirty minutes before operation.
For an adult.

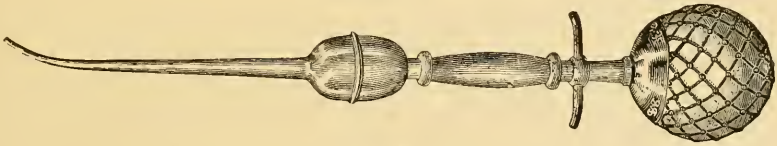
CHEMICAL TREATMENT.

The treatment of hypersensitive dentin by chemical agents includes the application of caloric by means of heated air and such coagulants as carbolic acid, zinc chloride, caustic potassa, chromic acid, nitric acid, and silver nitrate. Arsenic and cobalt have also been recommended for the purpose of obtunding hypersensitive dentin, but the dangers which are likely to follow their use—viz., of destroying the vitality of the pulp and ultimately producing discoloration of the tooth—should render the exhibition of these drugs for such a purpose entirely inadmissible.

Heated Air.—This means of obtunding hypersensitiveness of the dentin was first suggested by Brockway * (1872). It is perhaps the most generally efficient and safest means by which the dentin may be temporarily deprived of its sensation. The therapeutic effect is produced by the abstraction of a portion of the water contained in the dentinal tubuli, or, in other words, by a partial dehydration, which renders the dentinal fibrillæ less capable of transmitting sensation. Were it possible to completely dehydrate the dentin, complete suspension of sensation would be the result. More or less complete dehydration of the exposed surface of the dentin can be accomplished, but this process cannot be carried to any considerable depth, neither is it necessary, for usually the hypersensitiveness is markedly relieved under a partial dehydration of the exposed surface.

In using this means of obtunding hypersensitive dentin the rubber dam should always be used, *first*, to exclude the outside moisture, and *secondly*, to protect the soft tissues from the heated air.

Fig. 313.



Hot-air syringe.

The cavity is then dried with bibulous paper and pellets of amadou, after which the heated air may be thrown into the cavity from one of the variously formed air syringes. Fig. 313 represents the ordinary form of warm-air syringe, the cylinder of which is heated over an alcohol flame or a Bunsen burner. This cylinder contains a carbon core which greatly increases its heating power, and thus by means of the rubber bulb a continuous stream of heated air can be carried through the nozzle into the cavity. Another form of syringe, invented by Dr. S. G. Perry, is shown in Fig. 314. Care is necessary in the use of this instrument not to cause pain by overheating the surface of the dentin. The blast of air first thrown into the cavity should not be above a degree of heat that would be tolerated by the unprotected skin upon the back of the hand. In fact, the writer always tests the degree of heat to be first applied in this manner. As the process of dehydration goes on, the heat may be gradually increased until a degree can be painlessly used that could not be tolerated by the

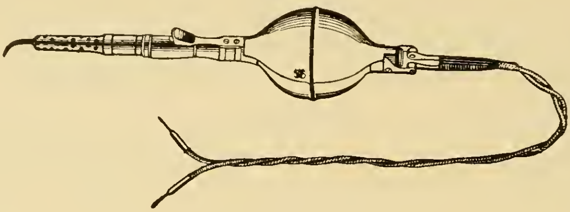
Fig. 314.

Perry hot-air syringe.

* Dental Cosmos, vol. xiv. p. 19.

skin. A certain amount of skill has to be obtained in order to direct the blast of heated air in such a manner as to cause the least pain when it comes in contact with the hypersensitive dentin. If the nozzle of the syringe is held too far away from the cavity, the heated air in passing through the surrounding atmosphere becomes cooled and thus causes pain; while, upon the other hand, if it is held too near, the blast is liable, by its high degree of heat, to cause equally severe pain. In applying heated air it is best to begin gently with a single short blast, repeated at intervals of a few seconds, but as dehydration progresses the length and force of the blast may be increased and at shorter intervals until the pain ceases.

Fig. 315.



Improved electric hot-air syringe.

Another instrument for this purpose is shown in Fig. 315. This syringe has a glass nozzle in which is a spiral loop or platinum wire, connected by flexible copper cords to a low voltage electric current. The platinum loop can be heated to any degree desired, and by pressure upon the rubber bulb attached to the opposite end of the instrument a continuous stream of air is made to pass over the heated loop and through the nozzle. To protect the lips from being burned with the hot nozzle it is covered with a perforated metal shield. With this instrument it is possible to maintain an even degree of heat for any length of time, and this is a very great advantage.

Some operators prepare the cavity for dehydration with heated air by first wiping it out with *absolute alcohol*, as this has a strong affinity for water.

In severe cases of hypersensitiveness which the employment of heated air does not relieve, and such cases are not infrequently met with, the crystals of carbolic acid may be applied to the cavity and followed by the heated air blast, at short intervals, for two or three minutes. This treatment will, in many cases, give complete relief. and yet it cannot always be relied upon to do this.

Hot Water.—Hot water thrown in a constant fine stream upon hypersensitive dentin greatly mitigates the pain caused by excavating the cavity of decay. This means of obtunding sensitive dentin has been known and practised for many years, but it remained for Dr. Merriman, of California, to perfect an apparatus whereby a constant stream of water, heated to *any desired temperature*, could be thrown in a continuous stream into the cavity of decay while operating. The apparatus consists of a small tank or boiler, heated by alcohol, gas or electricity, and a small rubber tube connecting it with a nozzle, having a very small outlet, attached to the engine hand-piece. The stream of hot water is controlled by the first finger of the right hand, through a valve operated by a lever attached to the nozzle. To obtain the best results the water should be heated to the highest temperature that can be borne by the patient without discomfort. Each case will be a "law unto itself" in this respect.

Carbolic Acid.—This remedy when used alone has but very little immediate effect in obtunding hypersensitive dentin, but when used as above suggested, or when combined with *oil of cloves* in the proportion of two parts of carbolic acid to one of oil of cloves, its efficiency is increased. Both carbolic acid and oil of cloves have slightly local anæsthetic properties, but when combined, this property seems to be greatly increased. Carbolic acid also coagulates albumin, and this property may effect the conducting power of the fibrils with which it comes in contact.

The best results, however, are obtained with this combination by sealing it into the cavity with zinc oxyphosphate cement for three or four days.

Carbolic acid combined with *tannic acid* to form a thin paste is many times of service in treating these cases, if allowed to remain in the cavity for a few days. In applying this combination the cavity should be lined with the paste and sealed in with zinc oxyphosphate cement.

Zinc Chloride.—This is one of the oldest and possibly the most efficient local remedy for obtunding hypersensitive dentin in the whole armamentarium of the dentist. It must, however, be used with the greatest caution and good judgment, on account of its escharotic action and its irritating effect upon the dental pulp. It should, therefore, be interdicted in all deep cavities, and under no circumstances placed in close proximity to a living pulp, if it is desirable to conserve its vitality.

The therapeutic action of zinc chloride is due to its affinity for water and its coagulating properties upon albumin, both of which have an obtunding effect upon the dentinal fibrillæ.

When using zinc chloride the rubber dam is indispensable, and it should be so adjusted that there will be no possibility of leakage of fluids from the mouth into the cavity, or of the zinc chloride coming in contact with the soft tissues of the mouth. After drying the cavity in the ordinary manner, the zinc chloride is applied upon a pledget of cotton to the walls of the cavity, and allowed to remain in position for five or ten minutes, or until pain ceases. As soon as this stage has arrived the operation of excavation may be entered upon. It is best, however, to remove the excess of the zinc chloride first by drying with bibulous paper, and then to irrigate the cavity to terminate the action of the agent, as its strong affinity for water quickly deprives the tissue of any remaining portion. Its coagulating effect upon albumin prevents it from penetrating to any considerable depth, and therefore makes it a comparatively safe remedy to employ in all but *deep-seated* cavities, or when the pulp is nearly exposed.

The pain is often intense for a few moments after the introduction of this remedy into the hypersensitive cavity, but this gradually subsides, and usually in a few minutes entirely passes away. If, however, the pain continues, it may sometimes be controlled by the application of heated air, or of carbolic acid, or of both combined. Its greatest sphere of usefulness is in the superficial cavities at the labio- and bucco-cervical margins of the incisors, cuspids, and bicuspids. When employing it in the approximal cavities of the incisors, especially in children whose age would indicate that the process of calcification was not fully completed, caution should be exercised not to cause irritation of the pulp, as the cornua in these cases often lie quite near to the surface.

Occasionally cases will be found in which this agent does not seem to act with any immediate effect; but if the excess of the agent be removed with bibulous paper, and the cavity dried as thoroughly as may be by this means, and then closed with gutta-percha or zinc oxyphosphate, it will be found that in two or three days the carious dentin can be removed without pain, or only such slight sensations as are readily tolerated by the patient.

Zinc chloride, to be most efficient, should be chemically pure. The fused form is the best, and this should be liquefied by the addition of just sufficient distilled water to produce this effect. It should be kept in a tightly stoppered bottle, as the drug has such an affinity for water that it will abstract it from the atmosphere.

Some operators prefer to obtain the obtunding effect of the zinc chloride by filling the cavities with zinc oxychloride, and allowing it to remain for a few weeks, when the hypersensitive condition will have been greatly lessened or have entirely disappeared. In this cement there is usually an excess of the zinc chloride which has not combined with the oxide, and as a consequence it is free to act upon the organic matter in the dentin. This method is, however, inadmissible in all deep cavities in vital teeth, for the reasons already mentioned.

Caustic Potassa.—Caustic potassa combined with carbolic acid in equal parts (Robinson's remedy) often serves a good purpose in obtunding hypersensitive dentin. The rubber dam should be applied to protect the soft tissues, and the remedy introduced upon a pledget of cotton. This often causes sharp, stinging pain, which usually subsides in a few moments. Its obtunding action is increased by the application of a blast of heated air.

Chromic acid and *nitric acid* have both been recommended as obtundents of hypersensitive dentin. Their escharotic action is so great, however, as to make them dangerous agents to use, while their decalcifying effect upon tooth structure is so strong that great care must be exercised to counteract this effect by the use of alkaline solutions immediately afterwards. The soft tissues should be protected from injury by the rubber dam, and the agents introduced into the cavity by means of a platinum- or gold-pointed instrument. These agents are only admissible in very shallow cavities, for the reasons just stated. Chromic acid acts by coagulating the organic elements of the dentin, while nitric acid decomposes the tissue.

Silver nitrate is used for obtunding hypersensitiveness of the dentin in superficial cavities and cervical hypersensitiveness resulting from recession of the gums, but it is not admissible except in the posterior portion of the mouth, where the black discoloration produced by it would not be objectionable. Two, and sometimes three, applications are necessary to entirely obtund the sensation. Moisture should be excluded, and the soft tissues protected during its applicatian. A fifty per cent. solution of the drug is applied to the cavity or the sensitive part of the tooth upon a pledget of cotton, and allowed to remain in contact for a few moments, after which the excess may be removed with bibulous paper and the parts irrigated with water.

Local anæsthesia of the dentin may be produced by ether or rigolene sprayed upon the tooth or into the cavity of decay, but, as a rule, the pain produced in the early stages of the process by the intense cold is often greater than the pain experienced in operating upon the hypersensitive dentin in its original state. The danger also exists, in treating these cases by this means, of producing inflammation, and finally devitalization of the pulp through the irritation of such severe thermal shock.

Basford claims the sulphuric ether spray may be used painlessly if the temperature is reduced gradually, and recommends the following procedure: After the rubber dam has been adjusted, a pledget of cotton is saturated with ether and applied to the cavity to be excavated, and renewed from time to time for about five minutes. This so reduces the temperature—and that without pain—that the spray may now be played upon the cavity without producing discomfort. The spray should be constantly played upon the cavity during the process of excavation.

Local anæsthesia may also be produced by a combination of sulphuric ether and cocaine, which is vaporized in a special apparatus and projected into the cavity by means of compressed air.

Knowles employs a combination of sulphuric ether, chloroform, alcohol, and menthol, which he claims is superior to any other combination that he has used for obtunding the dentin. The mixture is vaporized under compressed-air pressure and forced into the cavity of decay. "The apparatus may be constructed by using two short tubes passed through a cork which tightly fits the mouth of a small jar. A rubber tube connects one tube to the supply of compressed air, and a second tube of rubber leads to the nozzle employed. A minute platinum tube may be made by means of a draw plate and soldered to the inside of the end of a nozzle of the ordinary chip blower." The vapor-laden air may be led to the tooth cavity and directed against the surface to be excavated. The force of the vapor under pressure removes the chips and débris, thus making it possible to continue the operation of cavity preparation without interruption.

The chloroform seems to have a warm and stimulating effect, and in a measure counteracts the pain produced by the rapid evaporation of the ether, while the alcohol and menthol seem to act in conjunction with the chloroform in producing a local anæsthesia.

Vaporized mixtures do not possess in the same degree those objectionable features for obtundents as are possessed by mixtures which are reduced to a spray, for the reason that the vapor is more minutely subdivided, and therefore the quantity of the mixture carried into the tooth cavity in a state of vapor is much less than when in the form of a spray; consequently, the reduction of temperature is not so rapid nor the degree of cold so great. With the spray of ether or ether and cocaine it is possible to reduce the temperature of a tooth to the freezing-point in a very short space of time. This degree of cold is much too low for the safety of the pulp, and yet it is almost impossible with the spray apparatus to avoid coming perilously near to this low degree of temperature.

The methods of treating hypersensitive dentin by electro-cocaine anæsthesia or cataphoresis, and by cocaine-pressure anæsthesia, will be described in the next chapter.

CHAPTER XIV.

CATAPHORESIS.

CATAPHORESIS, electric osmosis, and electric transfusion are terms which have been applied in electrophysics to certain phenomena, by which the direct or galvanic current of electricity seems to convey fluids and chemical substances in solution through animal membranes and tissues, and deposits them at the poles.

The physical phenomena of natural osmosis, whereby fluids of unequal density pass through animal membranes and tissues in a direction from the lighter to the denser fluid, illustrates the process of cataphoric action. If two fluids of unequal specific gravity be separated by an animal membrane, and the positive pole or *anode* of the galvanic current conveying ten to fifteen milliamperes be placed in one, and the negative pole or *cathode* in the other, it will be found that the fluid in contact with the anode will rapidly decrease in quantity, while that in contact with the cathode will be increased in volume. This is, however, seemingly something more than simply the natural physical phenomena of osmosis, accelerated by the action of the electric current, for the direction of the movement of the fluid is controlled by the positive current,—viz., it flows from the positive to the negative pole. But if the current be reversed the volume of the fluid is changed at once by the denser fluid being carried into the partition containing the lighter fluid, thus reversing the established order of the movement of fluids in natural osmosis, and this phenomenon may be produced again and again at the will of the experimenter.

This power of conveyance of chemic elements possessed by the direct current is not confined to substances of elementary form, but may in many instances be applied to substances of very complex chemic structure, as, for instance, cocaine ($C_{17}H_{21}NO_4$), or methyl-blue ($C_{16}H_{18}N_3SCl$), which may be conveyed as molecules. On the other hand, certain chemic substances may be conveyed through animal membranes and tissues, but on coming in contact with the opposite pole are decomposed by the electrolytic action of the current and the radicles or individual elements set free.

For instance, if a pellet of absorbent cotton saturated with a *neutral solution* of *potassium iodide* (KI) be placed upon the cathode, another piece of cotton soaked in distilled water be placed upon the anode, a piece of animal membrane, like chicken-skin, be placed between them in contact with the cotton upon each electrode, and a current of from ten to fifteen milliamperes be made to pass for about fifteen minutes, no change will be noticed at the cathodal electrode, but the cotton at the anode and the surface of the membrane lying in contact with this pole will be found to be slightly colored with iodine.

This seems to prove, *first*, that the potassium iodide travels under the influence of the direct current from the negative to the positive pole, and *secondly*, that in all probability this chemic compound is conveyed through the membrane in a molecular form as potassium iodide, and upon reaching the anodal electrode is decomposed by the electrolytic action of the current, and the iodine is set free. On the other hand, if the potassium iodide solution be placed at the anodal electrode, the cotton at the cathode be soaked with distilled water only, and a current be turned on of the same strength and for the same length of time, no change will be observable in the color of the cotton at the cathode, nor of the cathodal surface of the membrane, while at the anode the cotton will be deeply stained with iodine.

In illustration of the conveying power of the direct current applied to the more complex chemic compounds, cocaine ($C_{17}H_{21}NO_4$) may be taken as a fair sample of these compounds.

If a *four per cent.* solution of cocaine hydrochlorate be placed in contact with the surface of the skin by means of absorbent cotton, disks of blotting-paper, sponge, or other absorbent material, it will have little or no effect in obtunding sensation, although it may be kept in contact for an hour or more. Let this same solution, however, be applied in the same manner, and then pass a direct current of from fifteen to twenty milliamperes through the tissues, the anode being placed in contact with the substance containing the cocaine solution and the cathode at some other point, the cuticle in the region of the anode will in a very short time be found to be thoroughly anæsthetic, and will remain in this condition for from several minutes to as many hours, the period of anæsthesia depending upon the strength and density of the galvanic current employed, the duration of its application, and the per cent. of the cocaine solution which had been applied.

Another simple experiment illustrating the conveying power of the direct current is made with methyl-blue. Take two open-mouthed jars having the capacity of one or two quarts. Half fill each of these jars with distilled water, adding a small quantity of methyl-blue, sufficient to slightly tint the water. Then place the anode in one jar and the cathode in the other. If the right hand be now immersed in one jar and the left in the other, thus completing the current, and be permitted to remain for twenty minutes, while a current of ten to fifteen milliamperes is allowed to pass through the circuit, it will be found at the expiration of this period that the hand which had been placed in the jar with the anode will be deeply stained with the methyl-blue, the pigment having penetrated the hair-follicles, sweat-glands, and cutaneous crevices, producing a discoloration which cannot be washed away, and will remain for several days ; while the hand which was immersed in the jar containing the cathode can be readily cleaned by a simple washing.

When this peculiar power or expression of electric force possessed by the direct current is applied to therapeutics, it is used to convey medicinal substances in solution which have been placed in contact with the positive electrode,—anode,—or with the negative electrode,—cathode,—into the tissues of the body or through them, with the object of securing the local effect of such remedial agents.

In dental surgery this may be applied to decolorizing or bleaching devitalized teeth, in sterilizing the dentin, or producing local anæsthesia in sensitive dentin.

The power of the galvanic current, however, is not limited to the conveying of medicinal substances in solution, but it may be employed to transfer substances already in the tissues, whether of normal or abnormal composition, from one part of the body to another, or from the deeper tissues within any part of the body to the surface, with the object of entirely removing such substances.

The fluids of the body and many medicinal substances, when subjected to the electrolytic action of the direct current, flow in a constant direction from the positive to the negative pole, but certain other chemical substances, which may be dissolved or held in suspension in the fluids of the body, applied to the surface, have been found to travel in an opposite direction,—viz., from the negative to the positive pole.

At the present time the subject of cataphoresis is still more or less in the experimental stage, and the electric affinity or direction in which the various medicinal agents will travel when subjected to the galvanic current has only been determined for a few of them, so that it becomes necessary to establish this fact by experiment for each new remedy used before attempting to apply it cataphorically.

The phenomena which are included under the term cataphoresis, or electric osmosis, "must be regarded as the result of several causes operating at the same time and more or less interdependent, since certain of these phenomena are electrolytic, some mechanical, and others chemical." *

Most physicists explain or base their explanation of the phenomena of cataphoresis upon the law first discovered by Thales about 600 B.C.,—viz., that amber when briskly rubbed attracted light bodies like chaff and bits of paper. This law is now expressed as follows: "When a difference of potential is established by a direct current of electricity sent through a collection of molecules, each atom or molecule of any substance that is free to move deports itself according as the electric charge which it receives is positive or negative. Those *ions*, atoms, or molecules with a negative charge will move towards the anode, and those with a positive charge towards the cathode." †

The direction, therefore, according to this law, in which a remedy in solution will be conveyed by the application of the galvanic current, whether from the positive to the negative pole or the reverse, will depend upon the electric affinity of the disassociated *ions*, or, in other words, upon the initial charge which they have received.

There is a question, however, in the minds of some physicists as to whether this is not the real explanation of cataphoric action, rather than that the current by its electromotive force or driving power forces the

* Lectures, National School of Electricity.

† Ibid.

remedy in solution into the tissues, as was generally supposed a short time ago.

Among the chemical substances which have been proved upon good authority to be conveyed into the tissues when applied by the anodal electrode of the galvanic current are cocaine hydrochlorate, aconitine, tincture of aconite, helleborine, mercuric chloride, mercuric succimide, lithium chloride, strychnia nitrate, strychnia sulphate, menthol, and thymol, while sulphur, eosine, potassium iodide, and the bromide salts are conveyed from the cathodal electrode.

Electrolysis.—Many chemic substances and compounds are decomposed by the action of an electric current, while the liberated elements show different attractions, some of them travelling to the positive pole, others to the negative.

This phenomenon of dissolution is denominated *electrolysis*, the compound decomposed or acted upon an *electrolyte*, and the products of electrolysis are termed *ions*. The elements thus liberated are attracted to one or the other of the poles; those which are attracted to the positive pole are called *anions;* those attracted to the negative pole are designated *cations*.

As an illustration of the electrolytic decomposition of chemic substances the familiar experiment of decomposing water by the action of an electric current may be cited. In this case the elements composing the water are dissassociated, and the *ions* immediately seek their electric attraction, the hydrogen—which is a *cation* or electropositive element—collecting in the form of bubbles at the negative or cathodal electrode, and the oxygen—an *anion* or electronegative element—gathering at the positive or anodal electrode.

In carrying this phenomenon a step farther to more complex chemic substances, it is found that "by passing a galvanic current from a primary battery or from a dynamo, through a liquid containing a metallic salt in solution, such as nitrate of silver, the metallic salt is decomposed, the metal being deposited upon the cathodal electrode, while the nitrogen enters into other compounds, as with oxygen, forming nitric acid, which accumulates at the anodal electrode." *

Decompositions of the same general character take place in all compound solutions, regardless of their degree of density, whenever they are made a part of the circuit of a galvanic current. The chemic constitution of such solution immediately begins to undergo electrolytic dissolution; the acids, oxygen, chlorine, and the electronegative elements collect about the positive electrode, while the alkalies, hydrogen, and the electropositive elements collect about the negative electrode.

"If these terminals or poles in contact with the solution are suitably devised electrodes, and the solution is some one of the tissues of the human body,—for such tissues, though differing in density, are bathed in liquids and permeated by them,—physical effects similar to those just described follow the passage of the current, the result depending upon the nature and composition of the tissues involved, the strength of the current, and the length of time it is permitted to flow." †

* Lectures, National School of Electricity. † Ibid.

The character of the changes which take place in the electrolytes—fluids or animal tissues—at distant points from the electrodes in the track of the current is not known, while "it is difficult to account for the phenomena of decomposition which takes place at the electrodes without assuming that some kind of rearrangement of the molecules composing the electrolytes occurs along the entire track of the current." *

Anodal Electrolysis.—This term is used to designate those phenomena which take place at the *positive pole*, or *anode*, as a result of the application of a galvanic current to or its passage through the tissues of the living human body.

Its action may be experimentally shown by taking a piece of fresh, lean meat and passing a needle into it which is connected with the positive pole or anode of a galvanic current having a strength of from five to ten milliamperes, the cathode being placed upon the opposite side. After the current has been allowed to pass for a few minutes, it will be noticed that at the point of insertion of the needle the meat has become dry, white, and shrunken. The extent and depth to which this effect may be carried into the tissue will depend upon the *strength of the current*, the *length of time it is employed*, and its *density*, the latter being determined by the size of the needle or anodal electrode. This effect in a measure is the result of the coagulation of the albuminoid substances contained in the tissues from the action of the acids collected at the anode, and partly to cataphoresis, or the electric affinity of *ions* possessing an electropositive charge, which directs them to the cathodal electrode.

If the needle or anode is made of a material that is not readily oxidized—like gold or platinum—and is not materially acted upon by acids or chlorine, no change other than that just mentioned is observable in the tissues; but if the needle employed is of iron, steel, or copper, salts are formed, and the tissues in its immediate vicinity are stained by a deposit of the oxide or oxychloride of the metal used.

The drying of the tissues in the vicinity of the anode is due to the cataphoric effect of the current which carries the fluids towards the cathode, or to the migration of electropositive *ions* which seek their affinity at the negative pole. This phenomenon may be illustrated by passing a galvanic current through a piece of wet clay. In a few minutes the surface of the clay in the vicinity of the anode will begin to show signs of drying and hardening, while at the cathode the moisture will collect in increasing quantity and softening of the surface takes place.

It may be stated briefly, therefore, that the effect of anodal electrolysis upon animal tissue is *destructive*, but that this destructive action may be employed to advantage in the treatment of various pathologic conditions where this destructive effect, if judiciously used, would retard or entirely arrest the progress of the diseased condition.

The phenomena of anodal electrolysis which takes place in animal tissues are:

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* Lectures, National School of Electricity.

1. The accumulation of *oxygen*, *chlorine*, and *acids* in the vicinity of the electrode.

2. The tissues in contact with and immediately surrounding the electrode, as the result of the accumulation of the above destructive anions, suffer more or less disintegration by the disturbance of their molecular composition, which later causes structural changes and arrest of function.

3. The acids formed at the anode, reacting upon the albuminoid substances and other organic elements contained in the tissues, produce *astringent*, *styptic*, *bleaching*, and *coagulating effects* upon those parts with which they come in contact.

4. When the electrode is made of some material which is readily oxidized, or has a strong affinity for the acids which collect about it, *secondary chemical compounds are formed*, like oxide or chloride of iron, of copper, or of zinc, as the case may be, which may possess therapeutic value or may produce indelible staining of the tissues.

The therapeutic employment of the secondary products formed at the anode or cathode is termed *metallic electrolysis*, but this function is almost exclusively confined to the anode.

Anodal electrolysis has a wide range of therapeutic application in both general and special surgery. In dental surgery and stomatology it may be applied to the removal of cysts and new growths upon the tongue or oral mucous membrane; to hemorrhagic conditions of this membrane, and in hemorrhage after extraction; to phagedenic ulcers, follicular diseases, and inflammatory conditions due to low forms of bacterial life; to the local treatment of pyorrhœa alveolaris; to the production of aseptic conditions in devitalized and suppurating teeth, and to decolorizing or bleaching devitalized teeth.

Cathodal Electrolysis.—This term is used to designate those phenomena which take place at the *negative pole* or *cathode* as a result of the application of a galvanic current to the tissues of the body. When such a current is passed through the compound solutions which compose a larger part of every animal tissue, the constituents of the tissues in the immediate vicinity of the cathode are decomposed, the hydrogen and the alkali *ions* gathering about the cathodal electrode. The alkalies which are thus collected are principally soda and potassa.

Inasmuch as these substances do not possess chemic affinity for the metals generally used for electrodes, with perhaps the exception of aluminum, which is corroded by the alkali *ions*, forming aluminates of soda and potassa, but which do not seem to possess any therapeutic value when locally applied, it only becomes necessary to consider the action and disposition of the hydrogen and the alkalies. If a piece of fresh meat or egg albumin be subjected to the action of a galvanic current, it will be observed that the hydrogen gas which collects at the cathode will bubble up and escape, or be detained in the meshes of the tissues, while the soda and potassa will unite with the albuminoids of the tissues immediately surrounding the cathodal electrode, causing softening of these tissues, and if continued for a sufficient period of time in the living body, disintegration, loss of vitality, structural changes, and liquefaction will take place.

The phenomena presented by cathodal electrolysis, therefore, are:

1. The accumulation of *hydrogen and alkalies* in the vicinity of the electrode.

2. The presence of *hydrogen gas in the meshes of the tissues* or its escape, and *the union of the alkalies with the albuminoids of the tissues.*

3. The *softening of the tissues* in the neighborhood of the electrode and *their final liquefaction.*

From the foregoing statements it will be observed that the phenomena of cathodal electrolysis are also destructive in their nature to the living tissues when much prolonged, and yet these phenomena when skilfully applied to certain pathologic conditions are capable of being rendered most beneficial.

Cathodal electrolysis has its greatest usefulness in the softening and relaxation of cicatricial tissue, in the reduction of hyperplasias and other inflammatory growths, in the removal of fungous growths, and in the treatment of bony and cartilaginous enlargements, especially of the nasal passages, the alveolar processes, and the palate.

Ordinarily the electromotive force required for electrolytic work will not exceed twenty volts, but the resistance of the tissues is so variable that a current of the strength of ten to fifteen milliamperes is not infrequently employed, making a greater electromotive force necessary for the most efficient work.

THE GENERAL PRINCIPLES OR LAWS WHICH GOVERN THE GENERATION AND TRANSMISSION OF ELECTRICITY.

Generation.—Electricity may be generated, first, by *friction*, when it is termed frictional or *static electricity;* secondly, by *chemic action*, when it is termed *chemic electricity;* thirdly, by *induction*, when it is known as *induced electricity.*

The *first* is a form of electricity used largely in medicinal practice, and is generated by a machine in which a glass disk is made to revolve rapidly while in contact with specially prepared rubbers, the electricity being collected and stored by apparatus adapted to the purpose.

The *second* or *chemic electricity* is generated by *primary* or *galvanic* batteries.

Primary batteries, of which there are a number of different forms, are composed of two plates of different metals,—*the elements*,—as copper and zinc, or of one metal and a non-metallic substance, as carbon, which are placed in a jar containing a liquid—*the electrolyte*—composed of a solution of sulphuric acid or of ammonium chloride, zinc chloride, or other suitable solution, the two plates being connected together outside of the liquid, when, by the chemic action taking place between the elements and the electrolyte, a current of electricity is generated. This constitutes a cell of a primary or galvanic battery. A battery may be composed of a single cell or any number of cells joined together in series by connecting with copper wire the negative pole of one cell to the positive pole of the next, and so on until the series is completed. The wire or cord attached to the copper element of the first cell would be the *positive pole*, while that attached to the zinc element of the last cell would be the *negative pole.* The current travels in the outside circuit from the positive to the negative pole. The poles are determined by the direction in which the current flows; the plate from which the electric current flows outside the liquid is termed the *positive pole*, while the plate to which the current returns outside the liquid is denominated the *negative pole.* In a cell composed of copper and zinc elements, with dilute sulphuric acid as the electrolyte, the zinc is most violently acted upon, and the electric current generated flows from the zinc or *positive element* through the liquid to the copper or *negative element,* and from that through the external conductors or wires back to the zinc element, thus completing a *circuit.* That portion of the zinc plate which is immersed in the electrolyte is positive to that part of the copper plate which is likewise immersed, but the portion of the copper plate above the liquid is positive, while the same portion of the zinc plate is negative. To indicate these conditions the signs plus (+) and minus (—) are used.

Primary batteries are divided into two classes,—viz., *open circuit* and *closed circuit* batteries. The open circuit battery is one which works best when not in constant use, and is usually employed for call-bells and signal circuits generally. The "Leclanche" is the best of this class of batteries. In this the elements used are zinc and carbon; the electrolyte is a solution of ammonium chloride; the carbon, being placed in a porous jar and surrounded by powdered manganese dioxide, is suspended in the liquid in the centre of the battery jar, and the zinc element is suspended at one side. This form of battery, if made to work continuously, soon runs down, and must be given a period of rest before it can be used again. When only brought into action for brief periods at a time it works most satisfactorily. The electromotive force of such a cell is about 1.47 volts.

The class of batteries known as closed circuit batteries comprise those varieties which work best when in constant service. The "gravity" battery, which is a modification of the "Daniell," is the best of this class.

The gravity battery is formed by placing the copper element in the bottom of the battery jar and suspending the zinc element from the top; these are cast in the form of a wheel or "crowfoot." A cupric sulphate solution is then poured over the copper element, and a quantity of cupric sulphate crystals added. Upon this solution is carefully poured a solution of zinc sulphate. The specific gravity of the two solutions is so different that they do not readily mix; the cupric sulphate solution, being the heavier, remains at the bottom of the jar. The zinc sulphate solution takes the place of the sulphuric acid in the Daniell's cell, and although it does not give quite so high a voltage, the action of the cell is more even and constant. The potential of such a cell is from 1 to 1.14 volts.

The *dry cell battery* is made either upon the principle of Zamboni's dry voltaic pile, or some such substance as sand, sawdust, or paper, moistened with acidulated water, separates the elements in each cell.

Secondary or storage batteries are composed of two or more plates of the same metal,—generally lead,—which are placed in a solution which, under ordinary circumstances, does not attack the metal,—usually dilute sulphuric acid,—and consequently no electricity is generated. But if a current of electricity, generated from some outside source, like a dynamo furnishing a one-hundred-and-ten-volt electric lighting current, is allowed to pass through the battery, a chemic action is set up in the solution termed *charging*, which decomposes it and causes plumbic dioxide (PbO_2) to be deposited upon one plate and metallic plumbum (Pb) in a spongy form upon the other. This forms a battery of two different elements,—viz., PbO_2 and Pb immersed in an electrolyte, hydric sulphate (H_2SO_4)—sulphuric acid—of full strength and specific gravity, which is capable of acting upon them.

The lead plates which form the element must be so constructed as to present a large surface upon which the chemic action may take place, as the amount of energy which can be stored in a cell depends upon the capability of the plates to appropriate the results of the chemic action.

If the poles of the battery are now brought together and the circuit closed, a current of electricity will be immediately generated. In the chemic action which takes place during the discharge of the battery, one atom of oxygen (O) contained in each molecule of the PbO_2 will pass to the opposite plate, joining with the Pb and forming *plumbic oxide* (PbO). This process continues as long as any molecule of PbO_2 remains upon the surface of the plate to give up its oxygen. When no more oxygen is liberated both plates become alike (PbO) over the entire surface.

The sulphur radical in the electrolyte (H_2SO_4) enters into combination with the active material on both plates, forming plumbic sulphate (Pb_2SO_4), the specific gravity of the electrolyte being correspondingly reduced. When all of the active material has been changed in this manner the cell is said to be discharged, for an equilibrium has been created between the two plates and the electromotive force is reduced to zero, and so remains until it is again *charged* by an electric current from the outside. Secondary batteries discharge their electric current in an opposite direction from that in which they were charged. Like primary batteries, the potential or electromotive force does not depend so much upon the size of the elements as upon the materials composing them and the nature of the electrolyte; but the amount of the electric energy furnished by any cell will depend upon the area of the surfaces of the elements exposed to the action of the electrolyte.

The electromotive force of the charging current should be about twice as high as that of the cells to be charged. On the other hand, the amount of current charged per hour should not exceed what is called the normal charging rate, and which differs according to the size of the cells. The normal rate of charge for small storage batteries is about ten hours, and if a cell has a capacity of fifty ampere hours, not more than five amperes should be charged, and for a cell of one hundred ampere hours, not more than ten amperes should be charged.

The rate of charge should be preferably kept at normal or under, as continuous charging at a higher rate than normal would injure the plates.

Storage batteries, however, have never come into general use for medical or dental purposes, and although they have been used to some extent for heating cauteries and lighting exploring lamps, they are by no means a convenient or economical method of obtaining an electric current.

Induced Electricity.—This form of electric current is produced by dynamo-electric machines, and is the common current now used so extensively for illuminating and power purposes. There are two general classes of dynamo-electric machines; one class produces an *alternating current*, and the other a *continuous current*.

The modern Edison dynamo-electric machine so generally used all over the world for lighting houses and shops and running small motors delivers a continuous current. This current is often used for therapeutic purposes by the physician, surgeon, and dentist. The current delivered by such a dynamo differs from that delivered from the primary battery in that it has a slight but uniform variation in strength. The strength of the current coming from a primary battery may be represented by a straight line, while that from the dynamo would be by comparison represented by a line waving slightly but uniformly. It has not been definitely determined whether this difference in the current has any effect upon the constituents of the body, but so far as known they seem to act alike.

The most convenient dynamo current for therapeutic uses is the Edison direct current of one hundred and ten volts. The pressure of this current varies from one hundred to one hundred and twenty-five volts, according to the position on the mains. The electromotive force can be reduced to any degree necessary to conform with the requirements of the physician, the surgeon, or the dentist by lamps or other resistances and shunts. By employing this form of current much of the annoyance attending the operation of primary batteries is obviated, and with the now quite common practice of placing the mains in underground conduits, the dangers from lightning or crossing with wires of dangerous potential is reduced almost to *nil*.

Transmission.—Electric currents are transmitted, conveyed, or conducted by various substances, like metals, charcoal, graphite, fluids, animal tissues, etc. Any substance which is capable of conveying electricity is termed a conductor, and those substances which do not convey it are termed non-conductors; dry air, glass, vulcanized rubber, porcelain, etc., belong to the latter classification.

In substances which are perfect conductors, like silver and copper, electricity moves with absolute freedom under any electromotive force, no matter how small. Copper wire is generally used as a means of conducting electric currents.

The conducting power of pure silver is 100, that of copper 97. In substances which are perfect non-conductors, electricity will not move under any electromotive force, no matter how great. In substances which are imperfect or partial conductors, electricity moves only upon the exhibition of great electromotive force, the amount of electromotive force required varying according to the ability of the substance to convey an electric current.

The transmission of electric currents is through metallic conductors, copper wire being chosen for economic reasons. The resistance of these conductors is varied by the character of the metal, the cross-section (size), and the distance to which the current is conveyed.

The percentage of conducting power possessed by the various metals and alloys employed in electric work is as follows: Silver, 100; copper, 97; gold, 75; aluminum, 54; zinc, 28; platinum, 17; wrought iron, 16; nickel, 12; tin, 12; lead, 8; mercury, 1.6; cast iron, 3; platinum silver made of two parts platinum and one part silver, 6.4; German silver made of five and one-half parts copper, two parts zinc, and two and one-half parts nickel, 3.5; German silver made of six parts copper, two and one-half parts zinc, and one and one-half parts nickel, 5; German silver made of five parts copper, three and one-half parts zinc, and one and one-quarter parts nickel, 7.5.

Units of Measurement.—The *electromotive force*, or electric pressure furnished by the cell or the dynamo, is the force which moves the current against the resistance of imperfectly conducting substances, and is termed *voltage*.

The *active energy* of electricity lies in a property designated as its *current strength*, and is termed its *amperage*.

The unit of *quantity* is the *coulomb*.

The unit of *pressure* is the *volt*.

The unit of *strength* is the *ampere*.

The unit of *resistance* is the *ohm*.

The unit of *power* is the *watt*.

A *coulomb* represents the *quantity* of electricity that passes during one second through a conductor having a resistance of one ohm, with one volt of electromotive force.

A *volt* represents the electromotive force (E. M. F.) which is required to move one ampere of current through one ohm of resistance. This force may be represented, for example, by the pressure necessary to move a certain number of gallons of water per minute through a pipe of given size; reduce the size of the pipe and the resistance becomes greater, thus calling for a greater degree of pressure to accomplish the task.

An *ampere* represents the volume of an electric current carrying one coulomb per second; hence it is the measure of the *rate of flow* of an electric current, and, in connection with the *voltage*, measures the *energy* of the *current*.

The measurement of the ampere of current is based upon the electro-chemical effects of currents, and is defined as that much current which will deposit silver at the rate of 0.0001118 grammes per second from a standard solution of silver nitrate in water, or which will decompose 0.00326 milligramme of water in one second.

An *ohm* of resistance is defined as equal to the resistance of a column of pure mercury which is 106.3 centimetres long, and has a uniform cross-section which contains 14.4521 grammes of mercury, the temperature being that of melting ice. This gives the column the uniform cross-section of one square millimetre. The ohm is that degree of resistance which will allow one ampere of current to pass under a pressure of one volt.

According to *Ohm's law*, when a current of electricity flows through a wire, under the pressure from a battery or other sources of electricity, *the effective strength of current which flows in the circuit is equal to the pressure divided by the resistance of the circuit.* It is often written thus: $C = \frac{E}{R}$, when C, E, and R stand for current pressure (electromotive force) and resistance, and may be read C equals E divided by R. It is evident, also, from the relation as written above, that E equal C times R, and R equals E divided by C. By this law if any two out of the three fundamental electric quantities which exist in a circuit are known, the third can at once be calculated. Thus, if a sixteen-candle-power incandescent lamp is known to take one-half an ampere when attached to a circuit which furnishes a current at a pressure of one hundred and ten volts, the resistance of the lamp when in operation may be calculated at once to be one hundred and ten divided by one-half, which gives the resistance of two hundred and twenty ohms. Or if two cells of a battery, each furnishing a pressure of 1.1 volts, and each having an internal resistance of three ohms, be connected with an external circuit of 2.8 ohms' resistance, then the total resistance in the circuit is 8.8 ohms, and the pressure which acts to pass the current through the circuit is 2.2 volts. The current flowing under these circumstances is therefore one-quarter ampere ($C = E\ R$ or $\frac{1}{4} = 2.2/8.8$).

A *watt* is the amount of power developed by a current of one ampere, having an electromotive force of one volt. It is the unit of *electric work*, and represents the *power* exerted by one ampere of current at one volt of pressure.

These propositions may be written thus:

Amperes = volts ÷ ohms.
Ohms = volts ÷ amperes.
Volts = amperes × ohms.
Watts = volts × amperes.

RHEOSTATS; CURRENT SELECTORS; CURRENT CONTROLLERS.

Rheostats.—Electric currents furnished by the various means already mentioned—viz., primary batteries, secondary batteries, and dynamos—need to be modified in strength in order to adapt them to the requirements of therapeutics. This may be accomplished by adding resistance to the external current, or by diverting a portion only of the available current into the circuit with the patient.

The substances which are introduced for the purpose of reducing the energy of the current by the interposition of increased resistance are selected because of their great resistance to the passage of electric currents. These substances are water, carbon, graphite, and coils of German silver wire.

Rheostats when constructed for therapeutic work have a mechanical device for increasing and decreasing, at the will of the operator, the amount of resisting substance in the circuit.

Water Rheostats.—Water rheostats vary in resisting capacity according to the quantity and purity of the fluid admitted into the circuit. Distilled water only should be used for such purpose. The current in passing through this resistance heats the water and decomposes or electrolyzes it. If the water is impure, deposits occur or the metal plates may be corroded, thus impairing the usefulness of the instrument. The chief objection to this form of rheostat is the fact that there is no simple or elementary means of measuring with accuracy such form of resistance.

In the water rheostat one pole is attached to two metal plates separated by about three-fourths of an inch and placed in the bottom of the glass receptacle containing the water. The other pole is attached to a sliding rod worked with a ratchet, the rod having attached to its lower end an angular plate of metal with the apex pointing downward,—both poles should be made of platinum,—which, as it is lowered into the water, increases the surface of this pole in contact with the water, and thus decreases the resistance. The current passes from the battery—or a suitable lamp resistance or shunt when the street main is used—through the water and the patient in series. The current is controlled by raising or lowering the pole having the angular plate of metal attached to its lower end.

Carbon and Graphite Rheostats.—This form of rheostat is usually constructed in the shape of a broken ring, one pole being attached to one end of the ring, and the other pole to the index which travels over the circular disk (Fig. 316). These serve fairly well for modifying the cur-

Fig. 316.

Jewell graphite rheostat.

rents from portable and stationary batteries, and also from dynamos when the amount of current used is small. They have the advantage of furnishing a high resistance in a very small compass, but they also have a disadvantage in that they cannot be graduated, since their resistance is variable even in instruments of the same size and shape.

German Silver Wire Rheostats.—German silver wire rheostats when well made are the most reliable and constant, and have this advantage over all other forms, that the resistance which they offer can be accurately measured. In this form of rheostat the degree of resistance is regulated by the length and the diameter of the wire, the cross-section being reduced to the smallest size which will conduct the current without overheating; it is therefore graded with especial reference to the amperage of the current it is expected to convey. In the construction of this form of rheostat two general methods are followed: one is to arrange the wire in unbroken coils between a certain number of contact points, disposed at equal distances from each other around a broken ring, one pole attached to one end of the broken ring, as in the graphite rheostat, and the other pole to the index which travels over the contact point. The other method is to wind the wire upon spools of fibre, one arranged as a permanent resistance, the other as a shunt resistance. The coil of the shunt resistance is wound in notches of a small fraction of an inch, and a contact-shoe is made to move from one end of the coil to the other, and in doing so touches several hundred turns of the wire, thus giving as many different gradations of current flow.

In the use of high voltage currents, such as the one-hundred-and-ten-volt circuit, it may be switched through the coils of such a rheostat and reduced to any degree required.

A *current selector* is a mechanical device for throwing a greater or less number of cells of a primary or secondary battery into the circuit. The amount of current can thus be made to vary as the exigencies of the case demand, while the electromotive force is gradually increased and decreased at the will of the operator.

A current selector or switch of this character does not, however, do away with the necessity of a rheostat, especially if it is constructed to increase the number of cells thrown into the circuit by groups rather than singly.

Dynamo Current Controllers.—These are resistances especially adapted to the dynamo current, either to be put in series with the patient or so constructed as to form a shunt circuit with the patient's circuit. In the former case the current is modified by a rheostat capable of increasing and decreasing the resistances, while in the latter the device is such as to admit a greater or less flow of current into the shunt circuit. The principal difference between these methods of controlling the dynamo current is that in the former the electromotive force remains the same regardless of the amount of current the patient is receiving, while in the latter this electromotive force varies with the current received.

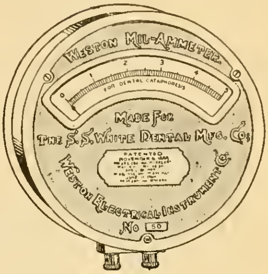
These instruments can be so controlled that the graduation will be exact.

Milliamperemeters.—Exact work in electrotherapeutics cannot be accomplished when using the direct current without the means of accurately measuring that current.

The milliamperemeter offers the means of measuring the strength of the current being used, and this is of first importance in cataphoric work, as it enables the operator to measure the resistance of the tissues involved in the circuit, and offers a sure means of detecting any leakage of the current, which is also important, for if it is not discovered, it prolongs the time necessary to produce the desired result or cause it to end in complete failure. Currents used upon the body for therapeutic purposes never exceed one-half an ampere, or five hundred milliamperes, and for nearly all cataphoric work much less than this, from five to twenty milliamperes being about the limits of the customary range.

Five milliamperes of current for dental cataphoresis is often more than can be used. A current strength of from two-tenths to two milliamperes is usually all that can be borne without producing pain.

Fig. 317.



Weston's dead-beat milliamperemeter.

There are two forms of milliamperemeters in use by physicians and dentists. In one the needle is magnetic and arranged to freely turn upon a pivot, and is easily influenced by outside magnetic forces. The needle is deflected away from the earth's magnetic meridian by the electric current which traverses a coil of wire which is parallel with the magnet before the current passes. In the other the construction is such that the indicator comes instantly at rest, and has no period of oscillation before the measurement can be read,—in other words, it is what is termed "dead-beat." (Fig. 317 shows such an instrument.) These instruments are made with a double scale, one for strong and the other for weak currents, the scale for the weaker current being divided into twentieths of a milliampere.

Conducting Cords and Tips.—The *conducting cords* are made of bunches of fine copper wire covered with cotton or silk, and should be pliable as well as strong and durable. If the cords are not made of good material, the strands or threads are liable to be broken with use, and the current thus be rendered fitful or interrupted by such defects.

The *tips* or terminals are metal devices placed at either end of the conducting cords for attaching them to the binding posts and the electrodes.

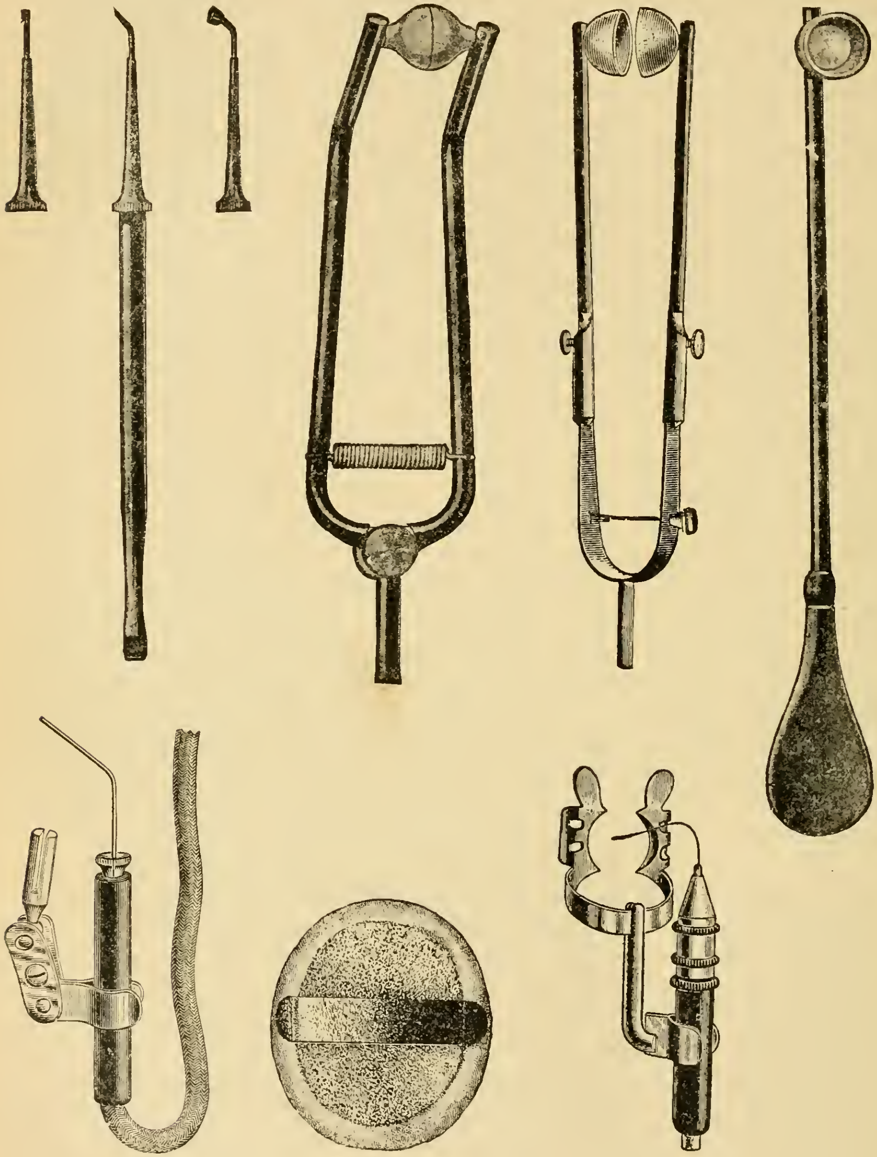
Electrodes.—These of necessity are made of various materials and of many sizes and shapes to meet the demands of special forms of treatment. The practical medical and surgical electrotherapeutist will need an entirely different line of electrodes from those required by the dental surgeon. Fig. 318 shows a selection of electrodes employed by the dental surgeon.

ELECTROCOCAINE ANÆSTHESIA.

As a means of obtunding hypersensitive dentin, anæsthetizing the dental pulp, and producing local anæsthesia for tooth extraction, the cataphoric or electrolytic action of the direct electric current in carrying cocaine into the dental tissues and thus paralyzing the function of sensation bids fair to become the most important means which has ever been placed in the hands of the dentist for relieving the pain of dental operations. Many successes and also many failures have been reported in the use of cataphoresis. The failures have been the result, no doubt, of those conditions which always surround any new method of treatment, especially if it introduces remedies or forces the action of which are more or less imperfectly understood, as was the case with nitrous oxide, ether, and chloroform. But in time these difficulties will be eliminated by research and experimentation, and the methods of treatment so perfected that failures will become either a matter of an individual idiosyncrasy of the patient or of a lack of ability upon the part of the operator to manipulate the apparatus.

The solutions of cocaine which are used in cataphoresis vary in strength from ten to forty per cent. These solutions may be made from either the

Fig. 318.



Cataphoric electrodes.

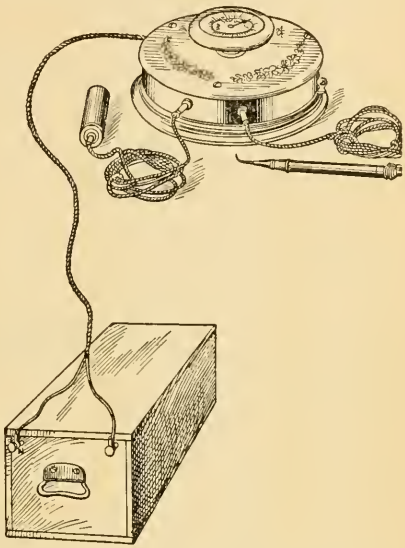
hydrochlorate or the citrate, dissolved in distilled water, glycerol, guaiacol, or guaiacol and ether. Morton recommends making fresh solutions for each case, because of the fact that cocaine solutions deteriorate and lose their anæsthetic property in a large measure in a few days.

Apparatus.—The apparatus necessary for producing electrococaine anæsthesia are a suitable primary galvanic battery; preferably a dry-cell chloride of silver, or a dry-cell Leclanche battery, having an electromotive force of from ten to thirty-five volts; a reliable rheostat or controller so arranged that the current may be increased or diminished by slow gradations at the will of the operator; a milliamperemeter graduated to register the twentieth part of a milliampere; conducting cords and electrodes.

The secondary or storage battery is sometimes employed for producing cataphoresis. When this form of battery is used the plates should be small,—three by three inches. The potential of a cell of this size will be about two volts, and the normal strength of current at eight hours' discharge is five-eighths of an ampere.

The Edison one-hundred-and-ten-volt street current may also be employed by suitably reducing the strength of the current. The objections which have been raised to the use of this current are the dangers from severe shock, if by chance the apparatus should be defective, or lightning should strike the supply wire, or it should become crossed with one carrying a current of much higher potential. These dangers may be guarded against by placing the mains underground, as is now being done in all of our large cities, and by inserting a suitable *fusible wire* connection in the apparatus that will not carry a current of greater strength than one-half an ampere.

Fig. 319.



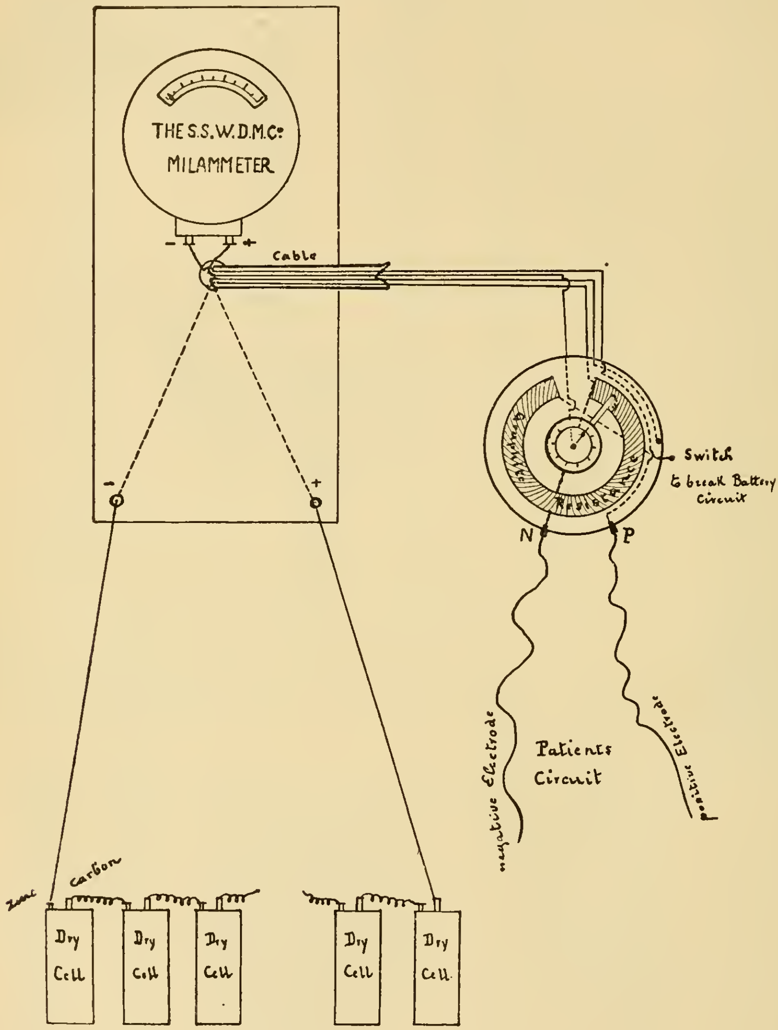
Cataphoric outfit without milliamperemeter.

In the arrangement of the apparatus for cataphoric work, the battery, or other source of current, the rheostat, the milliamperemeter and the patient are in series (Fig. 320). The direction of the current being from the battery to the rheostat, from the rheostat to the milliamperemeter, from the milliamperemeter to the patient, from the patient back through the rheostat to the battery, thus making the circuit complete.

The resistance encountered in the flow of the current are found in the conducting wires, the rheostat, and the tissues of the patient; the skin and the dentin being more highly resistant than the other tissues through which the current must pass in treating hypersensitive dentin. The result of resistance to the flow of an electric current is the production of heat, the amount of heat produced being governed by the degree of the resistance, and the size and character of the conductor.

Dentin is exceedingly resistant to the passage of a current of electricity, consequently heat is liable to be produced if the pressure of the current is too great, and pain would be the result. The teeth are very sensitive to an electric current, and respond vigorously to any sudden change in the pressure or strength of current-flow or amperage. There is, however, a considerable variation between individuals and between different teeth in the same individual as to the amount of current that can be used upon the teeth without causing pain. With some individuals the limit is

Fig. 320.



reached with a pressure of four or five volts and one-tenth of a milliampere of current. Under such circumstances it becomes necessary to increase the pressure very slowly until the cocaine paralyzes somewhat the function of sensation in the dentin. While in others the pain limit may not be attained until the pressure reaches fifteen to twenty volts, with an amperage of from three-tenths to four-tenths of a milliampere. The anterior teeth seem to be the most susceptible to the galvanic current. Teeth having acutely inflamed pulps are also exceedingly sensitive to the current, even at very low initial voltage.

Another factor in this connection which must be taken into consideration is the nervous irritability of the patient, which when highly exalted may render them peculiarly susceptible to the irritation of an electric current.

Resistance of Tissues.—According to Dr. W. A. Price,* the *average resistance* of a patient is about twenty-five thousand ohms from the cavity to the hand holding the negative electrode or cathode. This was computed from twenty-five cases, varying all the way from ten thousand to seventy-eight thousand ohms and higher. The difference of resistance from the hand to the tooth and from the cheek to the tooth he found to be from three thousand to five thousand ohms. In one case, in which the resistance was measured with the cavity barely moist, it gave a resistance of forty-seven thousand seven hundred ohms. On applying a forty per cent. solution of cocaine in water to the cavity, the resistance was reduced to twenty-eight thousand five hundred ohms, and upon transferring the cathode to the cheek it was further reduced to twenty-three thousand eight hundred ohms.

The greater portion of the resistance is, therefore, according to the above statements, in the tooth.

Dr. Price further states that the average resistance from the hand to the tongue with small electrodes is about nine thousand ohms, varying from seven thousand to twelve thousand ; and from the cheek to the tongue about five thousand ohms, varying from three thousand to seven thousand. This places the greater part of the resistance of the tissues of the patient in the dentin of the tooth, which varies all the way from ten thousand to seventy thousand ohms, with an average of about twenty thousand.

Sections of dentin in the fresh state tested out of the mouth in an almost dry condition, and also when saturated with various solutions, gave a wide range of resistance. As an illustration, a longitudinal section of fresh dentin, five millimetres thick and almost dry upon the surface, had a resistance of thirty thousand ohms ; after drying and then saturating with a forty per cent. solution of cocaine the resistance was reduced to four thousand five hundred ohms, and after drying and saturating with a solution of sodium chloride the resistance was reduced to three thousand and seventy ohms.

From the statement of the foregoing facts, and the principles involved in applying the galvanic current to the human body for its cataphoric effects upon hypersensitive dentin, it becomes patent that the greatest care must be exercised in the selection of the initial degree of voltage ; in employing a relatively low amperage and carefully measuring the strength of current used ; in so controlling the current that it may be increased or diminished by imperceptible gradations ; in avoiding a breaking of the

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* Dental Cosmos, vol. xxxix. p. 90.

current, or too rapidly advancing the strength of the current, and in maintaining a moist condition of the cavity during the flow of the current.

METHOD OF ADMINISTRATION.

The first step in the application of the galvanic current for electro-cocaine anæsthesia of hypersensitive dentin is the isolation of the tooth to be operated upon by means of a rubber dam, which must be securely ligated at the cervix to prevent leakage of moisture or of the current. As an added precaution against leakage, the cervix of the tooth should be coated with some quick-drying varnish. If metallic fillings are present in the tooth to be operated upon, or in the approximal surfaces of the adjoining teeth included in the rubber dam, these should likewise be covered with varnish, or an extra rubber dam may be placed on the tooth to be treated for the purpose of insulating them, or otherwise the current would be dissipated from the cavity by being switched off or shunted by these conductors.

The cavity of decay should be carefully irrigated with tepid water before adjusting the rubber dam, with the object of removing all the food *débris* and detached portions of disorganized tissue.

It is not necessary to attempt to remove the carious dentin before the application of the cocaine, and the surface of the cavity need not be more than partially dehydrated.

A pledget of cotton large enough to loosely fill the cavity is then saturated with the cocaine solution and placed in the cavity. The cathode is next placed in the hand of the patient or applied to the cheek, neck, or other suitable location. If the cathodal electrode is covered with sponge, this should be moistened with water, or, better, with a solution of sodium chloride. The anode is now applied to the cotton in the cavity and the current turned on, care being taken to start with the lowest voltage and weakest amperage. To obtain the best results from the cataphoric effect of the current the point of the anode (which should be made of platinum) should have a diameter as nearly the size of the cavity as possible, but as this would necessitate purchasing a very large number and variety of platinum anodal tips, the writer uses instead platinum disks cut from No. 30 gauge plate, and perforated with numerous holes for the ready passage of a reserve supply of the cocaine solution. These disks may be kept on hand in a variety of sizes and shapes at a very trifling expense.

One of these disks is placed over the cotton, care being taken that it does not touch the dentin, and the anode applied to this. As a result of using electrodes with points whose cross-section nearly equals the diameter of the cavity, greater *diffusion of current* is secured than is possible with small points, unless metal disks are used in conjunction with them, as just suggested.

Many operators have complained of their inability to secure complete anæsthesia over the whole surface of the cavity when employing cataphoresis, except by prolonged application. This is explained upon the supposition that the surface contact area of the anode was too small to cover the area of dentin upon which it was desired to produce anæsthesia. It is a law of electricity that the current travels by the path of the least resistance. This in the vital tooth is by the organic matter in the tubuli and the contents of the pulp-chamber. Primary anæsthesia will therefore occur only over the radius covered by the positive pole, because the current passes directly from the anode to those tubuli which are in the direct path of the current. Secondary anæsthesia of the dentin may be secured by producing anæsthesia of the pulp, as no doubt occurred in some of those cases reported in which the anæsthetic effect of the treatment was secured only after a very long application of the current through a small pointed anode, while in others it was due to leakage of current or great density of the tooth.

The anode should be constructed with a reservoir for holding a reserve supply of the solution, like Morton's tubular cataphoric applicator, or, better still, the syringe electrode of the S. S. White Company (Fig. 321).

Fig. 321.

Syringe electrode.

Teeth which are termed *soft*, or imperfectly calcified, especially children's teeth, respond more readily to electrococaine anæsthesia than do that class of teeth which are termed *dense*, or highly calcified, as the greater amount of organic matter in the former renders them better conductors of the electric current.

When the current is first turned on to the tooth a slight, uneasy sensation is experienced, but this immediately passes away, and the strength of the current may then be gradually increased a fraction of a milliampere at a time, or until the patient again becomes conscious of the current-pressure, but under no circumstances should it be advanced to such a degree as to be painful. The best results are obtained with low amperage—from one to three milliamperes as the maximum—and increasing the current very slowly. As anæsthesia advances the strength of the current may be more rapidly increased, but a current strength above five milliamperes is rarely required, and, finally, when this can be done without producing unpleasant sensations, anæsthesia may be considered as complete, the switch slowly carried back to the zero point, and the operation of cavity preparation commenced.

With a current above five milliamperes there is danger of decomposing the chemic structure of the cocaine, or of producing coagulation of the albuminoid elements of the dentin by electrolysis.

The period of application of the current may be stated to be from eight to fifteen minutes in ordinary cases, but in teeth which are very dense a much longer period is sometimes required.

The milliamperemeter should be carefully watched during the whole period of administration. Any rapid movement of the indicator, or a registration of a greater amperage than the dentin would admit, even at a higher voltage than that being used at the time, would be a sure sign that the current had found a path offering less resistance than the dentin, and if this is not corrected the administration will prove a failure.

It is wise to always test the polarity of the terminals before applying the current. This may be done by bringing the ends of the terminals together, when the switch of the rheostat is on the first or second point, or they may be tested with wet litmus-paper, or paper moistened with solution of potassium iodide, when the positive pole will give the characteristic reaction.

It has already been stated that the positive pole produces coagulation of the albuminoid substances contained in the tissues, and this may result in the dentin if too strong a current is used. This no doubt has been another source of failure in electrococaine anæsthesia. The use of coagulating remedies like carbolic acid should never be allowed in a cavity when cataphoresis is to be employed, as coagulated albumin is not a good conductor of electricity, and hence the diffusion of the cocaine by the current would be greatly retarded.

COCAINE-PRESSURE ANÆSTHESIA.

Pressure anæsthesia, as now understood by the profession, is local anæsthesia produced by solutions of cocaine hydrochlorate, forced into the dentinal tubules and the tissues of the pulp by *mechanical* pressure.

The phenomena which take place in the tissues under mechanical pressure is similar to that which takes place in producing anæsthesia by cocaine cataphoresis, the mechanical pressure being replaced by the electro-motive force or pressure of the electro-galvanic current. In either case the cocaine solution is carried into the tissues by an impelling force from behind.

As an obtunder of hypersensitive dentin this method of employing cocaine can hardly be called a success, as it consumes too much time, and in many instances fails altogether.

As a measure for producing anæsthesia for the extirpation of exposed and inflamed pulps it has no equal, for the whole operation can be performed in a few minutes and without pain to the patient.

The procedure as practised by the writer is as follows: After the rubber dam has been adjusted to the affected tooth the softened dentin is carefully removed and the pulp-chamber opened; excavators only should be used in this operation, for reasons that are obvious. The pulp is then covered with a pledget of cotton—about half the size of the cavity—which has been previously saturated with a 20 per cent. aqueous solution of cocaine hydrochlorate, and allowed to remain undisturbed for from three to four minutes. A piece of base-plate gutta-percha about the size of the cavity is next softened over the flame of a spirit-lamp and gently pressed into the cavity upon the pledget of cotton, care being taken not to produce pain or discomfort. After two or three minutes the pressure may be gradually increased, until the heaviest pressure can be endured without any unpleasant sensations. The gutta-percha and the cotton are now removed, the pulp-chamber thoroughly opened with a bur, and the pulp extirpated in the usual manner.

A very neat little instrument, having a small soft rubber cup attached to one end, has been devised by Dr. Tuller, of Chicago, for the purpose of producing pressure over the pulp without the danger of causing pain by a direct contact of the pulp with a foreign substance.

GENERAL ANÆSTHESIA.

The employment of general anæsthetics sometimes becomes necessary in the treatment of hypersensitive dentin, but they should be resorted to only in extreme cases, when all local means have failed, or when for some reason they cannot be employed.

The general anæsthetics which have been used for this purpose are nitrous oxide, sulphuric ether, and chloroform. In the employment of these remedies for obtunding the hypersensitiveness of the dentin, the confidence and intelligent co-operation of the patient is a *sine qua non*, for the reason that a profound anæsthesia, or even loss of consciousness, is not necessary or even desirable if the best results are to be obtained from their employment. During the *first* stage of anæsthesia, or just before the second, or stage of excitement, appears, sensation in the peripheral extremities of the nerves is greatly diminished or entirely obliterated, so that it becomes possible to make slight incisions in the skin or mucous membrane, or cut the most sensitive dentin without the slightest sensation of pain.

During the first stage of anæsthesia the patient is drowsy and the muscles are relaxed, but conscious cerebration is not impaired. This is an important consideration, for upon this fact rests the co-operation of the patient, and this is absolutely necessary if the operation is to be successfully performed. If the administration of the drug is continued to the development of the stage of excitement, the patient becomes unmanageable, and all delicate operative procedure is at an end; while if profound anæsthesia is induced, the insensible condition of the patient renders that co-operation which is so desirable to the performance of such operations entirely out of the question. Furthermore, the upright position of the patient is necessary to the performance of these operations, which adds greatly to the dangers surrounding general anæsthesia, especially when chloroform is used.

If, upon the other hand, it becomes necessary to remove a vital pulp, nothing short of a profound state of anæsthesia will suffice for a painless operation.

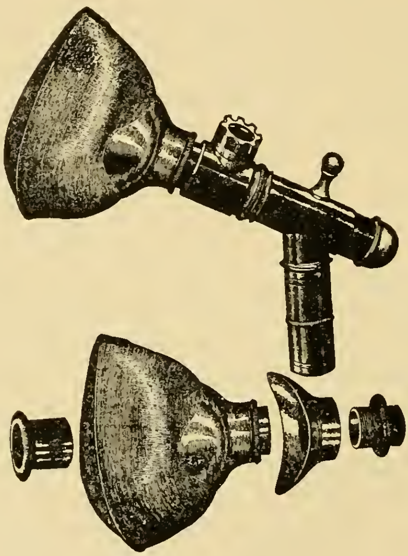
Nitrous Oxide.—The use of nitrous oxide as a means of producing partial anæsthesia for the relief of pain in operating upon hypersensitive dentin has often been advocated and successfully employed.

In the use of this agent the assistant should stand by the side of the chair ready to turn the gas on or off as the needs of the case may require.

It should then be explained to the patient that five or six deep inspirations will usually be sufficient to render the cutting of the dentin an entirely painless operation, but that this insensibility to pain will last only for two or three minutes, consequently it becomes necessary to operate very rapidly, and to this end the assistance and co-operation of the patient is earnestly solicited. Assurance should also be given that upon the slightest indication of a return of painful sensations the gas shall be again administered and this process repeated until the cavity has been prepared. With these explanations and assurances the confidence of the most timid patient will be secured and intelligent co-operation obtained.

The inhaler (Fig. 322) should then be placed in the hands of the patient and instruction given in the method of applying it and of breathing. The gas is now turned on, and after five or six full inspirations have been taken, the inhaler may be removed and the sensitiveness of

Fig. 322.



Flexible face-piece for inhalers.

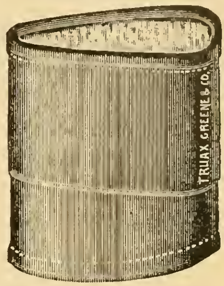
the dentin tested, and if it has disappeared, the excavation of the cavity may be proceeded with, but if not, then three or four inspirations more may be taken, when the sensitivity of the dentin will be found to have been entirely overcome. As soon as the anæsthetic effect begins to pass off the inhalation should be renewed.

Sulphuric ether is perhaps the most reliable general anæsthetic that can be employed for this purpose, as the obtunding effect upon peripheral sensation is more lasting than nitrous oxide, and far less dangerous than chloroform to the life of the patient.

In administering ether care should be exercised in the selection of an inhaler to obtain one that will permit an abundant admixture of atmospheric air with the ether vapor, as by this precaution the irritation to the air-passages which is so common in the early part of ether anæsthesia is entirely obviated. The Allis inhaler (Fig. 323) is constructed with this object in view, and is the best invention of its kind that is manufactured.

The time required to produce peripheral anæsthesia is about two minutes, and it lasts from two to five minutes.

Fig. 323.



Allis's ether inhaler, rubber covered.

When ether is to be employed for its anæsthetic effect, the patient should be cautioned against eating just before the operation, as under such circumstances nausea and vomiting might occur. It is safest to take only a light meal three or four hours before the operation and no stimulants. With these precautions there need not be the slightest fear of any unpleasant symptoms attending or following the employment of ether for this purpose.

Chloroform has been employed by some operators, while others have used the A. C. E. mixture, —alcohol one part, chloroform two parts, and ether three parts.

Chloroform and the A. C. E. mixture are not safe remedies to use for producing anæsthesia when the patient must be seated in an upright position, on account of the depressing effect of chloroform upon the action of the heart. Chloroform and its combinations are therefore contraindicated in all operations requiring the erect position as an essential feature of the procedure.

Bonwill Method of Rapid Breathing.—The late Dr. Bonwill advocated several years ago a system of rapid breathing as a means of producing peripheral anæsthesia. The system consists of making very rapid and full inspirations and expirations—as though one were running —and keeping this up until the head becomes dizzy, when it is found that peripheral sensation has been greatly obtunded, and in some cases as completely obliterated for a brief period as though some anæsthetic drug had been administered. The writer has occasionally employed this method with very great satisfaction in the treatment of hypersensitive dentin, and in a few instances has also extracted teeth which the patients have declared was done without producing the slightest painful sensations.

This method is based upon the long-known fact that during violent exercise or other great physical exertion which induces rapid and very full inspiration and expiration, the body becomes more or less anæsthetic or insensible to pain, as is proved by the fact that injuries of a slight nature, and sometimes traumatisms of considerable magnitude or severity, are unrecognized at the time of their occurrence. It is a well-known fact that children while at play frequently receive slight injuries of which they are entirely unconscious until the excitement of the game is over. The same is true of athletic teams, wrestlers, boxers, etc. While soldiers are often severely wounded in battle and remain entirely unconscious of the injury until an interruption occurs in the violent physical exertion, or the injured man falls from exhaustion through loss of blood.

The explanation of this insensibility to pain under mental excitement and violent physical exertion is to be found in the fact that all such mental and physical excitement induces rapid and deep breathing, thus introducing into the circulation a superabundance of oxygen, which acts upon the nerve centers to produce an obtunding or partial anæsthetic effect upon the peripheral nerves. The writer is aware, however, that this phenomenon has been attributed to the psychological effect of the excitement under which the individual was laboring at the moment, and that when the excitement had passed he became conscious of the injury. This, however, is disproved by the fact that rapid and full breathing, carried to the point of dizziness, will permit the introduction of an hypodermic needle into the tissues, the lancing of an abscess, etc., without pain.

CHAPTER XV.

THE CLASSIFICATION OF CAVITIES.

Carious cavities in the human teeth are usually divided into *two* general classes,—viz., *simple* and *compound.* These have been again divided into *three* general classes,—viz., 1, *simple cavities upon exposed surfaces;* 2, *simple approximal cavities;* 3, *compound cavities.*

The *first division* includes all of those cavities which are found upon the morsal, buccal, labial, and lingual surfaces of the teeth, which afford easy and direct approach to all parts of the cavity, and which are bounded by a continuous and unbroken wall of regular or irregular outline.

The *second division* comprises all of those cavities which are located upon the approximal surfaces of the teeth, and are likewise bounded by a continuous and unbroken wall, but which do not, on account of their location, give ready and direct approach to all parts of the cavity, except, first, by separating the teeth, and secondly, by using instruments for their preparation which have been curved or bent at suitable angles.

The *third division* is made up of all those cavities which are produced by a union of two or more cavities of the previous divisions, no matter whether they have been united by the extension of the process of caries or by surgical means.

Weeks, in his "Manual of Operative Technics," offers the following classification of cavities:

Class 1.	All cavities on any surface other than proximate.	A.—Cavities arising from structural imperfections in pits and fissures. B.—Cavities on labial, buccal, or lingual surfaces, caused by contact with secretions from diseased tissues, or the products of fermentation.
Class 2.	All cavities on the proximate surfaces of incisors and cuspids.	A.—Cavities which do not involve the mesial or distal angle. B.—Cavities which involve the restoration of the mesial or distal angle.
Class 3.	All cavities on the proximate surfaces of bicuspids and molars.	A.—Cavities which include the marginal ridge, but do not involve any sulci or grooves upon the occlusal surface. B.—Cavities which involve not only the marginal ridge, but also the sulci or grooves upon the occlusal surface.

For the purposes of more accurately locating and describing each individual cavity, the following admirable division and classification, which was first suggested by Dr. G. V. Black and afterwards variously modified by other teachers, has been taken from the "American Text-Book of Operative Dentistry," and slight changes made in it to give it a more comprehensive application. This classification is arranged progressively from the simplest form, A, to the most complex, W.

The writer, however, takes the liberty of changing the terms occlusal and incisal, to morsal, as the latter term is equally applicable to both, and, as a multiplication of terms is to be avoided, there can be no valid objection to the change.

I. Simple Cavities upon Exposed Surfaces.

Incisors and Cuspids.	*Bicuspids and Molars.*
A. Labial	D. Morsal.
B. Lingual.	E. Buccal.
C. Morsal.	F. Lingual.

II. Simple Approximal Cavities.

Incisors and Cuspids.	*Bicuspids and Molars.*
G. Mesial.	I. Mesial.
H. Distal.	J. Distal.

III. Compound Cavities.

Incisors and Cuspids.	*Bicuspids and Molars.*
K. Mesio-labial.	R. Mesio-morsal.
L. Disto-labial.	S. Disto-morsal.
M. Mesio-lingual.	T. Morso-buccal.
N. Disto-lingual.	U. Morso-lingual.
O. Mesio-morsal.	V. Mesio-disto-morsal.
P. Disto-morsal.	W. Bucco-linguo-morsal.
Q. Mesio-disto-morsal.	

Adopting this arrangement and classification as the best, the writer will adhere to it in all future descriptions of the location of carious cavities and of fillings.

I. SIMPLE CAVITIES UPON EXPOSED SURFACES.

Incisors and Cuspids.

A Class.—Cavities upon the *labial surface* of the *incisors* and *cuspids* are usually found in two locations,—viz., at the *cervix* and *near the morsal edge*.

Cavities at the cervix in the early stage of the carious process are generally in full view, and may consist of a softened condition of the enamel without visible loss of structure, or they may present any of the characteristics of the more advanced stages of the carious process. Fig. 324, *A*, *A*, shows the form and location of this class of cavities.

Fig. 324.

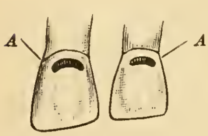


Fig. 325.

Fig. 326.

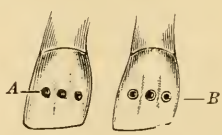
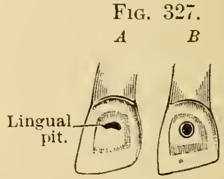


Fig. 327.



The preparation of those cavities which occur at the cervix offer no serious difficulties, unless they extend beneath the gum. Under such circumstances it becomes necessary, in order to gain a good view of the cavity and to properly prepare the cervical margin, to *evert* the overhanging gum. In the simpler cases this may be accomplished by pressing the gum away with a suitable instrument held in the left hand during the preparation of the cavity, care being exercised not to wound the gum, as the hemorrhage would obstruct the view. In the more complicated cases, where the edge of the gum has become *inverted*, it is necessary either to excise the inverted gum tissues or to *evert* them by packing the cavity over-full with gutta-percha and allowing it to remain for a few days. This procedure gives a clear field for the preparation of the cavity and the subsequent operation of filling. The adjustment of the rubber dam is sometimes a difficult procedure in these cases, but it can usually be accomplished by exercising a due amount of patience. Absolute dryness of the cavity is imperatively demanded in a proper preparation, as well as for the subsequent operation of filling. Spoon excavators and round burs will be found to be the most useful instruments in the preparation of these cavities. Retention may be obtained by slight under-cuts at the bottom of the cavity, at the cervical and morsal margins, and following its outline from one extremity to the other. Too much care cannot be expended in the preparation of the margins and terminal points of these cavities. They should be nicely bevelled, as shown in Fig. 325, and finished as smoothly as possible, so that the margin of the filling when finished will present a perfect outline.

Cavities which occur upon the labial surface near the morsal edge are the result of developmental defects in the enamel in the form of pits and grooves, which cross the surface in nearly a straight line or surround or girdle the entire tooth at an equal distance from the morsal edge. This condition is shown in Fig. 326, *A*.

These imperfections when quite shallow may be removed by corundum wheels and the surface polished. If, however, they are deep, it is better in the case of small pits to treat each one as a separate cavity, as illustrated in Fig. 326, *B*, but when they are large, leaving but little tooth substance between them, or in the case of deep grooves, it is better to convert them into a single cavity and fill it with gold, or set a porcelain inlay; but when the groove girdles the tooth and is deep, the better plan for the sake of the cosmetic effect would be to cut off the tip and replace it with porcelain.

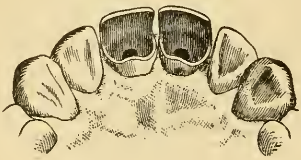
B Class.—The vulnerable point on the *lingual* surface of *incisors* and *cuspids* is the fossa formed by the union of the marginal and basilar ridges. This fossa is often deep and not infrequently presents a pit or fissure in its deepest portion, which sometimes becomes the seat of caries, as shown in Fig. 327, *A*.

As a rule, in the early stage of the disease these cavities are much deeper than they are broad. They are usually marked at the orifice by a dark spot, which often extends to a considerable depth, but rarely involves the pulp-chamber.

In the preparation of these cavities in the incipient stage of the disease the round bur is usually found to be the best instrument for the purpose. Retentive shaping is rarely necessary, as the depth of the cavity generally is greater than its diameter. The margins of the orifice, however, should be bevelled or countersunk, as in Fig. 327, *B*, by the use of a larger round bur, in order to insure perfect adaptation of the filling and to prevent bruising or fracturing of the enamel edge during the process of introducing the gold.

In cavities presenting the later stages of the carious process, and which involve the greater portion of the lingual surface of the tooth and complicated with an inflamed or devitalized pulp, anchorage may be secured by enlarging the pulp-canal, as shown in Fig. 328; the preparation should

FIG. 328.



After Dr. Marshall Webb.

FIG. 329.

be conducted upon the same general principles as those adopted in the treatment of simple morsal cavities in the bicuspids and molars.

C Class.—Cavities occurring upon the *morsal edge* of the *incisors* and *cuspids* are very rare, except as the result of fractures of the enamel or from mechanical abrasion or attrition. Fig. 329 shows such cavities in the superior incisors. These cavities are usually quite shallow, and being easy of access, no difficulty is experienced in their preparation.

Care, however, must be exercised in the preparation of the enamel margins to extend the bevel to the marginal edge, so as to prevent future fracturing of the enamel. Failure in this direction often ruins an otherwise substantial and beautiful operation. Retentive shaping is also an important feature in this class of cavities. The strain is often very great upon such fillings, particularly in those cases where the teeth have been shortened by excessive mechanical abrasion and the normal length is to be restored; consequently every effort should be made to give the filling the greatest security by proper retentive shaping. The drilling of retaining-pits is not to be recommended when the location and the extent of the cavity will permit it to be slightly enlarged at the bottom. This enlargement should extend in all directions, giving a dovetail or, more correctly, an inverted-cone form to the cavity (Fig. 330).

FIG. 330.

Caries sometimes occurs as a result of developmental defects in the enamel; such cavities are to be prepared and filled like other cavities of the same size and form.

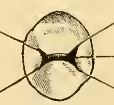
Bicuspids and Molars.

D Class.—This class comprises all of those cavities which occur in the pits and fissures upon the morsal surface of the bicuspids and molars. Their location is such that an unobstructed view can be obtained of all parts of the cavity, and they are easily accessible to direct instrumentation. The difficulties in operating are somewhat increased in the posterior part of the mouth, especially in the superior third molars, but with properly curved excavators, the right-angle hand-piece and reflected light, the preparation of such cavities becomes a comparatively simple matter.

The *lower first bicuspid* usually presents the simplest form of cavity upon the morsal surface of the teeth. The triangular ridge connecting the buccal with the lingual cusp is usually very large and prominent, and under such circumstances the mesio-distal sulcus is not strongly marked or is wanting altogether. The triangular ridge forms with the mesial and distal marginal ridges the mesial and distal pits. These pits are usually the first part of the tooth to be attacked by caries. Caries attacking the pits form simple roundish, penetrating cavities, which may be opened and prepared separately with round burs.

On the morsal surface of the *upper first* and *second bicuspids*, caries usually begins in the fissure between the cusps (Fig. 331). It sometimes presents as a simple dark line, into which the sharp point of an explorer will hardly enter, while at a later period the cavity will have been increased in size by the undermining of the enamel and the disintegration of its margins, so that an excavator will readily pass through the entire length of the fissure.

FIG. 331.



These cavities in their earlier stages may be opened with the tapering fissure-burs; in the later stage enamel-chisels will be found most useful. After the cavity has been opened, the decay should be thoroughly removed and a proper retentive shape given to it. Especial care should be given to the terminal pits and to the triangular grooves or fissures. The latter should be cut out to their fullest extent, or until all suspicious tissue has been removed.

The margins should then be carefully bevelled and the cavity is ready for the filling (Fig. 332). The student should be cautioned against sacrificing more of the sound tissue than is really necessary to gain the object in view. Whenever possible the mesial and distal marginal ridges should be maintained intact, as these bind the buccal and lingual cusps together, and if they are destroyed, the crown is greatly weakened and the cusps are liable to be fractured and broken away. Sharp angles are to be avoided, especially in the outline of the cavity margins. All angles should be rounded out, and the outline of the cavity should present, when finished, a series of graceful curves.

The morsal surface of the *lower second bicuspid* usually presents three cusps, which are divided by the triangular groove, the termination of each arm of the groove ending in a pit. The most vulnerable points in this groove are at its centre, where the arms of the groove meet, and at the terminal pits. Caries occurring in any part of the groove will make it necessary to cut it out in all directions as the only way to insure the tooth against a recurrence of the disease in this location.

Upon the morsal surface of the *upper first* and *second molars* there are two points at which caries is liable to occur, one known as the mesial fossa, the other as the distal fossa, and situated respectively upon the mesial and distal sides of the oblique ridge (Fig. 333). These fossæ are sometimes traversed by a broad sulcus or a deep fissure. The fissure of the mesial fossa often assumes a triangular form. To insure success it is necessary to cut out the fissures to their utmost limits. The instruments used for preparing these cavities should depend upon the progress which has been made by the disease; when limited in extent, small-pointed fissure-burs are the best for opening the cavity; in the later stages the enamel-chisels will be found most useful. The margins should be so prepared as to leave smooth, strong bevelled edges (Fig. 334).

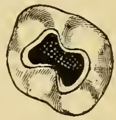
Occasionally the mesial and distal cavities will be found united beneath the oblique ridge. Under such circumstances the bridge between the orifices of the cavities should be cut away and the two cavities converted into one. Fig. 335 represents the prepared cavity. The mistake of

Fig. 332.

Fig. 333.

Fig. 334.

Fig 335.



leaving the bridge of enamel and dentin between them is often made, even by good practitioners, but such operations sooner or later come to grief, either from fracture during the operation of filling, or later from the stress of mastication.

The morsal surface of the *upper third molar* is usually surmounted by only three cusps, and has, like the lower second bicuspid, a single central fossa and a triangular fissure radiating from the centre of the fossa and passing between the cusps. This cavity should be so prepared that when finished it will be triangular in form, with the points of the angles rounded out so that the filling-material may be perfectly adapted to the walls and margins. Fig. 336 represents the prepared cavity. Failure more often occurs in these cases than in any other of their class, for the reason that the fissures are not always cut out to their utmost limit and perfectly sound enamel and dentin reached in every part before the filling is introduced. There is also more difficulty experienced by the patient in keeping these teeth perfectly clean after the operation; especial care should therefore be exercised to make the operation as nearly perfect as possible, so that no open point of attack may be left for the entrance of the micro-organisms of decay.

The morsal surface of the *lower first* and *third molars* each present five cusps,—three buccal and two lingual,—with sulci running between them. A cavity, therefore, occurring upon this surface and following the sulci would present a five-pointed or pentagonal outline (Fig. 337).

As a rule, chisels are the most serviceable in opening these cavities, the extremities of the fissures being followed with the pointed fissure-bur, and finished with larger round ones.

In following the fissure it is better to go a little too far into the sound tissue than to fail to remove every particle of the decayed or softened dentin or enamel. Thoroughness in the preparation of a cavity never gives a greater reward than in these teeth. Fig. 338 shows the finished cavity.

The morsal surface of the *lower second molar* presents four cusps with cruciform sulci separating them.

Caries is most often found at the point of meeting of the sulci (Fig. 339, *A*).

In preparing a cavity of this character the sulci should be cut out to their extreme limits, the sharp angles at the intersection of the sulci

Fig. 336.

Fig. 337.

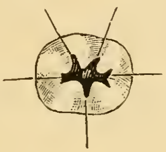


Fig. 338.

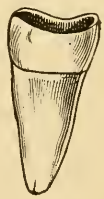
rounded out, and the margins bevelled. Sharp angles, if left at the intersection of sulci, are liable to be bruised and fractured during the introduction of a gold filling; these angles should therefore be properly rounded out, as shown in Fig. 339, *B*. Occasionally the morsal surface of the bicuspids and molars will be so extensively decayed as to involve the cusps, making a large open cavity extending over the whole morsal surface of the tooth. In preparing such cavities the morsal edge of the cavity should be first ground down with corundum wheels until strong walls are reached. The decayed tooth-structure should then be removed, the cavity given a shape as shown in the illustration of the longitudinal section of a tooth

Fig. 339.

Fig. 340.

Longitudinal section.

Fig. 341.



(Fig. 340), and the edges of the cavity nicely bevelled towards the cavity. Fig. 341 shows such a cavity prepared for the filling in a bicuspid tooth.

When the pulp is involved, this should first be removed and the canals filled, as described in Chapter XXVII. The pulp-chamber in these cases may be utilized for additional anchorage.

E Class.—This class includes all of those cavities which occur upon the *buccal* surface of the *bicuspids* and *molars.* Caries is rarely found upon the buccal surface of the bicuspids, except at the *cervix.* These cavities are usually long and narrow, and follow the line formed by the free margin of the gum, and often extend beneath it. They are usually half-moon shaped or elliptical in form, as shown in Fig. 342, *A*, and not infrequently involve the approximal surfaces by their lateral extension.

The upper molars have nearly the same exemption from caries upon the buccal surface, cavities appearing most often at the *cervix;* the *third molar* being more often affected than the others. The outlines of the cavities formed at this point are similar to those occurring in the bicuspids. Cavities occurring upon the buccal surface which do not involve the cervix are usually long, narrow, and elliptical in form, the long axis having a mesio-distal direction, as shown in Fig. 343, *A*. Occasionally, however, cavities will be found in the *buccal groove*, located well towards the cervix. In the lower molars this condition is much more frequently found, and the cavities are sometimes quite large, extending to and involving the morsal surface, forming a compound cavity.

As the disease extends it frequently passes beneath the free margin of the gum, thus increasing the difficulties in preparing the cavity for the reception of the filling. These difficulties may be overcome by adopting those measures already described in the preparation of labial cavities in

Fig. 342.

A *B*

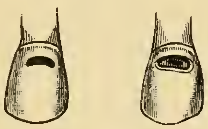
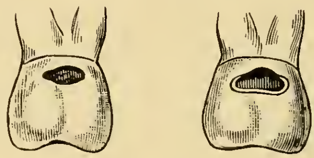


Fig. 343.

A *B*



the incisors and cuspids. Round engine burs and spoon excavators are the most suitable instruments for preparing this class of cavities. The right-angle hand-piece will also be found very useful in preparing the cavities in the molars, particularly those located in the second and third molars. The retentive form given to them should be that of slight undercuts at the base of the cavity, in a line parallel with its long axis; but sometimes it is well to make slight retention pits in the mesial and distal extremities of the cavity. The angles should be rounded out and the margins slightly bevelled, as shown in Fig. 342, *B*, and Fig. 343, *B*, in order that perfect adaptation of the filling-material may be secured.

Simple cavities occurring in the *buccal groove* of the upper and lower molars should be prepared with a slightly under-cut form. The preparation of those cavities which are compound in their nature will be described under T Class.

F Class.—Caries rarely occurs upon the *lingual* surface of the *bicuspids.* The *molars,* however, present a slightly increased liability. Cavities upon the lingual surface of the *upper* and *lower* molars occur in the *lingual groove,* at the *cervix,* and in the upper first molars in the *fissure* which exists between the mesio-lingual cingule or fifth cusp, when this is present, and the crown.

The degree of exemption from caries possessed by the lingual surface of the bicuspids and molars is doubtless due to their smooth and rounded surfaces, the friction of the tongue in speech and mastication, and the more abundant presence of the oral secretions, which have a tendency to keep them clean.

The most common location of caries upon these surfaces is the *lingual groove* of the *upper first molar*, which often presents a deep fissure termination in a pit about midway between the linguo-morsal margin and the cervix. Caries usually appears first in the pit, and sooner or later extends through the entire length of the fissure, passing over onto the morsal surface and forming a compound cavity. When the groove is shallow and not traversed by a fissure, the cavity is often confined to the terminal pit.

Caries occurring at the cervical margins of the lingual surface of the bicuspids and molars are, from the difficulties presented by their location, often troublesome to properly prepare and fill. They should be prepared and filled after the same manner as those cavities occurring upon the buccal surfaces of the same teeth.

Cavities occurring in the fissure between the mesio-lingual cingule and the crown should be opened through the entire length of the fissure as the only means of preventing extension or a recurrence of the disease. No especial description of the preparation is necessary in this class of cavities. They should be treated and filled according to general principles.

II. SIMPLE APPROXIMAL CAVITIES.

Incisors and Cuspids.

G and H Classes.—The location at which caries most frequently occurs upon the *approximal* surfaces is not at the actual point of contact of these surfaces, but in a location a little nearer to the cervix, just beyond the point of the *V* formed by the interapproximal space,—in other words, just where fluid and semifluid *débris* would be held by capillary attraction. Another location of caries of the approximal surfaces is just at the margin of the gum where the festoon forms the base of the interapproximal space. Occasionally two such decayed spots will be found upon a mesial or distal proximate surface; and it is a very common circumstance to find the approximating surfaces of the teeth decayed in exactly the same locations.

In the *incisors* and *cuspids* the carious spot is at first *round* in form, in the *bicuspids oval*, and in the *molars* it is *oblong*. (Jack.) In the later stages of the disease the cavities assume shapes more in accordance with the form of the proximate surfaces of the tooth,—as, for instance, in the incisors and cuspids the cavities will be triangular in outline, the base of the triangle being towards the cervix, as shown in Fig. 344, while in the bicuspids and molars the form will be more nearly that of a rectangle.

FIG. 344.

The mechanical difficulties presented in the treatment of simple proximate cavities of the anterior teeth are only those arising from their inaccessibility. In order to obtain an unobstructed view of the cavities, temporary separation of the teeth is a necessity. But sometimes, even after thorough separation, a good view of some parts of the cavity cannot be secured without cutting away a portion of either the lingual or the labial wall. The lingual wall, for the sake of the cosmetic effect, should be sacrificed in preference to the labial, as gold fillings upon the labial surfaces are at the best blemishes which seriously mar the beauty of the natural tooth. On the other hand, if the cavity is large and the labial wall is much weakened, the success of the filling, and perhaps the salvation of the tooth, will depend upon the thoroughness with which this weakened wall is removed ; but, nevertheless, care should be exercised not to remove more than is necessary to obtain strong margins.

Large cavities often come dangerously near to the pulp ; great carefulness should therefore characterize the work of their preparation, that this organ may not be exposed by an unnececessary sacrifice of sound dentin.

Small chisels will be found most useful in opening all simple proximal cavities, while small hatchet excavators having bayonet-shaped shanks, and cow-horn spoons, as shown in Figs. 345 and 346, will, as a rule, gain access

Fig. 345.

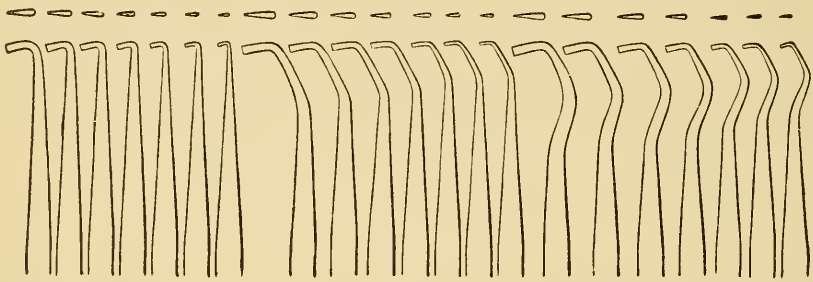
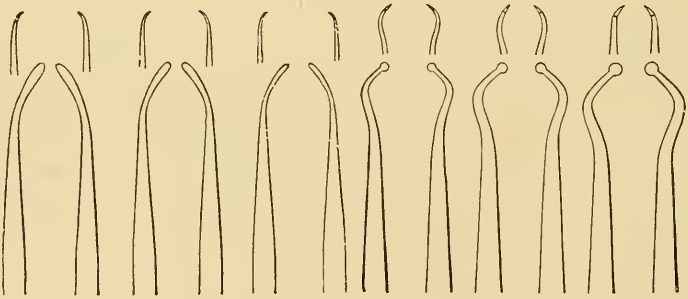


Fig. 346.



to all parts of the cavity and permit the ready removal of the decayed dentin.

Round burs of suitable sizes will be best adapted for trimming and shaping the cervical margin of the cavity, which should be so prepared as to leave a strong and but slightly under-cut or perfectly flat wall, care being taken, if the cavity reaches the cervix, not to leave a narrow rim of enamel which would be likely to be fractured in condensing the gold against it. The enamel margins should always be carefully bevelled with small chisels and polished with file-cut burs and Arkansas stones. All angles should be rounded with chisels, burs, or stones. Fig. 347 represents the prepared cavity.

Retentive shaping of these triangular-formed cavities requires that three points of anchorage be obtained, two at the base of the triangle in the angles and one at the apex. These may be formed by deepening the angles at the bottom of the cavity at the cervix with a small, round bur, and that in the apex at the morsal edge with a small hatchet excavator.

Fig. 347.

Shallow undercuts may also be used as a means of retention in the smaller cavities. Retention grooves, however, should never be cut in the labial and lingual walls, as these weaken the walls to a serious extent.

Cavities which extend beneath the gum should be treated beforehand by the removal of the overhanging gum tissue, so that a clear and unobstructed view of the cervical margin may be obtained.

Occasionally, either from the size or location of the cavity, it approaches very near to the morsal edge (Fig. 348, *A*), rendering the unsupported enamel very liable to fracture. Under such circumstances it is better to remove the weak corner and convert the cavity into a compound one, as illustrated in Fig. 348, *B*, rather than to attempt its conservation and have it break away at some future time under the stress of mastication.

Fig. 348.

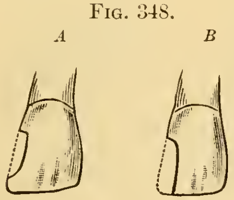
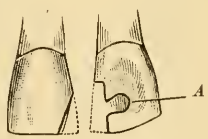


Fig. 349.



Black has suggested as a means of anchorage in these cases the extension of the cavity upon the lingual surface in the form of a dove-tail, as shown in Fig. 349, *A*, rather than by forming a retaining pit or groove at the morsal edge of the tooth.

Such an extension need not necessarily weaken the tooth to any appreciable degree if it is not formed too near the morsal edge or cut too deeply into the dentin, while it adds greatly to the retentive power of the cavity at the point where the greatest strain comes in biting or during mastication.

Bicuspids and Molars.

I and J Classes.—Small cavities upon the *mesial* and *distal* surfaces of the *bicuspids* and *molars* present considerable mechanical difficulty in their preparation. Figs. 350 and 351 illustrate cavities of this character. These difficulties, which are mainly those of inaccessibility, are greatest when the teeth maintain their normal approximation. They can, however, usually be overcome by making temporary separation, the space being made as wide as the circumstances of the case will permit. The wider the space obtained the greater will be the ease with which these cavities can be approached. Figs. 352 and 353 represent the prepared cavities.

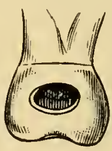
When ready access cannot be attained in this way, one of two other methods must be adopted,—either to convert them into compound cavities by cutting through the morsal surface until the cavity is reached, or by extending the cavity to the buccal surface. The former of these two methods should receive the preference as being the least difficult to accomplish, and makes the strongest operation from the mechanical stand-point; whereas in the latter method the difficulties are increased by reason of the limited amount of space in which to operate, while the overlying enamel at the morsal surface of the approximo-buccal angle will always remain an element of weakness as a result of its being undermined in extending the cavity to the buccal surface. Sometimes, however, this is the only method by which the cavity can be reached. Simple cavities upon the approximal surfaces of the bicuspids and molars more often fail after being filled than any other class of cavities. This is no doubt largely due to the fact that operations in these locations do not permit of ready access to all parts of the cavity, and cannot therefore be so thoroughly and perfectly prepared as those in which these difficulties do not have to be overcome.

Fig. 350.

Fig. 351.

Fig. 352.

Fig. 353.



In the opening of these cavities small, straight, and acute-angle chisels will be found very useful, while the removal of the decay and the preparation of the margins can best be accomplished with round burs in the straight or right-angle hand-piece, according to the mesial or distal location of the cavity.

Distal cavities are the most difficult to reach with instruments, and the only view that can be obtained of them is by reflection in the mouth mirror. This naturally adds to the difficulty in preparation and filling.

Retentive form may be given to the cavity by slightly enlarging it at its base, or undercutting at two opposite points. This may be accomplished with small hoe excavators of obtuse and acute angles and small hatchets.

In preparing and finishing the enamel margins, advantage can be taken of the natural outward radiation of the enamel-prisms to give the proper bevel to the orifice of the cavity.

In large cavities upon the approximal surfaces which approach the morsal surface it is best to cut through this surface and convert it into a compound cavity, rather than to run the risk of fracture of the enamel at a later period and consequent loss of the filling.

III. COMPOUND CAVITIES.

Incisors and Cuspids.

K and L Classes.—Compound cavities are formed by the union of two or more simple cavities located upon different surfaces of a tooth. The simpler class of compound cavities are those located upon the *mesio-labial* and *disto-labial* surfaces. Fig. 354 shows such cavities in the superior incisors. Teeth thus affected are generally of faulty organization and are markedly predisposed to caries. Such cavities are usually formed by the joining of an approximal cavity with one at the cervical margin of the labial surface. Sometimes the cavities will be separated by a narrow isthmus of more or less infected enamel or perhaps of sound tissue. In either case the cavities should be connected, the isthmus cut away, and the enamel edges straightened before the margins are finally finished for the filling. Acute angles, uneven marginal lines or peculiarities in form, are to be avoided in all operations that occupy a conspicuous position in the anterior part of the mouth, for the reason that things peculiar attract the attention much more quickly than those which follow the general order.

Temporary separations are commonly necessary in order to gain access to that portion of the cavity which is located upon the proximal surface.

FIG. 354.

FIG. 355.

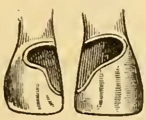
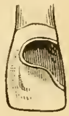


FIG. 356.

FIG. 357.



In the preparation of these cavities especial pains should be taken with the enamel margins, particularly at the cervical border and at the angle formed by the union of the cavities, as these are the points at which failures most frequently occur in this class of fillings.

Retention may be secured by grooves cut in the walls at the base of the cavity, and by a single shallow retaining pit at each extremity of the cavity to assist in starting the filling. Fig. 355 shows such cavities prepared.

Separate descriptions for the preparation of these two classes of cavities are not necessary, as one does not possess a peculiarity which is not common to the other, except that of location, and this does not materially affect the method or the difficulties of the operation.

M and N Classes.—Compound cavities of these classes are located upon the *mesio-lingual* and *disto-lingual* surfaces of the incisors and cuspids. These cavities are usually formed by the union of a proximate cavity with one occurring in the basilar pit or sulcus connected with it, as illustrated in Fig. 356. Such cavities are most often found in the central and lateral incisors, and from their location and the relative inaccessibility offer considerable more difficulty in their preparation and filling than those involving the mesio-labial or disto-labial surfaces. Fig. 357 represents the prepared cavity. When two simple cavities exist upon the proximate and lingual surfaces of these teeth which nearly approach each other, it is better to join them as in the manner described in K and L Classes, rather than to fill them as separate cavities with only a narrow isthmus of healthy dental tissue between them, for sooner or later this tissue will be attacked by caries and the whole operation prove a disastrous failure.

Retention is best gained by undercutting the lingual cavity and slightly grooving the cervical wall. Grooves in the labial or lingual walls of the cavity are not admissible, as they weaken these walls and increase the dangers from fracture. Occasionally it becomes necessary to connect a mesial and distal cavity with one upon the lingual surface. This is to be avoided whenever possible, for the reason that when both of the marginal ridges have been destroyed the crown of the tooth has lost its strongest support, and is very liable to be fractured whenever a severe strain comes upon the lingual surface near the morsal edge.

O and P Classes.—Cavities of these classes are generally confined to the incisor teeth, and are formed by a union of a *mesial* or *distal* cavity with one upon the *morsal edge*. They do not, as a rule, appear until after middle life, the morsal cavity being produced by attrition and gradually deepening until it becomes connected with a proximate cavity produced by decay. Occasionally through accident a mesio-morsal or disto-morsal angle of a tooth is lost (Fig. 358), necessitating the formation of a cavity

Fig. 358.

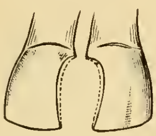


Fig. 359.

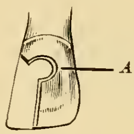
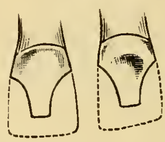


Fig. 360.



involving both the proximate surface and the morsal edge before restoration of the lost part with gold can be undertaken.

The preparation of these cavities involves no principle which has not already been emphasized. Each cavity may be prepared separately, after the manner already described, but especial care should be exercised in the preparation of the angle formed by the junction of the two cavities. The labial portion should be cut away just as little as is compatible with strength and the removal of unsound tissue. The lingual wall, which is more liable to be fractured by stress of mastication, may be removed more freely and its contour restored by the filling.

The enamel margins of the morsal portion of the cavity should be so bevelled that when the filling is inserted they will be protected by the gold from the dangers of fracture. When the enamel plates are very thin, they should be shortened and the normal length of the tooth restored with gold. The necessary retentive shaping may be obtained by slightly undercutting the morsal cavity and grooving the cervical wall of the proximate cavity. Additional retention may be secured by forming shallow retaining pits at the opposite ends of the groove at the cervical wall.

In certain cases it may become necessary, in order to obtain firm anchorage for such fillings, to form an extension-arm, as shown in Fig. 359, *A*, or by giving the extension a curved or hooked form. These are ingenious methods of retention, and afford a means of anchorage, which in many cases, on account of the thinness of the tooth, could not be secured so well in any other way.

Q Class.—Cavities belonging to this class are formed by the union of *mesial*, *distal*, and *morsal* cavities in the incisors and cuspids, as shown in Fig. 360. They differ from O and P Classes principally in extent, but the peculiarity of the form of the combined cavities makes their preparation and subsequent filling an operation requiring the greatest care and skill.

The methods of preparation and the securing of anchorage are in nowise different from those employed in the preceding class of cavities, but the exercise of a trained judgment is nowhere of greater value or more severely taxed than in the proper preparation and filling of these cavities. A thin or checked enamel wall, a deep undercut, an acute angle, or a rough or improperly bevelled margin are sufficient to cause the failure of an otherwise perfect operation.

Bicuspids and Molars.

R and S Classes.—These classes comprise all of those cavities in the bicuspids and molars which are formed by a union of *mesial* or *distal* with *morsal* cavities of decay, and represent classes which are the most common and in many ways the most difficult to successfully fill. Fig. 361 illustrates this class of cavities. Failures are common, after a few years, in this class of operations, even in the hands of the very best operators; therefore it cannot be entirely the result of faulty manipulation, as some writers would have the profession believe. The vulnerable points in fillings of this class are the cervical margin, and "that margin which is nearest to the operator during the process of the introduction of the gold." (Johnson.) These are the points also which clinical experience teaches are most often the seat of secondary caries, and they are no doubt in many instances caused by imperfect preparation of the cavity, faulty adaptation of the gold to the cavity walls, or lack of proper restoration of the interproximal space by adequate contouring.

FIG. 361.

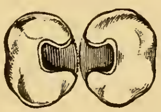


FIG. 362.

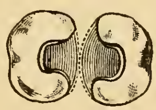
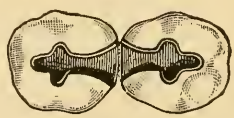


FIG. 363.



There are, however, other factors entering into the causation of secondary caries as important as those just mentioned,—viz., the character of the tooth-structure, the natural shape of the approximal surfaces, the hygienic condition of the mouth, the state of the general health, the character of the secretions, and the activity of the zymogenic organisms of decay.

While these conditions are operative in all parts of the mouth, the latter are, nevertheless, more active in some locations than in others.

Therefore, on account of the greater difficulties presented in keeping the approximal surfaces of the bicuspids and molars free from food *débris*, recurrence of caries is by that much more liable to occur in these locations.

Ordinary cavities in these locations present no serious difficulties either in their preparation or filling.

Such fillings, however, are subjected to great mechanical strain during mastication, and therefore require to be very firmly anchored. Retention may be secured by a shallow groove at the cervical margin with shallow pits at each extremity of the groove, and giving a dove-tail form to the morsal portion of the cavity, as shown in Figs. 361 and 362. In *molars* having mesio-morsal or disto-morsal cavities firm anchorage may be secured by extending the buccal or lingual fissures, as shown in Fig. 363.

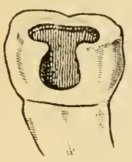
Large cavities, however, which extend beneath the margin of the gum, and have involved portions of the buccal, lingual, or morsal surfaces, often present difficulties which require a very high order of mechanical knowledge and of manipulative skill to successfully overcome.

In the preparation of all approximal cavities temporary separations are imperatively demanded, and these should be as wide as the surrounding conditions will permit.

The gum, if it overhangs the cervical margin, should be previously forced out of the way with gutta-percha or cotton. After the cavity has been roughly prepared, the rubber dam should be adjusted and the final preparation completed. The greatest care should be exercised to obtain strong walls, rounded angles, nicely finished margins, and firm anchorage.

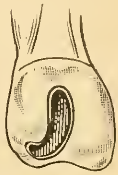
T Class.—This class of cavities is formed by a union of *morsal* with *buccal* cavities of decay, as shown in Fig. 364, and are more frequently found in the lower molars than in the upper. They have their origin in the pit and developmental groove of the buccal surface and in the fissures of the morsal surface. These cavities are often found united at their bases while still separate at their orifices. To insure a satisfactory result in filling such cavities it becomes necessary to unite them by cutting away the bridge of tissue which connects their orifices. To attempt to conserve this bridge of tissue, which would be more or less infected, and the enamel without the proper support of sound dentin, would only invite failure of the operation by the danger from fracture during the introduction of the filling, or later under the stress of force applied in mastication. In those cases in which the bases of the cavities have not been united by the carious process, but in which union has taken place at their orifices by extension of the disease along the buccal groove, care should be exercised not to cut away more of the sound tissue than is necessary to give proper retentive shape to the cavity, in order that the tooth may not be unnecessarily weakened. Strong walls and well bevelled margins are nowhere more imperatively demanded than in this class of cavities, as the strain upon these teeth during mastication is often very great.

Fig. 364.



U Class.—Cavities of this class are formed by a union of a *morsal* with a *lingual* cavity of decay. They are very rare except in the first and second upper molars. They have their origin in the pit and lingual groove which separates the mesio-lingual and disto-lingual lobes, and a cavity in a fissure of the morsal surface (Fig. 365). As a rule, these cavities do not involve the lingual surface of the crown to the same extent that the buccal surface is involved in the preceding class. Sometimes the cavity upon the morsal surface extends but very slightly upon the lingual surface, while at others it extends deeply towards the cervix. When the cavity upon the lingual surface is large, the disto-lingual cusp is liable to be much weakened by being undermined. Under such circumstances the cusp had better be cut away and the occlusion restored by contouring. The same general principles govern the preparation of these cavities as in the preceding class.

FIG. 365.



V Class.—Cavities which belong to this class are formed by the union of *mesial*, *distal*, and *morsal* cavities in bicuspids and molars, as illustrated in Fig. 366. The size of the combined cavities is often very large, and in those cases in which either or both the buccal and lingual walls are weak, it is better practice to restore the usefulness of the tooth by inserting a suitable artificial crown than by the introduction of a filling which in a few years would, in all probability, be lost from fracture of one of the two remaining walls of the tooth. Under favorable conditions, in cases where the walls are strong, a properly inserted filling would be the best means of restoring the usefulness of the tooth. No especial difficulties surround the preparation of this class of cavities other than those which arise from their size. The method of preparation is the same substantially as that described for R and S Classes.

FIG. 366.

W Class.—Cavities of this class are somewhat rare and are formed by a union of *buccal*, *lingual*, and *morsal* cavities, usually in the lower molars. These cavities do not present as great difficulties in their preparation and filling as many of those which have been already considered. The same general principle should govern their preparation and filling as are indicated for T Class.

CHAPTER XVI.

PREPARATION OF CAVITIES.

THE *first* important element in the treatment of carious teeth by filling is the proper preparation of the cavity for the reception of the material which has been selected for the purpose; the *second* is the introduction of the filling-material in such a manner as to hermetically seal the cavity; and the *third*, to so finish the filling as to leave perfect margins and a highly finished surface.

If these three conditions are successfully obtained, the operator has fulfilled his obligation to his client, and if failure follows, it will be due to conditions of health and local environments over which he has no direct control.

Guilford says, "As many fillings fail from lack of thoroughness in the preparation of the cavity as from any other cause."

Ottolengui asserts, "When a cavity is filled scientifically the tooth is safer than ever, because the vulnerable point is now occupied by a material which will resist destruction by caries. If decay occurs along margins, it is because those margins were improperly made, either as to shape or position, or else because the filling was unskilfully inserted or finished."

Black also lays great stress upon the proper preparation of the cavity, and enunciated the broad principle of *extension for prevention.*

He says, "A large proportion of decays occur in the proximate surfaces of the teeth, and for many years it has been noted that recurrence of decay after filling is especially liable to occur in these surfaces. A reason for this has generally been sought *in some fault in the management of the enamel margins.* The enamel margins about a filling should always be regarded as a weak point, and should be guarded in every possible way against the danger of a recurrence of decay. One great difficulty has been that the same rule of *extension for prevention* has not been applied to the proximate surfaces as has obtained in the grinding surfaces. Extension for prevention is *extension of the enamel margin from a line of greater liability to caries to a line of lesser liability.* Or, to change the phrase, it is to cut the enamel margins from lines that are not self-cleansing to lines that are self-cleansing."

Parreidt says, "One step is as important as the other. The slightest defect in either makes the result entirely questionable. Thoroughness and especially care are most important essentials expected of an operator who undertakes filling of teeth."

Tomes, in speaking of the importance of a proper preparation of the cavity, says, "Upon the proper performance of this the ultimate success of the operation will, in great measure, depend."

Statements of this character, which are based upon practical experience, might be multiplied almost indefinitely, but a sufficient number have been cited to indicate that there is but one opinion held upon the subject by the best authorities.

The student, therefore, will be wise if at the very outset of his professional career he determines to profit by the experience of those who have learned—perhaps by a long series of failures—that the proper preparation of the cavity is as essential in the filling of a tooth as are proper foundations in the building of a house. With solid foundations to build upon, the superstructure may be reared with the certainty that when the stress comes it will stand the test.

In the preparation of a carious cavity for the reception of a filling each step in the operation should be thoroughly and conscientiously performed, so that when it is completed all infected tissue will have been removed and the cavity be in the best possible condition for the reception and retention of the filling.

The general principles involved in the preparation of cavities are naturally divided into four progressive stages:

1. Opening the cavity.
2. Removing the decay
3. Retentive shaping.
4. Forming cavity margins.

Opening the Cavity.—The first step in the preparation of all cavities is to freely open the orifice by cutting away all overhanging edges of enamel, so that wherever possible the walls may be readily approached from all points.

Perhaps the most important step in the preparation of carious cavities is to *cut away all overhanging enamel margins which are not supported by sound dentin*, for *they are always a source of failure.* The only exceptions to this rule are perhaps a certain few cases where the enamel is not subjected to severe or direct strain; as, for instance, in proximal cavities in front teeth in which, for cosmetic reasons, it seems advisable to conserve the enamel of a thin labial wall. The brittle character of the enamel, however, renders it liable to be fractured whenever direct strain comes upon it, unless it is supported by something to counteract the strain. Its most natural support is the dentin, but occasionally in such instances as those just mentioned artificial support in the form of oxyphosphate cement may be given to it before the introduction of a gold filling. The student is warned, however, against attempting to apply this method of support in any other class of cases, as failure is more than likely to follow all such attempts from the severe strain brought upon the teeth during mastication.

Dr. Black, in his "Investigation of the Physical Character of the Human Teeth, etc.," demonstrated in the most positive manner, by elaborate and painstaking experiments, that many of the popular theories among dental practitioners in reference to the density of tooth-structure in early adult and advanced life, and their relative strength at these periods, were in many respects fallacious. The following table gives a general summary of the result of his investigations upon these points:

General Summary of Results.

	No. of Cases.	Average Age.	No. of Teeth.	Specific Gravity.	Per cent. of Water.	Per cent. of Lime Salts.	Per cent. of Organic Matter.
Average for total number of teeth	111	32.33	268	2.092	11.06	63.54	25.36
The highest percentage				2.133	13.56	65.75	27.59
The lowest percentage				2.036	9.32	61.08	23.26
Greatest variation				0.097	4.24	4.67	4.33
Average for persons under 15 years old	11	11.00	13	2.066	11.89	62.26	25.92
Average for persons 15 years old and under 20	8	17.00	9	2.080	11.46	63.18	25.33
Average for persons 20 years old and under 25	20	21.55	48	2.081	11.47	63.43	25.23
Average for persons 25 years old and under 30	15	25.93	43	2.086	11.27	63.44	25.28
Average for persons 30 years old and under 40	26	33.00	72	2.092	10.84	63.42	25.66
Average for persons 40 years old and under 50	12	42.66	38	2.094	10.91	63.73	25.34
Average for persons 50 years old and under 60	10	53.00	19	2.105	10.85	63.83	25.29
Average for persons 60 years old and over	10	63.60	27	2.019	10.66	64.56	24.81
Average for males 20 years old and under 30	12		24	2.082	......	63.30	......
Average for females 20 years old and under 30	26		67	2.083	......	63.51	......
Average for males 30 years old and under 40	12		18	2.090	......	63.35	......
Average for females 30 years old and under 40	14		54	2.094	......	63.48	......
Average for males 40 years old and under 50	6		19	2.093	......	63.54	......
Average for females 40 years old and under 50	6		19	2.094	......	63.92	......
Increase due to age				0.043	......	2.30	......
Decrease due to age				......	1.29	......	1.12
Average for persons who lost their teeth from diseases of the peridental membranes	15	50.00	51	2.101	10.88	62.90	25.19
Average for cases in which the teeth are classed as bad	32	28.00	121	2.087	11.25	63.33	25.49
Average for cases in which the teeth are classed as good	63	33.53	105	2.090	11.16	63.53	25.31
Average for cases in which the teeth are classed as fair	16	36.19	42	2.090	10.95	63.56	25.48
Average for perfect teeth	42	36.26	103	2.095	11.03	63.59	25.36
Average for carious teeth	91	31.50	165	2.091	11.06	62.50	25.36

It has been generally believed that the teeth were very soft in childhood and increased in density to old age; that the teeth increased in strength from childhood to middle life; that the strength of the teeth depended upon their density, and that the density of the teeth, or the percentage of lime-salts which the tissues contained, was a controlling factor in the liability to caries.

From the facts developed in this investigation the following conclusions are drawn by Dr. Black:

(1) "The teeth are strongest in youth and early adult age, diminishing somewhat in strength with advancing age."

This was ascertained first for *the dentin* by applying the stress to cubes eight-hundredths of an inch square cut from the dentin of permanent

EXHIBIT OF ELASTICITY AND CRUSHING STRESSES OF BLOCKS OF DENTIN EIGHT-HUNDREDTHS OF AN INCH SQUARE. ARRANGED ACCORDING TO THE AGE OF PERSONS.

	Case.	Age.	Tooth.	Carious or Perfect.	Pulp Living or Dead.	Specific Gravity.	Per cent. of Lime-Salts.	Elasticity at 100 lbs.	Elasticity at 150 lbs.	Crushing Stress.	Average of Stresses.
	246	9	F	c	l	2.069	62.83	1.5	3	285	
	212	10	F/	c	l	2.064	61.77	3	5	235	
	211	11	/F	c	d	2.061	......	2	4	247	
	207	12	/F	c	l	2.073	62.40	2	3	240	
	245	12	/F	c	l	2.068	62.42	1.5	3	235	248
	188	16	F/	c	l	2.067	61.71	2	4	275	
	218	16	6/	c	d	2.078	62.83	2	3.5	225	
	244	16	/F	c	d	2.080	63.59	2	5	210	
	208	18	/F	c	l	2.080	63.65	3	5	210	230
	210	22	H/	c	l	2.054	......	1.5	3.5	302.5	
	222	22	/4	c	l	2.098	63.80	2.5	4.5	235	
	229	22	/5	c	l	2.105	......	3	4.5	245	
	221	23	/F	c	l	1.100	64.39	2	3	270	
	223	23	6/	c	l	2.085	63.32	3	5	220	
			/6	c	d	2.067	63.27	2	4	235	
			/4	c	l	2.079	62.72	2	4	270	
	228½	24	H	c	l	2.068	......	2.5	4.5	245	
	173	25	7	c	l	2.110	......	....	....	260	
			8	c	l	2.131	......	....	....	216	
			G	c	l	2.095	......	....	....	275	
	213	25	F/	c	l	2.080	63.01	2	4	280	
	216	26	/6	c	l	2.099	63.31	2	3	235	
	200	27	H/	p	l	2.098	64.77	2	4	270	
	247	27	6/	c	l	2.104	64.79	1	2.5	285	
	200	28	8	c	l	2.070	63.19	1.5	3	300	
			8	c	d	2.043	62.01	2	4	260	260
	194	30	/F	c	d	2.101	63.71	2	4	250	
	215	31	/E	c	l	2.126	......	2.5	4	245	
			/F	c	d	2.117	......	2.5	4.5	230	
	196	35	6/	c	l	2.096	64.11	2	4	250	
	198	35	8/	c	l	2.123	64.77	2	4	255	
	203	35	8/	c	d	2.082	63.31	2	4	225	
	230	35	/5	p	l	2.102	63.39	3	4.5	265	
			3/	p	l	2.074	63.27	2.5	4.5	245	
			/7	p	l	2.097	64.63	2	4	252	
			7/	p	l	2.087	63.94	3	5	250	
	217	36	7/	c	l	2.108	63.77	5	8	200	242
	202	40	/F	p	l	2.072	63.99	2	4	225	
	228	42	/H	c	l	2.101	......	3	5	262	
			/E	c	d	2.108	64.06	3	7	200	
	192	44	4/	p	l	2.096	63.97	2	4	240	
			/4	c	l	2.108	63.74	3	6	250	
			/6	c	l	2.068	62.05	2.5	5	250	
			7/	p	l	2.111	64.51	2	4	265	
			/7	p	l	2.098	64.26	2.5	5	220	
	175	45	/3	c	d	2.078	......	....	....	183	
			/8	c	d	2.099	......	....	....	178	
			8/	p	l	2.085	......	....	....	225	
	231	47	F/	c	d	2.103	64.13	3	4.5	200	
	227	49	G/	c	l	2.105	64.53	3	5	220	224
	193	50	6/	p	l	2.109	64.66	2.5	5	220	
	174	51	8/	p	l	2.123	......	....	....	207	
	250	51	/6	c	l	2.103	64.29	1.5	3	235	
	209	58	7/	p	l	2.100	63.61	2	4	215	219
	214	60	/F	c	d	2.106	64.68	2	4	230	
	233	60	/3	p	l	2.091	63.78	2	4	200	
			3/	p	l	2.095	63.84	2	4	215	
			/4	p	l	2.088	62.95	1.5	3	210	
			4/	p	l	2.096	63.22	2.5	4.5	220	
			5/	p	l	2.059	62.25	2.5	5	195	
			6/	p	l	2.086	63.59	2	4	200	
			/6	p	d	2.093	63.62	1.5	3	260	
			/7	p	l	2.109	63.94	2.5	4.5	250	
			7/	p	l	2.097	63.59	1.5	3	250	
	234	60	6/	p	l	2.122	64.57	1	2.5	290	
	195	61	3/	p	l	2.118	63.07	2	5	260	
			8/	p	l	2.112	64.16	2	4	235	
			/8	c	d	2.113	64.16	3	6	225	
	226	63	/6	c	l	2.104	68.24	8	1.2	185	
	232	65	/8	c	l	2.119	64.10	2	3	215	227
Average ...								2.09	4.3	238	
Number ...	44		70								

teeth of all ages. The instrument for applying and recording the amount of stress used was especially made for this purpose.

The specific gravity of the dentin in all the specimens was ascertained, and the percentage of lime-salts also was obtained in nearly all, as well as the age of the individual furnishing the specimen, the particular tooth, whether sound or carious, the condition of the pulp, whether vital or dead, and all made a matter of record, together with the elasticity of the dentin under stress at one hundred pounds to the square inch, at one hundred and fifty pounds, and the number of pounds at which the block of dentin crushed.

A reference to the foregoing table of results will show the figures in detail. It appears from this exhibit that the average crushing stress of dentin between the ages of nine and twelve inclusive is two hundred and forty-eight pounds to the square inch; between the ages of sixteen and eighteen inclusive, two hundred and thirty pounds; between twenty-two and twenty-eight years of age, two hundred and sixty pounds; between thirty and thirty-six years, two hundred and forty-two pounds; between forty and forty-nine years, two hundred and twenty-four pounds; between fifty and fifty-eight years, two hundred and nineteen pounds; between sixty and sixty-five years, two hundred and twenty-seven pounds. The total average crushing stress was two hundred and thirty-eight pounds.

In the table of "General Summary of Results" the average specific gravity of the teeth at eleven years was found to be 2.066, while the average at the age of sixty-three was 2.019, giving a difference of forty-seven-thousandths of a volume.

The increase in the amount of lime-salts follows the same rule. Beginning with 62.26 per cent. as the average at eleven years of age, it is increased to 64.56 per cent. as the average at sixty-three years of age, an increase of 2.3 per cent.

The *enamel* was found to be very frail, the enamel-rods chipping off under very slight stress.

The blocks of enamel, which were the same size as the blocks of dentin, except that they were only four-hundredths thick (8 x 8 x 4), crushed under a stress of from thirty to seventy-five pounds to the square inch.

This emphasizes the need of the greatest care being exercised in the preparation of the enamel margins to prevent their being injured after the filling has been inserted, by the stress of mastication.

A study of the force of the jaws in mastication, which was first undertaken by Patrick and Dennis in 1893, developed the interesting fact that the stress exerted by the jaws in biting was very much greater than had been supposed.

Black discovered that there was a very great difference in the stress exerted by different individuals, ranging in adults from one hundred and twenty to two hundred and seventy pounds and more.

The following table gives the results of tests of fifty persons, ranging from four and one-half years of age to forty-five years:

GNATHODYNAMOMETER RECORDS.

No.	Occupation.	Sex.	Age.	Height.	Weight.	Incisors.	Bicuspids.	Molars
1	Farmer	M	25	5–5	127	55		125
2	Railroad passenger agent	M		6	203	100		210
3	Railroad man	M		5–7	128			150
4	Butcher	M		5–9	155	160		
5	Bookkeeper	F		5–3	112	40		130
6	....	F		5–5	90	85		125
7	Miss, seven years old	F	7	3–4	56	30		65
8	Servant-girl	F	23	5–2	98	45		100
9	Teacher	M	45	5–2	140	100		140
10	Dentist	M	38	5–6	165	175		240
11	....	F	30	5–2	130			155
12	Grocer	M	28	5–9	140	85		160
13	School-girl	F	18	5–2	117	75	135	150
14	Laborer	M	40	5–9	190	100		180
15	Physician	M	31	5–6	180	75		130
16	Salesman	M	22	5–7	140	80		135
17	Music-teacher	F	25	5–6	110	65		120
18	School-girl	F	18	5–6	110	50		75
19	....	F	24	5–4	130	90		160
20	Temporary molars	M	8					65
21	Merchant	M	30	5–10	110	45		155
22	Music teacher, on bridge	F	35	5–5	120			145
23	On temporary molars	M	8					45
24	Farmer	M	26	6–3	200	60		145
25	Watchman	M	25	5–8	150	100		160
26	Artist	F	35	5	110	45		65
27	School-girl	F	19	5–11	123	60		135
28	....	F	24	5	110	45		60
29	Chinese laundryman	M		5–4	140	50		165
30	Grocer	M		5–10	204	130		170
31	Athlete	M		6	230	70		160
32	Butcher	M	30	5–5	176	140		165
33	Lawyer	M		5–9	164	65		160
34	Blacksmith	M	45	5–8	195	45		110
35	Machinist	M	40	5–3	130	80		160
36	Banker	M	35	6	148	30		70
37	Bank clerk	M		5–5	130	60		85
38	Dentist	M	35	5–8	220	45		160
39	Grocer	M		5–8	150	80		160
40	Farmer	M		6	170	90		190
41	Temporary molars	M	4½		40			45
42	School-girl	F			100	70		120
43	Physician	M	35	5–11	205			270
44	Printer	M	32	5–6	105			70
45	School-girl	F	19	5–5	120			100
46	Student	M	18	5–8	130	70	130	
47	School-girl	F		5–4	102	50		120
48	Physician	M	32	5–7	135		185	
49	Dentist	M	40	5–5	120	60		100
50	Athlete	M		5–7	150	120		165

The application of these facts to the strength of the dental tissues, and to the effect upon fillings and their anchorage, will result in more careful preparation of the enamel margins and more substantial anchorage of fillings.

The instruments invented by Patrick and Dennis for measuring the strength of the jaws, and later perfected by Dr. Black, is known as the "Gnathodynamometer."

(2) "Teeth that have lost their pulps and have become discolored lose strength in a marked degree, apparently from a deterioration of the organic matrix."

Tests were made of the strength of fifteen pulpless and discolored teeth from persons ranging from twenty-five to fifty years of age, all of which succumbed to stresses between one hundred and thirty to two hundred pounds.

(3) "Teeth that have become badly worn from mastication and in which the pulps had become so calcified as to cut off the nutrition of the crown

portion of the dentin, lose strength apparently from deterioration of the organic matrix."

(4) "Teeth of old people, and especially those in which much calcification of the pulp occurs, deteriorate in strength."

(5) "There is no basis for the supposition that the teeth of children, under the age of twelve years, are too soft to receive metallic fillings."

(6) "Differences in density, or in the percentage of lime-salts in the teeth, is not the controlling factor in the strength of the teeth nor of their hardness, this seeming to depend upon the condition of the organic matrix."

(7) "Differences in the strength of the teeth have no influence as to their liability to caries. Differences in density or in the percentage of lime-salts in the teeth have no influence as to their liability to caries."

(8) "The active causes of caries is a thing apart from the teeth themselves, acting upon them from without, and from a consideration of the facts thus far developed, the logical inference is that the cause of the differences in the liability of individuals to caries of the teeth *is something in the constitution, operating through the oral fluids, and acting upon the exciting causes of caries, hindering or intensifying its effects.*"

(9) "Caries of the teeth is not dependent upon any condition of the tissues of the teeth, but on conditions of their environment."

(10) "Imperfections of the teeth, such as pits, fissures, rough or uneven surfaces, and bad forms of interproximate contact, are causes of caries *only in the sense of giving greater opportunity for the action of the causes that induce caries.*"

(11) "The objects to be attained in filling teeth are the perfect exclusion of the causes of caries from the tissues by sealing the cavity, and *securing such form as will prevent lodgement of débris about the margins of the filling*, and thus prevent the further action of the causes of caries."

(12) "There is no basis for the supposition that some teeth are *too soft* or *too poorly calcified* to bear filling with gold or other metal in use for that purpose, since all are found to be abundantly strong."

(13) "There is no basis for the selection and adaptation of filling-materials to soft teeth, hard teeth, frail teeth (in structure), or poorly calcified teeth. What basis there may be in the conditions surrounding the teeth for the selection and adaptation of filling-materials must be left to future development to discover."

(14) "With our present knowledge the only basis for the selection and adaptation of filling-materials to classes of cases is the individual operator's judgment, as to which he can so manipulate as to *make the most perfect filling*, considering the circumstances (*environment*), his own skill, and the durability of materials."

(15) "There is no basis for the supposition that calcic inflammation of the peridental membrane, or phagedenic pericementitis (so-called pyorrhœa), attacks persons who have dense teeth in preference to those whose teeth are less dense."

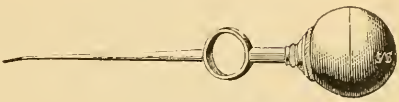
(16) "There is no basis for the treatment of pregnant women medicinally with the view of furnishing lime-salts to prevent the softening of

their teeth, or with the view of producing better calcified teeth in their offspring."

PREPARATION FOR OPENING THE CAVITY.

Many operators are in the habit of applying the rubber dam in all cases before commencing the operation of cavity preparation. The writer prefers to clear the cavity of the thin overhanging enamel edges, food *débris*, and the most softened portions of the dentin before applying the dam, as this gives opportunity for frequent use of the syringe (Fig. 367) and warm water charged with antiseptics or alkaline solutions, which often very materially adds to the comfort of the patient, and not a little to the sense of cleanliness, as well as relieving the patient for a portion of the time of what is to many the disagreeable presence of the rubber dam. Absolute dryness, however, is always necessary in the final preparation of the cavity, as the exclusion of moisture makes it more easy to locate slightly discolored and decalcified dentin.

Fig. 367.



Water-syringe (reduced).

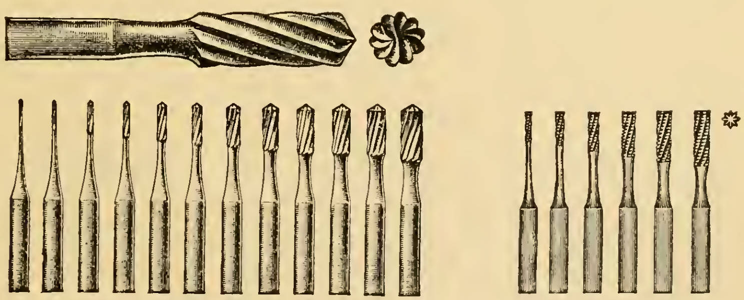
The selection of the instruments with which to open the orifice of a cavity will depend upon its location, size, and accessibility.

Cavities located upon the morsal, lingual, or labial surfaces of the tooth crown are easily accessible, but those upon the approximal surfaces do not give ready access until after space has been gained by some of the methods of temporary separation described in the preceding chapter.

Small cavities located upon any exposed surface can best be opened by the use of some form of small *engine bur*.

The forms of burs best adapted to the opening of small accessible cavities are the pointed fissure, dentate, round, and inverted cone. Figs. 368 and 369 illustrate these forms. The pointed fissure bur is by far the most serviceable instrument for opening very small cavities or fissures. Its shape facilitates its entrance into the cavity, while it also more readily follows a fissure.

Fig. 368.

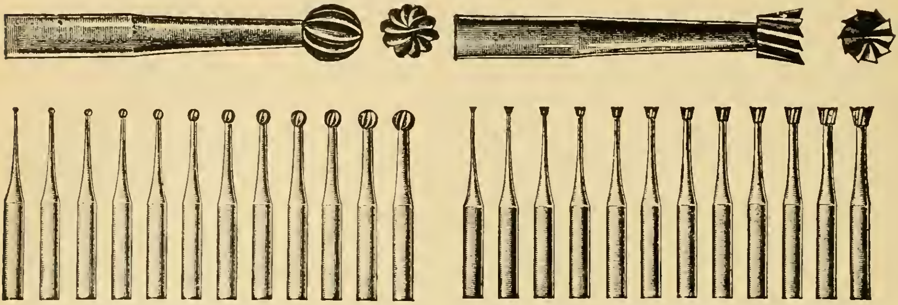


Fissure, pointed. Dentate.

Spear-pointed drills are not so serviceable for this purpose, on account of the fact that they are frequently broken by being caught in the irregularities of the cavities or in the fissures.

In the larger cavities enamel-chisels are much more useful for opening the cavity, and are less painful to the patient. In using enamel-chisels

Fig. 369.



Round. Inverted cone.

advantage is taken of the natural lines of cleavage of the enamel, as shown in Fig. 370, *a*, *b*. The overhanging edges of the enamel are thus rapidly

Fig. 370.

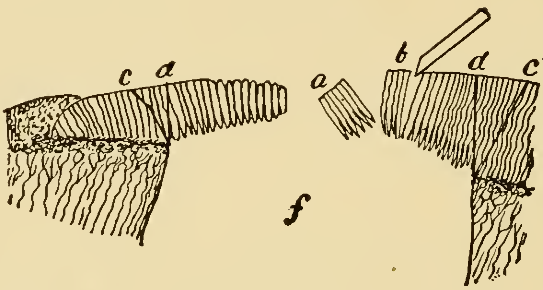
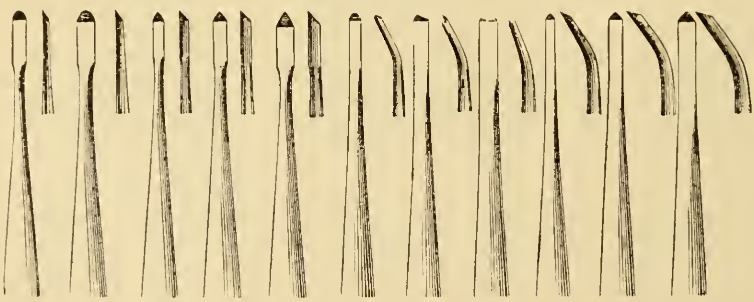


Diagram illustrating cleavage of the enamel and lines upon which the margin should be cut preparatory to filling. *a*, chip thrown off by the chisel; *b*, position of the chisel in splitting off overhanging margins; *c*, *c*, correct lines upon which to cut the margins preparatory to filling; *d*, *d*, incorrect lines for the preparation of the margins for filling; *f*, cavity in the dentin. (After Black.)

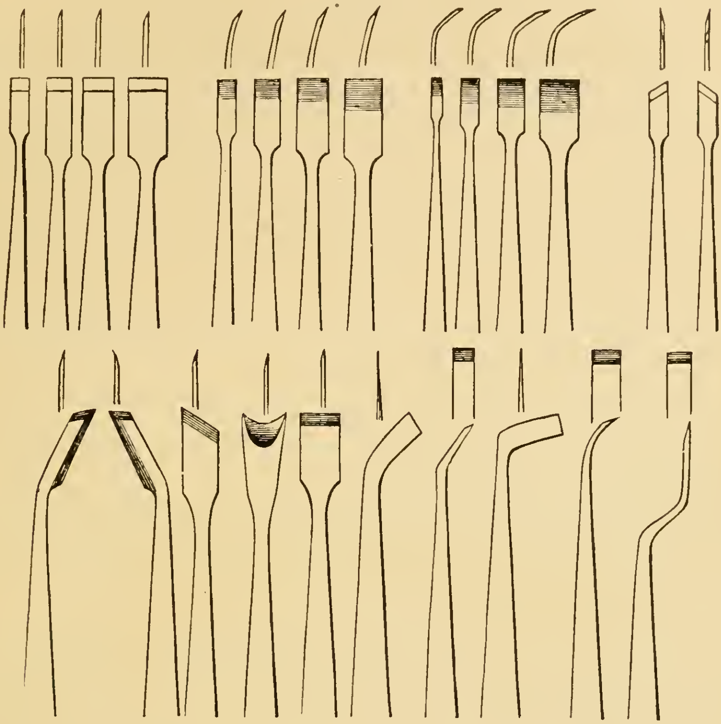
and effectually cut away. The selection of the form and size of the chisel should depend upon the size, location, and the accessibility of the cavity.

Fig. 371.



A set of three-edged chisels recently invented by E. Parmley Brown (Fig. 371) are most admirable for opening cavities, enlarging fissures, cutting away overhanging edges of enamel, and trimming the cervical margins of cavities. Other forms of chisels are shown in Fig. 372.

FIG. 372.



Chisels may be used either with hand-pressure or by the driving force of the mallet. The sharp, quick stroke of the mallet is the most effectual force to use in cleaving the unsupported edges of the enamel, while there is much less danger of the instrument slipping and injuring the soft tissues of the mouth or the pulp than when hand-pressure is used.

The chisel should be held between the thumb and first two fingers of the right hand, as a pen is held, while the ring and fourth fingers rest upon an adjacent tooth or some convenient part of the face or chin, to guard against slipping. This position of the hand in holding the chisel applies equally to the engine hand-piece, excavators, mallet pluggers, and other small-handled instruments.

In opening cavities upon the approximal surfaces which have been brought to view by separating the teeth, and which are superficial and of limited extent, small round or inverted cone-shaped burs will be found most useful; while in cavities of larger size one of the smaller sizes of the Parmley Brown chisels, which cut upon the sides as well as the point, will be found advantageous in cleaving the thin edges of the enamel. They are also especially useful in preparing approximal cavities in the incisors and cuspids, and for trimming enamel margins.

Time will be saved in the after-procedure of removing the decay if in the operation of opening the cavity the overhanging enamel has been at once cut away until sound dentin has been reached.

The unnecessary sacrifice of enamel-tissue is, however, to be avoided, but nothing is gained by temporizing.

In the heroic use of the enamel-chisel in the first step in the operation of cavity preparation lies the secret of rapid excavation, while much pain and fatigue will be saved to the patient and better results will follow than by timid, half-hearted measures.

Removing the Decay.—In removing the softened decalcified dentin from a carious cavity care should be exercised to inflict as little pain as possible. Its thorough removal, however, is absolutely necessary to the success of the after-treatment. The method of operation to be adopted in removing the carious dentin will depend upon the character and consistency of the disorganized material to be excavated. These characteristics of the decalcified dentin may be divided into three varieties: one is *white and of chalky consistency*, another is *light brown*, *semi-elastic*, or *leathery*, and the last *dark brown* or *black* and *quite hard*.

In the *first variety*, which is characteristic of the most rapid form of caries, the dentin is often exquisitely sensitive.

Spoon-bladed or round-bladed excavators will be found most useful in removing the decalcified tissue, and the risk of exposing the pulp will be much less than if engine-burs are used, from the fact that the decalcification of the tissue has many times progressed almost to the pulp before the cavity has been discovered.

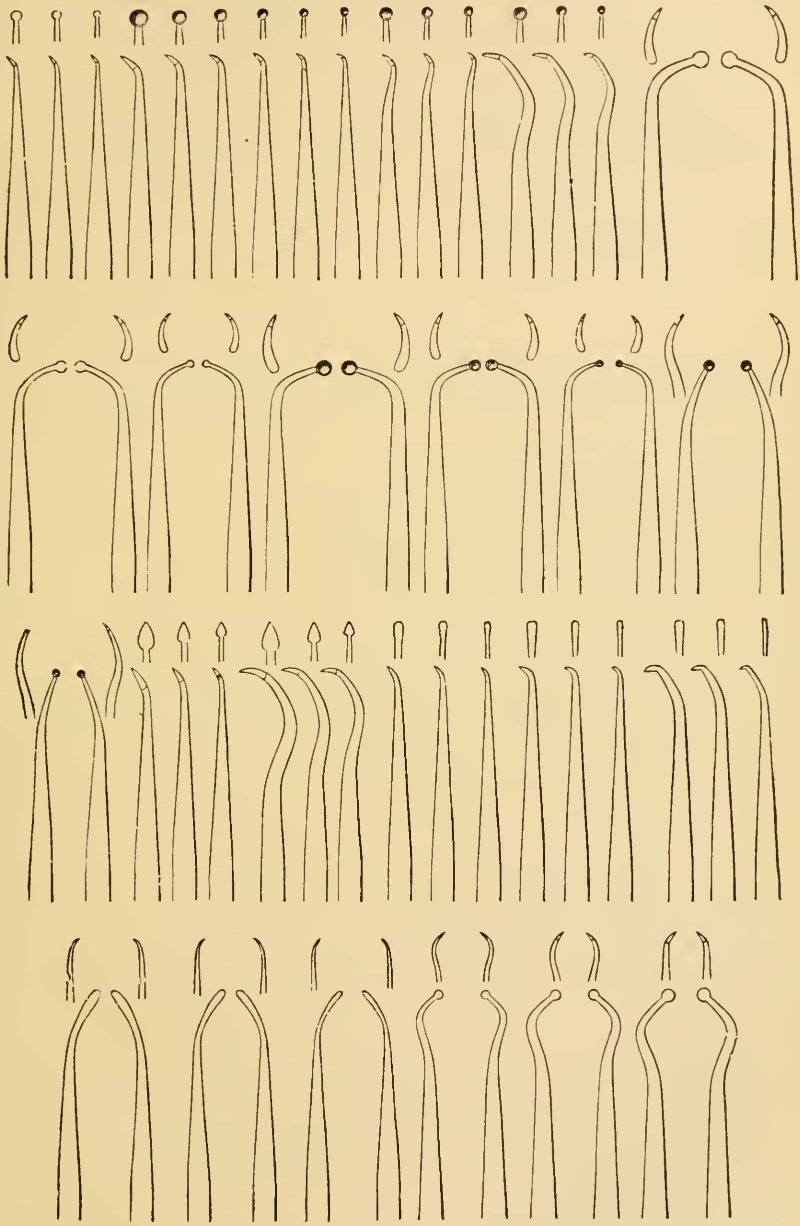
In the *second variety*, having a semi-elastic, leathery consistency, excavators having round or spoon blades (Fig 373) will also be found most serviceable in removing the carious dentin.

This character of decay is most often seen in the teeth of young people, and is not infrequently very sensitive. In all operations for removing carious dentin, the fact should be kept constantly in mind that the most sensitive portion of a tooth is at the periphery of the dentin, immediately beneath the enamel, and that the dentinal fibrillæ, in advancing from the pulp to the periphery of the dentin, have a direction which is perpendicular to the surface of the tooth. Much pain may, therefore, be saved the patient if at the outset of the operation a few bold sweeps of the excavator are made around the circumference of the cavity immediately beneath the enamel, and that all subsequent cuts of the excavator, so far as possible, follow a line from the centre of the tooth to the periphery, rather than from the periphery to the centre. In the leathery form of carious dentin, many operators advise removing the dentin layer by layer, beginning at the periphery of the cavity and gradually lifting them out until all of the material of this character has been removed.

The excavator should be kept sharp, and each cut of the instrument should be decided. Scraping of the sensitive dentin is much more painful than a firm, decided cut that accomplishes something. The greatest kindness that can be shown a patient under these circumstances is *to be thorough, but at the same time rapid*; and these conditions are not inconsistent to the mind of the bold but conscientious operator.

Thorough excavation of a cavity comprehends the removal of all *disorganized* and *infected* dentin. This may not always be done with safety

FIG. 373.



Excavators.

to the pulp, but, as a general rule, this procedure should be carried out. There is only one way to determine when all infected tissue has been removed, and that is by the density of the tissue. All soft, leathery dentin is infected, but Miller has proved that all partially decalcified dentin is not infected, as the process of decalcification is always in advance of the presence of the micro-organisms in the tubuli.

The meaning of the term *thorough excavation* would necessarily, then, depend somewhat upon the judgment and experience of the operator as to whether all infected tissue had or had not been removed. The only safe method, except in the case of nearly exposed pulps, is to excavate until sound, hard dentin has been reached.

Partially decalcified dentin may be allowed to remain in the bottom of the cavity, as recalcification will usually take place in this tissue, and also for the reason that it will protect the pulp from thermal shock. Thorough disinfection should, however, precede the introduction of the filling. For this purpose mercuric bichloride 1 to 500, carbolic acid ninety-five per cent., oil of cloves, oil of peppermint, or listerin, etc., may be used.

In the operation of removing the decayed dentin the surfaces of the cavity should be left as smooth as possible. Undercuts, grooves, or general unevenness of the walls of the cavity should be avoided, except those which are made for the definite purpose of retention, as the filling-material is more readily adapted to smooth walls.

In the *third*, or *dark, hard variety*, the carious process is very slow and sometimes becomes arrested or self-limited. In *arrested caries* the dentin is always of a darker color than ordinary dentin, and might be mistaken for caries but for its greater hardness. It should not be removed except from the margins of the cavity, where its color would be objectionable and prevent a clear, clean appearance of the finished operation.

The dentin in the dark variety of caries is not more sensitive usually than dentin in its normal state. Cavities of this character rarely penetrate to a depth involving or jeopardizing the integrity of the pulp; consequently they are the most favorable cases for restoration by plugging with gold.

Retentive Shaping.—After the cavity has been cleared of all disorganized and infected tissue, the next step in the operation of cavity preparation is to give it such shape that the filling, after it has been inserted, cannot be mechanically dislodged; while at the same time the retentive shaping must not be carried so far as to weaken the walls or to endanger the pulp. These points cannot be too strongly emphasized, for upon their proper appreciation and practical application will largely depend the future success or failure of the completed operation. Upon a correct application of the laws of mechanics to the art of filling teeth will depend the retention of the filling after it has been inserted. The shape of the cavity must therefore be such that the completed filling cannot be dislodged by mechanical force without fracturing the walls of the cavity or cutting the filling into pieces.

It is obvious, however, that a single method of securing retention will not suffice for all cavities. Various methods must therefore be employed, and their individual or combined application must depend upon the general form and character of the cavity to be filled; but, as a general rule, it may be stated that the cavity should be slightly larger at the bottom than at the orifice.

In small cavities, however, in which the depth is equal to or greater than the diameter, the walls may be left parallel to each other, as the lateral walls will contain a sufficient number of uneven points to secure retention of the filling.

In shaping the cavity, care should be used to leave the walls as free from angles as possible, as there is greater difficulty in adapting the filling to such surfaces. To this end the excavators used should be of the spoon or rounded form and the burs either round or oval.

The reverse of this is true in cavities of larger size, where the diameter of the cavity is greater than its depth. Guilford formulates two rules to govern these conditions, as follows:

"1. When the depth of the cavity is greater than the diameter of the orifice parallel lateral walls will prove retentive.

"2. When the diameter of the orifice is greater than the depth of the cavity the latter will have to be somewhat enlarged internally to retain the filling."

The first class of cavities are usually found occurring in the pits, upon the lingual surfaces of the superior incisors, the morsal surfaces of the superior and inferior bicuspids and molars, the lingual surfaces of the superior molars, and the buccal surfaces of the inferior molars.

The second class of cavities are found in nearly all locations upon the various surfaces of the crowns.

In some cases the cavities formed by decay will be found to possess a retentive form after the carious dentin has been removed, but, as a rule, retentive shaping will be required, making it necessary to cut away more or less sound dentin. *Care should be exercised, however, not to carry this part of the operation too far*, as the walls of the cavity would thereby be weakened, or the pulp encroached upon to such an extent as to cause after-trouble. The tendency of the student and the young practitioner is to carry retentive shaping too far.

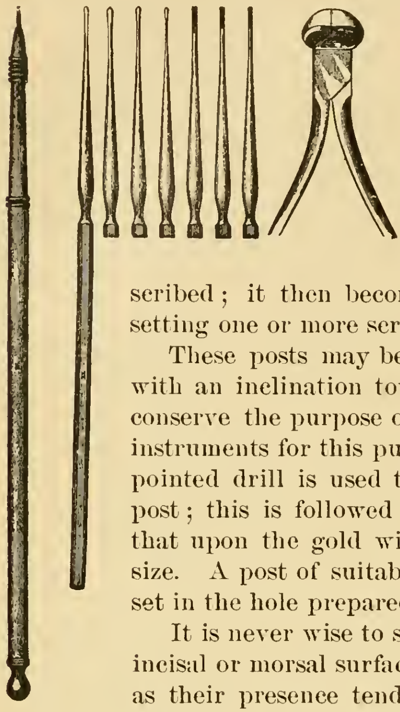
Deep undercuts. grooves, or pits are not necessary to retain a filling. These means of retention are just as effective from the mechanic standpoint if they are of moderate depth as though they were much deeper, while the dangers from fractured walls or pulp irritation are greatly lessened.

Approximal cavities in bicuspids and molars should be so shaped as to secure as broad and flat a foundation as possible at the cervical wall for the support of the filling. The laws of engineering require that the base or foundation of a structure shall be equal to, or greater, in surface area than the structure to be reared upon it. This applies with as much force to filling teeth as to building suspension bridges, twenty-story buildings, or Eiffel towers. The greater the load to be carried, the broader and stronger must be the foundations upon which the load is to rest.

If this fact is appreciated and applied to the preparation of this class of cavities, there will be many less failures in approximal fillings in bicuspids and molars.

Retentive forms may be given to cavities by making the bottom of the cavity slightly larger than the orifice; by the formation of shallow grooves at opposite points at the base of the cavity; by pits drilled at opposite points; or by a combination of these means of retention. In compound cavities — those involving two or more surfaces — retention is often strengthened by giving a dove-tail form to one portion of the cavity. Occasionally, on account of the loss of tissue, retention cannot be obtained by any of the means just described; it then becomes necessary to secure the filling by setting one or more screw-posts.

Fig. 374.



These posts may be set upon opposite sides of the cavity, with an inclination towards each other, or a single post may conserve the purpose of retention. Fig. 374 shows a set of instruments for this purpose. In setting these posts, a spear-pointed drill is used to make the hole which is to receive the post; this is followed by a tap, cut with the same thread as that upon the gold wire used for the post, and of the same size. A post of suitable length is then cut from the wire and set in the hole prepared for it.

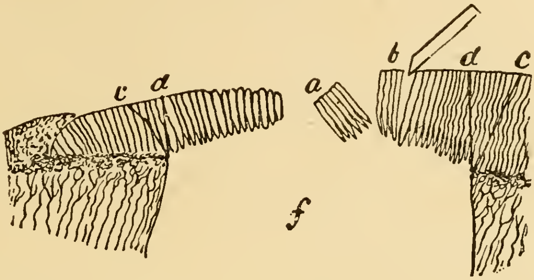
It is never wise to set a post or make a groove or pit in the incisal or morsal surfaces of the tooth or very near the enamel, as their presence tends to weaken this part of the tooth and makes fracture of the walls very liable to occur under the stress of mastication.

Forming Cavity Margins.—This part of the operation is also an exceedingly important one, from the fact that without a proper forming of the cavity margins perfect adaptation of the filling-material to the enamel borders is an impossibility, and consequently leakage soon takes place at these defective points and the operation becomes a failure. Another important point in the process of shaping the margins of the cavity is to cut away all thin and weakened enamel, for if it is allowed to remain fracture is liable to occur either in adapting the filling-material to it or in the stress incident to mastication.

In the final preparation of cavity margins, the best results will be obtained by slightly bevelling these borders by cutting the enamel-rods in an oblique direction, as shown in Fig. 375, *c*, *c*. If the walls are cut perpendicular with the wall of the cavity, as in *d*, *d*, certain of the enamel-rods would have no support of dentin, and consequently they would be more liable to fracture from cleavage than if cut away as shown in *c*, *c*.

In cavities occurring upon concave surfaces, as, for instance, in the fissures upon the morsal surfaces of bicuspids and molars, the lines of enamel cleavage would have an inward direction, the reverse of that shown at *d*. The bevel, therefore, given to the enamel margins in this class of cavities should—in order that no enamel-rods be left without proper support of the dentin—be a little greater than that given to the margins of cavities occurring upon convex surfaces.

Fig. 375.



The instruments which are best suited to the purpose of preparing the enamel margins are chisels, broad-face hoe excavators, barrel-shaped file-cut burs, and Arkansas stones. The margins should be left as smooth as possible, but in the use of the burs and stones care must be exercised not to round the edges of the margins, as this would leave a feather-edge to the filling after it was finished, and would be liable to peel up or become rough, thus spoiling the appearance of the marginal contact and opening the way for the establishment of secondary caries.

CHAPTER XVII.

TREATMENT OF CARIES BY OBTURATION, OR FILLING.

Definition.—Obturation (from the Latin *obturare*, to stop up), the act of stopping a hole or covering an opening.

"**Obturation of the Teeth.**—The filling of cavities in the teeth produced by caries with a substance capable of resisting the destructive action of fluids or the force of mastication."

The operation of removing disorganized substances from a carious tooth and mechanically *filling*, *stopping*, or *plugging* the cavity should, strictly speaking, be termed an *obturation*, and the inserted filling an *obturator*.

Custom, however, sanctions the use of the term *filling*, etc., as applied to the closing of a cavity in a tooth, and generally restricts the use of the term *obturation* to the mechanical procedure of stopping or covering an opening in other tissues caused by developmental defects, disease, accident, or surgical operation, and of *obturator* to the instrument or appliance which closes or stops the opening.

The introduction of a filling-material into a prepared cavity in a tooth is a purely mechanical procedure, but one which, nevertheless, with certain materials, like gold-foil, calls for a high degree of mechanical ability and manipulative skill. Upon the possession of these qualifications will depend, in no small degree, the success or failure in saving the teeth by the operation of filling. It matters not how perfectly the cavity may have been prepared, if the completed filling *is faulty in its adaptation to the walls of the cavity and the enamel margins*,—in other words, *does not hermetically seal the cavity*,—or the margins are not perfectly finished, or the surface is rough or not properly contoured, the final result will be failure.

The main objects in introducing a filling into a prepared cavity are to arrest the further progress of the carious process and to restore the tooth to its original form and usefulness.

The consideration of the ways and means by which these results may be obtained must comprehend,—

(*a*) The age of the individual; the character of the teeth; the condition of the health, and the local environment; also,

(*b*) The nature and physical characteristics of the substances used as filling-materials.

(*c*) Their capabilities of perfect adaptation to the walls of the cavity and the restoration of contour.

(*d*) Their conductivity and therapeutic action upon tooth-structure.

(*e*) Their resistance to chemical action and mechanical abrasions; and,

(*f*) Their harmony of color with tooth-tissue.

In the selection of the material with which to successfully fill a tooth an experienced judgment is required. This judgment in any given case must be based upon a full knowledge and appreciation of all the conditions presented by the individual to be operated upon, as well as the nature, physical characteristics, and adaptability of each of the various materials that are generally used for this purpose. In a wise selection of the material to be used in each individual case lies one of the most important elements in the conservation of decayed teeth.

The dentist who fails to appreciate this fact will fall far short of rendering the best possible service to his patients.

FILLING-MATERIALS AND THEIR INTRODUCTION.

The materials which are used for filling teeth are divided into two general classes,—viz., *non-plastics* and *plastics.*

The *non-plastics* include all of the various forms of gold-foils, sponge or crystal gold, platinum gold-foil, and tin-foil.

The *plastics* are amalgams, gutta-percha, and the various basic oxide cements.

The ideal filling-material, like the "fountain of life," still lies within the realm of the undiscovered. No substance or combination of substances yet discovered possesses all of the features and characteristics necessary to fulfil the requirements of the ideal material for filling teeth. Such a filling must be indestructible in the fluids of the mouth, and not susceptible to chemical change in the presence of substances which enter the mouth as aliment or as medicinal remedies ; it must be easy of adaptation and capable of making a moisture-tight plug ; it must be so dense in structure as to retain its form and resist the abrasion of mastication ; capable of being colored to match any shade of the natural teeth, and polished or glazed to imitate the enamel ; it must be a non-irritant and a non-conductor of thermal changes ; incapable of shrinkage or of staining the tooth-structure, and possessed of such adhesive and cohesive qualities as will retain it in any imaginable location and permit of the most elaborate contouring ; and, finally, it should possess such therapeutic properties as to make it preservative of tooth-structure.

NON-PLASTIC MATERIALS.

Gold.—Of all the materials that have thus far been used for filling carious cavities in the human teeth none possess in so high a degree so many of the *desiderata* of a perfect filling-material as gold, and yet this material falls far short of the ideal.

Gold, nevertheless, by reason of its peculiar physical properties, occupies the *first place* among the materials which are used for this purpose, and experience teaches that after all the constitutional and local conditions and environment are considered, gold in the majority of instances is the most reliable material with which to preserve the teeth and restore portions lost by disease or accident that the dentist at the present time has at his command.

PHYSICAL CHARACTERISTICS OF GOLD.

Until the publication of the experiments of Dr. Black with regard to the "Physical Characteristics of Filling-Materials," very little was known of the behavior of gold and gold fillings under stress, such as would be exerted in the mastication of foods.

In order to obtain data that would be reliable this investigator began his experiments with *cast*, *hammered*, and *annealed gold* of the same purity as that used by the dentist in filling teeth. The object of this was, first, to determine the amount of their strength and flow under stress of a given number of pounds, and then to compare these results with the strength of fillings made from the various preparations of gold-foil, etc., by the different methods of manipulation.

Strength of Gold.—Blocks were prepared from bars of cast and hammered gold by turning in a lathe to an even size of one-hundred-and-forty-thousandths (fourteen one-hundredths) of an inch, and cutting pieces from the bar of the lengths which appear in the accompanying table, the ends being accurately squared. The specific gravity varied from 19.1 to 19.3.

These were then subjected to compression in a dynamometer with a micrometer attachment. The pieces were placed with their squared ends between two parallel planes of steel, and the shortening of the blocks under a stress of two hundred pounds and three hundred pounds noted.

The same sections of hammered gold were afterwards *annealed* and again subjected to the same stress, with the result of finding them much softer and much more yielding to the same pressure or stress. This is also shown in the table.

Exhibit of the Strength of Cast, Hammered, and Annealed Gold under Compression.

All results reduced to the basis of one-tenth inch cross-section.	Number.	Length.	Weight.	Per cent. of shortening under a stress of		
				200 lbs.	300 lbs.	350 lbs.
Case 1. Cast gold, chemically pure. Specific gravity, 19.2; diameter, 140.	1	108.5	486.9	4.24	9.22	......
	2	107.5	481.9	4.27	12.16	......
	3	107.25	479.8	3.91	11.76	......
	4	106.0	477.8	5.07	11.70	......
Average				4.37	11.21	......
Case 2. Cast gold, chemically pure. Specific gravity, 19.25; diameter. 120.	1	86.0	284.2	1.79	8.39	13.18
	2	101.0	339.7	4.08	8.66	17.34
	3	98.0	316.4	2.62	9.36	14.19
	4	83.0	274.5	1.85	9.30	13.03
Average				2.58	8.92	14.43
Case 3. Hammered gold, pure. Specific gravity, 19.3; diameter, 140.	1	113.0	490.6	0.33	1.35	2.72
	2	121.0	534.3	0.63	2.53	5.07
Average				0.48	1.98	3.89
The same pieces annealed.	1	......	......	6.34	12.70	16.23
	2	......	......	6.01	12.71	16.71
Average				6.17	12.70	16.47
Case 4. Hammered gold. Specific gravity, 19.35; diameter of pieces, 115.	1	170.0	492.0	0.88	2.94	10.00
	2	121.0	372.4	0.40	1.64	6.14
	3	122.0	380.0	0.40	1.64	3.68
	4	109.0	323.5	0.53	2.24	7.13
Average				0.55	2.08	6.73
The same blocks after annealing.	1	......	......	3.14	12.93	18.18
	2	......	......	6.75	14 41	19.36
	3	......	......	6.63	14.16	19.02
	4	......	......	5.06	13.76	19.22
Average				5.39	13.38	18.94

Flow of Gold.—Dr. Black says, "As stress upon gold is increased to a point at which it begins to show signs of failure or yielding, it begins to flow or spread laterally. At first this flow is very slow, but as the stress is increased the flow occurs at a constantly increasing ratio."

He found, however, that gold possessed the peculiarity of *irregularity in its flow under pressure*, the movement being rapid for a little time, then stopping, and again flowing. This was observed to invariably occur no matter how steadily the pressure was increased.

It is generally recognized that gold is made stronger and denser by hammering and rolling. For the purpose of comparison with cohesive gold fillings, bars of gold were hammered as thoroughly as their size would permit.

Hammered blocks of gold gave no evidence of flow at a stress of one hundred and fifty pounds. The average shortening under two hundred pounds' stress was 0.48 per cent.; at three hundred pounds', 1.98 per cent.; at three hundred and fifty pounds', 3.89 per cent.

To test the strength and flow of gold fillings under stress, he caused to be made forty-eight fillings of the different preparations of cohesive and non-cohesive gold. Dr. Black made ten of these himself; the other thirty-eight being made by twelve different operators. These fillings were made in square and round cavities in a steel apparatus especially constructed for the purpose. The greater number were made in the square cavities, which measured one-third of an inch; others in round cavities giving the same area in cross-section, but a considerable number were made in larger cavities.

The only fillings that showed a specific gravity greater than that of hammered gold (19.3 or 19.4) were those made by Dr. Black. The first two were made with the intention of obtaining the highest specific gravity possible. In one a heavy mallet was used, and in the other a hammer, the *force used being much greater than would be employed in filling a tooth*. The specific gravity of the first was 19.38; of the second, 19.42. The third filling was malleted as would be usual in making a filling that would be exposed to unusual stress. The specific gravity of this filling was 19.18. The specific gravity of the other fillings ranged from 18.61 to 10.7. The highest specific gravity of a cohesive gold filling was 18.61, and the lowest, 10.7. The highest specific gravity of a non-cohesive gold filling was 18.2; the lowest, 16.9.

Dr. Black found in making test fillings of purely non-cohesive gold, by the old method of wedging and hand-pressure, that a specific gravity of 16.0 was about the best that could be done with a force that was admissible in filling teeth. These fillings went to pieces under very slight stress.

This of course was hardly a fair test of the strength of non-cohesive fillings. Such fillings should be tested under conditions similar to those obtaining when they are supported by the walls of a tooth cavity. There is no doubt, however, that the strength of these fillings under stress is much below that of cohesive gold.

Dr. Black recognizes this fact when he says, "Of course it must be understood that fillings made of purely non-cohesive gold depend upon the support of the walls of the cavity for their strength, and tests of naked fillings are of little value, but the facts developed in this way may be instructive to many in the placing of non-cohesive gold in the beginning of fillings in proximate cavities. It shows that it must be used in moderate amount, and so placed that it will be properly supported, or the strength of the filling will be notably impaired."

Gold fillings are often required to carry a stress of from one hundred to one hundred and fifty pounds, and even more in persons with strong masticatory apparatus. Gold fillings, in order to successfully carry a stress of one hundred pounds upon an area one-tenth of an inch square, Dr. Black thinks, must have a density or specific gravity "of about 17.0, and be pretty well hardened by malleting."

A filling one-tenth of an inch square, carrying a stress of one hundred pounds, should have a base equal to its size to rest upon. Dr. Black says, "If we obtain a flat gingival wall in a proximate cavity in a bicuspid tooth of only five-hundredths of an inch in breadth (one-twentieth of an inch) it will have to be full two-tenths of an inch long for the gold placed upon it to support one hundred pounds' stress, and to make it support one hundred and fifty pounds is out of the question."

In approximal cavities in bicuspids and molars it has been a quite common practice to groove or undercut the buccal and lingual walls as a means of retention or anchorage. This method of preparing the cavity does not place these walls in a position to assist in carrying the load, but rather weakens them; and if the seat of the filling is disturbed ever so slightly under stress, these walls are liable to be fractured, or the filling is drawn away from them, thus destroying the object for which it was inserted, by permitting the entrance of the agencies of decay and the ultimate destruction of the filling.

A better method is to prepare the cervical wall or base of the cavity as flat as possible, and the buccal and lingual wall without grooves or undercuts, and depend for support of a large part of the stress by cutting an additional seat in the morsal surface of the crown, and so shape this seat by dovetailing or other form as to give it good retentive powers.

Platinum-gold fillings showed a slight advantage in strength over those made of pure gold at the same time and under the same circumstances, but the difference was not so marked as was anticipated.

The difference found in the specific gravity of the fillings made for these experiments is explained by the difference in the consolidation of the gold, or, to state it in another way, was due to the difference in the number of air-spaces which the fillings contained.

The *flow of gold fillings,* with a specific gravity of 17.0 and above, under the ordinary stress of mastication is so small as to be a matter of little consequence.

Under a stress of one hundred and fifty pounds applied to hammered gold no evidence of flow was observed, while at two hundred pounds, a stress entirely out of the ordinary during mastication, it was only 0.48 per cent.

The surprise, however, lies in the fact that fifty per cent. of the test fillings, as shown by the exhibit, fell below the indicated specific gravity of 17.0, a density necessary to carry a stress of one hundred pounds upon a one-tenth-inch area, and could not, therefore, be expected to carry the required stress, while twenty-nine per cent. were below 15.0 in specific gravity, and readily gave way under a stress of one hundred and fifty pounds.

THE PROPERTIES OF GOLD-FOIL.

The *properties of gold-foil* which give it its great value as a filling-material are its toughness, softness, and pliability, which permit it to be readily adapted to the walls of the cavity; its tenacity, which facilitates its introduction and consolidation; and its resistance to mechanical abrasion. It, however, possesses an objectionable color, and yet it is the least objectionable in this respect of all the metals that are used for this purpose.

Miller in testing for antiseptic properties in gold-foil found that unannealed foil—Pack's pellets and Abbey's foil—retarded the growth of the mouth bacteria, while the same gold annealed had no effect. Some preparations of platinum-gold and sponge-gold acted in a similar manner.

Chemically, gold is inert as a filling-material. It possesses no therapeutic property upon tooth-structure, and it is not acted upon by any substances which are found within the mouth or that enter this cavity.

Gold-foil as used by the dentist for filling teeth is prepared in two distinct forms, which are distinguished from each other by the terms *cohesive* and *non-cohesive*. These terms are applied to designate the distinctive quality of which each is possessed.

Foils are manufactured from pure metal by the processes of *beating* and *rolling.* Absolute purity, however, is not essential in the manufacture of foils. A small amount of alloy does not injure the working qualities in the least.

All light-weight foils are made by beating, and heavy foils by rolling.

The bullion is first melted and poured into ingots of suitable size; these are then rolled into thin ribbons about one inch wide and a little thicker than ordinary note-paper, the thickness being governed by the weight of the foil to be produced; the ribbons are then cut into inch lengths, each of which will weigh two, three, four, five, or six grains, according to the weight of the foil it is desired to make.

These squares are then laid between sheets of goldbeater's-skins made from the intestines of bullocks; vellum paper made to imitate the skins is now extensively used because of its cheapness. These skins are cut into five-inch squares, and from one hundred and sixty to one hundred and seventy of them piled one upon the other, with a square of rolled gold between each, and the pile wrapped in heavy parchment, being bound both ways, so that all of the edges are protected.

This package is then placed upon a heavy stone block or pillar, three feet high by fourteen to fifteen inches square, and resting upon a large wooden block, which is set in the ground from three to four feet to give it solidity, the upper end or face of the stone pillar being smooth and polished. Then with a heavy, round-faced steel mallet the package is beaten with heavy blows, and after each stroke of the mallet it is turned one-quarter around. The time consumed in beating out such a package of gold is usually from two to three hours.

After the foil has been beaten to the desired thinness, the leaves are separated, trimmed, and placed in paper books ready for use.

Rolled gold is made by passing it through specially prepared mills until the desired thinness is obtained.

All foils as they come from the beater's-skins or from the rollers are non-cohesive. The cohesive quality is developed by a process of slow heating or annealing.

The light-weight foils in both the cohesive and non-cohesive forms are those most commonly used, Nos. 3 to 6, and of these, No. 4 is generally preferred. These numbers indicate the weight of each sheet in grains.

Rolled foil varies in weight from twenty to two hundred and forty grains to the sheet, and is always prepared in the cohesive form. Nos. 20 and 30 are the most popular at the present time, although a few years ago the heavier foils were in great demand.

Cohesive gold possesses in a high degree the quality of cohesiveness, which causes the surfaces when brought in contact under pressure to cohere or weld.

A filling made with this gold forms a solid mass, and may be afterwards hammered or rolled into plate. This quality gives great value to this form of gold as a material for restoring the contour of the teeth, but renders its adaptation to the cavity walls more difficult, as the cohesive quality makes it work stiff and hard under the plugger.

Non-cohesive gold is devoid of the cohesive quality and will not cohere or weld under pressure. This quality of non-cohesiveness makes it soft and pliable, and permits the surfaces of the gold to slip or slide upon each other when under pressure. This form of gold is valuable for the filling of all simple cavities, by reason of the fact that it is easy of adaptation to the walls of the cavity and can be very rapidly introduced.

The difference between these two forms of gold does not appear to depend upon their degree of purity, but rather to some trifling change in the physical condition, the nature of which is not definitely understood. If non-cohesive gold is thoroughly annealed it becomes cohesive, while if cohesive gold is exposed for a time to the atmosphere it becomes non-cohesive.

A few drops of aqua ammonia placed upon a pledget of cotton and left overnight in a box containing cohesive gold will render it non-cohesive, while the cohesive quality may again be restored by annealing.

The non-cohesive quality would therefore seem to be due to some accumulation or deposit formed upon the surface of the foil. The process of annealing appears to drive this off, leaving the surfaces absolutely clean and thus rendering the foil cohesive.

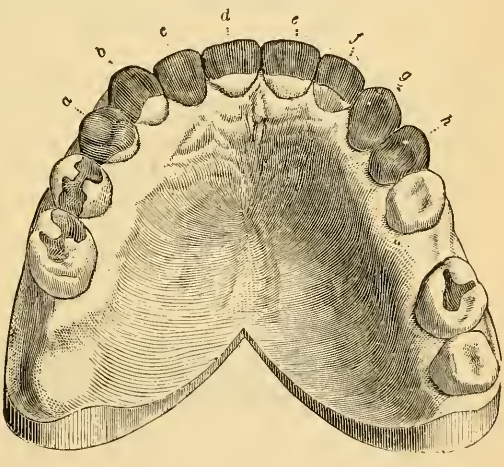
Black, in experimenting to ascertain the causes of this peculiarity, demonstrated the fact that if gold foil is subjected to the fumes of ammonia, hydrogen, hydrogen carbide, hydrogen phosphide, sulphur, phosphorus, or sulphurous acid gas, its cohesive quality is quickly destroyed. Annealing restored this quality except in those samples which had been exposed to the fumes of sulphur and phosphorus. In these the cohesive properties of the foil were permanently destroyed.

It is therefore important, especially during the winter months, that cohesive foil be excluded as much as possible from the atmosphere, which is then more or less impregnated with the gases arising from the combustion of coal. He further demonstrated that the fumes of ammonia have the power of preventing the deleterious effects of other gases upon the foil, and recommended that the foil be subjected to this gas by keeping with it in the drawer a vial of ammonium carbonate.

Non-cohesive foil was the only preparation of gold used by the earlier operators in filling teeth. Fifty years ago the cohesive property of gold-foil had not been discovered, and yet what marvellous operations such men as Westcott, Dwinelle, Maynard, Clark, and others were able to make with non-cohesive foil. Their skill in the use of this material was really wonderful, for many of them succeeded in making most beautiful contour operations in approximal cavities of bicuspids and molars, many of which have resisted decay and withstood the wear and tear of mastication for several decades without losing their beauty of form and finish.

These same men, upon the discovery of the cohesive quality of gold-foil, saw the great advantages to be derived from the discovery, and adapted it at once, to the salvation of broken-down teeth that were beyond successful filling with non-cohesive foil, and which otherwise would have been condemned to the forceps. So enthusiastic did some of them become that they were not content with restoring the contour of one-half of a tooth, but even restored the whole crown. Restorations of this character with cohesive gold were later carried to a very high degree of perfection by Dr. Marshall Webb. The accompanying illustration, Fig. 376, shows the extent to which he carried such restorations. *a*, *b*, *d*, *e*, *f*, are restorations of from two-thirds to three-fourths of the crown, while *c*, *g*, and *h* show restorations of the entire crown.

Fig. 376.



The differences in the working qualities of cohesive and non-cohesive gold-foil make it necessary to use two distinct methods of operating.

NON-COHESIVE FOIL.

Non-cohesive foil is best adapted to cavities which have *four walls*, such as are found upon any of the free surfaces of the crown.

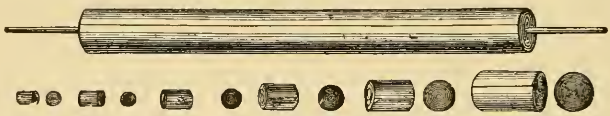
Successful operations can also be made with it in cavities having *three* good walls, as, for instance, in compound approximal cavities in the bicuspids and molars.

Non-cohesive, unannealed, or *soft foil* is the most ductile of all the forms of gold used by the dentist, and for this reason it does not "ball" under the instrument, is very readily adapted to the walls of the cavity, and insures a moisture-tight plug.

The *method of introducing it into a prepared cavity* is to first prepare the gold in the form of cylinders, ropes, ribbons, or pellets of various sizes and density, the cylinders and pellets a little longer than the depth of the cavity to be filled.

The cylinders are prepared by winding a ribbon of foil around a small Swiss broach, the ropes by rolling a strip of foil in a napkin, and the pellets are made by tearing the foil into small fragments and rolling them between the thumb and index-finger. Cylinders, however, are to be preferred to pellets, from the fact that they can be prepared with more uniformity in size and length than is possible in making pellets. The cylinders should be made of such size and density that several will be required

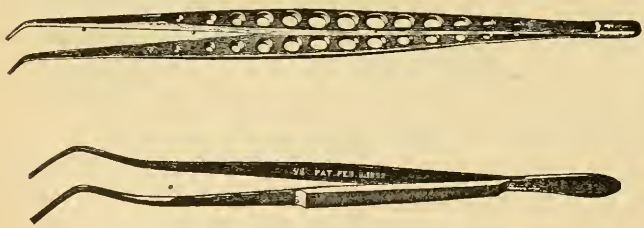
FIG. 377.



Cylinders.

to fill the cavity, and of such length that when placed upon their ends in the bottom of the cavity they will project slightly from the orifice. These may be obtained from the manufacturer already prepared, as shown in Fig. 377, but the writer always prefers to prepare the gold for each in-

FIG. 378.



Foil-carriers (reduced).

FIG. 379.

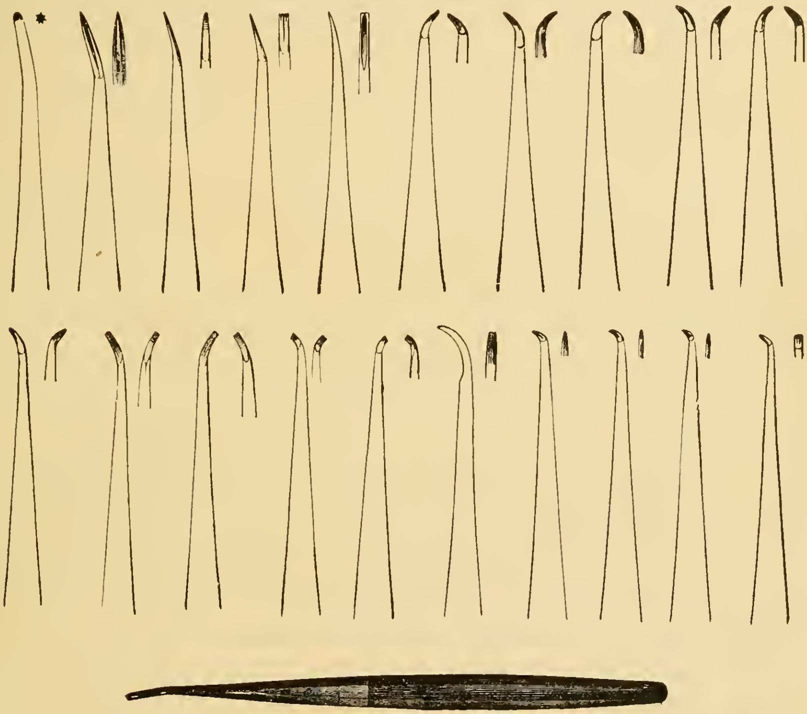
Cylinders and mats in the act of being introduced into a crown cavity.

dividual case as it is presented rather than to depend upon material prepared in advance, as this is very rarely just what is required.

The cylinders or pellets are then placed in the cavity with foil-carriers (see Fig. 378), being arranged side by side around the circumference of the cavity and condensed against its walls with suitable pluggers. Other cylinders or pellets are placed in like manner, and these are condensed towards its walls by the use of the wedging process, and this method continued until the filling is finally finished by a single hard-rolled pellet forced into the centre.

No instruments are better adapted for this purpose than those shown in Fig. 380, made from patterns furnished by Dr. Bing.

Fig. 380.



Bing pluggers.

The cylinders, if the filling has been properly introduced, should project a little above the surrounding tooth surface. These should now be thoroughly condensed by hand-pressure or the mallet. Large serrated, round-faced foot-pluggers, as shown in Fig. 381, are the best for this purpose, as pluggers with sharp angles are liable to pulverize the enamel margins, if by chance they should come in contact with them. Thorough condensation, directed always towards the cavity walls, is of the utmost importance in finishing the fillings. The surface should next be burnished, also towards the enamel margins, and the surplus gold cut away with finishing burs, stones, or the file, as the location of the filling may make most convenient, and the surface polished with sand-paper disks, emery strips, and pulverized pumice-stone or rouge, or burnished.

Many operators who use non-cohesive foil employ the hand mallet all through the operation in preference to the exclusive use of hand-pressure. The stroke of the mallet is entirely different from the tapping stroke used in welding cohesive foil. The object in malleting non-cohesive foil is to utilize to its fullest extent the spreading quality or flow of this form of gold, and this can only be accomplished by a firm driving blow, such as would be used in driving a nail of the same size as the plugger-point with which the gold is being packed, or it may be expressed as a lingering stroke that follows the plugger and remains upon it until the force of the impact has been exerted to its fullest extent upon the gold immediately beneath the plugger. The stroke, however, must be graduated to the size of the plugger and the strength of the walls of the cavity, otherwise damage might be done by driving the point of the plugger against the margins of the cavity or fracturing its walls.

Fig. 381.

Butler foot-plugger.

In *compound approximal cavities* (mesio-morsal or disto-morsal) in the *bicuspids* and *molars* the filling is commenced at the cervical wall by placing two or three cylinders side by side, with the ends projecting beyond the cavity, and condensing them against the cervical margin with broad-faced pluggers. This process is to be repeated until the morsal surface is nearly reached, when the cylinders should be condensed against the morsal margins with foot-shaped pluggers, and the filling finally finished in the centre with a rope or a single hard-rolled pellet.

Final condensation should begin at the morsal surface and be gradually carried over to the approximal, using the round-faced foot-pluggers for this purpose. The amount of contour obtained by this method will depend upon the distance that the cylinders projected beyond the walls of the cavity at the approximal surface and the thoroughness with which they were condensed in building the filling.

Many operators prefer to use non-cohesive foil for the base of the cavity and cohesive foil for the remainder.

If this method be pursued it will be necessary to partially anneal the pellets which are to form the last layer of non-cohesive foil, as by this means the cohesive foil can be welded to it. Or the cohesive foil may be driven into the surface of the non-cohesive foil by small wedge-shaped pluggers.

Another method is to pack non-cohesive foil against the walls of the cavity and over the margins, and finish the filling in the centre with cohesive foil. This was a favorite method with the late Dr. Allport, and one which he practised for many years.

In approximal cavities in bicuspids and molars he always used non-cohesive foil at the cervical margin, claiming that he secured a better adaptation of the gold to the cervical wall than was possible with cohesive foil, and that from the fact that large cylinders or pellets were used for this purpose, and thoroughly condensed with a broad-faced foot-shaped plugger, there was less danger of injuring the cervical margin than when cohesive foil was used, as with the latter it was absolutely necessary to use small pieces of foil and condense them with small pointed pluggers to secure perfect adaptation, while the danger of bruising the cervical margin was greatly increased by the liability of the plugger to being driven through the gold.

Ropes and *ribbons* are used by some operators in preference to cylinders and pellets. These are made from one to two inches in length, a sheet of foil being cut into two to four equal strips and rolled in a napkin to form ropes, or folded with a spatula to form ribbons.

The method of introducing the rope and the ribbon is to grasp one end of it with the foil tweezers and carry it to the bottom of the cavity, and lightly pack it against the wall *farthest* from the operator, then fold it over and carry it again to the bottom of the cavity, condensing it against the fold first inserted, but allowing the upper end to project slightly above the margin of the cavity. After the cavity has been about half filled in this way, another rope or ribbon may be introduced in like manner and packed against the wall of the cavity *nearest* to the operator, then against the *lateral* walls, and the filling finally completed by packing and wedging another rope or ribbon into the open space left in the centre. The surface is then thoroughly condensed and finished in the manner described with the use of cylinders and pellets. This method is thought by some operators to be superior to the use of cylinders, for the reason that the gold is more easily introduced and that it makes a more compact filling. This statement, however, is open to question in both of its features.

Herbst Method.—Another method of packing non-cohesive gold is that introduced by Dr. Herbst, of Germany, which consists of adapting or modelling the gold to the walls of the cavity by means of burnishers rapidly rotated by the dental engine. The gold used for this purpose was a very soft form of cylinders especially prepared by Wolrab, of Bremen.

Fillings introduced by this method show a most perfect adaptation of the gold to the walls of the cavity, are moisture-tight, as proved by their successful resistance of the carmine test. The surface of the filling presents a burnished appearance, which is rendered very cohesive by the friction and heat produced by the process of burnishing, so that each piece of gold as it is introduced adheres to the previous one which has been burnished into its position. The filling may be finished throughout by the same process, but better results are obtained by finishing with cohesive gold condensed by the mallet.

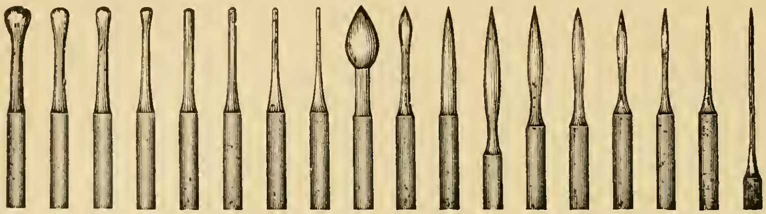
The instruments recommended by Dr. Herbst for the introduction of the filling are shown in Fig. 382, and consist of eighteen burnishers, some of steel and others with blood-stone points of various form and size.

It will be readily understood, however, that only the most accessible cavities can be successfully filled by this method; those, for instance, possessing four good walls, like the morsal cavities of the molars and bicuspids, being the most favorably located for this system.

For anchoring the filling, no especial preparation of the cavity is required other than that given to cavities which are to be filled with non-cohesive foil by the other method.

In starting the filling, the first cylinder introduced into the cavity should be large enough to cover the bottom, and it should be carried into position with a round hand-burnisher, and then followed with the engine-burnisher of the same size and form, and thoroughly adapted

FIG. 382.



Herbst burnishers.

to the floor of the cavity. Successive cylinders are then introduced and burnished against the walls of the cavity, keeping the edges next to the walls higher than the centre of the filling. As the filling nears completion, the cylinders should be so placed that they can be burnished against, and over, the enamel margins. The centre of the filling can then be finished by adding other cylinders by the same method, or with cohesive gold, condensed with foot-pluggers and the mallet. Fillings made by the Herbst method are not so dense as those made with the mallet, and the surface does not wear so well, as it shows a tendency to flake and bruise under stress of mastication. Contour fillings cannot be as successfully made by this process as with cohesive gold, and yet, by the use of the matrix, thoroughly good approximal fillings have been introduced in the bicuspids and molars.

COHESIVE FOIL.

Cohesive or *annealed foil* is stiff and harsh as compared with the "velvety" softness of non-cohesive foil. It does not work so easily as the latter, and requires an entirely different method of manipulation for its introduction.

In the manipulation of cohesive foil the student must keep in mind two rules if he would be successful in its use: first, *always to use small pieces of gold;* and second, *to condense them with small plugger-points.*

Many faulty fillings have been made with cohesive gold by not observing these two important rules.

On account of the cohesive quality of this form of foil it has a tendency to "ball" under the plugger and draw away from the walls of the cavity; while if used in large pieces there is constant danger of the mass clogging and bridging in the cavity, and thus making a porous and leaking filling.

Cohesive foil is prepared for introduction into the prepared cavity in the form of loosely rolled ropes, ribbons, pellets, and mats.

The loosely rolled ropes are made by dividing a sheet of No. 3 or No. 4 foil into strips and rolling them in a napkin. Cohesive foil should never be handled with the unprotected fingers, as the moisture or other impurities upon the skin would destroy its welding properties.

Pellets may be made by cutting the ropes into lengths varying from one-eighth to one-fourth of an inch.

Ribbons are made by folding a sheet of the same foil with a spatula to any desired width. Twice folding reduces the sheet to one-fourth its original width; this may be cut lengthwise in strips or ribbons from one-sixteenth to one-eighth of an inch in width.

These ribbons are composed of four thicknesses of foil, and in this form they constitute one of the best methods of introducing cohesive foil.

Mats are prepared by folding a half-sheet or a whole one into a ribbon about one-eighth of an inch wide and cutting it into suitable length for use in the case at hand. Ribbons and mats may also be made from No. 20 or No. 30 foil of a single thickness by cutting it in strips of suitable widths and lengths.

Some operators prefer the rolled gold to the beaten when using heavy foil, as it is claimed greater softness and ductility is obtained when the foil is prepared in this way.

Introduction of Cohesive Foil.—In the introduction of cohesive foil, retention grooves or pits are necessary for starting the filling. The first piece of gold introduced into the cavity should be firmly anchored by packing it into the retaining grooves or pits. This may be accomplished by holding the gold in position with an instrument held in the left hand, while it is packed into place with the plugger held in the right hand and the succeeding piece welded to it; this process being repeated until the cavity is full.

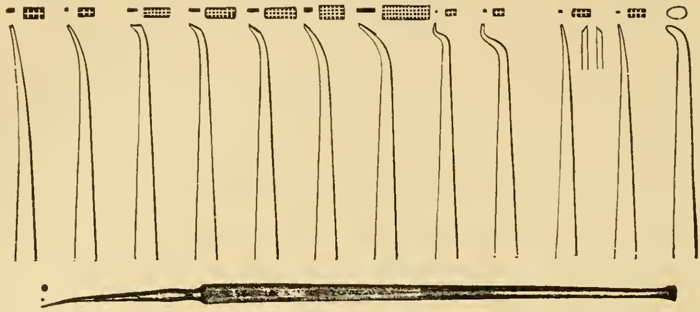
Care should be exercised that only a small quantity of gold shall at any time be under the plugger for condensation, and that each piece that comes in contact with a wall or margin of the cavity shall be thoroughly adapted to it without bruising the tooth-structure. The best results are only attainable by welding each lamina thoroughly to the preceding one. Hastily made fillings are usually faulty in their adaptation to the enamel margins, and sooner or later fail from leakage and recurrence of caries.

Plugging Instruments.—Cohesive foil can be manipulated either by hand-pressure or mallet force. The plugger-points which are required for adapting this form of gold to the walls and margins of the cavity and for condensation are considerably smaller, and the serrations much finer than those used for non-cohesive gold. The forms which are in the most general use are the Varney, Webb, Darby-Perry, Chappell, and Royce, as shown in Figs. 383, 384, 386, 387, and 388.

Serrated instruments are not, however, absolutely necessary for packing cohesive gold; smooth points answer equally well with rough ones. Some operators use ivory points with smooth surfaces, and hand-pressure entirely in packing cohesive gold. The ideal surface for a plugger-point for welding cohesive gold is that formed by breaking hardened steel. The nearer the serrations reproduce the roughness of this surface the nearer the plugger-point will approach the most perfect form for welding cohesive foil.

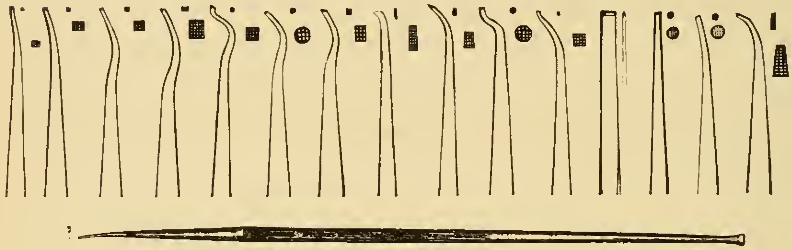
Mallet force or percussion, as a means of welding cohesive gold and condensing the surfaces of the filling, is now considered by the majority of operators as the only method by which perfect consolidation of a filling can be secured. Fillings of cohesive gold. made by hand-pressure in holes drilled in steel plates, do not weigh as much as those made in the same plates with mallet force, which proves conclusively that more gold can be

FIG. 383.



Varney pluggers.

FIG. 384.

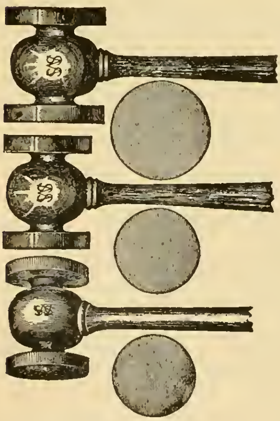


Webb pluggers.

packed into a cavity, and also more perfectly consolidated, by the use of the mallet than by hand-pressure alone.

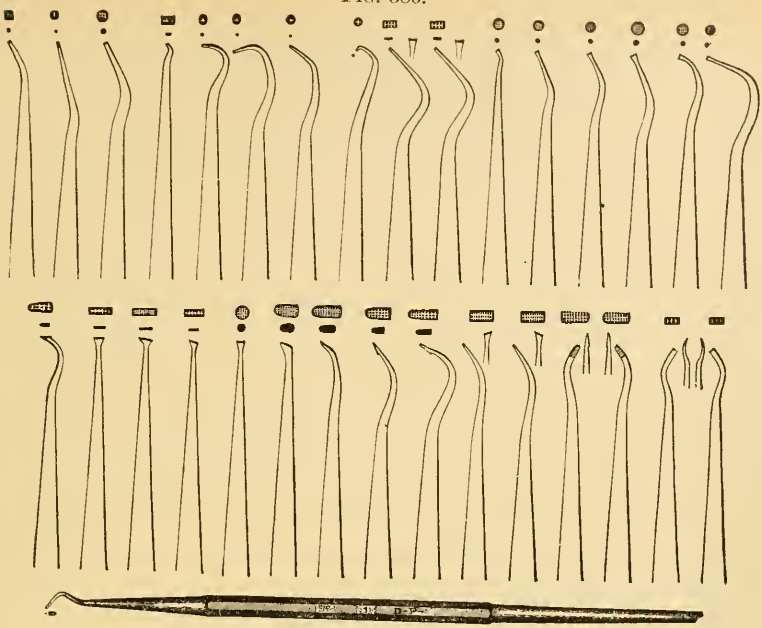
The mallet was first introduced as a means of packing gold-foil about the year 1838, by Dr. E. Merrit, of Pittsburg, Pa., who used a hand mallet for condensing the surface of fillings which had been introduced by hand-pressure. Earlier mention was made of this instrument for consolidating gold by Koecker in his "Principles of Dental Surgery," published in 1826.

FIG. 385.



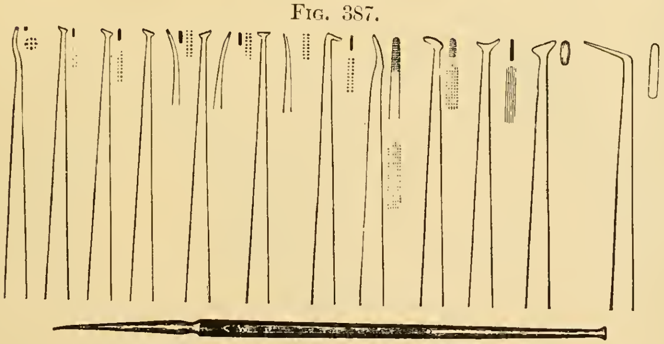
Mallet force, however, was not much used until the introduction of cohesive foil. The earlier operators with this form of gold soon discovered that in order to obtain perfect union of the surfaces percussion with the mallet was superior to hand-pressure. Various forms of hand-mallets were then introduced, made of wood, ivory, and metals, weighing from one-half ounce to two ounces. The metal mallets were made of soft steel, or of lead, block-tin, and various alloys encased in metal or wood rims. The steel mallet, Fig. 385, seems to be in the greatest favor at the present time.

Fig. 386.



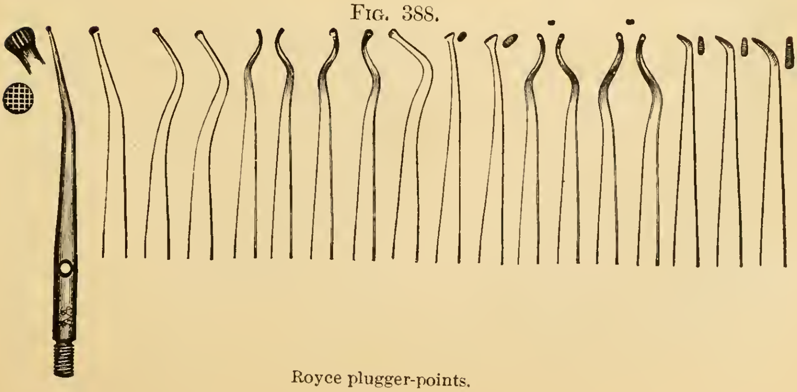
Darby-Perry pluggers.

Fig. 387.



Chappell pluggers.

Fig. 388.



Royce plugger-points.

With the introduction of heavy gold-foils came the use of heavy mallets, weighing from three to four ounces or more. It was thought by those using these extremely heavy foils that heavy mallets were necessary in order to weld the surfaces of the foil. The extremes in heavy foil were soon found to be undesirable, except for finishing fillings, and with the decadence in the use of these foils the heavy mallet ceased to find advocates.

Fig. 389.

Snow & Lewis automatic plugger.

Before the discovery that rubber sheeting or dam could be so utilized as to exclude the moisture from a cavity during the operation of filling a tooth with gold the operator was obliged to employ one hand in holding the napkin, while the other was used to introduce the gold and consolidate it. This made it necessary to have an assistant to do the malleting. For various reasons, however, suitable assistance could not always be obtained; consequently inventive genius was called into activity, and several ingenious automatic mallets were devised, in which by the use of a spring a percussion stroke is delivered upon the plugger, similar to the stroke of the hand-mallet.

The Snow & Lewis, the Foote, the Salmon, and the Abbott have found the greatest favor with the profession. Fig. 389 shows the Snow & Lewis instrument of the latest pattern. In using this instrument pressure is made upon the point of the plugger, as in packing gold by hand-pressure; this liberates the spring, and the plunger in the upper end of the instrument is thrown forward with considerable force, the impact being expended upon the gold beneath the point of the plugger. The force of the stroke can be regulated to almost any degree to suit the desire of the operator.

The Abbott instrument (Fig. 390) has a socket at each end of the handle or hand-piece,—one gives the ordinary forward stroke and the other a backward stroke. The latter was devised to carry especially formed plugger-points (Fig. 391) for condensing gold upon the distal surfaces of bicuspids and molars.

The Bonwill electro-magnetic mallet (Fig. 392) is by far the most perfect mechanical mallet that has been invented for condensing cohesive gold-foil.

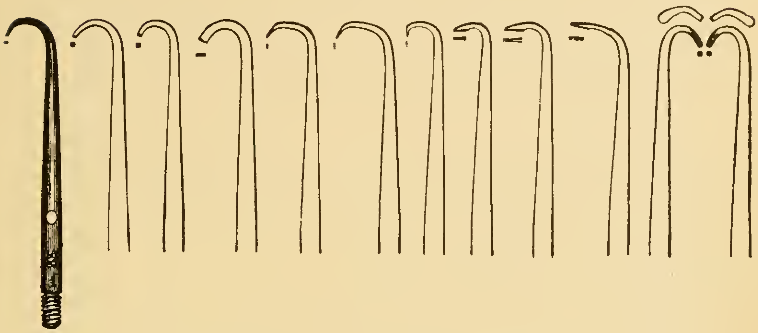
The strokes of this mallet are delivered with great rapidity and regularity, and with such force that the gold can be most perfectly condensed. Its essential parts are a horseshoe magnet with a hinged armature and an automatic interrupter, held in a framework or handle to support the plugger-point. The electric current may be supplied by a Bunsen or Partz battery, a storage battery, or the controlled current from a dynamo.

The novice will at first find some difficulty in using this instrument with satisfaction to himself and his patient, but with a little experience he will soon learn to control it and to appreciate its merits.

FIG. 390.

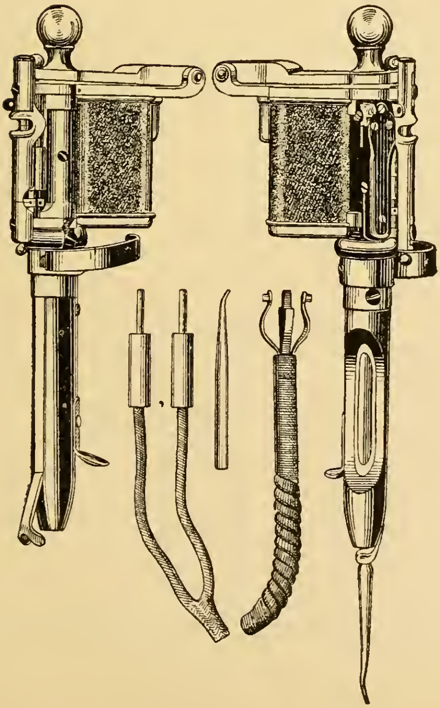
Abbott automatic mallet (reduced).

FIG. 391.



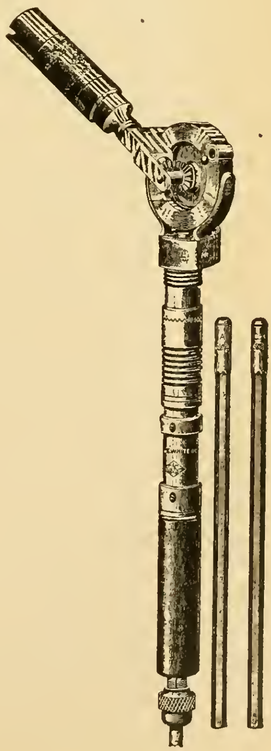
Plugger-points for Abbott's automatic mallet.

FIG. 392.



Bonwill electro-magnetic mallet (reduced).

FIG. 393.



Bonwill mechanical mallet.

The Bonwill mechanical mallet (Fig. 393) was devised as an attachment to the dental engine, to be used as a substitute for the electro-magnetic mallet. Its essential parts are a small revolving wheel, having a lug upon its periphery, which strikes the plunger and delivers a blow upon the upper end of the plugging instrument. The force of the stroke is under perfect control, and the number of strokes per second may be increased from five to twenty, according to the speed at which the engine is run.

Crystal or Sponge Gold.—This form of gold is made by two processes, one being chemical, the other electrolytic. It was first introduced to American dentists by the late Dr. Watts in 1853, under the name of *sponge gold.* It has been greatly modified and improved since that time, and now bears the name of *crystal gold*, and is one of the very best preparations of cohesive gold.

There are several ways of making this form of gold, but they are all embraced in three general methods,—viz., first, *by precipitation*; secondly, *by combining a certain quantity of mercury with the precipitate to obtain a definite crystallization*; and thirdly, *by electrolysis.* Only pure metal can be used in the manufacture of this form of gold.

In the *first method* gold is added to nitro-muriatic acid until a saturated solution is obtained. It is then precipitated by the addition of sulphate of iron or oxalic acid, the precipitant being added slowly so as to obtain a crystalline or fibrous form in the deposit. The precipitate is then carefully washed and slowly heated to nearly a cherry-red heat. After cooling it is ready for use.

The *second method* requires the combining of a definite quantity of pure mercury with the precipitate, and after allowing it to stand for a short time it is subjected to a mild heat, the mercury abstracted by treating the precipitate with dilute nitric acid, and washing it to remove the nitrate of mercury. It is then placed in a muffle and heated to a bright-red heat, after which it is ready for use as a filling-material.

By these methods of manufacture there always remained an objectionable feature in the presence within the spongy mass of traces of nitric acid, which it was difficult or impossible to get rid of.

Since the adoption of electrolysis in the place of the above methods of chemical precipitation this objectionable feature no longer exists.

By this *third method* a certain amount of pure gold is dissolved in acids, the solution is then placed in a suitable glass vessel and plates of pure gold suspended in it. Then by means of an electric current the solution is decomposed and the gold deposited in beautiful feathery crystals.

As fast as the solution loses its gold by the deposition of the crystals it is resupplied by the plates suspended in it. The deposited gold is then removed and washed to free it from any trace of the acids which held it in solution, and it is ready for use.

Gold prepared by this process manifests great cohesive properties and is generally used in large contouring operations. Fillings made with this gold are as beautiful and as serviceable as any made with cohesive foil. The secret of success in the use of crystal gold is to introduce it into the cavity in small pieces, and to thoroughly condense each piece before adding another. Failures usually result from attempts to introduce large pieces, which clog under the plugger, or to imperfect condensation of the gold.

Gold of this variety is sold in the form of bricks containing one-eighth of an ounce each. It is prepared for the cavity either by tearing it into small irregular pieces or by cutting it into small cubes with a sharp razor. Scissors should never be used for cutting this form of gold, as it condenses the edges which are cut and renders them stiff and difficult to work. Its working qualities are preserved by excluding it as much as possible from the atmosphere, and when used it should be well annealed. When freshly made it is sufficiently cohesive for general use without annealing. Many operators rely upon it for starting and finishing all fillings, but there is no form of gold that is so well adapted for starting fillings in shallow and irregular superficial cavities as this.

Crystal Mat or Solila Gold.—Several other forms of crystal gold have from time to time been introduced to the profession. That known as *crystal mat* or *solila gold* has found favor with some operators. It is manufactured by De Trey, and was first introduced in the United States in 1897. It is sold in the form of thick sheets or mats, and differs from sponge gold in that it is more compact in form and the crystals are smaller and matted together. It does not work as readily as the sponge gold, and breaks and crumbles under the plugger to a much greater degree, causing considerable waste. It possesses no good features which are not possessed by Watts's crystal gold except that it is more plastic. Deep undercuts and retaining-pits are not necessary for the retention of this gold. Cavities having three or four walls may be prepared as for plastics. Hand-pressure and broad-faced pluggers are best for working this gold. On account of its tendency to break and crumble under the plugger it is difficult to use it for contour work where a matrix cannot be used. In simple cavities and in approximal cavities where the matrix is admissible it makes a beautiful and serviceable filling and with little waste of material.

In annealing this gold, it should never be heated to a cherry-red; annealing just short of this point gives the best results.

In starting the filling a large piece should be used, large enough to cover the bottom of the cavity, and this thoroughly condensed against the walls. Smaller pieces should be used in building the balance of the filling, care being taken to thoroughly condense each piece before another is added.

Small instruments should be used for condensing the filling against the enamel margins, as perfect adaptations cannot be secured with large pluggers.

Operators who are accustomed to using non-cohesive foil will experience the least trouble in its manipulation, as the methods used in its introduction and consolidation are quite similar. The ordinary methods should be followed in finishing and polishing the filling.

Moss fibre gold, manufactured by the S. S. White Dental Manufacturing Company is the latest (1898) form of sponge gold that has been introduced to the profession. It is an exceedingly soft, tough, cohesive gold, and possesses these qualities in a much larger degree, perhaps, than any other sponge gold upon the market. It is easily adapted to the walls of the cavity, permits of extensive contouring, and when condensed presents a hard, tough surface, and takes a beautiful finish.

Deep undercuts or retaining-pits are not necessary in order to start a filling. The floor of the cavity should be as nearly flat as is possible, and the retentive shape given to it should be the same as for non-cohesive foil.

Round-faced pluggers with fine, shallow serrations, like the Royce instruments, are the best for packing and condensing this form of gold.

Small pieces of gold only should be used. Large pieces cause bridging and result in a porous filling.

In introducing the gold, each piece should be placed in the position required, and first "patted" with the plugger until evenly condensed, and then thoroughly condensed with hand-pressure or the mallet before another piece is added. Heavy malleting is not needed to condense this gold.

Care must be exercised in annealing "moss fibre gold" not to overheat it. Under no circumstances should it be brought into contact with the flame of the lamp. Slightly warming the gold over a lamp upon a sheet of mica is all that is required. Overheating makes it hard and gives it a tendency to "ball" under the plugger. Extensive contour operations can be made with it more easily than with Watts's crystal gold.

Gold-and-Platinum Foil.—This form of foil was first suggested by Moffet, of Boston, and is a combination of gold and platinum. It is made by "sweating" together an ingot of gold and one of platinum and then rolling to any thickness desired. No. 20 and No. 30 are the thicknesses generally made. It has the appearance of gold-foil before it is introduced into the cavity, but the condensing process brings out the color of the platinum.

This form of gold was in great favor a few years ago for restoring the morsal edges and labial surfaces of incisor and cuspid teeth, and for finishing fillings upon the morsal surfaces of bicuspids and molars. The advantages claimed for it over gold alone are its better, or, rather, less conspicuous color and its greater hardness.

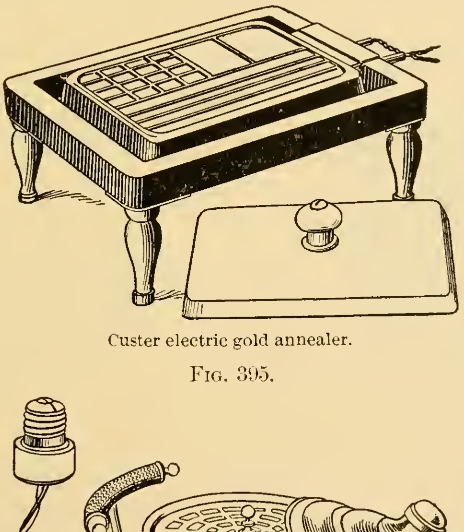
It is prepared for use by cutting the foil into narrow strips or ribbons, and after being freshly annealed it is welded to the gold filling in the same manner as heavy gold-foil. Especial care should be exercised, however, in its introduction to see that each layer is thoroughly welded over its whole surface before another piece is added. Mallet force is superior to hand-pressure in its condensation, and round-faced foot-pluggers with fine serrations give the best results.

On account of the stiffness of this form of foil it should be used only for the purposes just enumerated. To attempt to use it to fill the body of a cavity would only end in a disastrous failure, either by fracturing the walls of the cavity from the force necessary to condense it or from faulty adaptation to the walls and margins inviting secondary decay.

Annealing Process.—All metals become more or less stiff and hard by the process of hammering and rolling. Gold-foil which has been made by either of these processes has, when it comes from the beater's-skins or the rollers, lost its softness and ductility. To restore these qualities it becomes necessary to heat it. This process is termed annealing. The amount of heat used, and the length of time to which the foil is subjected to it, will depend upon the degree of softness or of cohesiveness desired. All pure foil is rendered cohesive by annealing, but certain non-cohesive foils—those in which it is claimed iron has been used as an alloy—may be rendered soft and ductile by annealing without rendering them cohesive. Freshly made cohesive foil does not need to be reannealed except for contour work. Exposure to the atmosphere, however, soon renders it non-cohesive and makes reannealing necessary if contouring is contemplated.

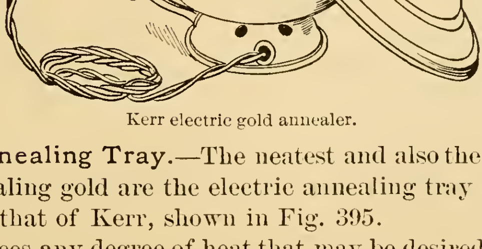
The alcohol flame or the gas flame from a Bunsen burner are generally used for the purpose of annealing. Some operators hold the piece of foil in the flame, others hold it just above, thus heating it to the desired degree. Others use annealing trays made of mica, Russia iron, or platinum, which are held over the flame of the alcohol lamp or gas-jet. The latter method is the best, for the reason that it excludes the possibility of deleterious substances like carbon, sulphur, or phosphorus being deposited upon the gold from the combustion of the lamp-wick, or particles of sulphur or phosphorus which have been dropped upon the wick in igniting it with a match, or in the case of the Bunsen burner, from imperfect combustion of the gas, which might deposit carbon or sulphur.

FIG. 394.



Custer electric gold annealer.

FIG. 395.



Kerr electric gold annealer.

Electric Annealing Tray.—The neatest and also the most satisfactory devices for annealing gold are the electric annealing tray of Custer, shown in Fig. 394, and that of Kerr, shown in Fig. 395.

By these devices any degree of heat that may be desired can be obtained, and with a uniformity not possible with any other device or method.

CHAPTER XVIII.

CONSIDERATIONS IN FILLING SPECIAL CLASSES OF CAVITIES.

I. Simple Cavities upon Exposed Surfaces.—This class of cavities presents the most simple forms of fillings in the whole range of operative procedures upon the teeth.

Fig. 396.

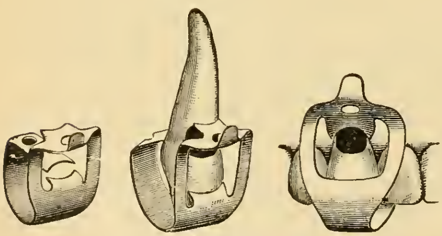
Gum retractor (reduced).

Cavities which are situated upon the *labial surfaces* of *incisors* and *cuspids*, especially when they have involved the cervix and extended beneath the margin of the gum, often present serious difficulties to the introduction of gold, which test the ingenuity, skill, and patience of the operator, as well as the fortitude of the patient.

One of the most formidable difficulties to be overcome is the adjustment of the rubber dam to those cases in which the cavity extends beneath the free margin of the gum. This may sometimes be accomplished by passing a ligature around the cervix of the tooth and forcibly carrying it towards the apex, until the dam passes beyond the border of the cavity, or the gum may be held away by the aid of the gum retractor, shown in Fig. 396.

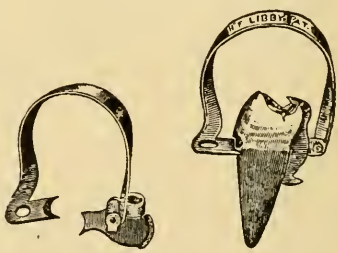
It is always best to include in the rubber dam not only the tooth to be operated upon, but at least one upon either side of it. The How cervix clamp, shown in Fig. 397, often serves a good purpose in retaining the rubber dam in position, as do also the Libby clamp (Fig. 398), the Johnson lever clamp (Fig. 399), and the Dunn clamp (Figs. 400 and 401).

Fig. 397.



How cervix clamp.

Fig. 398.

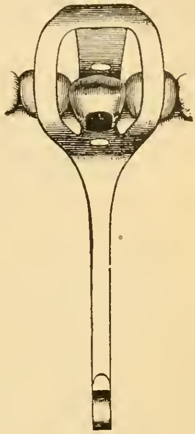


Libby clamp.

It is sometimes necessary to slit the edge of the gum above the cavity in order to gain a clear view of the gingival margin and to permit the rubber dam to go above it.

Cavities occurring in the labial surfaces of the incisors and cuspids are generally located either at the cervix or in the frequent imperfections of the enamel, due to developmental defects. As a rule they are shallow, and therefore need to be given a good retentive form, either by slightly enlarging the cavity at the bottom or by forming small retaining-pits in the extremities. Cohesive foil or crystal gold are the best for filling this class of cavities. The filling should be started in one of the extremities, care being taken that the first piece of gold is securely anchored and the balance of the filling built upon this. Many operators finish such fillings with platinum-gold foil, as the color is less conspicuous than pure gold. Figs. 402 and 403 show the location of fillings of this class.

Fig. 399.



Johnson lever clamp.

Cavities occurring upon the *lingual surface* of the *incisors* are generally confined to the laterals, and are the result of developmental defects, as shown in the imperfect closure of the pit or fissure at the base of the cingulum. These cavities are usually small, and are readily filled with a narrow ribbon of non-cohesive foil and finished with cohesive; or the entire cavity may be filled with a narrow ribbon of cohesive foil. Such a filling is shown in Fig. 404.

Fig. 400.

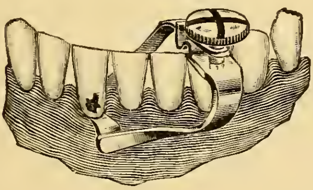


Fig. 401.

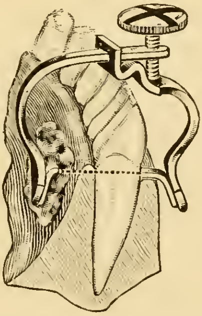


Fig. 402.

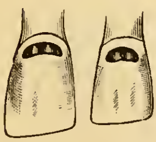


Fig. 403.

Fig. 404.

Caries rarely attacks the *morsal edge* of the *incisors* and *cuspids*, except as the result of imperfections in development, from mechanical abrasion, or from traumatic injuries which fracture the enamel. Consequently the operation of filling is usually confined to artificial cavities, made for the purpose of protecting the morsal edges against the loss of tooth-substance from mechanical or chemical abrasion, or for lengthening the teeth when it is desired to "open the bite."

Cavities prepared for this purpose must have strong retentive form, as fillings of this class are constantly subjected to great stress. Many operators are in the habit of inserting a couple of "Mack" screws in the artificially formed cavity, one near each extremity, as shown in Fig. 405. These add very greatly to the retentive strength of the cavity and make it very difficult to dislodge such a filling.

Care must be exercised in setting the screws not to encroach upon the pulp.

FIG. 405.

FIG. 406.

Cohesive gold only should be used for building up these fillings. It may be either foil or crystal gold, as suits the fancy or the ability of the operator to manipulate one form of gold better than another. In making the choice he should always select that form of gold with which he is confident the best filling can be made. In starting the filling it is advisable to begin at one extremity of the cavity by anchoring the gold in the undercut or retaining-pits, then repeat the process in the other extremity, and afterwards connect them together by a narrow ribbon laid upon the bottom of the cavity and folded back and forth, each fold being thoroughly condensed upon the preceding one, care being taken to accurately fill the undercut before the building process is begun.

Fillings in these locations must be thoroughly condensed with the mallet in order that they may obtain the greatest hardness possible to pure gold, as they are subjected to severe wear, which might result in abraded edges and flaking of the layers of gold. Fig. 406 shows the completed operation.

Platinum-gold in narrow ribbons of No. 20 or No. 30 is preferred by some operators for all of that part of the filling which extends beyond the walls of the retaining cavity. The Bonwill electric mallet or the engine mallet are invaluable for packing the gold in these cases.

Cavities occurring in the fissures and sulci of the *morsal surface* of the *bicuspids* and *molars* are the most accessible, and from their location offer the least difficulty to the introduction of gold fillings. Such cavities, if prepared with perpendicular or slightly undercut walls, need no other retentive shaping to insure firm anchorage of the filling. These cavities can be most rapidly and substantially filled with non-cohesive foil; in fact, this is one of the most favorable locations for the use of non-cohesive foil. The gold can be introduced in the form of narrow ribbons, small cylinders, or small spindle-shaped pellets.

In introducing ribbons, one end should be grasped with the foil-pliers and carried to the bottom of the cavity, *at that point which is farthest from the operator*,—this is a safe rule to follow in starting all classes of fillings,—and secured in place by a point held in the left hand, while with the pliers the ribbon is folded upon itself and carried again to the bottom of the cavity, and the fold packed firmly against its walls with a wedge-shaped or a foot-shaped plugger, but permitting the outer end of the ribbon to project a little beyond the walls of the cavity. A second ribbon is now introduced in the same manner and packed against the wall nearest the operator. A third ribbon is introduced in the same manner and packed against the two opposite uncovered walls, and the operation completed by driving ribbons of cohesive foil into the filling, and finishing with heavy foil. Or, cylin-

FIG. 407.

ders may be introduced instead of ribbons, placing them on end in the cavity and packing them against the walls, finishing in the centre with a hard-rolled pellet, and then thoroughly condensing the projecting ends of the cylinders. Or the spindle-shaped pellets may be used, the tip of one end of which should be annealed by passing it in the flame of the spirit-lamp, and the annealed ends allowed to project slightly beyond the walls of the cavity. These are packed against the walls of the cavity after the same manner as cylinders, the centre finally receiving a pellet of cohesive gold. The ends of the pellets which project beyond the walls of the cavity are then condensed, and the surface finished with mats of cohesive foil, which welds without flaw to the surface formed by the annealed ends of the pellets. By this method the danger of the surface of the filling scaling off is obviated. Scaling off of the surface of the filling often occurs when the union of the cohesive gold with the balance of the filling is only mechanical. All fillings upon the morsal surfaces of the teeth should be made as hard as possible by thorough but judicious malleting. Fig. 407 shows the finished fillings.

In cavities of larger size and depth, requiring the cutting away of the *triangular ridge*, and in those involving more considerable portions of the morsal surface of the *molars*, but in which the walls are perpendicular and strong (Figs. 408 and 409), cylinders will be found to offer the most rapid and efficient means of introducing the filling. These should be packed

FIG. 408.

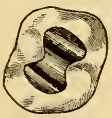


FIG. 409.

solidly against the walls in all directions, and the central portion filled by inserting cylinders, one after another, as long as space can be made for one with heavy wedge-shaped pluggers. The protruding ends should next be thoroughly condensed, and the surfaces finished in the manner described above.

In broad, shallow cavities, or those of uneven depth, cohesive foil is better adapted for the purpose than the non-cohesive. Such cavities need to be shaped with undercuts at opposite points, or retaining-pits or grooves at the bottom of the cavity, and so placed as to offer the greatest resistance to mechanical dislodgement.

In the introduction of cohesive foil, the retaining-pits or grooves are filled first, and the subsequent layers of gold welded to them and to each other. Cavities of uneven depth may be filled in the deepest portion with pellets of non-cohesive foil which have been rendered semi-cohesive at one end by annealing in the spirit-lamp, and the balance with ribbons, pellets, or mats of cohesive foil. In all deep cavities—those which approach very near to the pulp—this organ should be protected from thermal shock by the interposition of a layer of oxyphosphate cement or other suitable non-conducting medium.

Cavities in the *buccal surfaces* of the *bicuspids* and *molars* are a little more inaccessible to operation than those of the class just described, and as a majority of these cavities are at the cervical border, difficulty is often experienced in adjusting the rubber dam so as to expose the cervical margin of the cavity. The exclusion of moisture renders them but little more difficult to fill than those upon the morsal surfaces, except when located in the third molar, or when the patient's mouth is small, or the lips and cheeks are non-elastic.

In deciding which form of gold shall be used in each individual case, the size and the depth of the cavity must be taken into consideration. Deep cavities are best filled with non-cohesive foil made into ribbons, cylinders, or pellets, and the surface finished with cohesive foil. Shallow cavities are always more easily filled with cohesive foil or crystal gold than with the non-cohesive. Watts's crystal gold is most admirable for filling such cavities, as it requires but slight retentive shaping to obtain firm anchorage, and it does not possess the same tendency to "ball" or curl up at the edges and rock in the cavity as does cohesive foil.

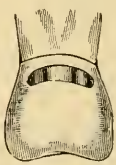
Especial attention should be given to the cervical margin in all those cavities which approach the gum line or extend beneath it. Non-cohesive foil will be more likely to insure a perfect sealing of the cavity at this point than cohesive foil by reason of its more ready adaptability. It is therefore advisable to place a thick mat or a large pellet of non-cohesive foil at the cervical margin, and make the balance of the filling with cohesive gold. Fig. 410 represents the finished filling.

Cavities located upon the *lingual* surfaces of the *bicuspids* and *molars* are quite rare except in the lingual fissures of the superior molars. Occa-

FIG. 410.

Filling in buccal surface of a bicuspid.

FIG. 411.



sionally, however, they are found in teeth of defective development, and at the cervix and upon the roots of the teeth as a result of gingival recession. Cavities of this class occurring in the inferior bicuspids and molars offer considerable difficulty to the introduction of gold fillings, and for this reason plastics are more often used in these locations than any other filling-material. When they occur in the superior molars, gold can be more readily introduced, though by reason of the limited accessibility of the cavity it becomes necessary to use hand-pressure for the greater part, if not the whole, of the operation. The same method of filling as described for cavities upon the buccal surfaces should be pursued in filling the accessible cavities of this class.

II. Simple Approximal Cavities.—This class of cavities are those which are found upon the approximal surfaces of all the teeth, but which do not involve any other surface, and are bounded by a continuous and unbroken wall.

Cavities of this class occurring upon the *approximal surfaces* of the *incisors* and *cuspids* generally require preliminary treatment by temporary separation, either by tape and wedges, or the more rapid method with the Perry or other screw separator. If the cavity is small and well within the labio- and linguo-mesial or distal angles, the case presents no difficulties other than those growing out of its degree of inaccessibility. Such cavities may be two-thirds filled with non-cohesive foil, cut in narrow ribbons, and the balance with cohesive foil. Curved pluggers are necessary in filling these cavities, on account of the proximity of the adjoining teeth.

In cavities which involve a considerable portion of the approximal surface, retention is secured at the cervical border by a groove at the base of the cavity, combined with a retaining-pit at the extremities, and by a shallow undercut at the morsal border. Grooving the labial or lingual walls for the purpose of retention is to be deprecated, as it tends to weaken them, and increases the liability to fracture and dislodgement of the filling.

The dentist who possesses the spirit of the true artist will at all times endeavor to conceal the gold as much as possible when he is called upon to place it in the anterior teeth. Consequently he will, whenever possible, conserve the labial wall of these teeth. The filling should be started in one of the retaining-pits at the extremity of the groove made at the cervical border, then the pit in the opposite extremity should be filled, and both united by attaching a ribbon of gold from one to the other, and malleting it into the retaining groove. This gives a firm foundation upon which to build the filling and secures thorough adaptation of the gold to the cervical wall. The balance of the filling is then completed after the manner already described in filling simple cavities. Cohesive gold, either foil or crystal gold, is best adapted for fillings of this character. Fig. 412 shows the completed filling.

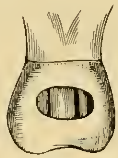
Fig. 412.

Simple approximal cavities in the *mesial* or *distal surfaces* of the *bicuspids* and *molars* offer considerably more difficulty in filling than similar cavities in the anterior teeth, by reason of their less accessible position. Temporary separation is always necessary in those cases presenting a normal approximation of the teeth. When the cavities are large it often becomes necessary, in order to gain a clear view of all parts of the cavity, to convert a simple into a compound one; or this procedure may be necessary on account of the extension of the disease in directions which undermine the enamel, making it too frail to bear the stress of mastication.

Simple cavities in these locations may be filled after the manner described for filling similar cavities in the anterior teeth, with the exception that by reason of their greater degree of inaccessibility hand-pressure becomes necessary in packing the gold for the greater part of the operation. Non-cohesive foil can be used to advantage in this class of fillings if used in narrow ribbons, or loosely rolled cylinders or pellets, and the surface finished with cohesive foil. Some operators prefer cohesive gold throughout the operation. In such case the filling is started in small undercuts or pits made at the cervical border. The mallet is sometimes

Fig. 413.

Fig. 414.



used for condensing the surface, but it is less applicable to the distal surfaces than to the mesial. Figs. 413 and 414 represent medium-sized fillings in the approximal surfaces of bicuspids and molars.

III. Compound Cavities.—Compound cavities are those which involve two or more surfaces of the tooth, and, by reason of this, present the greatest difficulties in the operation of filling.

Cavities which involve the *mesio-labial* and *disto-labial surfaces* of the *incisors* and *cuspids* are the least difficult of the series to fill, from the fact that an unobstructed view can be obtained of every part of the cavity by direct light and unaided vision. Each portion of the cavity should be so shaped as to give it an independent retentive form. Cohesive foil is best for filling this class of cavities, as the welding property is valuable in binding the fillings together, giving to them a proper contour and a more highly finished surface. Foil cut in ribbons and *freshly annealed* or crystal gold should always be used in this class of cavities. In starting these fillings the general rule of *beginning all fillings at the point farthest from the operator* holds good. When the approximal cavity is about two thirds full the filling in the labial cavity should be started and connected with the approximal filling, and the whole then treated as one filling; in this way both fillings are bound solidly together, and dislodgement is impossible except by fracturing the tooth.

As these fillings (Fig. 415) are constantly exposed to view, the greatest pains should be taken to give them an artistic form and finish by restoring the natural contour of the tooth, avoiding peculiar marginal lines, and so finishing the surface of the gold as to make it as little conspicuous as possible.

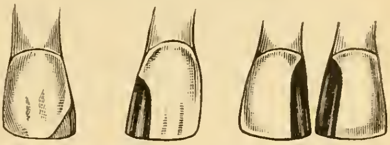
Mesio-lingual and *disto-lingual* cavities in the *incisors* and *cuspids* may be filled (Fig. 416) in precisely the same manner as those cavities last described, care being taken that the retentive form of each cavity is such as to secure independent anchorage, and the gold so prepared that its welding property will be at its maximum degree.

Cavities involving the *mesio-morsal* and *disto-morsal* surface of the *incisors* and *cuspids* are among the most difficult fillings to make substantial

Fig. 415.

Fig. 416.

Fig. 417.



by reason of their form and exposed position to stress and leverage (Fig. 417). The greatest care must therefore be exercised in securing firm anchorage, and if this cannot be done within the formed cavity, it should be extended in some direction which will secure this without unnecessarily weakening the tooth.

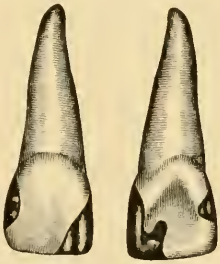
Figs. 418, 419, and 420 represent such methods of extension for anchorage. In teeth having a broad morsal edge, additional anchorage may be secured by slightly grooving the labial and lingual walls at this point.

Cohesive gold is best adapted to the requirements of such a filling, and used in such form as to preclude the possibility of the gold clogging under

Fig. 418.

Fig. 419.

Fig. 420.



(From *Dental Cosmos.*)

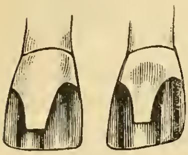
the instrument, as air-spaces resulting from imperfect consolidation of the foil are an element of weakness in the filling.

The filling should be started at the cervical border and built up from this point, keeping the surface of the gold as nearly flat as possible, and restoring the contour as the filling progresses, care being taken to secure perfect adaptation of the gold to the labial and lingual enamel margins. An electric or engine mallet greatly facilitates the rapidity of the operation, and insures more perfect consolidation of the gold than can be obtained by hand-pressure or the hand-mallet without the expenditure of an infinite amount of time and labor. To guard against bruising or flaking of the morsal edge of the filling, thorough condensation of the gold must be secured. Heavy foil, No. 20 or No. 30, if each piece is thoroughly welded to the surface of the filling before another is added, will make the hardest surface obtainable with gold.

Cavities which involve *both approximal surfaces* and the *morsal edge* of the *incisors* and *cuspids—mesio-disto-morsal* cavities—present the greatest difficulties from the mechanical stand-point in the whole range of operations for restoring lost portions of tooth-structure with gold, but when the operation is finished it becomes, by reason of its form, one of the most secure fillings that it is possible to make.

The filling may be started at the cervical border in the pits and grooves made for the purpose in either of the approximal cavities, preferably in that one which is farthest from the operator. Cohesive gold only is admissible in this class of fillings. The filling should be built up from the cervical border as squarely as possible until the morsal edge is reached. The same method is then employed in the approximal cavity nearest to the operator, and when the morsal edge is reached the fillings are united by carrying the gold across the morsal edge, and finally finished at the approximo-morsal angle nearest to the operator. Fig. 421 represents the completed filling. If the approximal fillings have been securely anchored, the force applied upon their morsal extremities will have no tendency to dislodge them during the process of building the morsal edge, but if this preliminary step has not been properly taken, dislodgement is more than likely to occur before the operation is completed.

Fig. 421.



Cavities involving the *mesial* and *morsal surfaces—mesio-morsal*—of the *bicuspids* and *molars* offer no difficulties which are not readily overcome. The only preliminary necessary for the preparation and filling of the cavity is the obtaining of such an amount of space by some of the methods of temporary separation as will enable the operator to gain a clear view of the cavity in all of its parts, and permit of the original form of the tooth being restored by the insertion of a contour filling, as illustrated in Fig. 422.

Fig. 422.

Failures in this class of fillings are prone to occur at the cervical border from secondary caries, and this is often due either to imperfect preparation of this portion of the cavity, to bruising of the enamel margin while condensing the gold against it, or to imperfect adaptation of the gold to the cervical wall. The greatest care should therefore be exercised in the preparation of the cavity and the introduction of the gold.

The cervical margin may be protected against bruising and perfect adaptation of the gold to the tooth secured by introducing a non-cohesive soft-rolled cylinder and condensing it against the cervical border. Many operators are in the habit of filling the cervical third of the cavity with non-cohesive cylinders and the balance with cohesive foil. Others prefer to fill the entire cavity with cohesive foil, using crystal gold at the cervical border to form the foundation of the filling, as on account of its great softness it is easily placed and can be readily adapted to the walls of the cavity.

A safe rule in all contour work is to extend the gold a little beyond the desired line of contour, in order that there may be opportunity for final shaping and polishing without destroying the artistic contour of the finished filling. Thorough condensation of the gold is an important factor in the stability of this class of fillings. Flow of gold fillings under stress is much less, as shown by Dr. Black, in fillings that had been thoroughly condensed and hardened by malleting than in those which had not been malleted. These fillings are subject to great stress, and therefore need to be thoroughly anchored in the morsal surface. Fig. 423 shows a method of anchorage obtained by extending some portion of the morsal cavity or by its natural form.

Figs. 424 and 425 represent the method of "*extension for prevention*" suggested by Dr. Black for filling bicuspids and molars. This method so

Fig. 423.

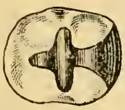


Fig. 424.

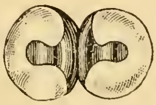


Fig. 425.

exposes the margins of the fillings that they can be kept clean with the tooth-brush, and it effectually secures them against a recurrence of caries with ordinary care of the mouth, provided the operation has been properly performed.

Cavities situated upon the *distal* and *morsal surfaces* of the *bicuspids* and *molars* unite to form *disto-morsal* cavities.

These are no different from the class just described except in their location, which adds very much to the difficulties in filling. All fillings of this class have to be made by the aid of reflected light, while the progress of the operation is viewed from the reflected image in the mirror.

When the cavities are located in the posterior part of the mouth, as, for instance, in the second molars the difficulties of obtaining unobstructed light and vision are considerably enhanced.

The operation of filling may be greatly simplified by the adjustment of a suitable matrix, thus converting a complicated operation into a simple one.

If the cavity has been given a proper retentive form, grooves and retaining-pits will not be needed, and the filling may be started with non-cohesive cylinders, mats, or pellets, thoroughly condensed against the cervical border and the matrix, which must be firmly fixed in position. After the cervical third of the cavity has been filled with non-cohesive gold, the balance can be completed with cohesive gold in the manner described in the preceding class.

Cavities occurring upon the *morsal* and *buccal* surfaces unite to form *morso-buccal* cavities. This class of compound cavities is usually confined to the *lower molars* and the *upper third molars*. They can usually be given a good retentive shape without forming grooves or retaining-pits. In the deep cavities non-cohesive gold can be used for the base of the filling and then finished with cohesive foil or crystal gold. In the shallower cavities it is best to use cohesive gold throughout. These fillings (Fig. 426) are subjected to great stress and wear ; they should therefore, be made as solid and hard as possible, that they may not be dislodged or battered by the occlusion of the opposing tooth.

Fig. 426.

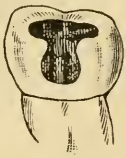
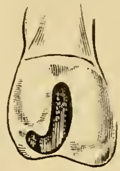


Fig. 427.



Cavities involving the *morsal* and *lingual surfaces* are usually confined to the *first* and *second superior molars.*

From the fact that these cavities are generally shallow, they should be filled throughout with cohesive gold. Their position makes them fairly easy of access. The morsal cavity is usually the deepest, and may be quite large, while the lingual cavity is narrow and shallow. In this case the morsal cavity being the largest should be filled first, the smaller cavity and the channel uniting them being filled by carrying ribbons of foil, which are first attached to the main filling, over into the channel and to the cervical extremity of the lingual cavity (Fig. 427).

Cavities situated upon the *mesial*, *distal*, and *morsal surfaces* of the bicuspids and molars, uniting to form *mesio-disto-morsal* cavities, are of not uncommon occurrence. These cavities might be filled by the methods described for filling the same class of cavities occurring in the incisors and cuspids. Such operations, however, may be greatly simplified when made in the bicuspids and molars by the adjustment of a matrix to the distal surface. The band-matrix is sometimes used, but this is not so satisfactory, as it obstructs the light and vision to a considerable extent. Non-cohesive gold can be used to good advantage in forming the base, while cohesive foil should be used for the bulk of the filling.

Fig. 428.

Fig. 429.

The filling should be started with a large, soft-rolled cylinder placed at the disto-cervical border and malleted into place. Others may be added until the entire floor of the cavity and mesio-cervical border are well covered, after which cohesive gold may be used to complete the filling (Fig. 428).

When the buccal and lingual walls are frail and likely to fracture under the stress of mastication, the cusps may be cut away and the whole morsal surface restored with gold. This operation decreases the liability to fracture and, if well done, restores the tooth to its original form and preserves it for many years of usefulness. (See Fig. 429.)

MATRICES.

In filling compound approximal cavities—disto-morsal—in bicuspids and molars with the various forms of crystal or sponge gold, the *matrix* will be found of great service, not only in simplifying the cavity but in securing a more perfect adaptation of the gold to the enamel margin, and by facilitating the operation. In fact, many operators utilize these instruments in filling all disto-morsal cavities in the posterior teeth, no matter what form of gold may be used. Their greatest value, however, lies in their use as just indicated, and in the introduction of plastic materials.

In the introduction of gold into disto-morsal cavities in the posterior part of the mouth, it is impossible to use a straight instrument for packing the gold; it therefore becomes necessary to curve or bend the shaft of the plugger near its point to suitable angles for reaching the various surfaces of the cavity; consequently the force or impact applied to the shaft of the instrument by the hand or the mallet is not directly expended upon the gold at the point of the plugger, but is more or less dissipated by the elasticity of the steel at the curve or angle, and by the tendency of each impact to drive the gold out of the cavity in a distal direction. By the adjustment of a suitable matrix a compound cavity is converted into a simple one, and the matrix used as a wall against which the gold may be packed. Objections have been raised to the use of these devices on account of the difficulty experienced in giving a proper contour to the approximal surfaces, and of securing perfect adaptation of the gold to the enamel margins which are contiguous to the matrix.

These objections are readily overcome by a proper preparation of the cavity margins, which leaves them strong and straight, the careful adjustment of the matrix, and the same degree of skill exercised in introducing and condensing the gold against the margins that would be used in other cavities.

Several forms of matrices have been invented, all of them possessing more or less valuable features.

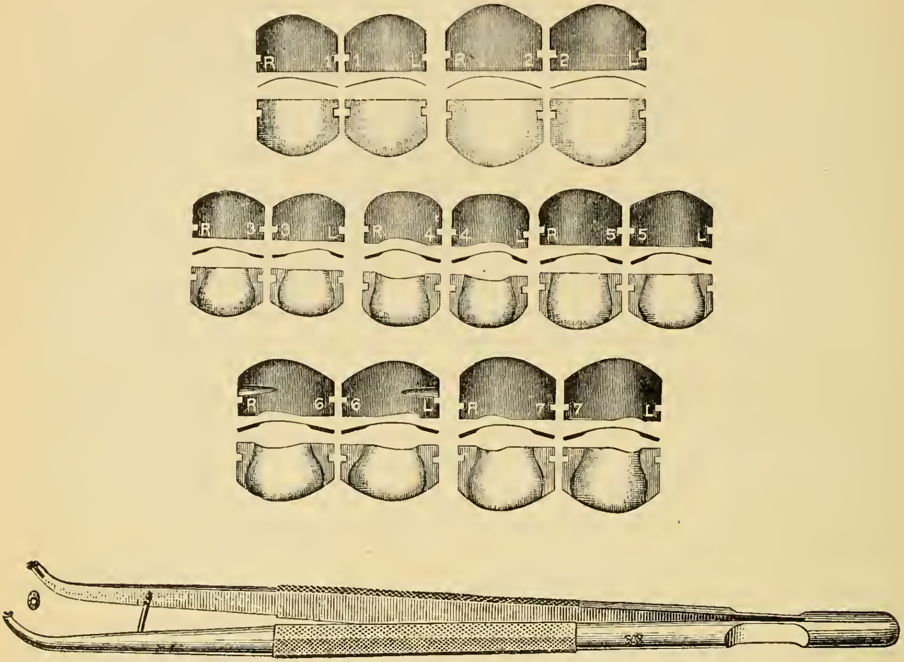
The Jack matrices, shown in Fig. 430, are so shaped as to provide for contouring, and are made in pairs, adapted for use upon the right and left sides of the mouth respectively. These are held in place against the tooth to be filled by wooden wedges driven between the matrix and the adjoining tooth, the wedges being first dipped in sandarach varnish to keep them from slipping; or it may be held in position by some quick-setting oxyphosphate cement. The matrix is applied by an especially designed forceps, which grasps them firmly, permitting easy adjustment and withdrawal.

When the rubber dam is used, this should be first adjusted, and the matrix applied afterwards.

The matrix, to fulfil the object of its placement, must be immovably fixed against the tooth to be filled. Motion of the matrix results in imperfect adaptation of the filling to the walls and margins by reason of the difficulty in packing the gold against a shifting body.

To overcome this difficulty, *loop* and *band matrices* were devised of various forms and sizes to accord with the differences in the size of the

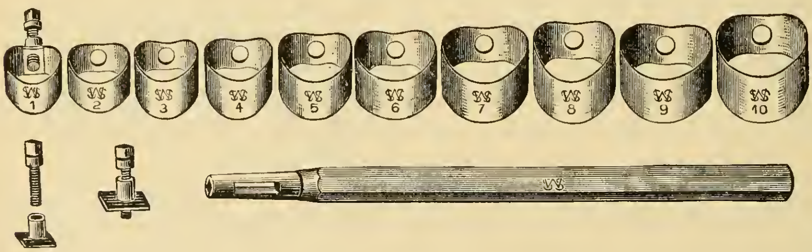
Fig. 430.



Jack matrices and forceps.

teeth. The Brophy and the Guilford patterns are the best of their kind, and are easy to adjust,—these are shown in Figs. 431 and 432. The only difficulty experienced in the use of loop or band matrices is to obtain a close adjustment at the cervix of the tooth, by reason of the smaller size

Fig. 431.

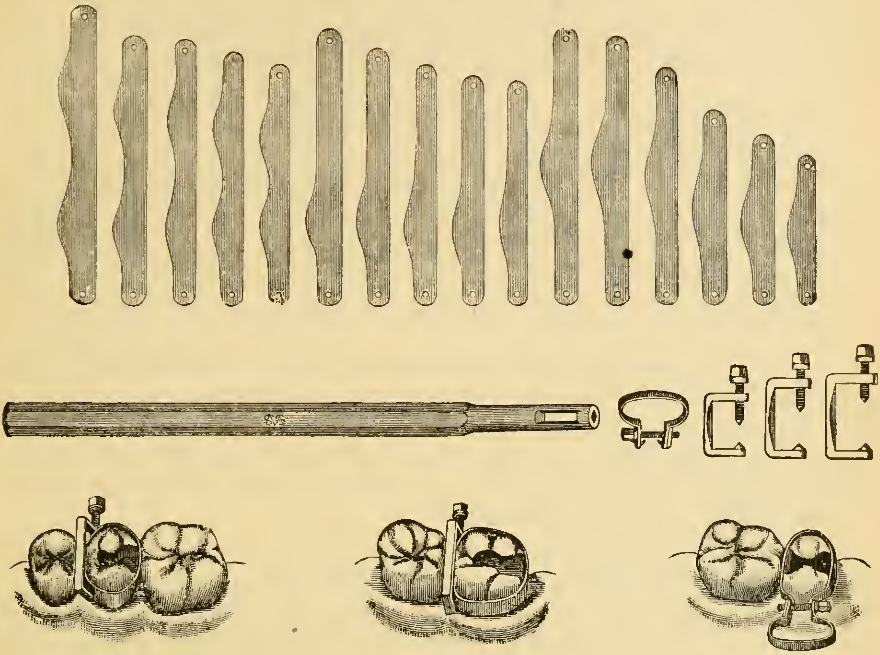


Brophy band matrices.

of the tooth at this location as compared with the morsal surface of the crown. This difficulty may be overcome by driving a wooden wedge between the band and the adjoining tooth at the cervix, as previously described.

The Woodward matrix (Fig. 433) is also an ingenious device, and in some features superior to the others just described. It has the great ad-

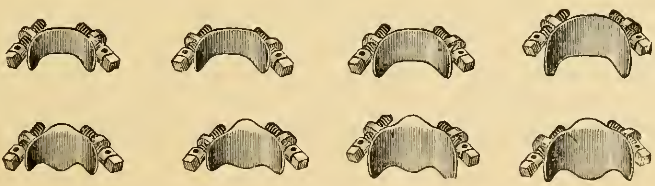
Fig. 432.



Guilford matrices, and manner of adjustment.

vantage of being readily adapted to the cervix of the tooth, and is maintained in position by means of two set screws, which rest against the tooth opposite the approximal cavity to be filled and act as separators.

Fig. 433.



Woodward double-screw matrices.

As the teeth move under the pressure of the screws, it becomes necessary to occasionally tighten them. The space thus gained is of great value during the process of finishing the filling.

TIN-FOIL.

Chemically pure tin is furnished to the dentist in three forms,—foil, fibrous mats, and rolled strips. *Foil* is the form most generally used. This is beaten after the same manner as gold, and is furnished to the profession usually in two weights, No. 3 and No. 4, the figures representing the weight of the foil in grains. No. 3 foil is the weight in most general use.

The *fibrous mats* or "*fibrous tin*" is made from fine shavings of tin loosely pressed into mats. This form of tin has a tendency to crumble, and is therefore not so readily introduced into the cavity as foil, neither has it any advantages which are not possessed in an equal or higher degree by the foil.

Rolled strips of tin are about the weight of No. 20 gold-foil, and are used in the same manner as ribbons of non-cohesive foil.

Tin is one of the oldest filling-materials, and until the introduction of amalgam was the only substance at the disposal of the dentist for filling that class of teeth which were not considered worthy of the precious metal, or which for pecuniary reasons the patient could not afford to have filled with gold.

It is much more ductile and easier of introduction than gold. It can be more readily adapted to frail cavity walls, and when properly introduced makes a perfectly moisture-tight plug. It does not readily oxidize, and but for its *objectionable color* and *softness* would be the very best material for filling frail teeth. Tin-foil when first made is cohesive to a certain degree, but this property is soon lost on being exposed to the atmosphere, and cannot be restored by annealing.

The *therapeutic action of tin* upon tooth-structure is decidedly antiseptic when oxidation takes place. For this reason it cannot be too highly recommended for lining the cervical wall in approximal gold fillings, and as a filling-material in those cases in which there is a persistent recurrence of caries, associated with a thick, ropy, tenacious saliva, which in all probability is due to the presence of gelatin-forming micro-organisms within the mouth.

Tin does not conduct thermal changes so readily as gold, and consequently causes much less irritation to sensitive dentin. This fact led many of the older operators to line the bottom of all hypersensitive cavities, and those in which the pulp was nearly exposed, with a layer of tin-foil.

Its most important use is for filling the temporary teeth and first permanent molars of children. The ease and rapidity with which it may be inserted and condensed, as well as its preservative qualities upon tooth-structure, make it the best material for this purpose that the dentist has at his command.

TIN AND GOLD.

Tin is also employed in combination with gold-foil. The metals are combined in various proportions; some operators enclose a sheet of No. 4 tin between two sheets of No. 4 gold-foil, and then either twist it into a rope or cut it into ribbons; others fold a sheet of No. 3 tin in a sheet of No. 4 gold-foil, and then twist it into ropes of various sizes or cut it into ribbons of varying widths to suit the case in hand. The ropes may also be cut into pellets or the ribbons rolled into cylinders.

This mixture of the metals works with about the same degree of softness as tin alone, and can be as readily adapted to the walls of the cavity.

Non-cohesive gold-foil is generally used in combination with tin, but some operators use cohesive foil, and then cover the surface of the filling with gold, claiming by this combination they are able to weld the gold to the tin and gold base.

Fillings which are made of tin and gold combined have a yellowish-gray appearance when first finished, but they soon become more or less discolored upon the surface by oxidation.

After a time some chemical change, which at present is not understood, takes place in the mass, rendering it exceedingly hard and giving it the appearance of an amalgam. It does not, however, stain the tooth-structure, as might be expected, and seems to exert a very decided preventive effect upon caries. Such fillings will resist the attrition of mastication as well as gold, but they have the disadvantage of being unsightly in color, and should not therefore be placed in any conspicuous part of the mouth.

Fillings made of this combination of metals do not conduct thermal changes so readily as gold alone, and consequently are better adapted to sensitive teeth. Such fillings are in every way superior to amalgam, and find their greatest field of usefulness in the bicuspids and molars during the periods of childhood and adolescence, and in persons subject to persistent caries.

It can be introduced as rapidly as tin alone, makes a very durable filling, and possesses a conserving action upon tooth-structure not possessed by gold alone or by amalgam.

Methods of introducing Tin and Tin and Gold.—The methods of introducing fillings composed of *tin* and *tin and gold*, are the same as those used in introducing non-cohesive gold-foil. Some operators prefer to use cylinders and wedge-pointed pluggers and hand-pressure; others use pellets and foot-shaped pluggers with the hand or mechanical mallet, finishing the filling by driving a hard-rolled pellet into the central portion of the plug, and then thoroughly condensing the surface towards the enamel margins with broad-faced pluggers and afterwards thoroughly burnishing.

Fillings made from tin or tin and gold combined should be finished with the same degree of care and thoroughness as is expended upon those made from gold. The labor, however, is much less, as the material is not so resistant as gold.

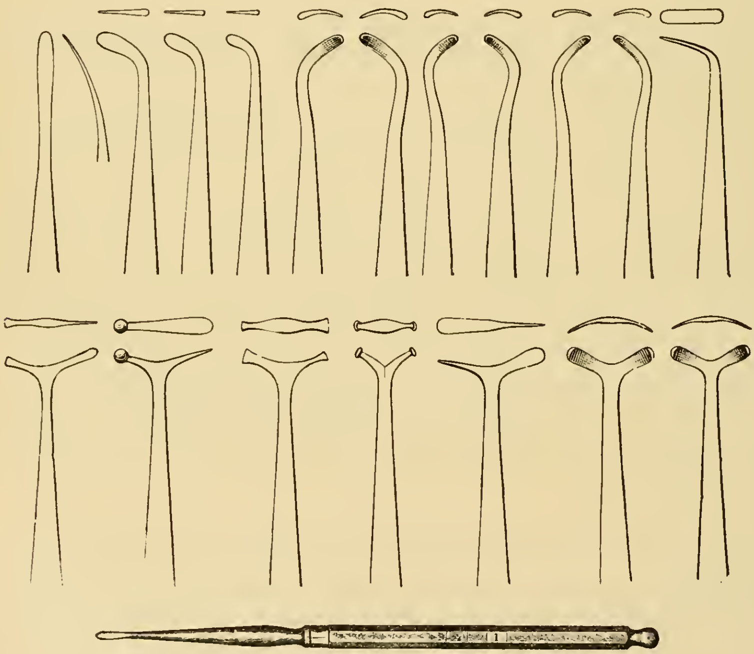
Finishing Fillings.—The beauty and the utility of gold fillings are greatly enhanced by perfect finishing. Fillings which have been well and carefully introduced sometimes fail for the reason that the margins have not been entirely freed from overhanging portions of gold, or the gold has not been cut down and finished flush with the enamel margins and highly polished. These imperfections are most often found at the cervical border of approximal fillings, particularly in the bicuspids and molars, where there is a tendency to bifurcation of the root, and the cavity extends beneath the gum, making a clear view of the cervical border very difficult to obtain.

Fillings which present rough surfaces or imperfectly finished margins invite recurrence of caries, by reason of the fact that these imperfections give lodgement to alimentary *débris*, where if it remains undisturbed it is soon attacked by the zymogenic bacteria, lactic acid is formed, and sooner or later secondary caries is established. The importance, therefore, of perfectly finishing all fillings cannot be over-estimated if the best results are to be obtained.

In order to secure a surface in a gold filling that will receive a fine finish thorough condensation is of the greatest importance. Fillings which are imperfectly condensed cannot be made to take a smooth and highly polished surface, while after a little time the surfaces exposed to wear will become rough and pitted.

In order to insure a good surface that will finish smoothly, many operators are in the habit of using heavy foils for the last few layers of the filling. After the surface has been thoroughly condensed the burnisher should be vigorously applied, especially to the margins, in order to obtain perfect contact of the gold at these lines and to secure a compact and hard surface. Hand-burnishers (Fig. 434) or those revolved by the dental engine may be used for this purpose. The latter are made of various shapes, some having smooth surfaces, others corrugated surfaces, as shown in Fig. 435.

Fig. 434.

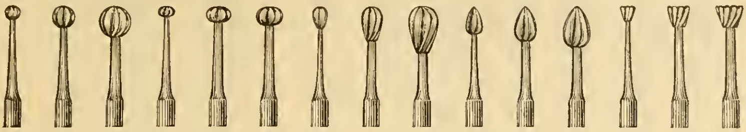


Hand-burnishers.

In all fillings the cavity should be filled a trifle fuller than the margins of the surface in which they are located, that there may be opportunity for a proper shaping of the surface of the filling to harmonize with the normal lines of contour.

This shaping or dressing of *simple cavities in the morsal surface* of the bicuspids and molars may be accomplished by finishing-burs, such as are

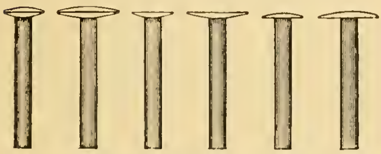
Fig. 435.



Engine-burnishers.

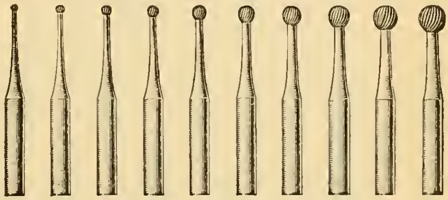
shown in Figs. 436 and 437. The "cut" of these burs is much finer than that of cavity burs, and gives the surface of the filling a finish similar to that given to a flat surface with a fine file. The gold should be cut away

Fig. 436.



Disk burnishers.

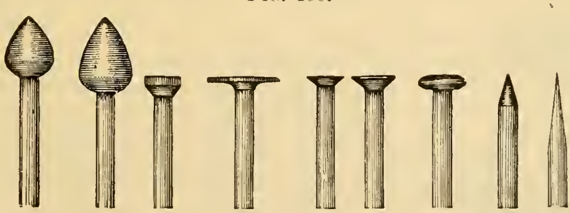
Fig. 437.



Plug-finishing burs.

until the margins of the cavity have been reached and all overlapping portions have been removed. The occlusion of the teeth should next be noted, and the surface of the filling made to conform to the occluding points or eminences of the morsal surface of the opposing teeth. As soon as a natural occlusion is obtained the surface of the filling should be polished, using fine powdered pumice and water, with a suitable wood point, as shown in Fig. 438, mounted in an engine porte-carrier. If the operator desires to give a burnished surface to the filling, this may be accomplished with a suitable engine-burnisher, lubricated with a solution of fine toilet soap in water.

Fig. 438.

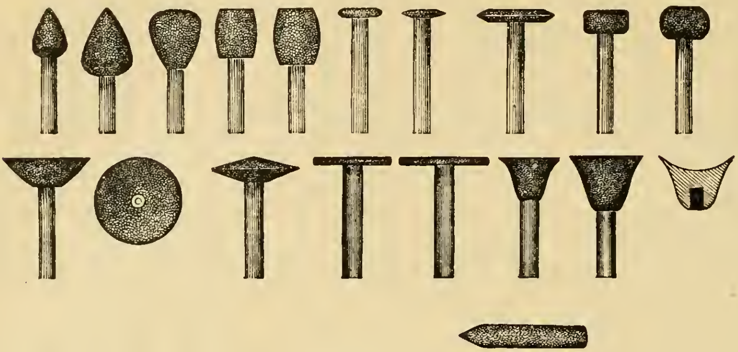


Wood polishing-points.

Large fillings in the morsal surfaces may be cut down with suitable corundum points or wheels. These instruments cut much more rapidly than the finishing-burs, and if kept wet with a stream of water from the syringe cause but little heating of the tooth. Fig. 439 shows a few of the various forms of these points and wheels. The best cutting and also the most durable corundum points and wheels are those made of fine corundum and vulcanized rubber.

In the use of corundum points for dressing down the surfaces of fillings there is danger, from the rapidity with which they cut, of grinding the

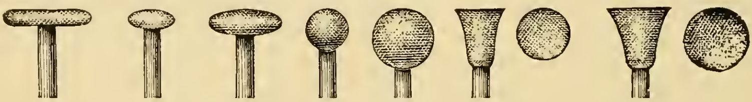
Fig. 439.



Corundum points and wheels.

edges of the cavity and thus producing a thin and weakened margin. A final finish may be given to the surface of the filling by smoothing with

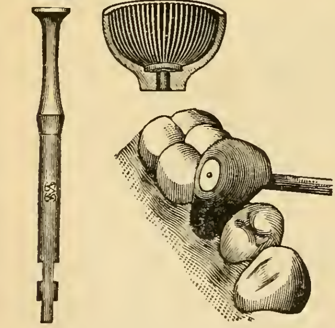
Fig. 440.



Arkansas, Hindostan, and Scotch stones.

Arkansas or Hindostan stones of similar shapes (Fig. 440) and polishing with pumice or the burnisher.

Fig. 441.



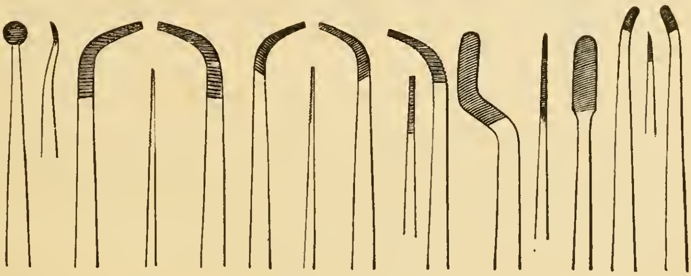
Soft rubber polishing-cups, corrugated inside.

Labial and *buccal surface* fillings are most readily finished with the corundum points, followed by the Arkansas stones and wood points carrying moistened pumice. The beauty of fillings lies in their perfect margins and natural contour. Any overlapping of the gold gives the appearance of a ragged edge, while any degree of deviation from the normal convexity of the surface detracts from their beauty of outline. The final polishing may be done with felt or leather polishing-wheels or soft rubber polishing-cups. The latter are especially valuable in finishing bucco-cervical fillings in bicuspids and labio-cervical fillings in the six anterior teeth.

They are shown in Fig. 441. If a dead or satin finish is desired,—and this is best for the anterior portion of the mouth, because it is less conspicuous, —pumice moistened with water or glycerol will be found most satisfactory for this purpose, but if a brilliant finish is required, the pumice should be followed with precipitated chalk, oxide of tin, or rouge.

Fillings which are located upon the *approximal surfaces* of the teeth are much more difficult to finish than those in any other portion, and consequently require a higher order of skill, while for obvious reasons there is no class of fillings which demand greater care in their finishing, or which repay the operator a higher reward for faithful service rendered.

FIG. 442.



Plug-trimmers and plug-finishing files.

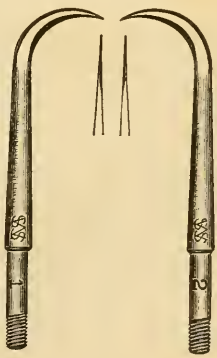
As a consequence of the difficulties encountered in finishing this class of fillings a great variety of instruments have been devised to overcome them. The oldest of these are the thin flat files cut only upon one side

FIG. 443.

Approximal trimmer.

and both edges. Some of them are made with a spring temper, straight and curved; others are tempered soft, and may be given any desired curve to suit the exigencies of the case in hand. These are shown in Fig. 442 and are most useful in the anterior part of the mouth.

FIG. 444.



Sickle-shaped trimmers.

For trimming the cervical margins of the filling, the approximal trimmer shown in Fig. 443 is one of the most useful instruments devised for this purpose. This is file-cut upon one or both faces, and should generally be used with a drawing motion, the blades of the file being set with that object in view.

The sickle-shaped knife trimmers of Dr. Gordon White, shown in Fig. 444 are also admirable instruments for trimming the cervical margins of fillings.

On account of the difficulties experienced in getting a clear view of the field of operation, it becomes necessary to examine the cervical margin by passing a fine probe or explorer over this portion of the filling, or, better still, floss-silk may be made to pass back and forth, from the cervix to the morsal border of the filling, and if the probe does not catch or the floss-silk becomes frayed in the process, it may be presumed that the overlapping edges of the filling have all been removed. The final shaping of the filling may be accomplished by emery tape or sand-paper strips drawn back and forth over the surface of the filling. When the margins are all well defined, the finishing may be completed with finer emery, silex, or buckhorn tape. A variety of these strips should always be on hand, comprising all the grits from the coarsest to the finest. The final polishing may be done with the soft rubber cups or thin soft rubber wheels charged with fine pumice.

Approximal fillings in *bicuspids* and *molars*, because of the difficulties of access which are presented by their position, make them the most troublesome of all fillings to finish. It therefore is necessary that the greatest care be exercised in this process, and that the cervical border receive particular attention. Fillings which have been placed in those locations without the aid of a close-fitting matrix usually present a considerable overlapping of the gold at the cervical border. The success of the filling, other things being equal, will depend largely upon the perfection with which the cervical margin is trimmed and finished.

In those cases where a properly adjusted matrix has been used, the labor of trimming the margins and finishing the surface will be found to be greatly lessened.

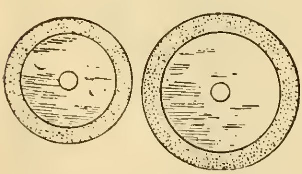
The pointed, right and left, curved files of Dr. Meriam, shown in Fig. 445, will greatly facilitate the work of removing the overlapping edges of

FIG. 445.

Dr. Meriam's right and left plug-finishing files.

gold at the cervical margin, and, supplemented with the trimmers just mentioned, will enable the operator to give the desired form to the surface of the filling. The final finishing can be accomplished with emery tape, sand-paper strips, etc., after the manner described above, or with emery cloth or sand-paper and cuttle-fish disks mounted upon suitable mandrels for use with the dental engine. These disks are made of various sizes, some of them having only a narrow rim of grit, the balance of the disk being plain (Fig. 446). The latter are valuable for polishing the cervical margin of contour approximal fillings, as it enables the operator to do this without cutting away the contour of the filling at the morsal border. Fig. 447 shows two of the popular forms of mandrels for carrying these disks.

FIG. 446.

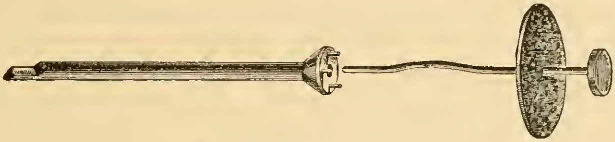


Thickened rim sand-paper disks.

Especial attention should also be given to the morsal surface of those approximal fillings which involve this surface of the tooth, that perfect occlusion may be secured. If the crushing stress of the jaws is expended upon such a filling, it is bound, sooner or later, to be dislodged, either

FIG. 447.

Screw-head disk mandrel.



The Morgan-Maxfield disk mandrel.

from the flow of the gold under stress, the disturbance of the anchorage, or from fracture of the walls of the cavity. Such surfaces should be so shaped that the filling will not be called upon to carry more of the load than the surrounding portions of the morsal surface of the crown or of the other teeth.

Fillings made of tin and tin and gold are finished in a similar manner.

REPAIRING DEFECTIVE GOLD FILLINGS.

Gold fillings which are defective from imperfect adaptation to an enamel margin, from recurrence of caries, or from fracture, are often susceptible to repair.

These cases many times present problems which are by no means easy to solve. In the consideration of the question, each case offers a peculiar condition which makes it necessary to treat it upon its individual needs. This consideration must take into account the nature of the defect, its location and accessibility, the condition of the remaining filling, and the material best suited for repairing the defective condition.

Defects which are the result of imperfect adaptation to an enamel margin are usually discovered during the finishing of the filling, and if the rubber dam has not been removed, the defect may be readily repaired with cohesive gold. Sometimes it may be necessary to cut away the filling at the defective point, forming a cavity in it of retentive shape. If the filling has been in contact with the saliva, the rubber dam must be adjusted, and the filling cleaned by bathing it with alcohol, ether, or chloroform, after which the defective point may be prepared as above, and filled with cohesive foil or crystal gold.

Defects resulting from recurrence of caries are most often found at the cervical border of approximal fillings. Thorough separation of the teeth is necessary to successfully repair such defects.

Defects of this character can often be repaired most efficiently by using non-cohesive foil cut in narrow ribbons, and packed into the cavity fold after fold, allowing the loops to project beyond the margins of the cavity, and when the cavity is full, thoroughly condensing the projecting loops and finishing the filling with emery strips, etc., in the usual manner.

If cohesive gold is used, a retentive shape must be given to the cavity, and a groove or pit provided for holding in place the first piece of gold.

The bicuspids and molars offer the most difficult cases to repair, by reason of their inaccessibility. Gold is the best material with which to make such repairs, provided the cavity can be made accessible; but sometimes it is not possible to accomplish this except by removing the entire filling, and this, when the filling is large and otherwise good, seems unfair to the patient, if there is a reasonable assurance of making a successful repair with one of the plastics. Gutta-percha is often successfully used in these places, but occasionally it will be found to undergo decomposition, and is therefore not as reliable as gold. The oxyphosphate cements are contraindicated on account of their tendency to dissolve and wash out after a brief period. Amalgam is more often used than any other plastic for this purpose, on account of the readiness with which it can be introduced into cavities that are entirely inaccessible to gold, and the greater assurance of making a good repair. It has the disadvantage, however, of becoming very black after a few weeks of contact with the gold, but this does not lessen its value as a tooth preserver. On account of the black discoloration which always follows this use of amalgam, it should not be used in the anterior teeth.

After the amalgam has become hard, it should be finished as carefully as possible, by removing all overlapping edges and polishing in the usual way.

Defects caused from fracture of portions of the cavity walls is a not infrequent accident, and one which may be successfully repaired, provided the filling has been firmly anchored in other portions of the cavity and the tooth is sufficiently strong to warrant the necessary retentive shaping of the cavity to receive the repair.

The *incisors* are prone to such accidents; the most common being the loss of the mesio-morsal or disto-morsal angle when large approximal fillings are situated well towards the morsal edge. Repairs of this kind are difficult to make, but they may be successfully accomplished by taking advantage of the favorable conditions that are presented. Each case must be carefully studied and treated according to the indications. No rule can be laid down for such cases. The operator must depend upon his knowledge of mechanics and his ingenuity to suggest a way to overcome the difficulties of each case as it is presented.

Anchorage may sometimes be secured by drilling a retaining-pit in the filling at one angle, and another in the sound dentin at a different angle, or shallow retaining grooves or channels may be cut in the labial and lingual walls of the cavity and re-enforced by a pit drilled into the filling. Crystal gold will be found most serviceable in this class of operations.

Accidents of this character sometimes occur in the *bicuspids* and the *molars*, most often in the *bicuspids*, especially when these teeth have been filled upon their mesial and distal surfaces, with the fillings uniting upon the morsal surface. The buccal or the lingual wall may be broken away by stress so applied between the cusps as to split off the weaker of these walls.

The prospect of successfully repairing these cases will depend upon the security of the anchorage of the approximal fillings, and the opportunity for obtaining good anchorage at the cervical border and laterally in the approximal fillings. When the buccal wall is lost it would be better practice, for cosmetic reasons, to amputate the balance of the crown and place an artificial crown upon the root.

If the lingual wall is lost, the objection to restoring it with gold is not so strong. Crystal gold gives the most satisfactory results in all cases of this character.

Occasionally amalgam can be used for restoring the lingual cusps of a second bicuspid, but the discoloration which eventually follows makes this substance objectionable.

Fractures of a similar character occurring in the molars are, as a rule, less difficult to repair, as they will usually admit of the proper retentive shaping without the same degree of danger to the pulp as accompanies the operation in the bicuspids. In those cases of fracture which extend beneath the gum, the difficulties are increased by the hemorrhage likely to attend the operation, and the difficulty experienced in retaining the rubber dam in a position beyond the fracture. Mack's screws can sometimes be set in such position as to offer strong anchorage and not encroach upon the pulp. Under such circumstances they become a valuable adjunct to the other means of anchorage. Cohesive gold only can be used for such repairs, and the form usually indicated is Watts's crystal gold.

CHAPTER XIX.

PLASTIC FILLING-MATERIALS.

Definition.—Amalgam (from the Greek αμα, together, and γαμέα, I marry), a combination of one or more metals with mercury.

Amalgam.—The use of amalgam as a filling-material was first suggested in 1826 by M. Traveau, of Paris, under the name of "Silver Paste," and it was first introduced in the United States about the year 1830 by two Frenchmen named Crawcour, under the high-sounding title of the "Royal Mineral Succedaneum." It was a purely metallic compound, composed of silver and copper,—"coin silver" (silver, nine parts; copper, one part),—which had been reduced to a coarse powder by filing and rendered plastic by the addition of mercury. The mixture consisted of fifty per cent. of mercury, forty-five per cent. of silver, and five per cent. of copper. Fillings made of this compound soon turned almost a jet-black color upon the surface, and stained the tooth to an almost equally dark or dark-green shade by the formation of various compounds of silver and copper with oxygen and sulphur, which penetrated the tubuli and even the pulp-canal, the effect of which, however, seemed to place the dental tissues in a position to more or less successfully withstand the action of the direct causes of caries, as was seemingly proved by specimens of teeth which had been filled with it for many years without further decay.

Some have thought this preservative action to be due to the formation of the sulphate of copper, which is an antiseptic of considerable value. In corroboration of this supposition the fact has been stated that when wood has been treated with solutions of sulphate of copper it is rendered much more enduring, as is known to civil engineers.

It has also often been noticed in opening old tombs in England that in the oak coffins which had been put together with copper nails the wood immediately surrounding the nails was in a state of perfect preservation, while the balance of the timber had literally crumbled to dust from decay. The inference is therefore drawn that inasmuch as the sulphate of copper preserves the wood that has been treated with it, tooth-structure will also be preserved if the tubuli are impregnated with this salt, as it destroys the bacteria already in the tubuli and renders the dental tissues an unfavorable soil for the growth of the lactic-acid-producing bacteria.

The merits and demerits of amalgam as a filling-material have furnished a "bone of contention" over which the profession has wrangled for years, and have been the cause of much heart-burning and bitterness. The strife and ill-feeling engendered between the contending parties ran so high at one time as to bring about a professional and almost a social ostracism of those who dared to advocate its use.

The opponents of amalgam looked upon this material as an agent which was destined to degrade the profession and set at naught the achievements which had been wrought with gold as a material for filling and saving teeth.

It was a fact, also, in the earlier years of the amalgam controversy, that a large majority of those who used this material were men not worthy of the name of dentist, men who had not the skill to make a creditable operation with gold; hence the contempt in which they were held by the better class of practitioners. This contempt was also heaped upon the material which had formed the basis of the controversy. A few, however, of the better class of practitioners, who had a scientific turn of mind, began an investigation into the merits and demerits of this material from the standpoint of science, and finally succeeded in clearing away much of error and misstatement upon both sides of the question.

As a result of this labor, the prejudice which was at that time so strong has of late years been gradually dying out, while to-day many of those who were among its bitterest enemies admit that under certain circumstances and pathologic conditions, amalgam has proved itself to be a very valuable adjunct to the *armamentarium* of the dentist for saving teeth.

Since the first introduction of amalgam as a filling-material many improvements have been made in its composition and in the methods of its manipulation.

To the *New Departure Triumvirate*, Flagg, Chase, and Palmer, belongs the credit of placing amalgam upon a scientific basis as a filling-material, although the earlier efforts of Townsend, Walker, and Arrington to perfect this material by eliminating the main objectionable feature of discoloration should not be forgotten.

Townsend, recognizing the one great demerit of the old form of amalgam, introduced in 1855, after a long series of experiments, an alloy composed of forty-four and one-half parts of pure silver and fifty-five and one-half parts of pure tin. The progress gained by this formula was, however, very doubtful, although there was a marked improvement in the tendency to discoloration. This feature was more than counterbalanced by its greater degree of shrinkage, which caused leakage and secondary decay.

The formula forty parts of silver and sixty parts of tin formed the basis of all the various alloys that were introduced to the profession from the time of Townsend until the New Departure Triumvirate gave to the profession the results of its researches into the nature and physical properties of amalgams and other plastic filling-materials. These studies resulted in a radical change in the composition of the alloys used in making amalgams. The amount of silver was increased and the tin decreased, the *basic formula* being sixty parts of silver to forty parts of tin.

The introduction of more scientific methods in the manufacture, preparation, and manipulation of amalgam and the other plastic filling-materials has greatly increased their usefulness as therapeutic agents, and made it possible for the poor, by a limited expenditure of money, to have their teeth cared for and saved for years of comfort and usefulness, while, upon the other hand, the more exact knowledge gained of the nature of their physical, chemical, and therapeutic properties has made it possible to apply them to particular pathologic conditions with a reasonable assurance that they will fulfil the requirements of the individual state or condition for which they were applied.

THE NATURE AND PROPERTIES OF AMALGAM.

One or more metals held in combination with mercury is termed an *amalgam.* Two or more metals combined by melting are termed an *alloy.* No combination of metals can be called an amalgam until they have been combined with mercury; hence the combinations of metals used for the purpose of making an amalgam should be termed dental *alloys*, and not *amalgams.* No mixture or combination of metals can be regarded as an amalgam unless it has mercury as one of its component parts, and that "in sufficient quantity to exert a combining influence over the other metals." (Flagg.)

Amalgams are classified according to the number of metals which they contain. Those containing two metals—as, for instance, copper and mercury—are termed *binary;* those containing two metals in combination with mercury are termed *ternary;* those containing three in combination with mercury are known as *quaternary amalgams.*

Mercury has the property of dissolving or melting certain other metals of a higher fusing character. "The combinations thus formed are in the case of solid amalgams definite compounds, but in which there is only a feeble chemical affinity between the constituents. Liquid amalgams are merely solutions of the various metals in mercury, and not, as a rule, definite chemical compounds." (Watts.)

Amalgams, however, may with correctness be classed as alloys. Matthiessen has suggested that "an alloy may be either (1) a solution of one metal in another, (2) a chemical combination, (3) a mechanical mixture, or (4) a solution or mixture of two or all of the foregoing."

Kirk is of the opinion that in combining mercury with dental alloys a *chemical combination* is formed. He says, "In all amalgams which possess the quality of setting or hardening from a plastic mass, we have to deal almost certainly with a chemical combination. The property of setting is in itself an evidence of chemical combination, and the formation of many amalgams is attended with elevation of temperature, more or less marked, which is another indication of chemical combination. Changes of the volume of the mass attendant upon the act of setting still further indicate that chemical union of some portion of the constituent elements of the amalgam has taken place."

The Physical Properties of Amalgam.—The peculiar physical properties of amalgams are,—viz., setting, contraction, expansion, flow, stability, color, conductivity.

Setting.—Du Bois says, "Our present theory in regard to the formation of an amalgam is, that metals which melt at comparatively high temperatures when brought under the fusing influence of mercury—which remains liquid at a temperature of —30° F.—are melted into union with it." The *setting*, hardening, or crystallizing of the mass is therefore due to the *secondary cooling effect* exerted upon the mercury by the admixture of those metals which possess a high fusing-point, and that the higher the fusing-point of the metals amalgamated, the more rapid will be the process of setting. Platinum, however, presents an exception to this rule.

Amalgams are decomposed by the application of heat sufficient to volatilize the mercury which holds the other metals in combination.

During the process of setting, and for some time thereafter, nearly all amalgams undergo a change in volume and form. This change in volume may be either a contraction or an expansion.

Contraction and Expansion.—Contraction, or "shrinking," and expansion, or "bulging," of amalgams is, according to Flagg, in a general way in harmony with the natural contraction or expansion of the metals composing it, when passing from a fluid to a solid state. Those metals which lose their fluidity slowly, like tin, for instance, cause the greatest amount of contraction, while metals like gold and copper, which lose their fluidity quickly, and silver, which *expands* when passing from the fluid to the solid state, exert a controlling influence upon contraction.

The *contraction* of an amalgam filling produces "cupping of the surface and a drawing away of the mass from the walls of the cavity, while *expansion* of an amalgam produces bulging of the surface.

Black has shown, in his studies upon the "Physical Character of Amalgams," etc. (*Dental Cosmos*, 1895), that contraction and expansion of dental amalgams are influenced by many factors,—viz.:

"(1) To the composition of the alloy.

"(2) To the fineness of the cut of the alloy.

"(3) To the amount of mercury used in amalgamation.

"(4) To the evenness with which the mercury is distributed.

"(5) To the method of manipulation."

Dental alloys which are composed of silver and tin—the tin in excess of the silver—contract very considerably during the process of setting, while in those containing silver in excess the contraction is notably lessened. The proportions of these metals which will produce an amalgam with the minimum amount of contraction has been demonstrated by Flagg, and later by Black, to be silver sixty-five per cent., tin thirty-five per cent. Reducing the amount of silver and increasing the tin produces an alloy which will form a contracting amalgam, while increasing the silver and decreasing the tin produces an expanding amalgam.

Black in his experiments found that in all silver-tin amalgams in which the percentage of silver was below sixty per cent. contraction was the rule, the amount of contraction seemingly being governed by the relative proportions of the silver and tin contained in the alloy. He also found that contraction occurred during the first twenty-four hours, being greatest during the first two hours. A slight compensating expansion then occurred, lasting for from one to three days. During the process of expansion the amalgam softens very materially. This process he thinks is normal to all amalgams containing less than sixty per cent. of silver, as its absence is the exception. Slight contraction again follows the expansion, and this he thinks extends over an indefinite period.

In alloys containing more than sixty per cent. of silver there is no primary contraction, while in those containing eighty per cent. of silver and twenty per cent. of tin the expansion was very great, causing bulging or "spheroiding" of the surface of the filling. This condition was always notably present in the old, coin silver amalgam, which contained ninety per cent. of silver.

The fineness of the cut of the alloys, also, seems to exert an influence upon the contraction and expansion of amalgams containing fifty to sixty per cent. of silver, for Black found alloys of the same grade or composition, if cut fine or comminuted into very fine particles, always contracted much more than when cut in moderately coarse filings. This was a constant condition with this grade of amalgam. He was unable to definitely explain this condition, but states the facts that the reduction of the alloy to such fine particles causes them to take up more mercury, and that the resulting amalgam is much softer and contraction greater.

The percentage of mercury contained in amalgam influences the contraction and expansion to a greater or less degree. Black says, however, that it "is not so important a factor in the contraction of amalgam as he had supposed, and yet when the mass has been worked very dry the change of bulk has been markedly less, whether contraction or expansion." An excess of mercury in *contracting* amalgams increases the contraction, while in *expanding* amalgams it increases the expansion.

He found that "soft fillings, or fillings made from a mass containing fifty per cent. or more of mercury, showed great irregularity in contraction."

This author also found that a difference of five per cent. of mercury, or even more, in the fifty to sixty per cent. silver alloys, did not materially affect the contraction, but when the mass was so dry that no mercury could be worked to the surface in the process of packing it into the cavity, there was a marked lessening of the contraction.

The amount of mercury required to amalgamate the different alloys depends largely upon the per cent. of silver which they contain. This fact has long been recognized.

Black found that the increase of mercury to form a workable mass was not very noticeable until the amount of silver passed beyond sixty-five per cent.; but with seventy per cent. silver alloys it became very difficult to amalgamate them with fifty per cent. of mercury; while with eighty per cent. of silver, sixty per cent. of mercury was necessary to form a workable amalgam. The increase in expansion became very notable with the increase in the percentage of mercury.

He also discovered that an increase of mercury was necessary for complete amalgamation of those alloys which contained less than sixty per cent. of silver, though this increase was much less marked. Alloys which contain sixty per cent. of silver require less mercury to form a good workable mass than those containing any other proportion.

These facts, and many others, are most graphically shown in the accompanying table or exhibit of Dr. Black, "On the Contraction and Expansion of Amalgams."

EXHIBIT OF CONTRACTION AND EXPANSION OF AMALGAMS.

Notes.	No.	Formulæ.	Per cent. of Mercury.	How mixed.
Hand-pressure.......... (Time, 40 minutes.) *Margins perfect.*	1	Silver 65 Tin 35	44.60	Hand.
Hand-pressure (60).......... *Margins appear perfect.*	2	Silver 60 Tin 40	37.85	Hand.
Hand-pressure (60).......... *Margins open irregularly, width from 0 to 1.2.*	3	Silver 42.45 Tin 57.55	37.27	Hand.
Burnished in, removing all softened material (45).......... *Margins open, 0.4 to 1.2.*	3	Do.	45.31	Mortar.
Hand-pressure (50).......... *Margins open around two-thirds of circumference, 0 to 0.6.*	4	Silver 55 Tin 40 Copper 5	39.70	Hand.
Burnished in, removing all soft material (60).......... *Margins open all around, 0.2 to 0.4.*	4	Do.	38.75	Mortar.
Hand-pressure, with all the force I was able to exert (50), and cutting out all softened material.......... *Margins perfect.*	4	Do.	39.70	Hand.
Moderate mallet-pressure, drying out with rubber point (45)... *Margins open all around, 0.4.*	4	Do.	42.74	....

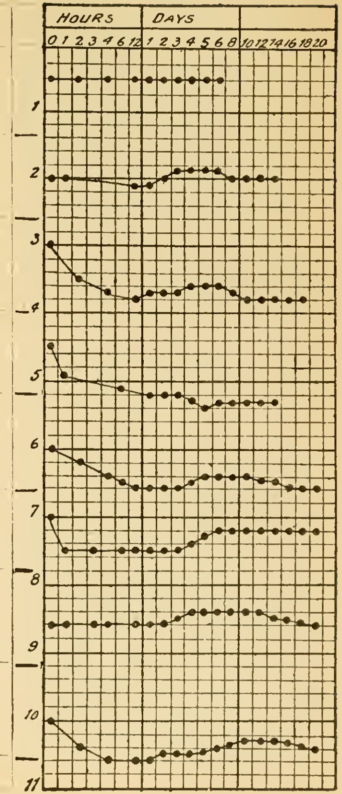


EXHIBIT OF CONTRACTION AND EXPANSION OF AMALGAMS.—*Continued.*

Notes.	No.	Formulæ.	Per cent. of Mercury.	How mixed.
Hand-pressure (43).......... *Margins open, 0.2 to 0.8.*	5	Silver 53.22 Tin 45.88 Copper 0.45 Bismuth 0.45	41.08	Hand.
Soft filling (15).......... *Margins open very irregularly, 0.4 to 0.1.*	5	Do.	50	Hand.
Pressed in with dynamometer (45) with a stress of 200 pounds *Margins slightly raised.*	5	Do.	32.39	Mortar.
Hand-pressure (40).......... *Margins open 0.2 to 0.3 all around.*	6	Silver 48 Tin 48 Gold 4	36.50	Hand.
Mallet-pressure (30).......... *Margins open slightly half-way around.*	6	Do.	37.65	Hand.
Hand-pressure.......... *Margins open irregularly from 0 to 0.8.*	7	Silver 60 Tin 37 Gold 3	34.24	Hand.
Hand-pressure (50).......... *Margins open all around from 0.2 to 0.6.*	8	Silver 48.5 Tin 48.5 Platinum 3.0	35.02	Hand.
Hand-pressure (35).......... *Margins open all around from 0.3 to 0.8.*	9	Silver 44.81 Tin 52.78 Gold 1.78 Platinum 0.62	39.18	Hand.

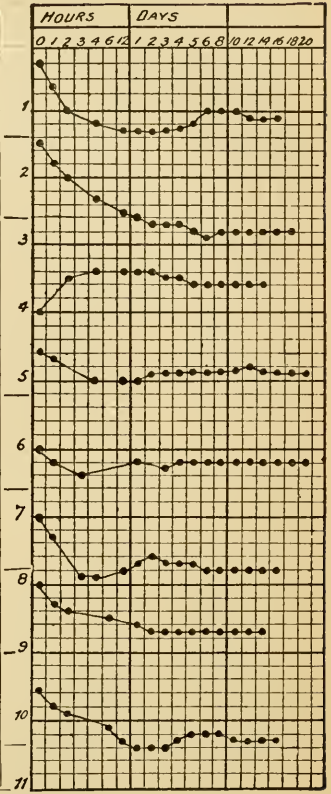


EXHIBIT OF CONTRACTION AND EXPANSION OF AMALGAMS.—*Continued.*

Notes.	No.	Formulæ.	Per cent. of Mercury.	How mixed.
Hand-pressure (3).......... *Margins open from 0.3 to 1.2.*	10	Silver 54.86 Tin 44.89 Zinc 0.25	32.05	Hand.
Burnished in with extraordinary force and removed all softened material.......... *Margins open half-way around.*	10	Do.	39.54	Mortar.
Filled quickly and lightly (25) by hand-pressure, removing no mercury.......... *Margins open all around, 2.0.*	10	Do.	41.51	Hand.
Pressed in with 500 pounds stress with dynamometer.......... *Margins slightly raised.*	10	Do.	30.84	Hand.
Hand-pressure.......... *Margins open 0.1 to 1.0; the filling seemed to be tilted to one side.*	11	Silver 54.86 Tin 44.69 Zinc 0.25 Palladium 0.25	43.54	Hand.
Burnished in, removing (50) softened material.......... *Margins open 0 to 0.6.*	11	Do.	40.88	Mortar.
Hand-pressure (40).......... *Margins open all around, 0.2 to 0.5.*	12	Silver 41.92 Tin 56 33 Platinum 0.44 Zinc 0.88 Bismuth 0.44	41.73	Hand.
Soft filling (13).......... *Margins very bad. Open all around. Widest points, 1.5.*	12	Do	50	Hand.

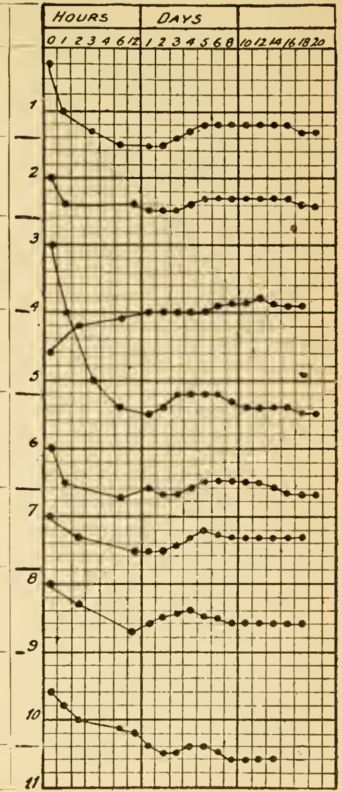


EXHIBIT OF CONTRACTION AND EXPANSION OF AMALGAMS.—*Continued.*

Notes.	No.	Formulæ.	Per cent. of Mercury.	How mixed.
The mass was laid aside (85) for one hour and the filling then made by hand-pressure.......... *Margins open, 0.1 to 0.5.*	12	Silver 41.92 Tin 56.33 Platinum 0.44 Zinc 0.88 Bismuth 0.44	50	Mortar.
Burnished in. Material (45) very dry and crumbling.......... *Margins open, 0.1 to 0.4.*	12	Do.	33.48	Hand.
Hand-pressure (55).......... *Margins open irregularly, 0.8 in widest point.*	13	Silver 47.06 Tin 51.76 Copper 0.94 Zinc 0.24	43.18	Hand.
Put in with the fingers.......... *Margins very bad and do not agree with micrometer, open 1.0 in several places.*	13	Do.	50	Hand.
Hand-pressure (65).......... *Margins perfect.*	14	Silver 42.83 Tin 51.62 Copper 4.65 Aluminum 0.55 Gold 0.01	46.70	Hand.
Hand-pressure.—This mix formed a dark semi-coherent mass that was difficult to pack.......... *Margins perfect.*	17	Silver 65 Tin 30 Copper 5	50	Mortar.
Burnished in. No mercury (30) could be removed.......... *Margins appear good.*	17	Do.	56.15	Hand.
Hand-pressure (40).......... *Perfect margins.*	18	Silver 70 Tin 30	46.36	Hand.

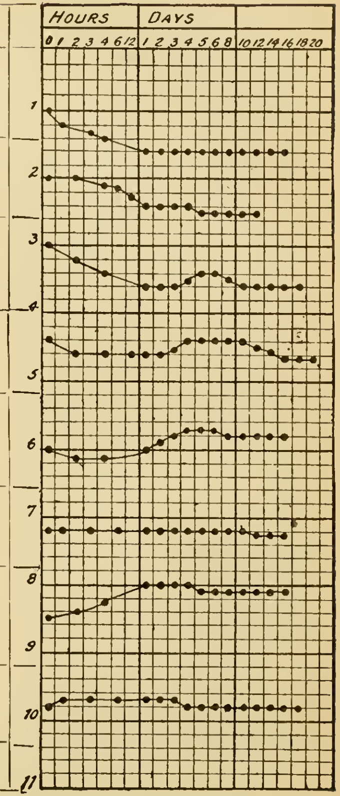
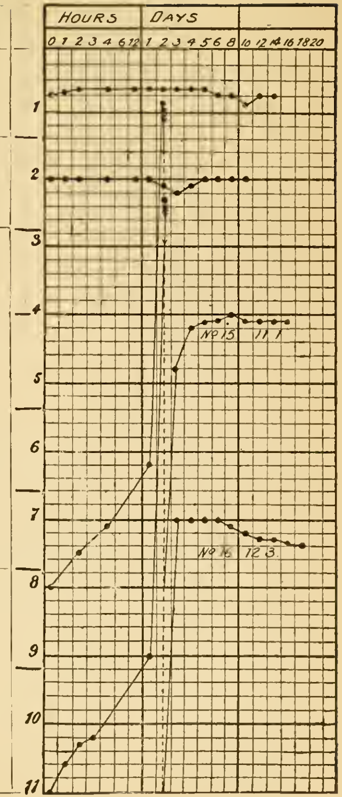


Exhibit of Contraction and Expansion of Amalgams.—*Continued.*

Notes.	No.	Formulæ.	Per cent. of Mercury.	How mixed.
Burnished in, cutting (45) out and removing all softened material.......... *Margins good.*	19	Silver 47.0 Tin 47.5 Copper 5.0	41.69	Hand
Hand-pressure, cutting (50) out and removing softened material.......... *Margins perfect.*	19	Do.	38.86	Hand.
Hand-pressure.......... *Margins much raised, with spherical surface spheroided, 11.1.*	15	Silver 80 Tin 20	60	Mortar.
Hand-pressure.......... *Spheroided, 12.3.*	16	Silver 75 Tin 20 Copper 5	56.56	Hand.



It will be noticed by a reference to this exhibit that formula No. 1—silver 65, tin 35, mercury 44.60, mixed in the hand—gave the best results, there being no change in volume by either contraction or expansion at the sixth day.

The evenness with which the mercury is distributed through the mass appears to be a controlling factor in the contraction and expansion of amalgams. This investigator found that wringing or compressing the mass in a piece of linen or chamois-skin had the effect of improving the amalgam both in its working qualities and in the stability of the final product, independently of the removal of an excess of mercury, especially if the compression is maintained for a little time. This he found to be the case when the amalgam was so dry that no mercury could be squeezed out of it, and suggests that the steady compression has the effect of producing an even distribution of the mercury through the whole mass.

The method of manipulation was also found by Black to be an important factor in controlling contraction in *contracting* amalgams and in obtaining good margins. In packing amalgams, he recommends that it should be introduced layer by layer, and the pressure so applied as to thoroughly condense the mass, without breaking it up or kneading it, and the softened material cut away with sharp spoon-shaped excavators before another layer is added, this process to be repeated until the cavity is full and a fine hard surface remains. To obtain good margins, the mass should be carefully compressed against the walls with a small instrument, but in such a way as not to break up the integrity of the partially packed material.

Flow of amalgams,—change of mass from molecular motion under stress. This is a property which has been observed to be possessed by the majority of metals, and described as the *flow of solids*, but hitherto entirely unsuspected as a property of amalgams until Black discovered it. In the "flow" of metals, iron, steel, gold, silver, etc., except tin and a few of the softer metals, a given stress will cause the metal to yield, spread, or flow. The phenomena occur immediately, and cease after a period of from one to two minutes after the stress is applied, even though the stress be maintained. The application of greater stress causes an increased flow, which again ceases until still greater stress is applied.

Black has discovered that the flow of dental amalgams is very different from this. He says, "When the flow of amalgam has begun, it continues so long as stress is maintained. No increase of the stress is required to maintain the flow, even after the area of the amalgam has been greatly increased by the flattening of the mass between plain surfaces. If a stress of fifty pounds be put upon a block of amalgam one-tenth of an inch square, and maintained for one hour, flow will occur at a certain rate; if the stress is reduced to twenty-five pounds, the flow will continue, but at a reduced rate. There is a manifest disposition of the material to creep out from under a load. It will go slowly with a light stress, somewhat quicker with a heavier one, but it cannot be made to go very quickly with a very heavy stress; but will instead break into fragments."

This investigator also discovered that there was a vast difference in the strength of amalgams under stress.

Exhibit of the Physical Properties of Silver-Tin Amalgams.

Notes.	No.	Formulæ.	Per cent. of Mercury.	How mixed.	Days Time for setting.	No. of Blocks tried for Flow.	Average per cent. of Flow.	Pounds Crushing Stress.
A mechanical mix of precipitates of the metals. Materials furnished by Dr. Ames, of Chicago	1	Silver 60 Tin 40	55.61	Mortar	2	4	33.26	160
Pressed in with serrated points, removing no mercury	1	"	55.61	Mortar	2	1	30.90	
Burnished in	1	"	55.61	Mortar	2	1	35.77	
Weighed and mixed and used without wringing out; fillings made at once	2	Silver 60 Tin 40	38.58	Hand	2	4	2.91	277
	2	"	41.64	Mortar	2	4	4.82	255
Fillings made after forty minutes	2	"	40.00	Hand	2	2	5.07	250
Made with hot instruments, after fifty minutes		"	40.00	Hand	2	2	8.32	250
		"	40.00	Hand	2	2	5.82	
As the blocks were made the odd numbers were placed in one box and the even numbers in another, so that they should be alike, and the tests made two days apart.	3	Silver 42.45 Tin 57.55	40.59	Hand	2	6	4.89	230
	3	"	40.59	Hand	4	6	8.61	230
	3	"	39.05	Mortar	2	5	9.00	235
	3	"	39.05	Mortar	4	5	9.76	220
	4	Silver 55 Tin 40 Copper 5	32.66	Hand	2	3	2.44	315
Pressed in	4	"	32.66	Hand	2	1	1.89	
Burnished in	4	"	32.66	Hand	2	1	4.10	
	5	Silver 53.22 Tin 45.88 Copper 0.45 Bismuth 0.45	39.08	Hand	3	4	7.57	253
Pressed in	5	"	39.08	Hand	3	1	5.12	
Burnished in	5	"	39.08	Hand	3	1	6.56	
	5	"	38.71	Mortar	3	4	11.75	257
Pressed in	5	"	38.71	Mortar	3	1	6.72	
Burnished in	5	"	38.71	Mortar	3	1	9.33	
	6	Silver 48 Tin 48 Gold 4	31.92	Hand	2	3	26.55	210
Pressed in	6	"	31.92	Hand	2	1	20.49	
Burnished in	6	"	31.92	Hand	2	1	22.95	
	6	"	40.18	Mortar	2	3	30.65	210
Pressed in	6	"	40.18	Mortar	2	1	31.97	
Burnished in	6	"	40.18	Mortar	2	1	40.16	
	7	Silver 60 Tin 37 Gold 3	30.31	Hand	2	3	25.64	225
Pressed in	7	"	30.31	Hand	2	1	22.76	
Burnished in	7	"	30.31	Hand	2	1	26.23	
	8	Silver 48.5 Tin 48.5 Platinum 3.0	26.47	Hand	2	3	26.28	220
Pressed in	8	"	26.47	Hand	2	1	15.78	
Burnished in	8	"	26.47	Hand	2	1	28.70	
	9	Silver 44.81 Tin 52.78 Gold 1.87 Platinum 0.62	37.45	Hand	3	3	19.81	225
Pressed in	9	"	37.45	Hand	3	1	15.57	
Burnished in	9	"	37.45	Hand	3	1	24.59	
	9	"	36.75	Mortar	3	4	25.14	225
	10	Silver 54.86 Tin 44.89 Zinc 0.25	41.18	Hand	2	3	27.59	237
	10	"	40.65	Mortar	2	3	34.91	227
Made with hot points	10	"	40.65	Mortar	2	2	36.11	

Exhibit of the Physical Properties of Silver-Tin Amalgams.—*Continued.*

Notes.	No.	Formulæ.	Per cent. of Mercury.	How mixed.	Days Time for setting.	No. of Blocks tried for Flow.	Average per cent. of Flow.	Pounds Crushing Stress.
	11	Silver 54.86, Tin 44.89, Zinc 0.25, Palladium 0.25	40.89	Hand	2	3	26.92	250
Made with hot points..............	11	"	40.89	Hand	2	2	19.55	
	11	"	40.61	Mortar	2	3	14.96	260
	11	"	33.01	Hand	2	4	16.34	275
	11	"	36.29	Mortar	2	4	22.44	252
	12	Silver 41.92, Tin 56.33, Platinum 0.44, Zinc 0.88, Bismuth 0.44	38.46	Hand	3	3	16.53	207
Packed lightly, without removing any mercury......................	12	"	41.43	Hand	3	3	11.33	195
Packed heavily with small points, removing all mercury possible..	12	"	41.43	Hand	3	3	19.92	
Mixed without wringing out and packed lightly without removing any mercury................	12	"	50.00	Hand	3	3	11.26	160
Pressed in........................	13	Silver 47.06, Tin 51.70, Copper 0.94, Zinc 0.24	41.00	Hand	2	3	25.09	235
Burnished in......................	13	"	38.74	Mortar	2	3	24.48	237
	14	Silver 42.83, Tin 51.62, Copper 4.65, Aluminum 0.55, Gold 0.01	35.95	Hand	2	3	14.22	220
Pressed in........................	14	"	35.95	Hand	4	1	4.09	
Burnished in......................	14	"	35.95	Hand	4	1	8.13	
	14	"	31.15	Mortar	2	3	28.44	200
	14	"	31.15	Mortar	4	1	16.40	
	14	"	31.15	Mortar	4	1	17.50	
Experimental alloys made by Dr. P. J. Kester, of Chicago, especially for investigation..........	15	Silver 70, Tin 30	50.00	Hand	2	4	4.28	300
(No mercury could be removed from these mixes by wringing through muslin.)	15	"	50.00	Mortar	2	3	4.12	345
	15	"	50.00	Mortar	5	3	5.71	360
(With 50 per cent. of mercury the mix was a dark, semi-coherent powder that was extremely difficult to pack.)	16	Silver 80, Tin 20	50.00	Hand	2	4	7.41	275
	16	"	50.00	Mortar	2	3	9.23	280
	16	"	60.00	Hand	2	3	2.40	330
(These mixes worked easily and well, only that they set very quickly.)	16	"	60.00	Hand	5	3	3.50	340
	16	"	60.00	Mortar	2	3	4.24	315
	16	"	60.00	Mortar	5	3	4.50	325

Note.—In the above experimental alloys the increase of mercury required as the tin is diminished is very notable. It shows that after a certain point, not yet accurately determined, we cannot diminish the flow by diminishing the percentage of tin.

The foregoing table gives the flow, crushing stress, etc., of a series of experiments conducted by Dr. Black with sixteen different formulæ for dental amalgams.

The flow of pure silver-tin alloys was found to range from two and one-half per cent. to ten per cent. under a stress of sixty pounds, the difference depending upon the composition of the alloy, the fineness of the cut, and the special mode of manipulation.

The silver-tin formulæ ranged in composition from forty per cent. of silver and sixty per cent. of tin to sixty per cent. of silver and forty per cent. of tin. The addition of a small per cent. of copper had a tendency to somewhat diminish the flow and give greater strength under stress. All other metals which enter into the composition of dental alloys markedly increase the flow of the amalgam, but do not seem to materially injure the strength of the amalgam under stress. He thinks, however, that the crushing strength of an amalgam is not a test of its stability under stress, but looks upon *the amount of flow as the important test.* The great difficulty with the silver-tin amalgams is that they will gradually change in form under the stress of mastication, as was demonstrated in the laboratory experiments by subjecting specimens of hardened amalgam to an intermittent stress.

The copper amalgams do not flow under stress, and the margins remain perfect. This was not the case with the silver-tin amalgams. Their disposition to flow under the stress of mastication allows them to move in the cavity, and on account of this movement they do not retain perfect margins, and thus, after a time, the way is opened for the establishment of secondary caries by reason of the re-entrance of the active agents of the disease.

A careful study of the table in reference to the relative influence of the various metals entering into the composition of dental alloys upon the flow of amalgams will be found to be exceedingly interesting, from the fact that, coupled with the discovery that all silver-tin alloys containing less than sixty per cent. of silver contract or shrink during the process of setting and for some time thereafter, it explains the condition which after a few months or years almost universally exists,—defective margins and imperfect adaptation to the walls of the cavity of fillings made from these alloys.

Annealing.—Dr. Black also made another important discovery while experimenting with alloys made by himself as to the influence of *time* upon cut alloys, or *aging* of the alloy, as it has been termed.

Flagg, in his work on "Plastics and Plastic Fillings," claims that freshly cut alloys do not mix as well, neither do they give as good "setting," "shrinkage," "edge-strength," or "color" tests, as when properly "aged."

Black in his experiments found the opposite of this to be true in relation to the shrinkage test. Freshly cut alloys which when made into amalgams did not shrink, or might expand, were invariably found to shrink after aging. The explanation of this phenomenon at first seemed to be due to a slight oxidation of the particles of the cut alloy, by which its chemical relations to mercury were profoundly changed. Further experimentation, covering several months of time, finally demonstrated the fact that neither *oxidation* nor *time* had anything whatever to do with the working qualities or the shrinkage of dental alloys. During these experiments the influence of temperature in aging of alloys was accidentally brought to his notice. He immediately set to work to verify or prove the error of the influence of this new factor, and finally discovered, after exhaustive experiments, that the change was due to a molecular alteration in the particles of the cut alloy, induced by heat, or, in other words, it was due to a process of *annealing* or *tempering.* Various degrees of temperature were used, ranging from 110° to 212° F.; but the lower temperature produced the best results. 130° F. was found to be the temperature which produced the greatest amount of shrinkage.

Each alloy was found to have a definite "*shrinkage expansion range.*" In some this range is all shrinkage, in others all expansion, and in still others it is both expansion and shrinkage. It was also found that by annealing or tempering any of the shrinking or expanding alloys these physical properties could be reduced to any amount, provided the temperature was maintained for a certain period.

Each alloy has its zero point of contraction or expansion, beyond which no amount of annealing has any effect.

"The modified silver-tin alloys that have seventy-five per cent. of silver or more expand only. They cannot be made to shrink by aging, though their expansion can be greatly reduced. The same class of alloys containing as much as sixty-five per cent. of silver and less than seventy-five per cent. expand when freshly cut, and shrink when fully aged or tempered. Those containing from fifty to sixty-one or sixty-two per cent. of silver shrink only, but shrink much more when aged than when freshly cut. Those that contain less than fifty per cent. of silver first shrink and then expand. When fresh cut the expansion is the greater, when aged the shrinkage is the greater.

"Alloys which contain sixty-five to seventy-five per cent. of silver are hard, and make hard and quick-setting amalgams; they are also the strongest amalgams that can be made of silver and tin. Alloys containing less than sixty-five per cent. of silver are soft, and make soft, slow-setting amalgams. Alloys containing more than seventy-five per cent. of silver are soft, and make frail, slow-setting amalgams; the slow-setting property occurs somewhat suddenly after passing the seventy-five per cent.

"Alloys which suffer no alteration in volume when unannealed shrink when annealed."

The tables given on page 311 show the extent of the change produced in the alloys by the process of annealing in the *unmodified* and the *modified* silver-tin alloys, and the influence of the modifying metals also upon the shrinkage, expansion, flow, and crushing strength. They also demonstrate the fact that less mercury is required to amalgamate a given sample of alloy when annealed than when unannealed, and that both the flow and crushing stress of amalgams made from annealed alloys are slightly increased.

Stability.—The physical property of amalgams designated as *stability* or *rigidity* is the antithesis of "flow." That amalgam is the best, other things being equal, which flows the least,—in other words, is most stable, shrinks the least, and has the highest crushing strength. Such amalgams have been said to possess great "edge-strength."

The term "edge-strength" was invented to designate the degree of resistance an edge or an angle of hardened amalgam offers to a force which on being applied might cause it to be fractured.

It is evident, however, from the discovery of the property of flow under stress possessed by the "unmodified" and the "modified" silver-tin amalgams, that it will be necessary to modify all former notions in relation to

EXHIBIT OF UNMODIFIED SILVER-TIN ALLOYS.

Formulæ.		How prepared.	Per cent. of Mercury.	Shrinkage.	Expansion.	Flow.	Crushing Stress.
Silver.	Tin.						
40	60	Fresh-cut.	45.78	6	7	40.15	178
40	60	Annealed.	34.14	9	3	44.60	186
45	55	Fresh-cut.	49.52	4	8	25.46	188
45	55	Annealed.	32.13	11	1	28.57	222
50	50	Fresh-cut.	51.18	2	2	22.16	232
50	50	Annealed.	37.58	17	1	21.03	245
55	45	Fresh-cut.	51.62	2	2	19.66	245
55	45	Annealed.	40.11	18	0	17.53	276
60	40	Fresh-cut.	52.00	1	0	9.06	239
60	40	Annealed.	39.80	17	0	14.10	297
65	35	Fresh-cut.	52.00	0	1	3.67	290
65	35	Annealed.	33.00	10	0	5.00	335
70	30	Fresh-cut.	55.00	0	14	3.45	316
70	30	Annealed.	40.00	7	0	4.67	375
72.5	27.5	Fresh-cut.	55.00	0	42	3.92	275
72.5	27.5	Annealed.	45.00	3	0	3.76	362
75	25	Fresh-cut.	55.00	0	60	5.64	258
75	25	Annealed.	50.00	0	6	5.40	300

EXHIBIT OF MODIFIED SILVER-TIN ALLOYS.

Formulæ.			How prepared.	Per cent. of Mercury.	Shrinkage.	Expansion.	Flow.	Crushing Stress.
Modifying Metal.	Silver.	Tin.						
	65	35	Fresh-cut.	52.33	0	1	3.67	290
	65	35	Annealed.	33.00	10	0	5.00	335
	66.75	33.25	Fresh-cut.	51.52	0	4	3.35	329
	66.75	33.25	Annealed.	33.53	7	0	5.06	380
Gold 5	61.75	33.25	Fresh-cut.	47.56	0	1	4.62	330
Gold 5	61.75	33.25	Annealed.	30.35	7	0	6.07	395
Platinum 5	61.75	33.25	Fresh-cut.	51.87	0	9	9.68	273
Platinum 5	61.75	33.25	Annealed.	37.33	7	0	8.20	352
Copper 5	61.75	33.25	Fresh-cut.	53.65	0	23	2.38	343
Copper 5	61.75	33.25	Annealed.	35.60	5	0	3.50	416
Zinc 5	61.75	33.25	Fresh-cut.	56.65	0	68	1.83	290
Zinc 5	61.75	33.25	Annealed.	40.65	0	9	2.07	345
Bismuth 5	61.75	33.25	Fresh-cut.	46.26	0	0	4.78	288
Bismuth 5	61.75	33.25	Annealed.	23.67	6	0	5.58	308
Cadmium 5	61.75	33.25	Fresh-cut.	57.57	0	100	6.40	225
Cadmium 5	61.75	33.25	Annealed.	47.25	0	5	3.54	290
Lead 5	61.75	33.25	Fresh-cut.	44.17	0	1	4.88	290
Lead 5	61.75	33.25	Annealed.	32.76	10	0	7.18	276
Aluminum 5	61.75	33.25	Fresh-cut.	65.00	0	445	....	....
Aluminum 1	64.5	34.5	Fresh-cut.	46.98	0	166	12.60	198
Aluminum 1	64.5	34.5	Annealed.	38.26	0	48	17.90	213

their rigidity, for certain of them possess great resistance to fracture of the edges or angles, and still under the stress of mastication evince a decided tendency to flow, and consequently to a disturbance of the margins. All are therefore more or less unstable, and still some of them might be said to possess great "edge-strength" when in reality they possess very little. It therefore becomes necessary to discard or to modify the generally accepted meaning of the term "edge-strength" to make it harmonize with the new data regarding the flow of all silver-tin amalgams under stress.

Those amalgams which flow least have also the highest crushing strength, as will be seen by a reference to the above tables. The most *stable* "unmodified silver-tin" amalgam contains 72.5 per cent. of silver and 27.5 per cent. of tin; its shrinkage when annealed was 3; expansion, 0; flow, 3.76; crushing stress, 362 pounds.

The most *stable* modified silver-tin amalgams are those which contain *gold* and those which contain *copper*.

The formula of the former is, silver, 61.75; tin, 33.25; gold, 5. Fresh-cut, shrinkage, 0; expansion, 1; flow, 4.62; crushing stress, 330. Annealed, shrinkage, 7; expansion, 0; flow, 3.07; crushing stress, 395.

The formula of the latter is, silver, 61.75; tin, 33.25; copper, 5. Fresh-cut, shrinkage, 0; expansion, 23; flow, 2.38; crushing stress, 343. Annealed, shrinkage, 5; expansion, 0; flow, 3.50; crushing stress, 416.

Color.—The tendency of amalgam to discolor upon its surface through the action of oxygen and sulphur has restricted the use of this material to those portions of the mouth where the objectionable color would not attract attention. Ever since the early efforts of Townsend to manufacture a dental alloy that would not discolor, it has been the ambition of manufacturers and individual experimenters to discover a formula which would produce an amalgam that would maintain its color under all conditions that are likely to be met in the mouth. The formula, silver 61.75, tin 33.25, gold 5, comes nearest to making an amalgam that will not discolor. Flagg's formula, silver 58, tin 37, gold 5, also gives excellent results. The writer has for years made an alloy containing silver 65, tin 30, gold 5, which has stood the clinical test of twenty years without discoloration, and shows as good margins as many gold fillings which have done service in the same locations for a like period of time.

The discoloration of amalgam is not confined alone to the exposed surfaces of the filling, but often extends to the surfaces which lie against the dentin, causing discoloration of that tissue. This discoloration of the dentin occurs most frequently under fillings which shrink or have been improperly introduced, or in which secondary caries is progressing, causing leakage.

This discoloration may be shallow or deep according to the character of the composition of the alloy, and is due to the formation of metallic sulphides, from the decomposition of albuminous substances and the generation of hydrogen sulphide. Black discolorations are found in amalgams containing silver and copper; yellowish stains in those containing cadmium.

To prevent discoloration of the dentin many operators are in the habit of lining the cavity with zinc oxyphosphate cement, or other barrier, before introducing the amalgam.

Conductivity.—Amalgam as a conductor of *heat* and *cold* stands midway between gold and the basic zinc cements in the scale of the filling-materials. As a conductor of electric currents it stands next below gold.

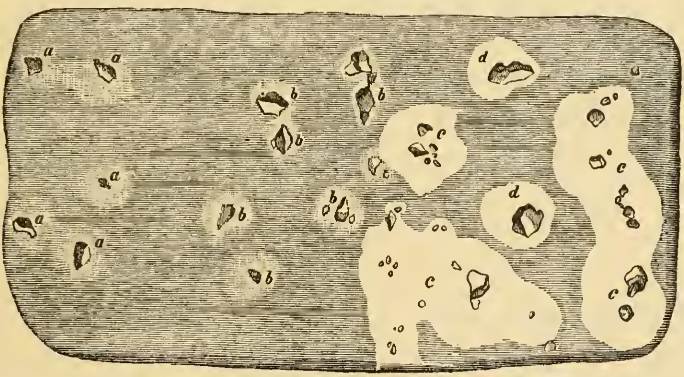
On account of the fact that amalgam is often used to fill cavities which are very large and dangerously near to the pulp, this organ should be protected from the dangers of thermal shock by the interposition of some low-conducting filling-material, like zinc oxyphosphate cement or gutta-percha.

Galvanic shock is sometimes experienced when some other metal having a higher or lower potential than the amalgam filling comes in contact with it, as, for instance, a gold filling in an opposite tooth when contact is made and broken during mastication, or when a table fork touches it.

As soon as the external surface of the filling becomes discolored galvanic shock ceases. This is due to the interposition of the metallic sulphides, which are non-conductors of electric currents.

Chemical Relations.—It has never been positively demonstrated that amalgam exercises any specific therapeutic influence upon the dentin, although clinical evidence is abundant that such is the fact with those that contain copper. Miller, in experimenting with the various plastic filling-materials, as to their antiseptic properties and their retarding influence upon the growth of mouth bacteria, found that *copper amalgam* was the only one which possesses such qualities, and that it invariably manifested a retarding or preventive action upon the growth of bacteria. Fig. 448 shows this action upon a gelatin plate.

FIG. 448.



An inoculated gelatin plate containing: *a*, pieces of oxyphosphate cement one day old; *b*, pieces of gold amalgam one day old; *c*, pieces of an old copper amalgam filling, age unknown; *d*, pieces of stained dentin from a tooth which had been filled many years previously with copper amalgam. (Miller.)

Weagant, in writing upon this subject, says, "Instead of having any injurious effect upon the teeth or surrounding tissues, it is decidedly beneficial to them, *acting as an antiseptic or germ destroyer.*"

Fletcher also maintains the same view.

According to Tomes, the sulphide of copper formed by the action of the hydrogen sulphide of the mouth upon the copper of the amalgam is readily converted, on exposure to air and moisture, into copper sulphate; hence it is almost certain that the latter is formed upon the exposed surface of the filling. Cupric sulphate is freely soluble, and therefore is likely to permeate the dentin by following the tubuli. Sulphides of the other metals are not so readily converted into soluble salts, and therefore do not penetrate the dentin so freely.

Flagg believes there is a gradual formation of soluble salts of silver, tin, and copper,—these metals forming the usual constituents of dental alloys,—which being dissolved are taken up by the contiguous dentin, thus changing the relations existing between the filling and the dentin, and rendering them more in harmony with each other ("compatible"), and, "*with its incorporated metallic salts,* becomes so in affinity with the amalgam filling as to insure almost completely harmonious apposition of tooth bone and filling, cessation, practically, of decay, and recalcification (?) *with metallic lustre* of decalcified dentin."

Cadmium amalgam and amalgams which contain cadmium gradually soften and disintegrate, and if the cadmium is present in large quantity, the dentin becomes decalcified and stained a bright orange-yellow from the formation of cadmium sulphide.

Dental amalgams, as a class, are, however, chemically, practically insoluble in the secretions of the mouth. Lactic acid and the other less common solvent agents found in the mouth have little or no effect upon them.

COMPOSITION OF ALLOYS.

The metals which are used in the manufacture of dental alloys are antimony, aluminum, bismuth, cadmium, copper, gold, platinum, palladium, and zinc.

The following condensed table gives the composition of a few of the best-known dental alloys.

	Tin.	Silver.	Gold.	Platinum.	Copper.	Zinc.	Antimony.
Welch's alloy	51.52	48.48	......	......	......	......	......
Welch's gold and platinum alloy	51.90	46	1.70	.40	......	......	......
Arrington's alloy	57.5	42.5	......	......	......	......	......
Fletcher's platinum and gold alloy	50.35	43.35	3.35	1.30	1.65	......	......
Flagg's contour alloy	37	58	5	......	......	......	......
Flagg's submarine alloy	35	60	......	......	5	......	......
Flagg's facing alloy	35	60	5	......	......	3	......
Davison's white alloy	49.27	48.24	0.05	......	......	2.44	......
Standard (Eckfeldt and Dubois)	40.60	52	4.40	......	3	......	......
Chase's stannous gold	40	40	20	......	......	......	......
Chase's incisor alloy	40	50	......	......	......	......	10
Chase's plastic tin	50	50	......	......	......	......	7

Antimony. (*Stibium.* Symbol, Sb. Fuses at 840° F.)—This metal has but little place in the manufacture of dental alloys. It is still used, however, in a few of the alloys offered for sale, sometimes in large quantities.

Amalgams containing antimony in considerable quantity are notably fine grained, very plastic, and do not shrink, but are exceedingly dirty to work.

Small quantities of antimony added to silver-tin alloys,—tin in excess,—it is claimed, control the shrinkage.

Aluminum. (*Aluminum.* Symbol, Al. Fusing-point, 1292° F.)—This is the lightest of the known metals, its specific gravity being 2.50 to 2.67. When alloyed with silver and copper it gives a non-tarnishing and non-corrosive quality to these metals and greatly increases their tensile strength. (Mitchell.)

Aluminum has been used as a constituent of dental alloys for the purpose of controlling the color and imparting greater tensile strength, but it destroys the integrity of the amalgam. Black found that the addition of five per cent. of aluminum to sixty-five of silver, and thirty-five of tin formed an alloy that when mixed with mercury "amalgamated nicely, forming a very white, soft mass, but it soon became too hot to handle." The thermometer indicated 186° F. The setting was also attended with the formation of considerable heat and enormous expansion, and later disintegration of the mass took place, resulting in the formation of a dark powder which would cohere a little on being pressed together.

Disintegration did not take place when the mass was rapidly worked and packed in glass tubes, but the tubes soon became too hot to handle. A remarkable phenomenon is observed during the combining of the alloy with the mercury,—viz., the evolution of gas, which gave off a distinct crepitating sound from the bursting gas-bubbles. The instruments used in packing the amalgam were darkened and corroded.

The expansion of the material seems to be almost continuous, for Black states "that in twenty-four hours an expansion of one hundred and twenty points had occurred, as indicated by the micrometer; at the end of the second day the expansion reached one hundred and eighty-one points; and at the end of the third day two hundred and seventeen points, and though diminishing it did not stop. At the end of forty-three days it had reached the enormous figure of four hundred and forty-five points of expansion, when it passed beyond the capacity of the micrometer to register.

"Annealing the alloys at 130° F. controlled the expansion somewhat,—it was stationary from the second day to about the fifth day, when it again began, slowly, and continued for about forty days."

Aluminum, therefore, should have no place as a constituent of dental alloys, as its use not only destroys the value of the metals with which it is combined, but the added danger is to be considered of fracturing or bursting the thin walls of the cavity by the enormous expansion which takes place during the process of setting and afterwards.

Bismuth. (*Bismuthum.* Symbol, Bi. Fusing-point, 507° F.)—This metal has been used in dental alloys to control the shrinkage in the low-grade silver-tin alloys, in which the tin is largely in excess of the silver, as it expands very considerably on cooling.

Alloys containing bismuth amalgamate with great readiness and with less mercury. Amalgams made from alloys containing bismuth are very dark.

Dr. Black found the expansion-shrinkage range reduced in those amalgams which contained it, but the flow was increased.

Cadmium. (*Cadmium.* Symbol, Cd. Fusing-point, 442° F.)—The use of alloys containing cadmium was first suggested nearly fifty years ago by the late Dr. Evans, of Paris. It was claimed for this metal that it amalgamated readily, that it did not discolor, and that it set very rapidly, and made a durable filling. The hopes raised by these claims were soon dissipated, however, for gradual softening and disintegration of the mass took place, the dentin was decalcified and stained a bright orange-yellow; but worst of all, the pulps of many of the teeth filled with this material were devitalized from the poisonous—irritating—effect of the cadmium sulphide, and which is stained yellow by the action of sulphuretted hydrogen. Cadmium is still used as an occasional component of dental alloys, being introduced in the proportion of from one to three per cent. It is claimed by those using it that it causes more ready amalgamation, controls discoloration, and increases the rapidity of the process of setting. Even this small quantity, nevertheless, would seem to be out of place, for all of the above advantages can be obtained by more satisfactory and less objectionable means.

Dr. Black found "by the addition of five per cent. of cadmium to 61.75 per cent. of silver and 33.25 of tin that it greatly increased the expansion of the amalgam; that it requires a large amount of mercury to amalgamate it; that it sets very quickly, and makes very white and beautiful-looking fillings.

"The expansion of the unannealed alloy was one hundred points in five days. Annealing largely controlled the expansion, reducing it to five points. In the expansion, the mass, if the walls of the cavity are smooth, slips squarely up and remains flat upon the top.

"The flow in the unannealed alloy was 6.40; in the annealed, 3.54. The crushing strength was increased by annealing from two hundred and twenty-five to two hundred and ninety pounds."

Copper. (*Cuprum.* Symbol, Cu. Fusing-point, 1996° F.)—This metal in small quantities enters into the composition of all of the better class of dental alloys. An addition of five per cent. to the silver-tin alloys—tin in excess—increases the rapidity with which it sets, controls the shrinkage, gives a white color to the amalgam, increases its hardness, and exerts—by reason of the formation of sulphide of copper, which on becoming oxidized forms the sulphate—an antiseptic action upon the dentin.

Dr. Black found that five per cent. of copper added to the 61.75 of silver and 33.35 of tin alloy caused the unannealed alloy to set very quickly. When annealed it set as slowly as the unmodified alloy.

The expansion and the expansion-shrinkage range was greatly increased, the flow was diminished, and the crushing stress was raised to the highest in the series.

Copper Amalgam.—This substance is a combination of pure copper and mercury in varying quantities, and is therefore a *binary amalgam.* It is made by several processes:

(1) By adding freshly precipitated and washed metallic copper to an excess of mercury; as soon as solution of the copper is complete, the surplus mercury should be expressed by wringing the mass in a piece of chamois-skin. The plastic material remaining should then be formed into small tablets by pressing in suitable moulds; when hardened it is ready for future use.

Rollins, Ames, and others have published methods for making it by electrolysis.

(2) Rollins's method is as follows:

Distilled water, five gallons; sulphate of copper, enough to saturate; sulphuric acid, one pound. Mix, filter, and pour into a wooden firkin with wooden hoops. All of the chemicals should be absolutely pure. Place ten pounds of pure mercury in a glass jar and immerse in the copper solution. To the zinc plate of a galvanic battery attach a gutta-percha-covered wire, having one end bare for about an inch. This exposed end is to be immersed below the level of the surface of the mercury. Tie granulated pure copper in a bag and hang it in the copper solution, connecting with a wire to the carbon of the battery. The battery is to be kept in action till the mercury has absorbed enough copper to make a thick paste. Then remove and wash thoroughly in hot water till all of the sulphate solution has been removed. Squeeze out the softer amalgam and allow the remainder to harden; heat it and renew the squeezing as before. This method insures an amalgam of perfect purity, and is simpler than any of the old and faulty methods in use.

(3) Chandler suggested another method of making copper amalgam, which is as follows:

To a hot solution of sulphate of copper add a little hydrochloric acid and a few sticks of zinc, and boil for about a minute. The copper will be precipitated in a spongy mass. Take out the zinc, pour off the liquid, and wash the copper thoroughly with hot water. Pour on the mass a little dilute nitrate of mercury, which will instantly cover every particle of copper with a coating of the mercury. Add mercury two or three times the weight of the copper, triturate slightly in a mortar, and finish by heating the mixture a few minutes in a crucible.

Copper amalgam is prepared for introduction into the cavity of a tooth by heating one of the prepared and hardened tablets, crushing and grinding it in a mortar, when it again becomes plastic. It may be made to set quickly or slowly as desired by squeezing out a portion of the mercury or by adding to it. On setting it becomes very hard,—in fact, it is the hardest of all the dental amalgams. It neither shrinks nor expands, retains good margins, and when properly made does not waste in the mouth. Its most objectionable feature is the black discoloration of its surface; but this does not appear so objectionable if the surfaces of the fillings have been nicely polished, for then the surface has a black polish instead of the rough, dirty black color that prevails if the surfaces are left in a rough state.

This material has no equal for filling the posterior teeth of children under twelve years of age, where antiseptic qualities are needed. Its greatest value, however, lies in its use in the deciduous molars of little children for whom rapid operations are a necessity.

Copper amalgam was the only alloy tested by Dr. Black which did not flow under stress. It suffers no change of form under stress, except to crush into fragments. It is as rigid and unyielding within the limits of its strength as a piece of hardened steel, and can neither be bent nor compressed. No shrinkage during setting could be discovered. A very slight expansion was always present, but it was so slight as to be of no importance. In the large majority of the fillings which he tested it did not exceed $\frac{2}{10000}$ of an inch.

When it is once adapted to the walls of the cavity and hardened the adaptation is permanent, for it can suffer no change of form from the stress of mastication. These physical properties of copper amalgam give it permanence, and according to the opinion of Dr. Black, explain the power of the material to arrest caries rather than any chemical or disinfectant property of the copper or of its salts.

Copper amalgam fillings, when well placed in properly prepared cavities, retain their perfect margins, and do not discolor the tooth-structure; and but for the wasting which sometimes occurs at the exposed surface and its dark color, this material would be the most satisfactory of all of the amalgams.

Gold. (*Aurum.* Symbol, Au. Fusing-point, 2016° F.)—This metal during late years has become, in small quantities, a quite common component of most of the high grade dental alloys. It enters into these alloys in the proportion of from three to five per cent. Experiment has demonstrated that more than any other metal used, in proportion to the small amount required, except copper, it diminishes shrinkage, increases the rapidity of setting, controls the color, adds to its crushing strength, and imparts fine grain while in the plastic state. The addition of from five to seven per cent of gold to the silver-tin alloys—silver in excess—gives the best results.

According to Dr. Black, the addition of five per cent. of gold seems to give a little softer working property to the amalgam and slows the setting.

Annealing increases the soft working property. It requires a little less mercury than the unmodified alloy, and the flow was slightly increased. This amalgam is very tough and bears a heavy crushing stress before breaking, and it controls the shrinkage-expansion range, three points.

Palladium. (*Palladium.* Symbol, Pd. Fusing-point, a little below that of platinum, about 3500° F., but requires the oxyhydrogen blow-pipe to fuse it.)—Palladium in combination with mercury forms a compound or binary amalgam, which has been recommended for use in the posterior teeth of children. It is made by combining palladium with three times its weight of mercury. Palladium is precipitated from a solution of its chloride by iron or zinc washed in nitric acid and dried. To this precipitate the mercury is added. Care is necessary in the mixing, as palladium forms a true chemical compound with mercury, and the action is so intense and the evolution of the heat so great that under certain circumstances an explosion might take place. Palladium amalgam turns black upon the external surface, but it does not discolor the dentin. It sets so rapidly that unless it is mixed very soft it becomes hard before it can be introduced into the cavity, consequently it should be worked rapidly and with warm instruments. Chandler found that the adding of a large proportion of gold rendered the palladium amalgam more tractable.

It has no good qualities which are not possessed in a higher degree by copper amalgam. The only thing in its favor is its name, as it is one of the precious metals.

Platinum. (*Platinum.* Symbol, Pt. Fusing-point, above 3500° F., and requires the oxyhydrogen blowpipe.)—According to Essig, platinum is only of value in an amalgam when combined with tin, silver, and gold in a proper proportion of mercury. Fletcher claims that the addition of a small quantity of platinum to a three-metal alloy, forty silver, sixty tin, ten gold, causes it to set quickly.

Flagg looks upon platinum as having no value in a dental alloy over the same equivalent of tin, and therefore valueless as a component of amalgams for filling teeth.

Black found by adding five per cent. of platinum to the silver-tin alloy it made a dirty working amalgam, which blackened the hands, set slowly, flowed badly, and increased the shrinkage-expansion range.

Silver. (*Argentum.* Symbol, Ag. Fusing-point, 1873° F.)—This is the most valuable and important of all the metals which enter into the composition of dental alloys. In the superior grades of alloys it forms the largest portion, while in the inferior grades tin holds the first place.

Silver is essential to the proper setting of an amalgam. Alloys in which silver predominates set much more rapidly than those in which tin forms the largest proportion.

Alloys containing a large proportion of silver expand, while those composed largely of tin shrink. When silver and tin are united in the proper proportions they will make an amalgam having the lowest shrinkage-expansion range possible with any other known metals, except copper amalgams. This formula has been demonstrated by Dr. Black to be, silver, 65 ; tin, 35 ; which gave shrinkage, 0 ; expansion, 1.

Tin. (*Stannum.* Symbol, Sn. Fusing-point, 442° F.)—This metal occupies the next most important place to silver as a component of dental alloys. It shrinks in cooling more than any of the other metals which enter into these compounds. Amalgams which contain an excess of tin shrink badly, set slowly, and lack hardness. These objectionable features are overcome by combining it with silver or with silver and copper or silver and gold. The advantages of tin in a dental alloy are that it facilitates amalgamation, aids in producing a good color, and reduces conductivity.

Zinc. (*Zincum.* Symbol, Zn. Fusing-point, 773° F.)—This metal in combination with copper formed one of the most ancient alloys of which there is any record. When added to dental alloys in which tin predominates in large quantity, in the amount of one to one and one-half per cent., it completely controls the shrinkage, adds a satisfactory whiteness to the filling, and prevents discoloration. (Flagg.)

Black found the addition of five per cent. to the 61.75 silver, 33.25 tin, formula greatly hastened the setting, and that it required more mercury for amalgamation ; but that the flow was decidedly decreased, the expansion range increased, and the crushing strength above the average.

MAKING DENTAL ALLOYS.

The rational method of making dental alloys is to melt that *metal first which fuses at the lowest degree of heat.* Tin, which forms a considerable part of all dental alloys, fuses at 442° F. This is the lowest fusing metal that enters into their composition, and should therefore be melted first, and the other higher fusing metals added in the order of their fusing-point, as, for instance, in a binary alloy the silver, which melts at 1875° F., should be added to the melted tin ; in a ternary alloy the copper, which fuses at 1996° F., should be added after the silver ; and in a quarternary alloy the gold, which fuses at 2016° F., should be added after the copper, etc.

The object of thus reversing the old method was to prevent the volatilization of the tin and thereby secure a definite compound, which was not the case when the tin was heated to more than 2000° F., as volatilization immediately takes place and an indefinite compound is the result.

The practitioner who would make his own alloys should provide himself with a good Hessian or sand crucible, holding ten or twelve ounces liquid measure, a pair of crucible tongs, and a quantity of borax to be used as a flux.

Tin may be obtained at any hardware shop in the form of bars or ingots. Banca tin is the best, as being most free from impurities.

Silver can be obtained of any silversmith. Granulated silver is the best for the purpose, as it is divided into small beads or granules, and is therefore dissolved more rapidly in the melted tin than larger pieces would be.

Copper can also be obtained at the hardware shop. Soft copper wire is the best form in which to buy it. This should be cut into very small pieces, about one-eighth of an inch in length.

Gold in the form of foil scraps is always on hand in the office of every dentist.

The other metals which sometimes enter into the composition of dental alloys are easily obtained, if it is desired to experiment with them ; but tin, silver, copper, and gold are the only metals that are used in a really first-class alloy.

Flagg, in describing a "melt," says the crucible should contain a liberal amount of borax, which should be melted first, filling it about one-third full. "This is intended for a 'flux.' An ordinary coke or coal fire is all that is required for the 'melt ;' but it is, of course, more systematically and perhaps more readily done in the usual dental or smelting forge-fire.

"Having perfectly fused the borax, in it *the tin is melted first*, requiring but a low temperature, and after it is melted the granulated silver is added. These two metals are thoroughly stirred together with an iron rod or clay pipe-stem of suitable size and length, and when completely incorporated the copper—small pieces of wire—is added. This, like the silver, is soon melted, and may be equally homogeneously mixed. Lastly the gold is added, melted, and all is thoroughly stirred together with the iron rod or pipe-stem.

"When perfectly melted and mixed, the fused mass should be quickly poured into a broad, open, flat, shallow matrix made of iron or soapstone : this favors prompt cooling, and thus secures the greatest uniformity of distribution to the components."

After the ingot has cooled it can be reduced to fine grains or coarse powder by filing, or the ingots may be cast in round bars or rods, and reduced to fine shavings by turning in a lathe.

CHAPTER XX.

MANIPULATION AND INTRODUCTION OF PLASTIC FILLING-MATERIALS.

Amalgam is generally used under those conditions and circumstances in which a permanent filling is desired, but in which gold or tin and their combinations are inadmissible, either from the inaccessibility of the cavity, the frail condition of the tooth, the physical state of the patient, forbidding the nervous strain of long and tedious gold operations, or the inability of the individual to pay for such expensive service. Under no conditions, however, should amalgam be used in the anterior teeth. It may be used in some cases upon the distal surface of the first bicuspids, but never in a more anterior position. If the conditions require the use of plastics in the anterior teeth, the oxyphosphate cements and gutta-percha are the best for this purpose.

Gutta-percha in the form of Hill's stopping is the most reliable of the plastics that are admissible in the anterior teeth.

Amalgams, however, are not used to the same extent as they once were; for many teeth that were formerly restored to normal contour by extensive operations with amalgam can now, since the introduction of the more advanced methods of crowning, be better and more permanently treated by these methods.

Various combinations of filling-materials have also been resorted to, in order to limit the uses of amalgam as far as possible to those positions in which they would be unobserved, to prevent discoloration of the tooth substance, or to give added beauty, strength, and durability to such fillings as were subjected to great stress; as, for instance, in compound cavities in the bicuspids and molars, when the cervical portion of a filling is made of amalgam and the morsal portion of gold.

The preparation of cavities for the reception of amalgams requires the same care and thoroughness in all of its details as would be observed in preparing them for gold fillings, the only difference being that retaining grooves and pits are not necessary to aid in the permanent anchorage of the filling, nor for starting it. If a general retentive form is given to the cavity, that is all that will be required to prevent its dislodgement under stress. Temporary separations are an essential preliminary step in the preparation of approximal cavities and in the restoration of contour in these locations.

The Especial Uses of Amalgam.—1. Amalgam is especially indicated in that class of cavities in which the cervical margin lies at some distance beneath the border of the gum, making it impossible from its inaccessibility and the difficulties in excluding moisture to successfully introduce gold.

2. In large distal cavities in the second and third molars, where, by

reason of their location, their size and frail walls, or the physical condition of the patient, gold fillings could not be satisfactorily placed.

3. In large buccal cavities in the molars, which extend to the gum line or beneath.

4. In large approximal cavities in bicuspids and molars.

5. In large morsal cavities in the molars.

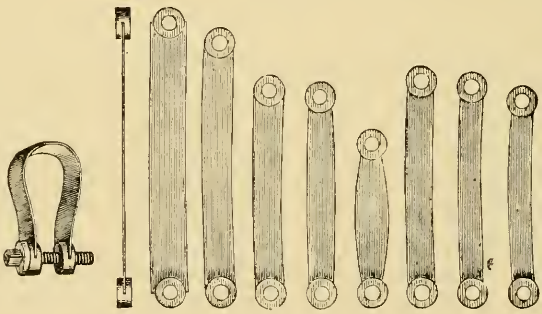
6. In compound cavities involving the mesial, distal, buccal, or lingual surfaces united with the morsal.

The last four classes of cavities can, of course, be successfully filled with gold, and usually with better results, than with amalgam ; but conditions and circumstances are often presented in which the operator is obliged to choose amalgam to the exclusion of the better material.

The exclusion of moisture is as essential in the preparation and sterilization of cavities to receive amalgam as when gold is to be used, and the rubber dam should be adjusted for this purpose whenever and wherever it is possible to do so. Because amalgam is a cheaper material, and requires less skill to manipulate it than gold, is no reason why its introduction should be less carefully and conscientiously performed, or less pains taken with the finishing of such a filling, than would be expended upon it if it were gold. Better results, no doubt, would be obtained in the use of amalgam if a higher degree of care in details were expended upon it.

The employment of matrices is often a necessity in filling large compound cavities in the molars when it is desired to restore the contour of the involved surfaces. In these cases the band matrix is the most serviceable, and to obtain the best results from its employment it should be permitted to remain until the amalgam has set sufficiently hard to allow it to be dressed to the desired form and polished.

FIG. 449.



Creager loop matrices.

The ordinary loop matrix (Fig. 449) and the Guilford and Brophy matrices are not adapted to be left in the mouth by reason of their screw mechanism being in the way of the cheek.

Dr. Herbst's method of forming a matrix to suit each individual case is admissible in this class of cases, for the reason that they are made in a moment, and can be so shaped that they will not injure the gum or the cheek, or interfere with the occlusion of the teeth ; consequently they may be permitted to remain upon the tooth for several days if desired. They are made as follows: A strip of German silver, No. 33 gauge, is cut of such width as will reach from the gum to the morsal surface of the tooth, and of sufficient length to embrace it and have about one-fourth of an inch to spare. This strip is then passed around the tooth, and the ends grasped with a pair of Herbst pliers—any flat-nose pliers will answer the purpose, however—and drawn tightly around the tooth by pinching the ends together. A close adaptation of the band to the tooth is thus secured. While still holding the ends of the band with the pliers it is removed from the tooth, and the ends soldered together over an alcohol flame or a Bunsen burner with tinner's solder. The matrix is then replaced upon the tooth, and if it impinges upon the gum or interferes with the occlusion of the teeth, it is again removed and trimmed with small curved scissors to suit the requirements of the case, when it is again replaced after the rubber dam has been adjusted.

If the band does not fit properly at the cervico-approximal border, it can be brought to position by the insertion of a wooden wedge. On the removal of the matrix, which should not be done until the amalgam has set, the filling can be shaped and polished as though it were gold.

Mixing Amalgams.—The proper mixing of amalgams is an important factor in the "shrinkage-expansion range" and in the "flow" of the mass, as shown by Dr. Black. Amalgams in which the alloy has been well incorporated with the mercury, or in which the mercury has been evenly distributed, shrink or expand less—heavily tinned amalgams *shrink;* heavily silver amalgams *expand*—than when they are insufficiently mixed or the mercury is unevenly distributed. The flow is likewise decreased by an even distribution of the mercury.

Alloys made of metals which fuse at a comparatively low degree of heat, or alloys in which these metals predominate, require less mercury to dissolve the particles of the alloy and to form a plastic mass than do those made of metals which fuse at a considerably higher degree of heat. The silver-tin alloys—tin predominating—require less mercury to form a plastic workable mass than the same binary alloy in which the silver is in excess.

Flagg and Fletcher both recommend the *weighing of the alloy and the mercury* for every "mix." Flagg's submarine alloy, which is composed of silver 60, tin 35, copper 5, requires from forty-six to forty-eight per cent. of mercury to make a workable mass.

Flagg's contour alloy, containing silver 58, tin 37, gold 5, and other alloys of this grade require from forty-eight to fifty per cent. of mercury for perfect amalgamation, while those containing tin 60, silver 40, require only from thirty-seven to thirty-nine per cent., and those composed of tin 60, silver 35, gold 5, from forty-one to forty-three per cent. of mercury.

If the operator knows the exact formula of the alloy which he is using, the proportion of mercury necessary to completely amalgamate the alloy is readily determined by the above. If, however, he does not possess the formula, he can ascertain by an experimental "mix" the amount of mercury necessary to obtain the best results in working any grade of amalgam.

The amount of mercury required for the amalgamation of dental alloys is greatly increased as the amount of silver passes beyond sixty per cent., so that with an alloy containing seventy per cent. of silver it was very difficult to form a workable mass with fifty per cent. of mercury; while with eighty per cent. of silver it becomes necessary to use as much as sixty per cent. of mercury.

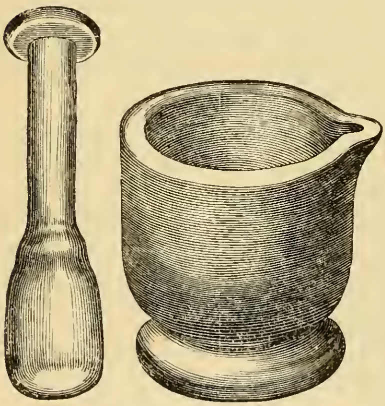
In mixing amalgams by weight, the amount of the alloy necessary for the case in hand should first be weighed, and then the exact proportion by weight of mercury added to it. These should be placed in a mortar and

FIG. 450.

Flagg wafering pliers.

mixed with the pestle until the mercury is thoroughly incorporated, making an even mass of firm consistency. It is then taken in the palm of the hand and kneaded into a mass, and compressed in a piece of chamois-skin or silk fabric, by wringing with the fingers or with a pair of flat-nosed pliers, or with Flagg's wafering pliers, shown in Fig. 450.

FIG. 451.



Glass mortar and pestle.

If the "mix" has been properly proportioned, no mercury can be expressed by gentle pressure with the pliers, and but very little under severe pressure. The practice of adding more mercury than is needed in mixing an amalgam, and then expressing it in order to obtain a good working mass, is to be deprecated, from the fact that the mercury is the solvent or fusing element in the amalgam, and whenever any portion of it is taken from the mass, by just that much the composition of the amalgam is altered and its physical characteristics changed.

Dr. Black advocates the plan of mixing the amalgam in the hand until a fairly even distribution of the mercury is secured, as by this method his experiments showed that the strongest amalgam was secured. He found also that "*any form of violence weakens the product*," either in mixing, expressing the excess of mercury by compression with a vice, or by undue manipulation in packing it into the cavity.

Mixing amalgams in the hand is a dirty process, which discolors the hand and the fingers with the metallic oxides. To overcome this difficulty

Dr. Genese invented a rubber mortar to be held in the hand, the finger used in the mixing to be covered with a rubber finger-stall.

Fletcher's method of mixing is to place the weighed proportions of alloy and mercury in a long glass tube and then violently shake it until amalgamation takes place.

The writer prefers to mix amalgams by placing the desired amount of alloy in a mortar (Fig. 451) and adding the mercury little by little while the mass is being triturated, until a rather dry, crumbly mass is formed ; it is then turned into the palm of the hand and kneeded with the index-finger for a little time, when from the heat imparted to it from the hand it becomes softer, and can be worked into a mass that will hold together. It is then placed in a napkin and compressed into a compact mass by wringing and squeezing between the thumb and finger, and afterwards cut into cubes of suitable size for the case in hand. This forms a mass which works easily and without the appearance of an excess of mercury upon the surface of the filling during the operation of packing it into the cavity.

Washing Amalgams.—The idea of washing amalgams originated in the fact that alloys that had been cut for some time became oxidized upon the surface, and it was thought caused discoloration of the filling. It was believed that these oxides could be removed by washing in alcohol or other fluids and thus prevent discoloration.

The real value of washing amalgams is, however, still a mooted question in the profession. Flagg believed that "washing" increased the tendency of the filling to shrink. Fletcher demonstrated that "washing" was absolutely detrimental, as it greatly facilitated and increased shrinkage. Burchard * recommends washing the amalgam in spirits of chloroform, as it has been observed that washed amalgams retain their color better. The writer has never been able to discover any difference in the maintenance of color between washed and unwashed amalgams, and he has experimented very considerably in this line and has carefully observed the results in the mouth.

The composition of the amalgam and the finish given to the filling are the main factors in controlling the tendency to discoloration.

INTRODUCTION OF THE AMALGAM.

The cavity having been prepared, the rubber dam adjusted, and the surface of the dentin dried and sterilized, the tooth is ready to receive the filling. The amalgam should be introduced into the cavity in small pieces. The first piece should be large enough to cover the bottom of the cavity when it is packed into place. The packing should always be done by hand-pressure. Another piece is then added to this and pressed into position with suitable instruments, and the filling built up layer after layer until the cavity is full.

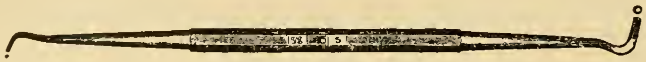
Various instruments have been devised for carrying the amalgam to the cavity besides the ordinary curved pliers. Fig. 452 represents an instrument for this purpose, which has one end armed with coarse serra-

* American Text-Book of Operative Dentistry.

tions into which amalgam has been packed and permitted to harden. This produces a surface which will, by affinity or attraction, pick up small pieces of amalgam and hold them until they are deposited in the cavity.

Other efficient instruments are shown in Fig. 453. These are of equal value in carrying the amalgam to cavities in the teeth of the upper and lower jaws.

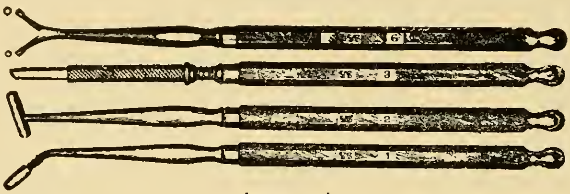
FIG. 452.



Loadstone amalgam-carrier.

For packing the amalgam into the cavity and shaping the filling there are no better instruments than those shown in Figs. 454, 455, and 456.

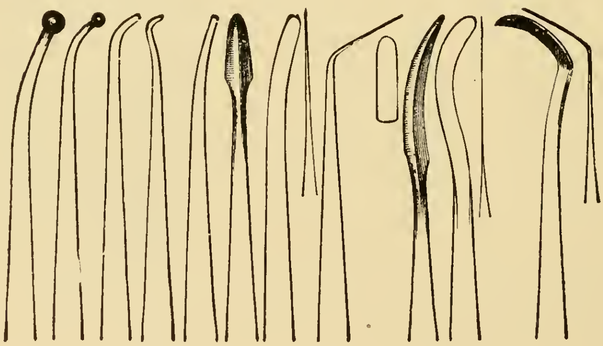
FIG. 453.



Amalgam-carriers.

Packing and Condensing.—Several methods have been recommended for packing and condensing the amalgam,—viz., by *burnishing*, *pressing*, and *tamping*.

FIG. 454.



Dr. J. Foster Flagg's amalgam-instruments.

Burnishing the amalgam into place is the method most commonly followed, and it is claimed for this method that a better adaptation of the material to the cavity walls is obtained than by any other. Dr. Black has shown that "severe burnishing makes a weak filling."

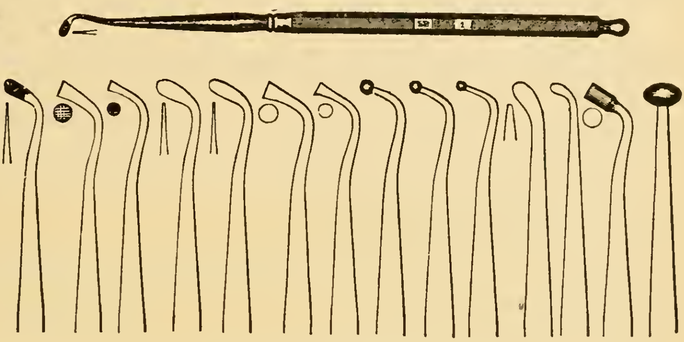
Pressure, steady and light, has, according to the same investigator, given the best results in his experiments upon the manipulation of amalgams. Strong pressure, while bringing free mercury to the surface,—which was removed,—gave the next best findings. Burnishing the filling into the cavity, if done moderately, gave about the same results.

Tamping or tapping the amalgam into position is a method which was introduced by Dr. Flagg, and is described as follows: "Tamping consists of delivering light blows, from the appropriate filling-instruments, upon the amalgam *after it has been crushed* into approximate position and apposition. This 'tamping' is not to be done with the mallet, either hand, automatic, or electric, as a different kind of blow from any so given is far

FIG. 455.

Kirk's universal approximal instruments for plastics.

FIG. 456.



Revised set of amalgam-instruments.

preferable. Tamping is a *mingled push and blow*, which is soon acquired, and is as promptly recognized as very efficient in producing admirable results." The writer has followed this method for many years, and has never seen any good reason for changing to another.

Wafering.—As the filling nears completion many operators are in the habit of finishing it with "wafers" of hard amalgam, after the manner suggested by Flagg. These wafers are made by compressing a portion of amalgam—either from the mix then being used or of a higher grade alloy —in chamois, with a pair of strong pliers, until all the mercury possible is expressed from it. The process of wafering hastens the setting of the amalgam and facilitates the final finishing.

Lining.—In large cavities having thin walls it often becomes necessary to "line" the cavity, in order to give them the needed support and to prevent discoloration from the bluish appearance of the amalgam showing through the enamel, or from discoloration caused by the formation of sulphides and oxides of the metals contained in the amalgam.

The materials generally used for this purpose are the zinc oxychloride and oxyphosphate cements.

In lining cavities, the cement should never be allowed to rest in contact with the enamel margins. The margins should always be free from the cement, so that the amalgam may be in perfect contact with them throughout their whole extent. If for any reason the cement is allowed to remain in contact with the enamel margins, and the amalgam makes contact with that instead of the enamel, failure of the filling is bound to result by the washing away of the cement and opening the cavity to the agencies of caries.

Two methods of lining are employed: one is to partially fill the cavity with the cement and allow it to become thoroughly hardened, and then to prepare it for the amalgam filling by removing the cement from the enamel margins, and give a retentive shape by undercuts in the base of the cement. Another method is to line the cavity with rather soft cement, care being taken to keep the enamel margins free, and while the cement is yet soft to introduce the amalgam, rubbing it into the surface of the cement. It is claimed for this method that by introducing the amalgam while the cement is in a plastic state it adheres to the enamel and renders retentive shaping unnecessary.

Guarding.—In large cavities in the approximal surfaces of the bicuspids and molars which extend beneath the gums, it becomes necessary to introduce a filling-material which by reason of its physical character and antiseptic action will conserve the tooth-structure. Flagg describes "guarding" as "placing a material in apposition with the cervical wall of a cavity of decay, which shall, by its possession of certain physical characteristics, act under certain 'law,' to prevent, in greatest degree, the recurrence of decay at that 'vulnerable spot.'"

Tin-foil is generally used for this purpose under gold fillings, while some operators use amalgam.

In guarding the cervical margin under amalgam fillings, alloys are used which contain copper and a high per cent. of silver. For this purpose there is no alloy better than Flagg's "submarine," composed of silver, 60; tin, 35; copper, 5.

Copper amalgam may also be used for the same purpose, and some operators prefer it.

Guarding with amalgams is usually employed in those cases in which caries has extended so far beneath the gum as to make it impossible to keep the cavity dry by adjusting the rubber dam. Under such circumstances, after the cavity has been prepared an antiseptic should be applied, and sealed into the cavity with a temporary stopping. On the next day, after adjusting a napkin to prevent the entrance of moisture, the dressing is removed, and the submarine amalgam, which had been previously prepared, should be rapidly introduced, packed into position with suitable instruments or pellets of bibulous paper, and built up to the gingival border, the balance of the cavity being filled with a temporary stopping. The surface of the amalgam should be smoothed and overhanging edges removed while it is in the plastic state, for after it has "set" it is cut with great difficulty. At a subsequent sitting the surface of the amalgam filling beneath the gum should be nicely finished, when the rubber dam may be adjusted, the temporary stopping removed, and the balance of the cavity filled with ordinary amalgam. The amalgam which is used for the bulk of the filling should be one which will maintain a good color. An alloy containing silver 60, tin 35, gold 5, will best subserve the purpose.

It sometimes becomes necessary to complete the operation at one sitting. Under these circumstances, the rubber dam can be adjusted after the cervical section of the cavity has been filled and the operation completed. This method is, however, not so satisfactory as the other, because of the danger of displacing the cervical section of the filling while the other is being packed into position, and the greater difficulty of perfectly finishing the cervical portion after the entire filling has been completed.

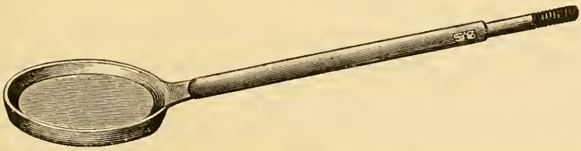
Flagg recommends in all of those fillings which are located in surfaces of the teeth exposed to view, and where any discoloration would be objectionable, wafering such fillings with "facing" alloy, composed of, relatively, silver 57, tin 35, gold 5, zinc 3, as this gives a more acceptable color.

COPPER AMALGAM.

For the purpose of guarding and for submarine work in unexposed positions, and in the molar teeth of little children, some of whom will not tolerate the rubber dam or even a napkin, copper amalgam occupies a high position as a filling-material and a conserver of tooth-structure.

Cavities prepared for this material require but slight retentive shaping to retain it in position.

FIG. 457.



Heating-spoon.

Ebony cone-socket handle,

In preparing copper amalgam for introduction into a cavity, a cube of the material is placed in an *iron* spoon (Fig. 457), or grasped with a pair of pliers, and held above an alcohol or Bunsen flame until the mercury shows itself in tiny globules upon the surface, when it is placed in a mortar, crushed and ground into a soft mass.

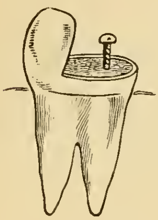
The cavity, when possible, should be protected from moisture by adjusting a rubber dam or a napkin and sterilized. The amalgam is then introduced in small pieces, and packed by tamping or burnishing the material against the walls of the cavity until it is full. The surface of the filling may be smoothed with a broad spatula or by wiping with pellets of cotton.

Large cavities may be advantageously filled or lined with zinc oxyphosphate cement for the lower two-thirds or three-fourths of the cavity and the filling finished with amalgam. This practice, however, is imperatively demanded in large and deep-seated cavities which have extended nearly to the pulp, to guard against shock from thermal changes.

By the aid of "Mack's" screws, set in the pulp-canals, the Herbst matrix, and a strong, quick-setting alloy—Flagg's contour—large contour operations, like the building of a large section of, or the whole crown of, a molar, may be successfully accomplished, as shown in Figs. 458, 459, 460, and 461. It is important that the matrix fit the cervix of the tooth closely, and be so adjusted to the occlusion of the opposing teeth that the jaws can be closed in a normal manner. After the cavity has been filled or the crown restored, the matrix should be allowed to remain for a few hours, or better, overnight, when the surfaces may be trimmed and shaped by filing and grinding.

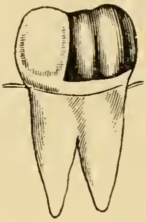
In packing the amalgam great care, for obvious reasons, should be exercised to secure perfect adaptation of the material to the walls of the matrix and the surfaces of the screws.

Fig. 458.



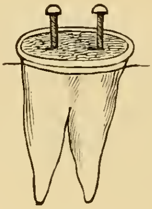
Cavity prepared.

Fig. 459.



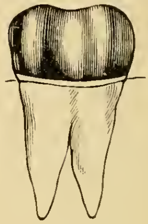
Cavity filled.

Fig. 460.



Cavity prepared.

Fig. 461.



Crown restored.

If the matrix has been carefully fitted to the cervix and the occlusion properly adjusted, there will be very little trimming and carving required to give proper form to the restored crown.

Finishing.—The proper finishing of an amalgam filling is as important as the finishing of gold fillings. An imperfectly finished filling will, by the roughness of its surface, its ragged or overhanging edges, invite a recurrence of dental caries at the enamel margins by the retention of fermentable material and the protection offered to the zymogenic bacteria, while fillings that are highly finished retain a better color, or, in other words, do not tarnish or oxidize so readily.

The process of finishing amalgam fillings which have become hard by crystallization is so similar to the finishing of gold fillings that it is not necessary to describe it, as it would be only a reiteration of these methods.

GUTTA-PERCHA.

Gutta-percha was first introduced to the consideration of dental practitioners a little over fifty years ago (1847) as an admirable material for temporary fillings in frail teeth, on account of the ease with which it could be manipulated, its non-irritating and non-conducting qualities, its insolubility in the fluids of the mouth, and its fair resistance to the attrition of mastication. Its color, dark brown, was so objectionable that it found little favor with the profession on this account. But upon the introduction soon afterwards of a secret preparation known as "Hill's stopping," which was white in color and possessed all of the advantages of the crude gum, it rapidly came into use for a temporary stopping.

Its inventor, Dr. Hill, however, had very exalted views of its value, for he said, "Though I do not expect it to supersede gold entirely, yet I believe it can be advantageously substituted for that material in many instances." Although this opinion has never been generally concurred in by the profession, it was nevertheless the very best material for temporary fillings that the dentist has ever had placed in his hands; and, in fact, it has proved in many instances, when introduced into cavities which by their position were not subject to the attrition of mastication, to be worthy to be classed as a permanent filling-material, for it has been known in such locations to have perfectly preserved the teeth so filled for from five to ten years, and even longer. With the death of Dr. Hill the manufacture of the "stopping" ceased, and although several alleged analyses of the material have been published, no one has ever been able to produce a substance that possessed all of the qualities of Hill's stopping.

A formula which makes a very good substitute for it, and which, when published, was claimed to be identical with Hill's formula, is as follows:

℞ Quicklime, 2 parts;
Quartz, 1 part;
Feldspar, 1 part.

These are ground to an impalpable powder and mixed. Pure gutta-percha is then heated to a plastic state and the powder kneaded into it as long as it will receive it without becoming brittle.

The white gutta-percha preparations of to-day are made in imitation of Hill's stopping, but they are *only imitations* to those of the older members of the profession who had any experience in the use of the original material.

The gutta-percha preparations as manufactured at the present time are composed chiefly of *gutta-percha* and *oxide of zinc*, these materials being kneaded together—upon an iron or porcelain slab heated over boiling water—by the aid of a broad steel wedge-shaped instrument termed a kneader. The greatest care has to be exercised in its manufacture to prevent overheating (heat-rotting), as this spoils the material by destroying its toughness and causing disintegration of the mass.

Gutta-percha as prepared for the use of the dentist is in three forms, —one, the well-known pink base-plate gutta-percha; another, the white gutta-percha prepared in small cakes, sticks, or pellets; and the third, a softer "temporary stopping" used for covering dressings. The white gutta-percha is prepared in three grades,—viz., "low heat," "medium," and "high heat." The "low heat" grade becomes sufficiently plastic for manipulation at temperatures ranging from 140° to 200° F. The "medium" grade is rendered of equal plasticity by a temperature ranging from 200° to 210° F. The "high heat" grade requires a temperature of from 216° to 230° F. to render it sufficiently plastic for manipulation, and is therefore more liable to be overheated and its integrity destroyed than are those which can be rendered plastic over hot or boiling water. Flagg thinks for this reason the medium grade of gutta-percha is the best for general use.

Flagg's formulæ for the "low heat" and "medium" grades of gutta-percha are, "low heat," gutta-percha, one part; oxide of zinc, four parts; "medium," gutta-percha, one part; oxide of zinc, six to seven parts by weight.

Physical Characteristics.—Gutta-percha stopping is the most bland and non-irritating filling-material known, and by its non-conducting properties of both heat and electricity it becomes the most valuable filling-material for the temporary treatment of hypersensitive dentin and nearly exposed pulps that the dentist has at his command. It is not acted upon by the fluids of the mouth, at least in any appreciable degree, while it is a notable fact that it maintains its integrity better in the fluids of the mouth than when exposed to the atmosphere. Softened gutta-percha pellets will unite with each other under pressure when the surfaces are dry, but they cannot be made to do so when wet. It contracts on cooling, so that it is almost impossible to make an absolutely moisture-tight plug; in fact, very few fillings made out of the mouth will resist the "carmine test;" and yet with this great fault its record as a "tooth-saver" is exceptionally good. It is susceptible of being colored to imitate any shade of the teeth. It is not so hard nor so rigid as the other filling-materials, but it has been noticed that its hardness increases with time when it has been properly introduced into a cavity that is protected from attrition. Gutta-percha fillings which soften and disintegrate in the mouth have been spoiled by "heat-rotting," either during the process of manufacture or in being prepared for introduction into the cavity. The pink base-plate gutta-percha assumes a polished surface, and seems to wear better when subjected to attrition than do the white varieties.

Some operators prefer the pure gum to any other form, believing that its admixture with the substances that are used to harden and bleach it detract from its wearing qualities and only render it more destructible.

Use of Gutta-Percha.—Gutta-percha is employed principally as a temporary filling in the deciduous and permanent teeth, for "sealing in" dressings, treating hypersensitive dentin, for the permanent filling of root-canals, for "guarding" oxyphosphate fillings, for capping or protecting nearly exposed pulps, for permanent fillings in locations not exposed to attrition, and in badly broken-down teeth which are too frail to be filled with metallic stoppings. Dissolved in chloroform—chloro-percha—it is often used to line cavities which are to receive zinc oxychloride or zinc oxyphosphate cements, the object being to protect the pulp from irritation and pain which might be induced from the zinc chloride in the former and the glacial phosphoric acid in the latter.

The form of gutta-percha known as "temporary stopping" is furnished in two colors, pink and white, and is used principally for "sealing in" dressings that have been placed in carious cavities to reduce hypersensitiveness or to destroy the vitality of the pulp, or for covering dressings that have been placed in the root-canals of devitalized teeth. On account of its extreme softness, however, it is not intended to subserve more than the most temporary purpose, although this feature makes it very valuable, as it is easily and quickly introduced, and as easily and quickly removed.

Many operators confine their use of the *pink variety* to covering arsenical applications and other dressings which the conditions of the tooth make imperative should be changed at the next sitting, while the *white* is used for those cases which are not urgent, or are being tested as to their fitness to receive a permanent filling.

Gutta-percha which is prepared for *filling the root-canals of devitalized teeth* is made in the form of long slender cones or points, either by rolling or cutting of proper size and form to be readily introduced into the canals. They may be prepared either from the pink base-plate gutta-percha or from the white variety.

Gutta-percha by reason of its indestructibility, non-irritating character, ready adaptability, and ease of manipulation is the material *par excellence* for filling root-canals.

For "*guarding*" *zinc oxyphosphate fillings* at the cervical margin it is of great value, for it prevents the dissolution of the cement which is so common at this location, and thereby relieves the anxiety of the operator over the possibility of the oxyphosphate being undermined in a few months and the carious process re-established. In many individuals the oxyphosphate cement wears well, even in positions exposed to the attrition of mastication, but is rapidly disintegrated at the cervical margins. By "guarding" with gutta-percha at these locations the durability and value of such fillings is greatly increased.

As a *capping for nearly exposed pulps* gutta-percha of the "low heat" grade has no equal, its greatest value lying in its non-conducting quality, which protects the pulp from thermal shock.

As a *permanent filling* in large cavities in the deciduous and permanent teeth not subjected to the friction of mastication, especially buccal cavities in molars and simple labial or approximal cavities, the "high heat" grade may be depended upon to wear well and to protect from a recurrence of caries. It has its greatest usefulness in those cavities in which the carious process has penetrated to such depth as to nearly expose the pulp,—the pulp being first protected by a layer of the "low heat" grade,—and in devitalized teeth which have very frail cavity walls or are inclined to pericemental or apical irritation, and by reason of its non-irritating quality in all cavities which extend beneath the free margin of the gum. Many operators use it to the exclusion of all other filling-materials for stopping approximal cavities in the anterior permanent teeth of children under twelve to fourteen years of age. Fillings in these locations, if properly introduced, may be counted upon for doing good service for from five to eight years or longer.

The pink base-plate gutta-percha wears better in all exposed surfaces than the white, but the white, by reason of its more harmonious color, should be invariably used in all cavities in the anterior part of the mouth.

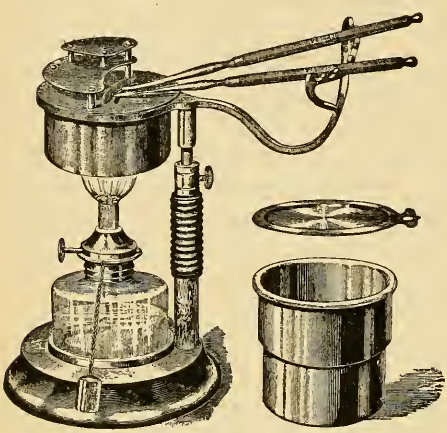
The pink base-plate is also a very serviceable material for maintaining a temporary separation of teeth which are to be filled with metallic stoppings, but in which the pericemental irritation induced by the separating process is so great as to make it necessary to postpone the operation to a later date. Or it may be used for gaining temporary separations between the bicuspids and molars preparatory to introducing contour fillings, by packing the approximal cavities full of the material and allowing the force of mastication coming upon the fillings to gradually separate the teeth by the spreading of the material.

Methods of Softening.—*Upon the proper softening of the prepared gutta-percha stoppings depends their integrity and durability.* The greatest of care should be exercised in softening gutta-percha that it be not overheated ; this caution cannot be emphasized too strongly, as the complaints so often made of gutta-percha "rotting" or disintegrating in the mouth are the result of overheating, or "heat-rotting," before introducing the filling, and not disintegration of the material from the action of the oral secretions, as some have supposed.

Permanent results cannot be obtained with gutta-percha—except by accident—when the material is heated by holding it in the flame of a lamp or Bunsen burner, as practised by so many operators, as by this method it is usually overheated, and as a result, when subjected to the influences of the oral secretions, softening and disintegration take place.

Dr. Flagg some years ago invented the device shown in Fig. 462 for heating the various grades of gutta-percha and the packing instruments. It is composed of a lamp-stand, which carries a small metal water-tank, upon the cover of which are arranged two shelves; the upper one, which receives the least amount of heat, is intended for softening the "low heat" grade of gutta-percha, the lower one softening the "medium" grade, while the cover of the tank is utilized for heating the "high heat" grade and the packing instruments, the handles of which rest upon a notched rack and the points upon the cover of the tank. Water is placed in the tank and heated to the boiling-point. Overheating of the various grades of the material becomes impossible by using this method of softening.

Fig. 462.



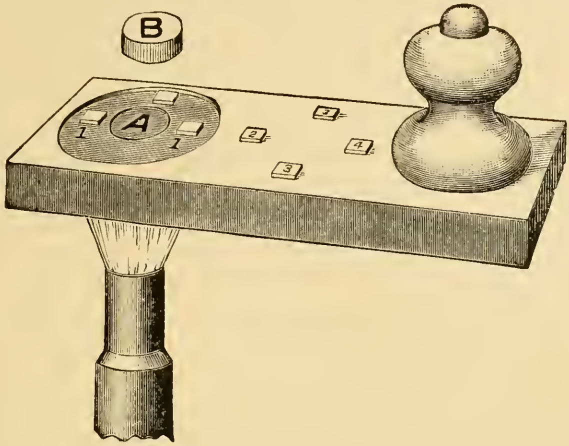
Flagg's improved gutta-percha softener and tool-heater.

Of late years there has been a demand upon the part of some operators for harder grades of gutta-percha, which require a degree of heat for their softening greater than can be obtained by boiling water. The thermoscopic heater of Dr. W. Storer How,* shown in Fig. 463, meets these requirements in a most perfect and scientific manner. The heater is composed of a block of steatite, selected for its heat-retaining qualities and the desirability of its surface. At one end is a wooden handle, at the other end a circular recess, in the centre of which is a small disk, A, made of fusible metal which melts at 212° F. On the heater within the circular recess are placed a suitable number of gutta-percha pellets, as 1, 1, and the heater is held over the flame of a spirit-lamp or Bunsen burner until the disk of fusible metal is melted, when the gutta-percha will be sufficiently softened for introduction into the cavity. The heater will maintain the proper temperature long enough for the completion of an ordinary

* Dental Cosmos, vol. xxxiv. p. 281.

operation, but if the metal in the mean time loses its fluidity and thus indicates the lowering of the temperature. it can be restored by holding the heater for a moment over the flame until the metal again becomes fluid.

FIG. 463.



Dr. How's thermoscopic heater.

When the metal disk is fused the pellets 1, 1, will be at a temperature of about 212° F., while pellets at 2 would have a temperature of about 200° F., and those at 3 and 4 about 194° and 180° F. respectively. Disk B, which is made of fusible metal which melts at 230° F., is provided as a substitute for disk A, which may be melted and poured out, and B used in its stead. In this manner the "high heat" gutta-percha and the lower grades may be properly softened without the least degree of "heat-rotting" of the material.

Manipulation of Gutta-Percha.—*Instruments* which are suitable for filling difficult and inaccessible cavities with gold are best adapted for packing gutta-percha, for, as a rule, the cavities in which this material is generally used are in difficult and inaccessible locations. In packing this material it is best to use warm instruments, as it is important that the whole mass of the filling be kept in a plastic state until perfect adaptation to the walls has been secured.

The *preparation of cavities* to receive gutta-percha fillings, while requiring the thorough removal of all decalcified and infected dentin, should also be directed to the conservation of the enamel walls to the full limit of safety against fracture, especially in preparing approximal cavities in the incisors and cuspids.

With an intact labial enamel wall, though it be transparent, gutta-percha can be so packed against it as to protect and strengthen it, and at the same time so restored in color as to defy detection except by close scrutiny.

It is important in the *introduction of gutta-percha* that moisture be excluded from the cavity. The rubber dam should therefore be adjusted, and as much care taken in this respect as would be given to it if the cavity were to be filled with gold. The cavity should next be dried and sterilized, and again dried, after which the gutta-percha may be packed in place. This may be done by either one of two methods.

The *first* method is by introducing the gutta-percha in small pellets into the cavity,—which has been previously warmed by a blast of heated air,—packing them first into the most inaccessible parts of the cavity, and finishing with a larger mass.

The *second* method is to introduce a single large mass somewhat larger than the cavity, and with a broad spatula-like instrument, with a rocking motion work it into the cavity much as would be done in taking an impression of the part.

Some operators prefer to line the cavity walls with oxychloride or oxyphosphate of zinc cement in those cases in which the walls are very thin and frail; tinting these materials to match the color of the tooth, and after it has hardened to fill the balance of the cavity with gutta-percha after one of the above methods.

Dr. How believes that the common method of introducing the filling in small pellets is responsible for leaky fillings. He says, "There is good reason for the belief that the common mode of successively introducing small pieces of perfectly softened gutta-percha into a comparatively cold cavity, and employing instrument points more or less heated for packing the cooled plastic against one side of the cavity after another, must in the nature of the case result in a leaky filling, such as gutta-percha is commonly said to make, whereas the defect is due not to the material, but to its inconsiderate manipulation." Dr. How claims that by the "single mass" method perfectly moisture-tight plugs can be made, as demonstrated by him, such fillings successfully resisting the aniline-dye test after several days' immersion.

Finishing Gutta-Percha Fillings.—Gutta-percha fillings which have been properly introduced need but little trimming or finishing. To hasten the hardening of the filling, a spatula which has been immersed in ice-water and quickly dried should be applied to the surface of the filling to abstract the heat, and as soon as it has been sufficiently cooled the overlapping edges may be removed with Dr. Gordon White's sickle-shaped trimmers (Fig. 444) or those of Dr. E. K. Wedelstaedt. The surplus material should be shaved off in thin slices, never in large mass, as this effort would be likely to drag the filling away from the margins. The trimming should always be from the centre of the filling towards the circumference, for the same reason. The surface may be finished by a rapidly revolving cuttle-fish disk, or by wiping the surface of the filling with a tape moistened in chloroform.

ZINC CEMENTS.

The zinc cements—or "osteoplastics" as they are sometimes called—used in dentistry are the oxychloride, the oxyphosphate, and the oxysulphate. The oldest of these is the oxychloride, which was first introduced to the profession about the year 1850, or a little later, by M. Sorrel as a permanent filling-material, and on account of its hardness, whiteness, and apparent insolubility, it gave promise at first of fulfilling the expectations of its inventor, but later all hopes in this respect were abandoned, as it was found to undergo rapid disintegration whenever the material was placed in contact with the margin of the gum or very near to it, and it also contracted very considerably in hardening, and therefore resulted in leaky fillings.

Zinc oxychloride is formed by the combination of calcined and pulverized zinc oxide with a solution of zinc chloride in distilled water: $ZnO + ZnCl_2 + H_2O = 2ZnClHO$.

"Zinc oxide is made by heating metallic zinc in a current of air. To make a pure white zinc oxide for pharmaceutical purposes, pure precipitated zinc carbonate should be heated at low red-heat until the water and carbonic oxide are wholly expelled. This can be done below 500° F. Too high heat will give the product a yellow color and make it feel harsh. A small quantity should be used in heating. A good quality of zinc oxide should come in the form of a soft, flaky, impalpable powder of sp. gr. 5.6. It should turn yellow when heated in a test-tube, and become white again on cooling. It is insoluble in water, but completely soluble in dilute acids. It is not darkened by sulphuretted hydrogen.

"Zinc chloride is made by heating zinc in a current of chlorine, or by the action of hydrochloric acid on granulated zinc, or zinc carbonate, and evaporating the solution to dryness. It occurs in the form of hard, dirty-white masses, very deliquescent, and forming a clear solution in water. It is one of the most soluble substances known. Zinc chloride has a caustic, sharp taste, and is acid in reaction. It is soluble in alcohol and in ether." (Mitchell.)

Zinc oxychloride as prepared for dental use is composed of a *powder* and a *liquid*.

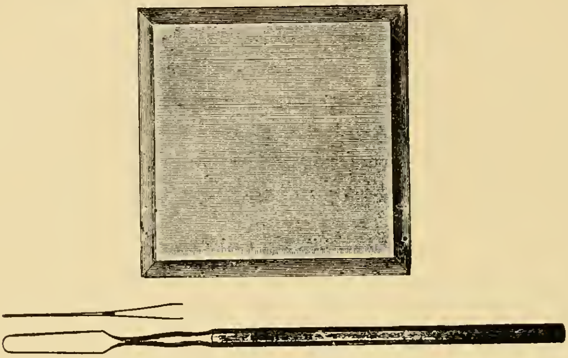
The *powder* is made by thoroughly triturating in a mortar two grains of borax and four pennyweights of zinc oxide. These are then placed in a small crucible and subjected to a glowing red-heat for from seven to ten minutes, forming what is termed a "frit," which when cooled is finely pulverized in a mortar. Sixteen pennyweights of zinc oxide are then placed in a crucible and subjected to a moderate red-heat for three or four minutes, and allowed to cool. After which it is gradually added to the "frit," and the whole thoroughly pulverized and mixed. It should then be transferred to a glass-stoppered bottle to protect it from the moisture of the atmosphere.

The *liquid* is made by dissolving half an ounce of zinc chloride in two or two and a half drachms of water, and after several shakings allowed to settle for a few days, when the clear fluid may be decanted off. If the solution does not clear it should be filtered. (Flagg.)

Mixing.—For mixing zinc oxychloride, or in fact any of the zinc cements, a glass slab and a suitable spatula are necessary (Fig. 464). Upon the mixing-slab are placed one or two drops of the fluid, and near it a quantity of the powder. These are then incorporated and worked into a thick creamy paste, and it is ready for use. The filling is introduced into the cavity by small spatulas (Fig. 465), and adapted to the walls by means of pellets of bibulous paper, which remove any surplus of liquid, and thus hasten the setting.

Characteristics and Properties.—Zinc oxychloride sets rather slowly and is not so hard when set as the oxyphosphate cements. About fifteen minutes are required for it to set sufficiently hard to allow amalgam to be packed upon it without displacement, and half an hour to an hour for a

Fig. 464.



Bevelled edge (glass) mixing-slab and spatula.

gold filling. Some operators defer the operation of covering it with a metallic filling until a future sitting, protecting the cement with a gutta-percha filling until that time, in order that the cement may furnish a harder foundation for the metallic filling.

When used in large masses it shrinks notably. It stands low in the scale as a conductor of caloric, and like all compounds which contain zinc oxide, it is readily decomposed by the action of acids and alkalies.

Fig. 465.

Zinc oxychloride is not a definite chemical compound, and cannot be made by the method of mixing without one or the other of the constituents being found in excess.

According to C. S. Tomes, there is always free zinc chloride to be found in the finished filling, and consequently the filling is hygroscopic.

When freshly mixed, if it is brought into contact with vital soft tissues it is irritating and escharotic. Consequently it should never in the creamy state of the mix be brought into contact with an exposed pulp, or one nearly exposed, as inflammation and devitalization in a large majority of instances would be the result. If the material is mixed to a doughy consistency, it may sometimes be used as a capping for nearly exposed pulps. The danger to the pulp lies in the irritating effect of an excess of the zinc chloride. After the filling has set, it retains antiseptic properties for some time thereafter, as shown by Miller in his experiments upon the antiseptic properties of filling-materials.

Zinc oxychloride has also an obtunding effect upon hypersensitive dentin if left in the cavity for a month or more. It is also, by reason of its antiseptic properties, an excellent material with which to fill the roots of devitalized teeth. It may be used alone for this purpose, or combined with other materials like gold-foil, gold wire, lead, or gutta-percha points; while on account of its extreme whiteness it may be successfully used as a lining of cavities to restore the color of devitalized teeth.

Zinc Oxyphosphate.—Cements of this class are formed by a combination of calcined zinc oxide and orthophosphoric acid, $3ZnO + 2H_3PO_4 = Zn_3(PO_4)_2 + 3H_2O$, nominally, for on account of the impurities in the zinc oxide and of the inconstancy of the acid itself, their actual composition is one of considerable variability.

"Phosphoric acid has modifications—metaphosphoric and pyrophosphoric acids—which differ from it in the number of the combined equivalents of water; and these forms pass into one another somewhat readily. Thus a solution of metaphosphoric acid when boiled passes into orthophosphoric acid; pyrophosphoric acid may be prepared by evaporating a solution of orthophosphoric acid at a temperature of about 215° F.; but it, in the presence of water, slowly passes back into the orthophosphoric acid at ordinary temperatures. Each of these acids is capable of forming a number of different salts—monobasic, dibasic, tribasic, or tetrabasic salts—with the same metal, and thus a large number of zinc phosphates are known." (C. S. Tomes.)

Zinc oxyphosphate as known to the dentist is composed of a *powder* and a *liquid.* The powder is zinc oxide, the liquid one of the many forms of phosphoric acid.

When glacial phosphoric acid is used, the cement is termed *oxymetaphosphate.* Cements which are made from the commercial phosphoric acid are not so durable as are those which are made from the pure acid.

Purity in the materials which enter into the composition of the zinc oxyphosphates is a *sine qua non.*

Some manufacturers are in the habit of preparing the powder from the commercial metallic zinc, and as a result it often contains impurities, like the arsenic compounds, which, according to some writers, explains in a measure the reason why teeth which have been filled with oxyphosphate cement, and vital teeth carrying crowns and supporting bridges which have been set with this material, have sometimes been devitalized.

The writer, however, has never seen a case of devitalization of the pulp under zinc oxyphosphate which could not be satisfactorily explained upon some other hypothesis.

Ames, in experimenting on the zinc oxyphosphates (*Dental Cosmos*, 1890), prepared specimens of zinc oxide containing seven per cent. of arsenous oxide (zinc arsenite), and with this compound applied to cavities in vital teeth he was unable to produce devitalization of the pulp.

The zinc oxide and arsenic compound used in these experiments was prepared "by heating in a sealed tube certain proportions of zinc oxide and arsenous oxide. In confinement a full red heat will effect a thorough combination of the maximum amount of arsenic with the zinc, which seems to be about seven per cent. This is sufficient to give an extensive mirror with the Marsh test. This combination is such that 3000° F. can afterwards be applied to the compound in an open crucible without affecting the composition. This is necessarily the same compound which is formed in infinitesimal quantities in the manufacture of cement powders." He believes that the arsenic found in the zinc cements is in combination with the zinc in the form of zinc arsenite, and that this combination is wholly devoid of poisonous properties *per se*; and that the combination is not broken up to the extent of forming potent arsenous acid, except under rare and unjustified conditions.

To obtain zinc oxide and glacial phosphoric acid in a pure state are expensive processes; the temptation, therefore, of the manufacturers to send out materials which are less troublesome to make and of inferior grade is very great.

The *powder* is made by treating zinc oxide with nitric acid, evaporating it to dryness, calcining and pulverizing. (Flagg.) The calcining process requires several hours, the material being kept at the highest forge heat during this time, thus forming a vitreous mass, which on cooling is removed by breaking away the crucible. After thorough pulverization it is sifted through a fine bolting-cloth and placed in tightly stoppered bottles to protect it from the atmosphere, for if it is exposed it absorbs carbon dioxide from the air, and a portion of the material is converted into hydrated zinc carbonate. The presence of carbon dioxide is noticed by the effervescence which takes place in such samples when phosphoric acid is added to them, the effervescence being due to the liberation of carbonic oxide. Coarse powders, according to Ames, produce cements with greater crushing stress than those made from fine powder.

Rollins's process for making the powder is, "Dissolve pure zinc in chemically pure nitric acid to saturation, then evaporate to dryness, pack in a crucible, and heat until no more fumes are given off. When cool break up the crucible, and after separating the oxide of zinc, pulverize it to a fine powder."

Flagg terms the zinc oxide made in this manner "nitrate of zinc," and claims it makes a far superior cement to those powders which are produced by calcining zinc oxide.

The *liquid* which is combined with the powder in making zinc oxyphosphate cement (oxymetaphosphate) is glacial phosphoric acid, HPO_3 (metaphosphoric acid). This form of the acid is derived by subtracting two molecules of water from orthophosphoric acid, $H_5PO_5 - 2H_2O = HPO_3$, metaphosphoric acid.

Rollins's process of making metaphosphoric acid is, "Take a pure solution of orthophosphoric acid, which is easily obtainable, of a strength of sixty per cent.; evaporate it in a platinum evaporating dish until white fumes are given off. Then heat it to a bright redness to be sure that it is all converted; cool and make into a thick syrup." (Mitchell.)

The impurities found in the commercial glacial phosphoric acid forbid its use in the making of zinc oxyphosphate cement. These impurities consist of variable quantities of sodium, calcium, and magnesium phosphates.

"These salts are permanently soluble in the phosphoric acid, and therefore give no evidence of their presence by the formation of precipitates. They are also soluble in water, which fact has a direct bearing upon the durability of cements made with the impure acid." (Burchard.)

The various preparations of phosphoric acid are proverbially unstable, and none more so than the metaphosphoric acid used in the formation of the zinc oxyphosphate cements.

Precipitates are often thrown down in a few weeks after manufacture or crystallization takes place. The precipitates are in all probability metallic phosphates, while crystallization may be due to imperfect conversion during the process of heating. These acids are all strongly hygroscopic; the metaphosphoric acid being slowly converted into the common phosphoric acid by abstraction of water from the atmosphere. It is therefore important that the *liquid* be kept tightly corked when not in use to prevent change taking place in it, if the best results are to be obtained with the cement.

Properties and Uses.—Zinc oxyphosphate cements possess certain properties which make them exceedingly useful in the daily practice of the dentist, the most important of which are: First, as a *lining* for large cavities with thin, frail walls it is far superior to zinc oxychloride, by reason of its stronger adhesion to the walls of the cavity, thereby increasing their strength and lessening the danger from fracture, and its greater hardness, which makes it a better foundation for metal fillings; second, as a *temporary filling* in devitalized teeth which have been placed upon probation, in vital teeth having large and very sensitive cavities, and in the deciduous teeth of children, by reason of its easy introduction, ready adaptability, and its evident obtunding effect upon hypersensitive dentin; third, for sealing in arsenical dressings; and fourth, for cementing crowns, bridges, orthodontic appliances, and inlays.

As a conductor of caloric it possesses a slightly higher ratio than zinc oxychloride. On account of the strong affinity of metaphosphoric acid for water it often causes pain when first placed in sensitive cavities by abstracting the moisture from the dentinal tubuli, while if placed in contact with an exposed or nearly exposed pulp the pain is often excruciating. This may be obviated by lining the cavity with one of the quick-drying ethereal varnishes or by interposing a layer of softened gutta-percha.

Zinc oxyphosphate, however, should never be used for fillings which approach the gingival margin or extend beneath it without guarding this vulnerable point with gutta-percha. Zinc oxyphosphate is readily dissolved by solutions of lactic acid, and this is almost always present at the crevices of the teeth, along the borders of the gingivæ and in the interapproximal spaces. Fillings thus guarded, if well made, will last from one to five years, and in favorable cases they have been known to do good service for a much longer period, while the operator will be relieved of the anxiety incident to the tendency of the material to disintegrate at the cervical margins when guarding is neglected.

Mixing and Introducing the Cement.—As a preliminary to preparing the cement for introduction into the prepared cavity the rubber dam should be adjusted, in order that perfect dryness of the cavity may be maintained during the insertion of the cement and the early stage of the hardening or setting process.

In mixing the oxyphosphate cement one or more drops of the liquid, according to the size of the cavity to be filled, are placed upon the glass mixing-slab, and near it a quantity of powder; with a spatula a portion of the powder is then drawn into the liquid and mixed by rubbing with the flat surface of the spatula, other portions being added a little at a time until a mass is formed of the consistency of soft dough, the surface being sticky or *tacky*, so that when it is applied to the dried surface of the cavity it will adhere or stick.

Cements which are made so hard that they can be rolled in the fingers have not given, in the practice of the writer, as good clinical results either in hardness or wearing qualities as those mixed as above described.

The instruments which are the most applicable for the introduction and packing of the oxyphosphate cements are those generally used for introducing amalgam fillings, the spatula-shaped instruments being the most useful.

If the mix has been made of a sticky or tacky consistency, the final packing of the filling and the shaping of the surface will be more readily accomplished by covering the surface of the instrument with oil, vaseline, or glycerol, to prevent the material from sticking to it. The writer prefers the glycerol for the reason that it is just as good as the other substances for preventing the material from clinging to the instruments, while it has the advantage of not leaving an unpleasant taste in the mouth.

The rubber dam should not be removed until the filling has set sufficiently hard to permit of finishing the surface. The finishing may be accomplished with cuttle-fish disks, Arkansas stones, and burnishers. It has generally been thought that the process of crystallization was promoted by protecting the filling for some considerable time from the moisture of the mouth, and the manufacturers of these cements usually recommend covering the surface of the filling with some protecting substance, like sandarach varnish, or burnishing hot wax or paraffin over it. The utility of such a procedure would seem to be questionable in the light of recent investigations upon the cements, conducted by Ames* and Wedelstaedt.

Shrinkage and Expansion.—Ames thinks there is no advantage to be gained by protecting the cement fillings for an indefinite period from the saliva, as he found a distinct and radical difference in the amount of shrinkage when the two classes of cements—viz., first, those modified by alkaline phosphates; and second, those modified by non-alkaline phosphates—were permitted to harden in a dry state; but when the process of crystallization was allowed to take place with the mass subjected to water there was a marked modification of the amount of shrinkage, which was often changed to expansion in the second class of cements.

"In the oxyphosphates wherein the phosphoric acid has been modified by *alkaline phosphates* only, the basic phosphate which is formed, and which

* Dental Cosmos, 1899.

accounts for the hardening of the mass, is of a friable nature, and is of itself a porous material; so that in agglomerating the crystals or granules of the zinc oxide it exerts no special force which would result in a drawing together of the granules and make evident a shrinkage at the periphery.

"In the oxyphosphates wherein the acid has been modified by *non*-alkaline phosphates, the basic phosphate formed has a glassy nature, and not only agglomerates, but agglutinates the zinc oxide granules. In the previous case the basic phosphate itself becomes porous in its crystallization; while in the second case it is a glassy material which agglutinates the granules to such an extent as to cause a drawing of them towards a centre if the composition happens to give a tendency to a diminution of volume during the crystallization. This diminution of volume sometimes depends on a lack of water of crystallization, which if present in the composition would give too rapid setting, but which if added to the crystallizing or hardening mass will be taken up and give the difference between a shrinkage and zero or an expansion.

"In the first there is a diminution of volume which is not apparent, because the material forms a porous mass, and there is shrinkage towards an infinite number of centres instead of one, as in the second class. In the second class there may be diminution of volume in the dry state, and zero or expansion by furnishing extra water of crystallization."

Wedelstaedt* in his investigations was surprised to find "that some of his experimental fillings of oxyphosphate would expand two millimetres beyond the cavity in which they were made, and was equally surprised to find shrinkage in some cement fillings when made in fresh teeth and tested in moisture. The aniline ran completely around the filling, leaving the axial wall of the cavity as well marked as though no cement filling had been placed in that cavity."

Penetration of Moisture.—Wedelstaedt† discovered also that the oxyphosphate cements were readily penetrated by moisture, as was proved by the fact that out of more than thirty different specimens of cements only one was not penetrated from circumference to centre when subjected to the aniline test. The same was found true of the oxychlorides, for only one sample, "Justi's Acme," was not penetrated by moisture. The writer, in conducting a similar series of experiments, found but one form of zinc oxyphosphate cement that was impervious to aniline dyes. Specimen fillings made from the "Ames Metaloid," after being immersed in aniline for ten days, showed no penetration either at the margins of the filling or within the mass.

Crushing Stress.—Wedelstaedt‡ also found that some of the oxyphosphate cements would sustain a surprising amount of stress when thoroughly hardened, and that *age*, up to a certain point, added very greatly to the strength of the filling. Six fillings were made in cylinders of the uniform size of two and a half by three and a half millimetres, and all made from the same cement and from one mix. These were tested in a dynamometer, two at the end of twenty-four hours, when it was found that at a pressure

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* Dental Cosmos, 1899. † Ibid. ‡ Ibid.

of from eighty to ninety pounds they crushed to pieces. At the end of forty-eight hours two others were subjected to the pressure of the dynamometer, and sustained a stress of two hundred pounds before going to pieces. At the end of seventy-two hours, the two remaining cylinders were found to successfully carry a weight of from three hundred and fifty to four hundred pounds before crushing. Other fillings, tested ninety-six hours after they were made, carried over four hundred pounds of stress before going to pieces, which is a sustaining strength superior to that of the best-made amalgam or gold fillings. The best-made fillings of the former material, according to Black, crush at from three hundred and twenty-five to three hundred and sixty pounds of stress, while the fillings made from the latter material show a shortening of the mass under a stress of three hundred and fifty pounds of from two to fifteen per cent.

Zinc Oxysulphate.—This preparation is in no sense a filling-material, but it is a valuable adjunct to the other materials for protecting and capping pulps which are nearly exposed.

Zinc oxysulphate is composed of a *powder* consisting of one part of calcined zinc sulphate to two or three parts of calcined zinc oxide. The *liquid* consists of a solution of gum arabic to which a small quantity of calcium sulphite has been added. The powder and liquid mixed together form a mass which sets quickly and attains considerable hardness. (Flagg.)

It is non-irritating to sensitive dentin and to exposed pulps, a good non-conductor of caloric, slightly astringent, and seems to possess a peculiar conserving action upon the pulp not shared to an equal degree by any other material used for this purpose.

For protecting nearly exposed pulps a thin paste is made of about the thickness of cream, which is carefully flowed over the bottom of the cavity and allowed to harden,—setting takes from five to fifteen minutes,—when it should be covered with a layer of oxyphosphate.

In capping exposed pulps a tiny disk of writing-paper or other suitable material is dipped in the paste and quickly and carefully laid over the exposure and covered with a small quantity of the paste. When set oxychloride or oxyphosphate cement may be placed over it and the cavity lined with the same material, preparatory to the introduction of a metal filling or a porcelain inlay.

The rubber dam should invariably be used, as the exclusion of all moisture is absolutely necessary to the success of the operation.

VARNISHES.

Varnishes are often used for *lining* cavities preparatory to the introduction of the plastic fillings, especially of the zinc oxychlorides and oxyphosphates, the object being to protect the sensitive dentin and the pulp from the irritation sometimes induced by the action of the acids contained in the liquids of these compounds, and by the non-conducting quality of the varnish to lessen thermal shock.

These varnishes are made by combining certain gums and resins with alcohol, chloroform, and ether, such as gum sandarach in alcohol, virgin rubber in chloroform, Canada balsam, copal, or dammar in ether, and trinitro-cellulose in methyl alcohol. These solutions should be made thin enough to flow readily, and be applied to the cavity by a pellet of cotton.

As soon as the varnish has dried the cement lining may be introduced, the enamel margins having first been freed from any portion of varnish. The same precaution must be observed in freeing the enamel margins of the cement before the permanant filling-material is introduced, as carelessness in this regard is bound, sooner or later, to result in a leaky filling from disintegration of the film of varnish or of the cement allowed to remain between the filling-material and the enamel margin.

Some operators are in the habit of lining with varnish all cavities that are to be filled with gold or amalgam, claiming for this method that it greatly lessens thermal shock by sealing the open ends of the tubuli and interposing a non-conducting film between the sensitive dentin and the filling, and prevents discoloration when amalgams are employed.

The same method is pursued by these operators when filling with gutta-percha, especially when employing the "high heat" material, as the adhesiveness of the varnish in retaining the first pellets in position is considered an added advantage of the varnish lining.

CHAPTER XXI.

INLAYS.

Definition.—As applied to dental surgery, an *inlay* is a piece of any substance, like gold, glass, porcelain, etc., which is inserted in a cavity prepared to receive it, or attached to a portion of the crown of a natural tooth. The distinction between an *inlay* and a *filling* being that the inlay is inserted into the cavity in a solid piece and retained in its position by means of cement, while a filling is introduced in numerous small pieces, which either cohere or weld to make a solid mass, or are held together by mechanical pressure or the interlacing of particles, the completed filling being held in place by the adaptation of the material to the walls of the cavity, assisted by the retentive form which has been given to it.

The dream of the truly scientific and artistic dentist has always been the discovery of a material with which to restore those portions of the natural teeth which have been lost by the disintegrating effect of dental caries, or by traumatic injury, that would be indestructible in the secretions of the oral cavity, protect the tooth against the further ravages of caries, restore its original beauty of form, color, and translucency, and at the same time place it in a position to perform all of its functions in a normal manner.

The art of the porcelain-worker has already reached such perfection in the construction of artificial crowns that the visible portions of such restorations are so natural in their appearance as to be beyond detection except by a critical examination.

The success in this direction has stimulated the desire to successfully restore by the same means such portions of the tooth crown as have been lost by disease or accident.

In studying the history of primitive dental art, it will be found that the idea of restoring lost portions of the teeth by the introduction of inlays is as old as the art itself. In the early Greek epoch, teeth were filled with metal inlays by driving solid pieces of lead into the cavity; while doubtless at a still earlier date jade or graystone was used for the same purpose, as found in the central incisors of the skull of a man of an extinct race, discovered at Copan, Honduras, by Professor Owen, a few years ago, and which is now to be seen in the Peabody Museum of Harvard University.

Inlays made of various materials have been employed by the modern dentist, but none possess in so high a degree the many requisites for the ideal filling as does porcelain.

Inlays have generally been used in two classes of cavities only,—viz., in very large cavities in the bicuspids and molars the walls of which were too frail to support gold fillings, and in cavities located upon the labial surfaces of the anterior teeth when it was desirable to use a material that would be less conspicuous than gold, and which would harmonize with the color of the tooth in which it was inserted.

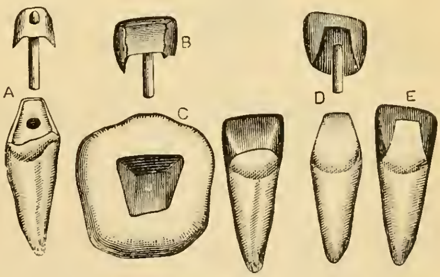
Metal Inlays.—Gold has been recommended for making inlays for large compound cavities in the bicuspids and molars, and is still used for this purpose by some dentists as a saving of time and strength to both operator and patient.

These inlays are made in two ways. One by swaging gold plate over a die made from an impression taken in wax, gutta-percha, a modelling compound, or by burnishing gold or platinum-foil to the walls and margins of the cavity; and the other by fusing gold into a matrix made in sand and plaster mixed with asbestos modelled from a similar impression. The finished inlay is then cemented into place with zinc oxyphosphate cement or gutta-percha. In order to secure the swaged inlay against dislodgement a retaining loop should be soldered to its under side, or pins may be attached, which in devitalized teeth may be made to enter the pulp-canals. The fused inlay should be roughened upon the surfaces which come in contact with the cement for the same purpose, or headed pins may be attached.

Dr. C. L. Alexander describes a method of making gold inlays* which has many good features and may frequently be applied in cases when the restoration of contour by the means of porcelain inlays might, on account of the severe strain to which this material would be subjected, and its liability under sudden and excessive stress to be fractured, be of questionable utility.

The method is equally applicable to vital and pulpless teeth. In the former, anchorage is secured by short posts set in such positions as not to infringe upon the pulp, while in the latter the pulp-canals are freely opened and longer posts so set as to penetrate the canals, as shown at A, Fig. 466, the tooth being prepared as represented at A.

FIG. 466.



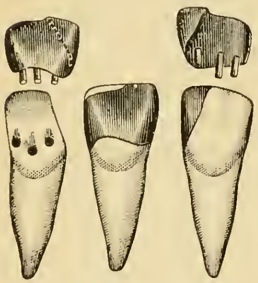
Showing details of the process for making cast filling for incisor. (After C. L. Alexander.) A, post with plate adapted; B, restored contour in wax; C, the contour invested; D, cast contour detached; E, E the finished restoration.

Platinum plate, No. 40 gauge, is then thoroughly annealed and a piece cut from it of proper shape to cover the lingual surface of the crown and extend over the mesial and distal surfaces. This is bent into shape, fitted to its place, and a hole punched in it over the opening to the pulp-canal; the post is then passed through the opening and into the pulp-canal, being long enough to project a little distance beyond the outer surface of the plate. A small piece of soft modelling compound is then moulded over the plate and the projecting end of the post, which when hardened holds them in their relative positions. The piece is then invested in sand and

* Dental Cosmos, October, 1896.

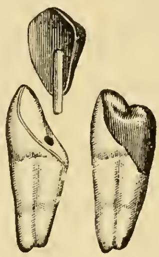
plaster, and the post soldered to the plate with pure gold. It is then returned to the tooth, the platinum plate carefully burnished to the surface of the crown, and the edges are trimmed to the desired shape. An impression and bite are next taken as for making a crown and set up in an articulator with sand and plaster. After removing the modelling compound the contour of the tooth is restored in hard wax upon the platinum base. A piece of No. 60 gold-foil or platinum-foil is then burnished over the wax, covering it except at one wall, preferably the lingual surface. The whole tooth is then cut from the model and invested, care being taken to completely cover it except at the surface of wax not covered with the foil. When hardened the wax is boiled out, leaving the metal lining the matrix, which acts as a carrier for the metal which is to be fused into it. The matrix is then fluxed, filled with pieces of twenty-two-carat solder, and the investment thoroughly heated, when with a fine blowpipe flame directed into the matrix the solder is flowed, more being added until the matrix is full. After it is removed from the investment the casting is finished and cemented into its position; the final polishing to be done after the cement has thoroughly set.

FIG. 467.



Restoration of incisor by cast filling.

FIG. 468.

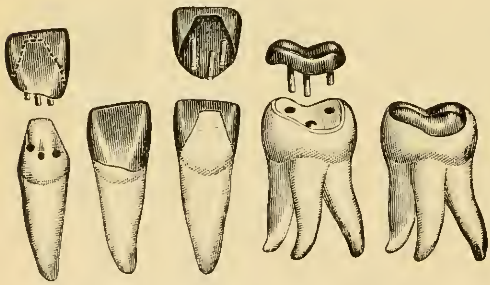


Restoration of molar by cast filling.

(After C. L. Alexander.)

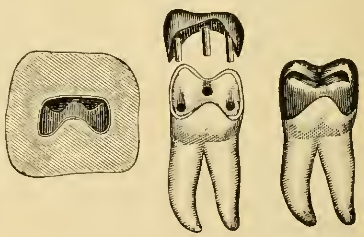
Fig. 467 shows the method of restoring a mesio-morsal angle in a vital tooth. Fig. 468 shows the restoration of the lingual cusp and morsal surface of a devitalized bicuspid. Fig. 469 gives a labial and a lingual view of incisor restoration and cast filling for molar as adapted to vital teeth. Fig. 470 shows a more extensive restoration of a molar tooth. This method may also be adapted to the making of abutments for carrying pieces of bridge-work, as shown in Figs. 471 and 472.

FIG. 469.



Front and back views of an incisor restoration and cast filling for molar. (After C. L. Alexander.)

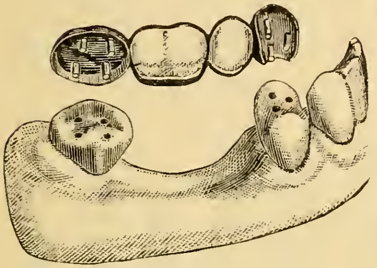
FIG. 470.



Foil matrix invested. Cast filling for molar. (After C. L. Alexander.)

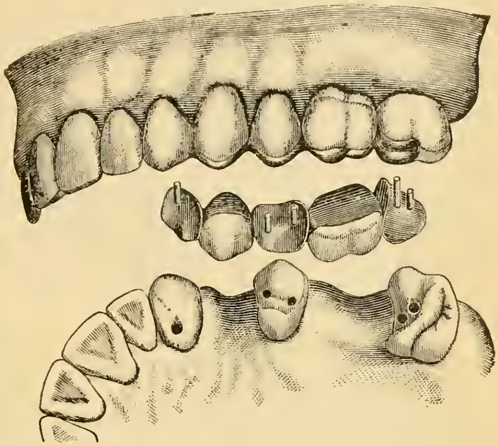
Amalgam inlays were quite extensively used a few years ago in Germany for restoring the contour of the posterior teeth. These were furnished by the dealers in several different shapes and sizes, and were set in position by means of freshly prepared soft amalgam. The only advantage of amalgam inlays is the ease with which they are made, but aside from

Fig. 471.



Method of bridging with inclined abutment. (After C. L. Alexander.)

Fig. 472.



Bridge with cast filling abutments. (After C. L. Alexander.)

this they have nothing to recommend them, and are in no respect as good as amalgam fillings made in the usual way.

Porcelain Inlays.—Porcelain is the only material which has so far been discovered that can be made to imitate natural tooth-structure, and this art, in the manufacture of artificial teeth, has been carried to such perfection that when properly arranged and mounted they are capable of deceiving any one who is not a professional expert in the art. For this reason the artistic dentist has always looked forward to the time when porcelain could be substituted for gold and amalgam in filling teeth in the anterior part of the mouth and in conspicuous locations in the bicuspids and molars.

Various efforts have been made in the past to introduce porcelain as a material for filling teeth, but the difficulties which have always, until very lately, surrounded the operation have deterred all but a very few practitioners from attempting the task.

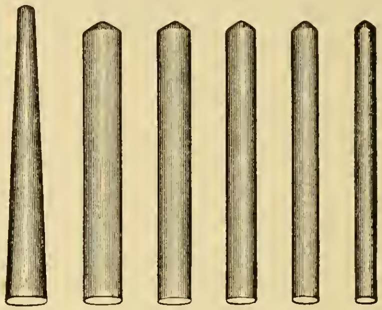
The earliest method of using porcelain as a filling for decayed teeth was to prepare the cavity—usually in the labial surface of an anterior tooth—with slightly flaring walls or bevelled margins, and then to grind a piece of a porcelain tooth having a color that would match that of the tooth in which the inlay was to be inserted until it would fit the cavity, and retaining it *in situ* with zinc oxychloride cement, or by packing gold around the edges. The writer has seen one such inlay, which was inserted by the late Dr. W. W. Allport, that had done service for more than thirty years, and was still as perfect as upon the day in which it was completed. The method of grinding adopted by the earlier operators was to smear the margin of the cavity with a water-color, generally red, and then to place the inlay in the cavity, and after removing it grind those places which had received the color as is practised in grinding gum sections to fit the rim of a gold plate.

Another and perhaps better method of fitting such inlays is to take an impression of the margin of the cavity—after it has been prepared to receive the inlay—with a piece of No. 20 tin-foil, by placing it over the cavity and with a soft rubber eraser or a rubber bottle-stopper pressing the foil firmly until the margin is sharply marked. This impression should then be carefully trimmed to the line of the cavity margin, and the pattern glued to the upper surface of the piece of porcelain tooth that is to become the inlay to serve as a guide in the grinding. The section should be cemented with shellac to a piece of wood on its under surface to assist in holding it during thé process of grinding. With care, patience, and unlimited time at the disposal of the operator a perfect fit may be obtained, but only after repeatedly trying the inlay in the cavity. The final fitting of the inlay may be expedited by cementing with shellac the end of a short section of wire or a broken excavator handle to its upper surface, as this overcomes the difficulty in holding the section during the process of grinding, and offers a ready means of inserting and removing the section from the cavity. The time consumed in this process of fitting inlays is so great that few people are willing to sufficiently remunerate the dentist to make it a profitable or popular operation.

Fig. 473.

Porcelain stoppers.

Fig. 474.



Inlay rods.

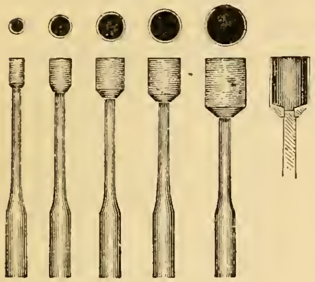
As a means of overcoming some of the difficulties attending this great time-consuming operation the dental porcelain manufacturers have placed upon the market ready-made porcelain inlays of different shapes, sizes, and colors, known as porcelain stoppers (Fig. 473). These stoppers cannot be used until they are ground to fit the cavity, which may be done after the manner just described.

Another method is that devised by Dr. G. H. Weagant, which consists of cutting inlays from artificial teeth or inlay rods (Fig. 474) by the aid of especially devised trephines of five different sizes (Fig. 475), made of copper and charged with diamond dust.

These trephines are to be used in conjunction with How's inlay burs (Fig. 476), which correspond in size to the trephines.

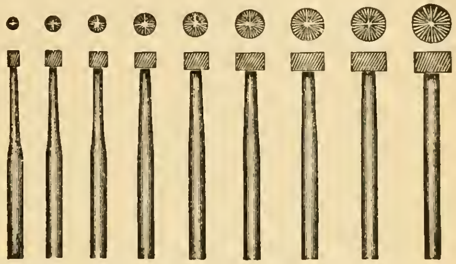
After the decay has been removed from the cavity, a bur is selected from the How set which will be large enough to include the utmost limits of the cavity, and the final preparation of the cavity completed with it. A trephine is next selected which corresponds in size with the How bur. and a section cut from an artificial tooth, preferably of English make, whose color matches that of the natural tooth. This inlay is then cemented *in situ* with zinc oxyphosphate, and after the cement has set any projection of the inlay may be dressed off with fine Arkansas stones, or diamond disks or burs. If English artificial teeth are used, or those of

FIG. 475.



Weagant trephines.

FIG. 476.



How inlay burs.

the Consolidated Dental Manufacturing Company, the inlay will receive a fine polish, and, not being of porous material, it will show no tendency to discoloration. This method is, however, open to one very serious objection,—viz., the necessity of sacrificing a large amount of sound dental tissue in order to give a circular outline to the walls of the cavity. For this reason, principally, the method has never been employed to any great extent.

A very beautiful and close joint may be made by this method if the joint is ground while the inlay is *in situ*. This may be accomplished by cutting the inlay a size larger than the cavity which is to receive it, and slightly tapering the section until the lower end will freely enter the margins of the cavity. It may then be cemented to an engine mandrel, and ground into place by revolving it in the cavity, using pulverized pumice moistened with water as the grinding medium, just as the plumber grinds the joint of a water-cock.

Glass Inlays.—Herbst, of Bremen, in 1887, introduced a system of making inlays by fusing powdered glass in a matrix of platinum-gold foil, made by pressing the foil into the prepared cavity with pellets of cotton and burnishing it to the margins.

The powdered glass, which was made from Venetian glass beads, and sold under the names of "Richter's Glasmasse" (glass-body) and Meyer's and Herbst's Venetian Enamel, was furnished by the dealers in several shades, so that it was possible with care to match the color of the natural teeth fairly well, and when the inlay was cemented *in situ* it presented an appearance which very closely imitated the vitreous surface of the enamel.

The method of fusing the glass was to hold the matrix, which had been filled with the material, in the flame of a Bunsen burner or alcohol lamp. In order to render the glass fusible at so low a degree of heat it was necessary to reduce the melting-point by the introduction of a large amount of flux. This rendered the material soft and porous, so that it was unable to withstand the action of the oral secretions or the attrition of mastication, and soon lost its satisfactory appearance, first becoming opaque, then discolored, and later almost black, while the surfaces which came in contact with occluding teeth disintegrated and wore away like zinc phosphate cement.

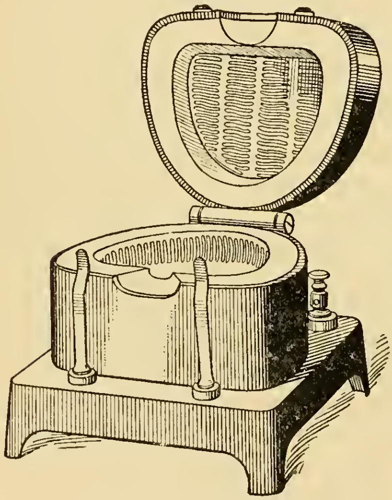
The invention of the *metalic matrix* by Dr. William Rollins, of Boston, and described by him in a paper read before the Society for the Advancement of Oral Science, June, 1880, though almost forgotten for nearly two decades, has, nevertheless, the enviable distinction of having led the way to, and made possible the construction of, artistic and perfect-fitting porcelain inlays.

Another important step towards the perfection of this process was the invention by Dr. C. H. Land, in 1884, of the gas furnace. Before this time the dentist who desired to make a porcelain inlay by fusing the material in a metal matrix was hampered in his work by being obliged to depend upon the slow-heating and cumbersome coke furnace.

This invention was followed by the Downie crown furnace, which was still smaller than the Land furnace, and later by the electric oven of Custer and the electric furnace of Mitchell (Figs. 477 and 478).

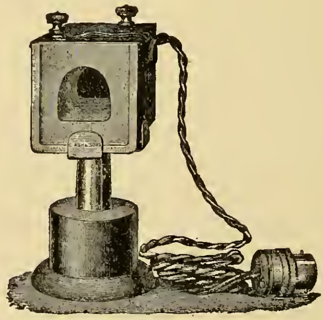
Since the introduction of electricity as a means of heating furnaces for the firing of porcelain the size of the apparatus has been greatly reduced, and the time consumed in heating the furnace and firing the porcelain has

Fig. 477.



Custer electric oven.

Fig. 478.



Mitchell electric furnace.

been curtailed to a few minutes, while the danger from changing the color of the material by the presence of gases has ceased to cause anxiety, and the noise, dirt, and hard labor incident to working the foot-bellows of the gas furnace have all been done away with.

Porcelain.—Until quite recently the porcelain used for making inlays was of the high-fusing grade, the Close or Downie *porcelain body* generally being employed. These *bodies* require a platinum matrix in which to fuse them, as the fusing-point is about 2500° F., which is considerably higher than the fusing-point of pure gold.

The Downie bodies are furnished in twenty-four different shades of color, which makes it possible, when skilfully and artistically combined, to reproduce any shade of color to be found in the natural teeth. These porcelains are admirably adapted for crown- and bridge-work, but they have never been extensively used for inlays, for the reason that a platinum matrix is required in which to fuse them, and this material is so stiff and harsh, even when annealed in a furnace, that it cannot be readily adapted to the cavity walls and margins, and therefore does not furnish so reliable a means of taking an impression of the cavity as does gold-foil, and failures in the fit of the inlay are more liable to occur. For this reason various efforts have been made to produce a low-fusing porcelain that could be fired in a gold-foil matrix, and which at the same time would not be porous, would not change its color in firing, would be susceptible of taking a polish after being ground, would not disintegrate or change its color in the mouth, and would have sufficient strength to withstand the stress of mastication.

For several years Dr. N. S. Jenkins, an American dentist, of Dresden, Germany, experimented with porcelain, and consulted the best chemists and expert porcelain- and glass-workers of Europe in an endeavor to perfect a low-fusing porcelain which would fulfil the requirement of the dental practitioner for inlay work. In March, 1898, he announced to the members of the American Dental Society of Europe—before whom he had frequently discussed the question of porcelain inlays, and had reported from time to time the progress of his experiments—that he had finally succeeded in his undertaking; that he could now pronounce his work finished, and desired first to announce his discovery to them, and then to the profession at large. The announcement attracted universal attention, and dentists everywhere, both in Europe and America, began experimenting with Jenkins's porcelain enamels and his method of making inlays.

These porcelains are very finely ground, and are furnished to the profession in eighteen different color shades, whites, blues, yellows, and browns. Dr. Jenkins says of his porcelain enamel, that he took as his model the Ash & Son's tooth, and tried as far as possible to imitate the fine texture and character of this porcelain tooth body, but so changed its composition as to make it fuse at a degree of heat which would allow of its being fired in a gold-foil matrix. Great difficulty was experienced in obtaining colors which would not change during the process of firing, but he finally succeeded, so that there is absolutely no change at any degree of heat which will not melt the gold-foil matrix.

The permanency of the color in the fluids of the mouth he believes is scientifically certain; the material is not acted upon by any chemic substance except hydrofluoric acid, and is so hard and tough that it will withstand the stress brought upon it in mastication without appreciable attrition or chipping, and retain its polish under the use of the tooth-brush and powder.

Ash & Son, of London, have perfected a high-fusing body in six shades, with two shades of enamel, one dark, the other light, which Dr. J. Leon Williams very highly recommends in an article on "Ceramic

Art in Restoration of Teeth" (*Dental Cosmos*, November, 1899). They have also prepared a low-fusing body in seven colors, and one enamel, which he thinks are in no way inferior to those prepared by Dr. Jenkins.

The Consolidated Dental Manufacturing Company of New York, and Brewster of Chicago, have also prepared and placed upon the market high-fusing and low-fusing porcelains, which seem to be in every way equal to the Jenkins and Ash bodies.

METHODS OF MANIPULATION.

The first important consideration in making porcelain inlays is a *judicious selection of the cases* in which this method of filling teeth is to be employed. It is not, for instance, applicable to cavities in the distal surfaces of the second and third molars, for the reason that in such locations a perfect impression would be difficult or well-nigh impossible to obtain, and consequently an inlay could not be constructed which would be as good as a metal filling inserted in the usual manner. In all other locations in the mouth, with skill and patience, satisfactory inlays may be inserted.

The locations, however, in which they are most applicable are :

1. In cavities upon the labial and buccal surfaces of the incisors, cuspids, and bicuspids.
2. In large cavities located upon the approximal surfaces of the six anterior teeth and the mesial surfaces of the bicuspids.
3. In large cavities involving the mesio-morsal surfaces of the first molars.
4. In large morsal cavities in any of the molars when the walls are thin and the pulp nearly exposed.

One of the great advantages of porcelain as a material for stopping carious teeth is its low conducting power of caloric, which greatly lessens the shock incident to the sudden changes of temperature so constantly taking place in the mouth, and which sometimes makes a metal filling unendurable.

Preparation of the Cavity.—In preparing a cavity to receive a porcelain inlay, the same degree of care should be exercised in removing the decayed and infected dentin that would be expended upon it if it was to receive a gold filling.

The shaping of the cavity is an important feature, and too much care cannot be expended upon it. In general terms it may be stated that the cavity should be formed with flaring walls—in other words, cup-shaped—without undercuts, and the enamel margins slightly bevelled outward, so that when the foil is removed and the inlay is inserted it will set into the cavity the thickness of the matrix and fit tightly at the margins.

In preparing the enamel margins all corners and sharp angles must be removed, the outline of the cavity following graceful curves. The bevel must not be too great, as this would give a thin edge to the inlay and might cause it to chip. In restoring a mesio-morsal or disto-morsal angle of an incisor, it is best to leave the margin *square* at a right angle to the morsal edge, as by this method there is less danger of the enamel edge being fractured. The margins of all morsal cavities should be prepared in the same manner.

Preliminary separation of the teeth for approximal cavities is an essential in inlay work, as plenty of space must be secured if a perfect impression is to be obtained and the normal contour restored.

Taking the Impression.—A perfect impression is a *sine qua non*, without which every effort at making a perfect fitting inlay will prove futile.

The materials which are employed for this purpose are platinum- and gold-foils, platinum No. 30 being used for high-fusing bodies, and gold No. 30, and occasionally No. 40, for low-fusing bodies.

Several methods have been suggested for taking impressions of cavities in teeth which are to be filled with porcelain inlays. The simplest is to cut a piece of foil a little larger than the cavity of which an impression is desired—if platinum-foil is used, this should be thoroughly annealed in a furnace for several minutes and allowed to cool slowly—and place it over the cavity, and then with a ball of cotton, bibulous paper, or amadou, held in a pair of slender curved foil-carriers, gently press the foil into apposition with the walls of the cavity, smoothing out the wrinkles towards the margins. Next pack the cavity with small pieces of amadou, holding them in position with an instrument held in the left hand, while with a ball-burnisher the enamel margins are well defined. The amadou is then removed, and the foil matrix jarred out of the cavity by tapping the tooth with the foil-carrier, or by carefully teasing it out with a curved pointed explorer. Sometimes the matrix will come away with the amadou packing, but if it has to be removed by the means just suggested, a small receptacle should be held under the tooth to receive it when it falls. A small sugar-spoon or a small pill-box will answer the purpose. The surplus foil is then trimmed off a little distance from the line of the enamel margin, and the matrix returned to the cavity and moulded as before. The greatest of care must be exercised not to change the shape of the matrix after it finally leaves the cavity. For this reason some operators recommend investing the matrix in sand and plaster, or in powdered asbestos and plaster. The writer combines the latter materials in equal parts, which form a sufficiently firm and stable investment for the purpose. The investing material should be mixed quite soft, so that when the matrix is laid upon its surface it will embed itself up to the described margins of the cavity.

Some operators think the platinum matrix is sufficiently rigid after being fitted to the cavity to need no supporting investment, and this is doubtless true when heavy foil is used, but not so with light-weight foil, and in any case the investment removes the anxiety of its becoming changed in form, and also insures a perfect fit if it has not been altered before it is invested. As soon as the investment is dry the matrix is ready to receive the porcelain body.

Another method is to fill the matrix with moderately hard wax or gutta-percha before removing it from the cavity, and then, turning it bottom side up, invest it. After the investment has hardened, the wax or gutta-percha is removed by boiling water.

The same methods are employed for taking an impression with gold-foil, but greater care is necessary in removing the matrix not to alter its shape. Gold-foil, however, has the advantage over platinum in that it gives a sharper impression of the walls and margins of the cavity, and therefore insures a more perfect fit. A tear in the foil at the bottom of the cavity is of no consequence, as the body will not pass through it, but a tear occurring at the margin ruins the fit of the inlay.

Dr. Jenkins recommends investing the gold-foil matrix in simple powdered asbestos mixed with water to a thick creamy paste. This investment will be found to be sufficiently strong for the purpose, and it can be fired any number of times without cracking. As soon as the investment has been dried—and this should be done slowly—the matrix is ready to receive the body.

Dr. Van Woert recommends taking an impression with inlay cement, such as that manufactured by the Consolidated Dental Manufacturing Company. The method is as follows : Mix the cement to a stiff paste that can be manipulated with the fingers, press it into the cavity,—which has been previously anointed with vaseline,—and allow it to harden, care being taken to use a mass sufficient to overhang the cavity margins in all directions. When hard, trim sufficiently to allow it to be removed from the cavity without fracturing it. It is then embedded in a piece of warm modelling compound with the impression of the cavity uppermost and the edges free. Then cool in ice-water, and make a counter-die of the cement impression in softened modelling compound. When cooled, this will be found sufficiently hard to permit of swaging No. 30 gold-foil to the exact shape of the cavity in the tooth. The matrix thus fashioned is to be removed and invested in moistened powdered asbestos as above described. Dr. Van Woert claims for this method a more perfect fit, inasmuch as the matrix was made over a die which gives the exact outline measurements of the cavity, and does not leave a deficiency equal to the thickness of the matrix.

Another method of making a matrix is to take an impression of the prepared cavity with a pellet of ordinary oxyphosphate cement, first having lubricated the cavity with oil or vaseline, so that it can be easily withdrawn, and then mounting the impression in plaster of Paris. After the plaster base has become hard the whole should be oiled and a counter-die made upon it with another pellet of cement. The latter will be an exact duplicate of the prepared cavity, and upon it a matrix may be swaged of platinum or gold by any of the ordinary methods or by means of the Brewster Swaging Press and the rubber water-bag furnished with it.

By this method a perfect adaptation of the matrix to the cavity is secured, the matrix can be returned to the cavity and the edges burnished as often as desired, and any number of inlays made from the same counter-die. Another advantage of this method lies in the fact that the patient can be dismissed as soon as the impression of the cavity has been taken and color shade selected, and the balance of the operation completed in the laboratory by an assistant, or at the leisure of the operator.

Packing the Body and Firing.—The selection of the color for the inlay must be done with the shade ring which accompanies the porcelain powders, and with the tooth in the moist state. Drying a tooth changes its color very materially. The writer selects a porcelain tooth that matches the color of the tooth to be filled, and uses this as a guide while baking the inlay. First ascertain the basal color, and then any tone may be given to it by a proper combination of the other colors.

The body may be mixed either with distilled water or absolute alcohol. In mixing the body a consistency of soft dough should be obtained. It is then placed in the matrix with a small spatula, and settled into place by tapping the pliers that hold the platinum matrix or the tray containing the invested gold matrix. In packing the first instalment of the body it should not be allowed to come quite up to the margins of the matrix. If the matrix is filled at the first firing, the contraction of the material is very likely to warp the matrix and spoil the fit of the inlay. This is now placed in the furnace and fired until a glaze appears upon the surface, when it is removed, cooled, and returned to the cavity, and the edges of the matrix again carefully burnished to the margins.

The partially filled matrix is again removed and, if of gold, invested as before, and the second instalment of body added to that already fired, bringing it up to the edges and giving it the desired contour, but carefully removing with a camel's-hair pencil any portion of body which may have projected beyond the line of the enamel margins, when it is again fired. It is a safe plan to replace the inlay in the cavity after the second firing and study its contour; if this is not quite right, more material can be added and the piece again fired.

To fire an inlay perfectly is perhaps the most difficult part of the process. It is very important that the porcelain be not overheated, as this converts it into glass, burns out the color, and destroys its strength. Much of the complaint made against the use of porcelain has come from those who have not been sufficiently skilled in the art of firing porcelain to be able to judge when it has reached the proper fusing-point.

There are no two porcelain bodies that fuse at the same degree of heat, consequently it is better to thoroughly test each material until familiarity is gained of its working qualities and fusing-point before attempting work that is to be placed in the mouth.

The use of a Price pyrometer, in connection with the electric furnace, will overcome the difficulty of over-heating the body, and thus more uniform results in quality, color, and strength are obtained.

After the inlay has cooled the foil matrix may be peeled off by starting it from the edges first and working towards the centre. If it is peeled towards the edges, chipping is likely to occur. Any particles of the foil which remain may be scraped off with an excavator, and it is important that all be removed, or a perfect fit of the inlay will not be secured.

When high-fusing bodies are employed the platinum matrix is often difficult to remove, and particularly so if all of the wrinkles within the matrix have not been carefully burnished out. With low-fusing bodies and the gold matrix the foil peels off with the greatest ease, which is an advantage of considerable importance to the busy practitioner.

In building large contours or restoring the angle of an incisor, a chip of a porcelain tooth of the proper color may be placed in the matrix and the body built around it. Such cases, however, require to be heated and cooled more slowly than small inlays, or otherwise there is danger, from the sudden expansion and contraction, of cracking and checking the piece.

A safe rule to follow is to make all inlays a trifle darker than the tooth when inserting them in the labial and buccal surfaces or the approximal surfaces of the incisors, as they are less conspicuous if a little darker than when a little lighter. In approximal cavities in the bicuspids and molars lying well in the shadow of the tooth the inlay should be a trifle lighter in shade than the tooth, as the shadow makes them appear darker.

Williams suggests that the contraction which occurs in firing large inlays, which often warps the matrix and thus destroys the accuracy of the fit, may be obviated by mixing the porcelain paste to the consistency of soft putty, and building a "*ring of this putty around the entire circumference of the cavity in the matrix, leaving the centre free and empty.* In melting a porcelain paste it naturally shrinks towards the largest mass of its own body, or towards the centre of the mass. If, then, this centre be removed, we should naturally expect the mass to shrink *towards the circumference*, and this is precisely what happens when manipulated as directed. The matrix always comes out from the first baking with the porcelain everywhere firmly melted to the walls of the matrix. Nor will it ever start from this position at any subsequent baking unless it is very much overheated."

Setting the Inlay.—After the foil matrix has been removed, retaining grooves should be cut at opposite points upon the under side of the inlay, or the under surface of the inlay may be roughened by grinding off the glazed surface with a fine corundum wheel, in order that firm attachment may be secured to the cement, or the inlay may be embedded, face downwards, in a piece of warm base-plate wax and hydrofluoric acid applied to the back, and allowed to remain for about five minutes. On carefully washing the inlay with water it will be found that the acid has attacked the surface of the porcelain, removing the gloss, roughening the surface, and giving it the appearance of ground glass. To this surface the cement will adhere with great tenacity, preventing the inlay from being dislodged.

The edges of the inlay will usually present a slightly thin, jagged appearance, as the result of an overflow of the porcelain during the process of firing; this should be carefully smoothed off with cuttle-fish disks or Arkansas stones.

The inlay is then secured in place by setting it in zinc oxyphosphate cement. Any ordinary cement having a finely ground powder, like the Justi or Harvard, will answer the purpose, but these are improved by grinding in a mortar until the powder is impalpable.

Coarse powders do not give good results, as the particles prevent a close approximation of the inlay with the walls of the cavity, thus spoiling an otherwise good fit.

An inlay which fits perfectly, and which matches the color of the tooth, forms a joint which is almost imperceptible to the unaided vision.

The cement should be mixed to the consistency of cream and spread evenly over the floor and the walls of the cavity. The inlay is then placed in position by means of the spatula, which should have a tiny bit of cement on its surface to cause the inlay to adhere to it, and then pressed home. Pressure should be maintained until the surplus cement has had time to escape around the margins of the inlay.

In approximal cavities, after the inlay has been inserted, a wooden wedge may be placed between the approximating teeth to support the inlay during the setting of the cement, or cotton and sandarach varnish may be used for the same purpose and allowed to remain for twenty-four hours. The wedge may then be removed, and any projection of the inlay beyond the surface of the tooth dressed off with Arkansas stones or cuttle-fish disks. Inlays made from the porcelain furnished by Dr. Jenkins, Ash & Son, Brewster, or the Consolidated Dental Manufacturing Company, will take a polish after being ground equal to Ash & Son's artificial teeth.

Zinc oxyphosphate cements have recently been placed upon the market by the Consolidated Dental Manufacturing Company and Ames of Chicago, which have been prepared with especial reference to setting inlays, and are known as "inlay cement." Each box contains a bottle of liquid and four bottles of powder, representing the four basal colors used in the making of the inlays. It is, therefore, possible with a little care to match the color of the inlay. The powders are very fine, and form, when mixed with the liquid, a very smooth and fine-grained mass which does not set too rapidly and makes a very hard and resistant cement.

The cement forming the joint of the inlay should be protected from moisture for a few hours by coating it with sandarach varnish, melted paraffin, or chloro-percha.

In finishing the inlay the stones and disks should be run in a direction from the edge to the centre, and never in the reverse direction, as there is danger of chipping the edges of the inlay if they are run in a direction from the centre to the edge. The final polishing may be completed with pumice and chalk.

CHAPTER XXII.

DENUDATION OR EROSION OF THE TEETH, AND ATTRITION OR ABRASION.

Definition.—Denudation (Latin, *denudare*,—*de* and *nudare*, *nudatum*,—to lay bare), the condition of a part deprived of its natural coverings, whether by wounds, gangrene, or abscess. It is particularly applied to the bones when deprived of their periosteum, and to the teeth when they lose their enamel or cement substance, or when the gums recede from them and their alveoli are destroyed.

Erosion (Latin, *erodere*, *erosum*,—*e* and *rodere*,—to eat away), the action of a corrosive substance, or the gradual destruction of a part by a substance of that kind. The term is often employed in the same sense as ulceration. It is a molecular disintegration of tissue caused by the action of some corroding agent.

Various terms have been applied to this disease, such as denudation, erosion, surface wear, abrasion, and atrophy.

Denudation or erosion of the teeth is a disease which attacks these organs, beginning with the enamel and gradually involving the subjacent dentin without any of the appearances or characteristics of dental caries. It consists of a gradual wasting away of the enamel and dentin, generally upon the labial and buccal surfaces, most often beginning with the incisors, though it may attack the other teeth first, and may involve all of the teeth to the second molars. It usually begins at the gum, forming depressed plains, cavities, or grooves, which follow the curves of the gum lines. They are as evenly and smoothly cut as though made with a file or disk, are highly polished, perfectly hard, and many times absolutely free from discoloration.

The surface of the groove is generally quite sensitive, sometimes exquisitely so, causing the patient much uneasiness and pain. Occasionally the process begins at numerous irregular points on the labial surface, which extend, and after a time coalesce, involving the loss of the entire enamel wall of this surface. The disease progresses in rare cases as far as the pulp, laying that organ bare, while in the majority nature provides against it by filling up the pulp-chamber with secondary dentin and thus protecting it from exposure.

In other cases, after progressing to a greater or less extent, it seems to become self-arresting.

The rapidity with which the disease progresses is also variable. In some cases the loss of substance will be so slow as to require ten, fifteen, or twenty years to reach the pulp-chamber, in others only a little more than as many months. The superior teeth are much more liable to be attacked than the inferior, though cases are quite common in which both are affected, but the writer has never seen the lower teeth destroyed to the same extent as the upper. The bicuspids are most often the seat of the disease when located in the lower jaw.

Causes.—Upon the question of the causation or etiology of the disease there is a great variety of opinions. Up to the present time no definite conclusion has been reached by investigators as to the real factors of its etiology, and our knowledge of the subject is very unsatisfactory indeed.

John Hunter was the first writer to notice and describe this disease. He named the disease "decay by denudation," and thought the disease was inherent in the tooth itself, and stated that he had seen cases where it appeared as if the outer layer of dentin had been destroyed first, and that the enamel afterwards broke through for want of support.

This theory is evidently erroneous, for no such phenomenon occurs in this disease. He has doubtless confounded it with that form of caries in which the enamel becomes partially decalcified in spots and permits the pathologic condition to extend to the subjacent dentin, when after a time they break away together, leaving a shallow cavity more or less irregular in form, but lacking that smooth, polished condition which always attends a case of true denudation or erosion.

Bell dissented from the views of Hunter, but expressed himself at a loss to explain the cause of the disease. He suggested, however, that the cause might be one of faulty development of certain concentric portions of enamel, which would render such portions more liable to mechanical abrasion or other injury than the rest.

If such were the true explanation we should expect to see the grooves extending completely around the necks of the teeth, but this condition never occurs, and yet certain portions of enamel may, as he states, be faulty in their development, but not necessarily, however, extending completely around the tooth, and thus predispose such teeth to the action of solvent agents, as is believed to be the case in dental caries.

Fox in writing upon the subject frankly admitted that he was unable to assign a cause for the disease, but thought that it was dependent upon some solvent property of the saliva. If the saliva contains the solvent which is responsible for this disease, we would expect to find all the surfaces of the teeth equally affected, for they are always more or less in contact with it. The inferior teeth are completely bathed in the saliva, so that if this suggestion was correct the lower teeth would be most often affected, while clinical experience teaches the very opposite to this.

Wedl describes the disease and classes it among the atrophies, but makes no attempt to account for its peculiar manifestations. He calls attention to the fact, however, that sometimes the mucous membrane of the cheeks and lips is raised into a fold opposite the dental arches, and suggests that it may be well to consider, in future cases, whether any relation exists between the defects upon the necks of the teeth and these folds or ridges.

These folds or ridges the writer has noticed many times, but they are by no means a constant accompaniment of the disease, and when such instances have occurred he has been inclined to consider it a result rather than a cause of the disease.

Salter calls the affection "surface wear," and ascribes it to friction of the lips, cheeks, and tooth-brush.

The surfaces of the teeth attacked are those usually reached by the tooth-brush, and by many the disease is thought to be one of mechanical origin entirely; but this cannot be the case, for often the grooves or cavities will reach around the teeth mesially and distally to points impossible to be reached by the tooth-brush or by folds of the mucous membrane of the lips or cheeks.

The break in the tissue is also, in some cases, so decidedly undercut as to prove conclusively that such a condition could not have been caused by the friction of the tooth-brush. Tomes also observed a case of the disease where the patient rarely or never used the tooth-brush, and Mr. Harrison reported a similar case at the meeting of the Odontological Society of Great Britain in May, 1870. But the most conclusive argument against the mechanical origin of the disease was furnished by Dr. Murie in a paper read before the same society at its meeting held in June, 1870, in which he related the fact of having found a sea-lion (the *Otaria jubata*) whose teeth showed the results of this disease to a very considerable extent. The positions most notably affected were the sides of the teeth where friction would be reduced to the minimum; the tusks or great cuspids were most conspicuously affected by the disease.

Tomes thinks this condition, "at least in so marked a degree, is not common among seals, but has seen an approach to it in the teeth of several specimens of different species," and he further says that in the museum of the Royal College of Surgeons may be seen the skeleton of a seal in which this condition of the teeth is well exemplified, some of the teeth being deeply grooved in positions not exposed to friction.

Coleman * is inclined to the opinion that mechanical attrition is among the possible causes of the affection. In discussing the question of the presence of the disease in seals, he points out the fact that some seals are known to be in the habit of taking stones in their mouths, and very probably sand also; while hard fish-scales are frequently in their mouths. Their long and flexible tongues are also capable of being swept over the surfaces of these eroded teeth. It is not difficult, therefore, to suppose that by these means the surfaces of the teeth may be worn away. Although there is some uncertainty still resting upon the subject, and it is difficult to account for, still he thinks from the foregoing that the question of mechanical attrition cannot be fairly ruled out as not being among the possible causative factors in these animals.

Bland Sutton thinks there must be some association between erosion of the teeth and defective development. In a paper upon comparative dental pathology,† after referring to the condition of erosion in seals, he calls attention to the reduced dentition of the elephant seal (the *Macrorhinus coninus*) whose peg-shaped molars present a groove around the entire circumference, which is perhaps caused by erosion, and also to a skull of the

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* Transactions International Medical Congress, 1881.

† Transactions Odontological Society of Great Britain, January, 1884–April, 1885.

Otaria jubata in the possession of Mr. Bartlett, in which the skull and the jaws are affected with a peculiar porous, soft hyperostosis, similar to that seen in the skulls of rachitic animals at about the period of puberty. He also refers to having found in a raccoon-like dog evident characteristics of *mollities ossium*, and in which the teeth had undergone erosion. He therefore comes to the conclusion that, from these instances of erosion, associated with constitutional bone disease, and with comparatively functionless, imperfectly developed teeth, there must be some connection between erosion and defective development.

He says further, in reference to the process of absorption which sometimes attacks the functionless tusks of the female Indian elephant, "Pathologists have long been aware that morbid changes are more prone to attack undeveloped functionless or imperfectly acting organs; hence I imagine that the tusks of female elephants are more prone to inflammation than the fully developed representatives in the male."

Magitot regarded the disease as a result of caries which has been spontaneously cured or arrested by the obliteration (filling up) of the dental tubuli.

It is difficult to understand how this author, for whom the writer has the greatest respect, can arrive at such a conclusion from the phenomena presented by the disease. If, as he suggests, it is caries in the incipient stage, arrested by or cured by the obliteration of the tubuli from a deposition of calcareous matter, why is it that in almost every case the teeth thus affected are sensitive, sometimes exquisitely so, to the touch of an instrument, changes of temperature, acid condiments, and confections? Calcified nerve-tissue has no sensation (assuming that nerve-fibrils penetrate the tubuli of the dentin); hence his theory in this respect must be erroneous. These cases are also usually progressive, many times extending over a series of years, and perceptible changes can be noted from time to time.

Tomes calls attention to another form of the affection in which the loss of substance is not merely confined to isolated spots or surfaces, but in which the whole exposed portion of the tooth is attacked. "As the morbid action goes on the enamel is slowly removed from the crown, so that the teeth become shorter and thinner and assume a peculiar yellowish, translucent appearance, the position of the pulp being strongly marked by the difference in color. In the only case which has come under my own observation, the wasting of the teeth was established beyond all doubt by taking models from time to time. The patient, an anæmic girl, was reduced to a state of great prostration by acute dyspepsia, and was for a considerable time confined to her bed; she was, however, so hysterical that it was exceedingly difficult to rightly estimate her condition. At one time there was great tenderness of her teeth and general periostitis in the front of the mouth, which, judging by color alone, appears to have resulted in the death of one of the upper central incisors. The use of alkaline applications seemed to have no effect whatever, but the patient's condition has now greatly improved, and the disease appears to be no longer progressing. It is remarkable that during her prolonged illness, while the teeth were being rapidly eroded, no caries occurred in the mouth."

The writer has reported a case * of a somewhat similar character occurring in a gentleman of leisure about forty-five years of age, in which the six anterior teeth and the right first bicuspid of the upper jaw are quite extensively denuded, the enamel being entirely removed from all of the teeth named upon their labial surfaces, with a considerable portion of the dentin, leaving an inclined plane pointing backwards, and extending from the margin of the gums to the ends of the teeth, shortening the anterior teeth to the extent of about a sixteenth of an inch.

The denuded surfaces were not all grooved in one direction ; the central incisors and the left lateral were grooved horizontally like the others, but were also grooved longitudinally at the cutting edges.

The first and second bicuspids of the lower jaw on the right side were also affected, but not to the same extent as those of the upper jaw. Fifteen years before, Dr. Allport, of Chicago, filled with gold the six anterior teeth upon their cutting edges, for the front teeth originally occluded squarely, and by mechanical abrasion cup-shaped cavities had been worn into the dentin, making it necessary to fill them. The centrals were also slightly decayed at the margin of the gums, and small fillings were also inserted there.

Six years afterwards it was first observed that the disease had attacked the teeth ; two years later it had progressed so far as to make the edges of the fillings stand out above the surrounding tissue on the labial surfaces. These edges were rounded off and the case dismissed for the time being. Shortly afterwards the gentleman went to Europe and remained there four years. On his return not a vestige of the fillings was left, nor even a depression to indicate where they had been, the surface being as smooth and regular as though cut and polished with file or disk.

There had also been a perceptible loss of structure during the past three years, but the destruction had been much less rapid than previously.

Numerous other cases might be mentioned to substantiate this position, as well as the fact that it does not originate in incipient caries. Cases have occurred in their incipiency and progressed stage by stage under our eyes, and at no time have they shown any signs of decay.

In the case just mentioned two of the teeth were slightly decayed at the gum line, but none of the others were at any time affected in this way.

Underwood † reported a case "occurring in a lady of middle age, who became the subject of erosion after a severe attack of rheumatic gout accompanied by great depression and mental shock of a severe character. She had never worn an artificial denture. All of the surfaces of the teeth were impartially attacked, so that one bicuspid was reduced to a cube of dentin minus the enamel on all sides, while others presented polished grooves traversing their surfaces in all directions, contrary to the usual form in which the loss of substance is limited to the crevices of the teeth. True caries was also present in the mouth ; the reaction of the saliva was strongly acid even just after a meal. Two sisters and a niece of the patient

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* Transactions of the American Medical Association, 1884.

† Aids to Dental Surgery.

were free from the affection. One of the sisters, however, had at a later period shown signs of the disease."

The late Dr. Eleazer Parmley, of New York, reported some years ago a case in which erosion attacked natural teeth that had been set upon an artificial piece in precisely the same manner as in teeth having natural attachments to the alveolus.

J. Tomes and Harris are both inclined to think the disease is one of chemical origin. Tomes suggests that it is caused by the fluid secreted by the mucous membrane covering the parts affected, undergoing fermentation, or affording a nidus for fermentation, and thus may provide an acid solvent.

Harris adopts the opinion that the loss of substance which characterizes the affection is produced by the action of acidulated buccal mucus. In every other part of the mouth this fluid is mixed with saliva, and the acid it contains is so diluted as to prevent it from acting on other portions of the teeth.

The view held by these authors is the one most generally accepted, perhaps because no better theory has been advanced. This theory, however, does not account for all the peculiarities of the disease. To illustrate : certain teeth are affected in individual cases to the exclusion of others. The writer has had several cases where the disease attacked the superior incisors and bicuspids, while the canines were entirely free, and *vice versa*, and one marked case of the disease in the lower bicuspids on both sides, while all the other teeth of the mouth escaped entirely.

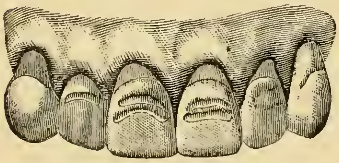
The writer has frequently tested these cases with litmus-paper to ascertain the condition of the mucous secretions of the lips and cheeks, but has never found any very marked acid reaction ; in fact, has often found greater reaction in mouths where the teeth were entirely free from the disease.

For several years two brothers who were manufacturers of sulphuric acid were under the professional care of the writer. One of them had charge of the stills, and the other of the chemic laboratory. The former was for hours at a time in a room the atmosphere of which would be highly charged with the fumes of the sulphuric acid, making it necessary to wear a wet sponge over the nose and mouth to protect the air-passages from its irritating effects. The latter was also subjected to the fumes of the acid, but to a much less extent than his brother. Both of these gentlemen suffered very greatly from dental caries during the years that they occupied these positions, but when they gave up this part of the work there was a marked decrease in the amount and progress of the caries.

In the brother who spent so much time in the distillery room a condition similar to erosion occurred upon the labial surfaces of the ten anterior teeth of both jaws, but upon leaving this work to be done by others the progress of the disease was permanently arrested, as shown by the fact that there has been no further progress for the past ten years.

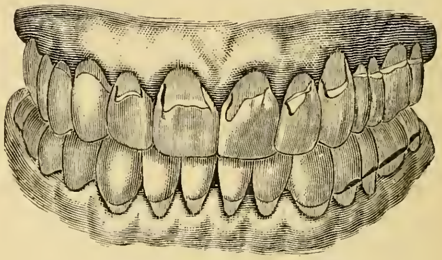
In an article translated from the German by C. E. Koch, and published in the *Missouri Dental Journal*, August, 1872, the author advances the theory that the disease is one having a close analogy to the process of resorption, attacking the roots of the deciduous teeth prior to their being replaced by the permanent organs. He claims that "the gum may secrete a fluid endowed with functions similar to those possessed by the absorbent organ found at the roots of the deciduous teeth, and by this means the tissues are removed, leaving the surfaces, as in the case of the roots of the teeth just mentioned, smooth and polished;" but qualified his statement by saying that he "feels inclined to assume at least a predisposition of the tooth concerned, for the reason that in all cases only certain teeth are attacked by it." He bases his argument, however, upon what he assumes to be a fact,—viz., "that denudation always appears upon the neck of the tooth." He has evidently overlooked the fact that cases of the disease occur, as we have already stated, upon the labial and buccal surfaces, remote from the margin of the gums, at points not likely to be reached by the eroding fluid in sufficient strength to account for the rapid progress of the disease in some of these cases.

Fig. 479.



Teeth where the grape-cure has been taken. (After Dr. Darby.)

Fig. 480.



Case attributed to the use of acid phosphate. (After Dr. Darby.)

Fig. 479 represents a case of this character reported by Dr. E. T. Darby, in which the affection developed while the patient was taking the grape-cure, and another case, illustrated in Fig. 480, in which the loss of tissue is at the cervices of the teeth, was ascribed to the use of acid phosphate.

Taft is of the opinion that an acidulated buccal mucus is the essential factor in producing erosion, and thinks that constitutional treatment may have a controlling effect upon the disease.

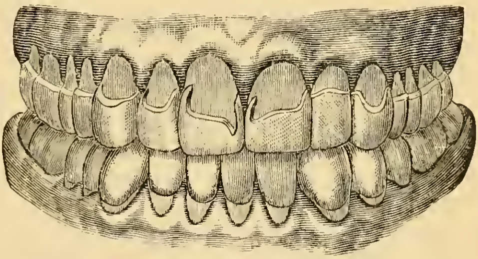
Charles E. Tomes is inclined to the belief that mechanic abrasion does not fully account for the disease, and that some other factor must play an important part in the process.

Truman has long maintained that the disease was caused by an acid fermentation taking place in the mouth, more especially at night or when the mouth was in repose, and in corroboration of this theory proved by tests with litmus that the secretions of the mouth almost invariably gave an acid reaction upon rising in the morning and after a fast of several hours' duration.

Garretson was of the opinion that the true explanation of the cause of this disease was that enunciated in the experiments of Mr. Kincely Bridgman, the author of the electrochemical theory of decay, and he says, "My present convictions have led me to believe that in this direction will be found to lie not only the cause of the disease but the prophylaxis." He further says, "It would seem, however, that back of the immediately acting cause must be a predisposition ; here it would seem to be the result of impressions made on the enamel at the period of its formation, and which deficiency the nutritive functions have failed to correct. It might, indeed, very well be that such enamel is entirely deficient in vital resistance, and thus subject to be acted upon as any inorganic structure, being by electrolytic action simply dissolved."

Black* has produced a condition by artificial means out of the mouth which closely resembles erosion. In one experiment which he records two freshly extracted and sound bicuspid teeth were placed with their proximal surfaces together and their roots enveloped in gutta-percha, so that their crowns only were exposed. These were then placed in a glass jar containing a dilute solution of hydrochloric acid (one to four hundred), and by means of a revolving glass paddle-wheel, run by a clock-like mechanism and making forty revolutions per minute, a current was made to impinge upon their outer surfaces, the current striking one with greater force than the other. The result at the end of five days was the disappearance of the cusps and the formation of a groove between the teeth. This groove was most marked upon the tooth which received the greatest force of the current. These experiments were repeated a number of times with slightly varying results. Stronger solutions produced general softening, while solutions of the strength of one of acid to fifteen hundred of water, after a three months' trial, gave no appreciable results. Dr. Black, however, does not look upon these experiments as proving anything as to the etiology of the disease. He says, however, "the theory that it is caused by acid mucus is supported by several who have written on the subject, and our present knowledge affords no alternative but the acceptance of the general idea that it is the action of an acid under some peculiar modifying influence as yet unknown to us."

Fig. 481.



Case where there was gouty relation. (After Dr. Darby.)

Fig. 482.

Case where there was gouty relation. (After Dr. Darby.)

Darby maintains that many cases of erosion are associated with the gouty diathesis, and believes that this constitutional condition is an important factor in the causation of the disease. The accompanying illustrations (Figs. 481 and 482) represent cases that were associated with the gouty diathesis.

* American System of Dental Surgery, vol. i. p. 1004.

Michaels,* through carefully conducted clinical and laboratory investigation, has arrived at the conclusion that chemical abrasion or erosion of the teeth is due to the constant contact of secretions from the labial glands in individuals of the gouty or rheumatic diathesis—the hyperacid diathesis—in whom oxidation in the nutritional process is incomplete, resulting in the formation of acid salts as end-products of metabolism; and that in all probability the chemical agent which produces the peculiar phenomena of the affection is the potassium sulphocyanate. In proof of this statement he says, "erosion was not present in individuals when the saliva contained ammonium sulphocyanate (K C N S), while in those whose teeth were thus affected he invariably found the potassium sulphocyanate present in the saliva.

Kirk,† following the lines of salivary investigation laid down by Michaels, has arrived at a different conclusion in relation to the active chemical agents causing the local phenomena of erosion, but confirms his opinion as to the constitutional cause, viz.: the hyperacid or gouty and rheumatic diathesis.

Kirk found in his investigations two distinct forms of the affection, which he denominated, from their peculiar characteristics, "general" and "graphic."

"*General*" erosion, "in which all the surfaces of the teeth are uniformly involved," he believes is due to a general acid condition of the saliva, "lactic acid being the acid solvent;" while in the "*graphic*" form "it is distinctly due to the exudate from an abnormal mucous gland or glands, the acidity of which is due to one of two things—the acid sodium phosphate or the acid calcium phosphate."

In a more recent paper read before the Ohio State Dental Society, December, 1902, he directed attention to a form of tooth dissolution frequently observed in the deciduous teeth of children, and in adults of hyperacid diathesis who are overindulged in carbohydrate foods, which has been mistaken for rapid caries, but which he believes to be a process of rapid erosion due to an unusually active production of dihydrogen sodium phosphate.

In a still later paper on "The Saliva as an Index of Faulty Metabolism,"‡ he confirms his belief, based upon further investigation, that dental erosion is caused by faulty metabolism, which produces in the individual of hyperacid diathesis certain phenomena which are expressed in the oral cavity by an excessive production in the saliva and mucous secretions of lactic acid, acid sodium phosphate, and acid calcium phosphate in sufficient quantities and strength to produce the various phenomena of the affection.

The writer has frequently noticed that the teeth most often attacked by denudation or erosion are those that are generally classed as medium or soft teeth, or are low in vital resistance, the patient often inheriting a peculiar cachexia, the scrofulous or syphilitic, which has had a depressing influence

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* International Dental Journal, April, 1900.

† Items of Interest, July, 1902.

‡ Dental Review, May, 1903.

upon the developmental process, thus lowering the power of vital resistance and predisposing the teeth, as well as other organs of the body, to the ravages of disease.

There is no doubt that the structure of the teeth is often affected by certain diseases. The marks which they leave on particular portions of the tissue tell at what time the injury was wrought and indicate the cause of the disturbance. Syphilis, small-pox, whooping-cough, scarlet fever, and the pustular diseases leave characteristic marks by which it can be told at what portion of the developmental period their influence was felt.

A peculiar form of the disease is that in which the loss of the substance of the teeth is confined to the morsal edges of the anterior teeth.

Harris* relates a case of this character in which, during the course of two years, a separation was formed between the ends of the incisors of three-eighths of an inch.

Bell has also described a similar case affecting mainly the morsal edges of the incisors and cuspids, which could not be brought into contact with each other. The opening formed between the ends of the teeth was elliptical in shape. Several similar cases have come under the observation of the writer. This form of the disease cannot by any possibility be attributed to mechanical abrasion or attrition. By some it has been thought to be caused by an acid mucus secreted by the glandular structures of the surface of the tip of the tongue, which lying in contact with the lingual surfaces of the anterior teeth at the morsal edges—except during speech or mastication—would keep the solvent fluid in almost constant contact with these surfaces.

Pathology.—Underwood found in the examination of sections of enamel at the seat of erosion that the tissue was structurally defective, having an exaggerated granular appearance. Sections of dentin showed simply the abrupt ending of the fibrils and tubules as if cut with a sharp instrument. An interesting fact was also discovered,—viz., that stained as carefully as possible the substance adjacent to the eroded surface does not take the stain, a condition that might be expected if really due to the action of an acid solvent.

Black says, "Neither the dentin nor the enamel immediately adjacent to the portions being removed, even up to the immediate surface, shows any changes whatever, except it be a slight discoloration which is present in only a portion of the cases."

The writer has observed that when discoloration became permanent upon an eroded surface caries soon attacked this surface. The disease in some cases appears to be self-limiting, while in others it is progressive.

Treatment.—The treatment of denudation or erosion is very unsatisfactory, for no remedy has yet been discovered which will arrest the progress of the disease. Certain remedies are sometimes applied in an empirical sort of way, with the view of checking the progress of the disease, like alkaline mouth-washes, antiseptic solutions, and alcohol, and the discontinuance of the use of tooth-powders and stiff tooth-brushes. To relieve

* Dental Surgery, p. 264.

the extreme hypersensitive condition of the dentinal fibrillæ the eroded surfaces may be touched with zinc chloride, or if the surface is not exposed to view, it may be touched with silver nitrate.

In the more advanced stages of the disease the cavity thus formed may be properly shaped and filled with gold. This operation in many cases does not seem to arrest or even check the progress of the disease, for it is the experience of most operators that in from three to six years these fillings will be lost by reason of the disease progressing until the supports of the filling were dissolved away.

The writer has found that in a certain few cases zinc oxyphosphate cement seemed to exert a controlling effect upon the disease, and in these cases the cement fillings lasted exceptionally long. Whether this was due to some peculiar action of the cement, to a chance association of a changed condition in the oral fluids, or to a natural limitation of the disease, it would be very difficult to decide. One marked effect of protecting the eroded surfaces with zinc oxyphosphate was the abatement, after a few weeks, of the extreme hypersensitiveness.

ATTRITION OR ABRASION.

Definition.—Attrition (Latin, *atterere*, to rub against), any rubbing or friction which wears a surface. Applied to the teeth, it is the wearing away of the tooth-substance, caused by the friction of mastication. Abrasion (Latin, *abrasio; ab*, priv., *radere*, to rub), in dentistry, the wearing away of the enamel and dentin upon the morsal surfaces by mechanical means, or a loss of substance through friction of a foreign body.

Mechanical attrition of the teeth is a common condition in individuals past middle life and in the deciduous teeth of children. The morsal surfaces of the bicuspids and molars are most often the seat of this loss of substance, but when the occlusion of the teeth is such that the six anterior teeth impinge squarely upon each other, the morsal edges of the incisors and the cusps of the cuspids also become worn away, forming broad surfaces, which has given rise to the notion among some of the less intelligent laity that some people "have double teeth all around." As the process of attrition goes on the teeth become shorter and shorter until in some cases they are actually worn down to the gums. Some animals, notably the rodents, have teeth which grow continually, so that the wear which takes place from the severe use to which they are subjected is counterbalanced by their continuous growth. Not so with man, for with his teeth when once fully developed there is no compensation for wear or injury. Unlike other organs and tissues of his body, they are incapable of repairing losses which may be sustained by disease, injury, or wear. A certain amount of wear always takes place upon the morsal surfaces and edges of the teeth from childhood to old age; this would be termed normal attrition.

On the other hand, the wear which takes place in some cases is entirely abnormal.

Causes.—The amount of attrition which may take place in any individual case will depend very largely upon the character of the food, the density of the tooth-structure, the form of the occlusion, and the habits.

It may attack the morsal surfaces of all of the teeth, or it may affect only one or two teeth. When the anterior teeth occlude squarely together all of the teeth will be worn by attrition. When the occlusion is normal only the bicuspids and the molars will be affected, but when the attrition is localized it will be due to malposition or irregularity of one or more teeth, or to some peculiar habit, like holding a pipe between the teeth always in the same location.

The character of the food plays an important part in the normal wear or attrition of the teeth. Foods which are hard and require considerable mastication or grinding to reduce them to a proper state to enter the stomach cause more surface wear of the teeth than foods which are soft. This is particularly noticeable in the museum collection of skulls of aboriginal peoples whose food was coarse and contained much gritty material intermixed with it, as a result of their primitive method of grinding their cereals. The same conditions are noticeable in the negro of the South, and in sailors and soldiers who have been in service for long terms, and whose food has been of necessity composed of coarse and hard materials.

Predisposing Causes.—It has been thought by some authorities that the difference in the density of tooth-structure was an important predisposing factor in the attrition of the teeth. Confidence in the importance of this theory as a causative factor in the wearing away of the teeth has been somewhat severely shaken by the publication of the results of Dr. Black's experimental research into the question of the differences of density in the teeth of individuals from youth to old age. He found, as already referred to in another part of this work, that the differences were so slight as to be of no importance as a controlling influence in the predisposition to caries, and these conclusions are equally applicable to the predisposition of the teeth to be worn away by attrition.

The most important predisposing cause of mechanical attrition is an abnormal occlusion of the teeth. When the teeth of the opposing jaws form a normal occlusion, the cusps of the bicuspids and molars interlocking with each other, the buccal cusps of the superior teeth shutting over the buccal cusps of the inferior teeth, and the superior incisors and cuspids shutting over those of the lower jaw, the surface wear or attrition will occur in the bicuspids and molars upon the sides of the cusps which come into antagonism, and thus the grinding and triturating character of these teeth will be maintained to the end of life; while the incisive and tearing character of the anterior teeth will be maintained by the same normal process or wear.

If, on the other hand, the occlusion of the teeth is such that the points of the cusps of the posterior teeth and the morsal edges of the incisors and cuspids only come in contact, a sliding motion of the teeth of one jaw upon those of the other becomes necessary in triturating and grinding the food. In time the cusps of the teeth are completely worn away, and the morsal or incisive edge of the anterior teeth is destroyed, thus reducing the morsal surfaces to flat planes. As soon as the enamel upon these surfaces is lost at any one point, the dentin wears away so much more rapidly than the remaining enamel that cup-shaped depressions are formed in the dentin, which grow deeper and deeper until they become an annoyance either from their extreme sensitivenesss or from the retention of food *débris*.

The malocclusion of one or more teeth often causes a localized attrition, as, for instance, when a lateral incisor or a bicuspid is so malposed as to throw it out of the normal alignment of the dental arch, thereby causing it to interlock with the opposing tooth in such a manner as to produce excessive attrition upon the labial or lingual surfaces of these teeth.

Another cause of abnormal attrition is the loss of several teeth upon one or both sides of the jaw, thus throwing extra work upon the remaining teeth. The most common condition of this character is where the posterior teeth have been lost, and the whole labor of triturating and grinding the food is thrown upon the anterior teeth.

Habit is also an important factor in the attrition of the teeth. This is noticed in certain individuals who when the mind is engaged are constantly grinding their teeth together, or who, by carrying the jaw forward or laterally, bring two teeth together, and by a constant rubbing motion wear away the prominent points of these teeth. The habit once formed usually remains, and thus an abnormal attrition of the teeth involved is produced.

Pathology.—Smale and Colyer* claim that attrition is always most marked in those individuals who are of a gouty diathesis.

The only changes observable in the structures of the dental tissues are the abrupt ending of the dentinal tubules at the worn surface, the evident consolidation of the fibrillæ in certain cases, the deposition of secondary dentin in the pulp-chamber nearest to the point of surface wear, and atrophic changes in the pulp itself.

Treatment.—In many of these cases treatment is not required. In those in which cavities or depressions have been worn in the surfaces of the teeth a retentive shape should be given to them and the cavities filled with gold. In those in which the pulp has been dangerously approached gold crowns may be inserted and the normal separation of the jaws restored, porcelain facings or porcelain crowns being used in all locations in which the artistic sense would be offended by the exhibition of glittering gold crowns.

When the posterior teeth have been lost and the anterior teeth are being rapidly worn down, artificial dentures should be inserted and the "bite" lengthened so as to relieve the wear upon the anterior teeth. When the insertion of artificial dentures will not be permitted, the ends of the anterior teeth may be protected by the insertion of gold fillings which cover the edges of the enamel and lengthen the "bite," as described in a preceding part of this work.

Abrasion.—By the use of the term *abrasion* the writer means that loss of tooth-substance which is caused by the friction of foreign bodies, as, for instance, artificial dentures made upon a metal base or retained in the

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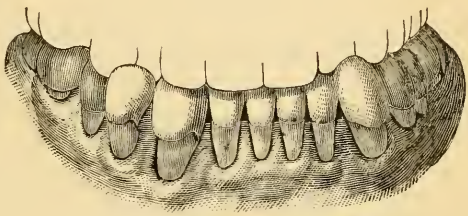
* Diseases and Injuries of the Teeth, p. 282.

mouth by metal clasps which surround certain teeth; the undue application of the tooth-brush and of dentifrices; the use of the clay pipe, and of chewing tobacco and the betel-nut.

The most common cause of abrasion is the friction of metal plates and clasps. This condition is most likely to occur when the plate or the clasp does not properly fit, thus permitting constant motion during speech and mastication. These losses of substance are always at those points upon the teeth where the friction has been applied. Such abraided surfaces often become exquisitely sensitive and call for treatment. When these abrasions occur in locations not readily kept clean caries is liable to supervene.

Abrasions from the use of the tooth-brush and dentifrices are exceedingly rare. A few such cases will, however, present in the practice of nearly every dentist, but they appear so seldom that they are usually encountered as a surprise. Individuals who have this form of abrasion are those who are so scrupulously neat about the care of their mouths that for fear they will not keep their teeth clean they employ the stiffest brushes that can be found, and often add pulverized pumice-stone to their dentifrices to be sure that all stains and deposits are prevented from accumulating upon them. These abrasions are usually found upon the labial and buccal surfaces of the teeth, and might be readily mistaken for denudation or erosion (Fig. 483).

Fig. 483.



Case showing abrasion by tooth-brush. (After Dr. S. B. Palmer.)

Abrasions from the use of the clay pipe are most frequently seen among the people of the lower walks of life, particularly among laborers having out-door occupations, who smoke a great deal, and hold the pipe gripped between the teeth while at work. The stem of the pipe is usually held in the same place, and after a time the teeth become worn at this point to such an extent that they do not occlude, and an open space the form of the pipe-stem remains when the other teeth are in contact. The writer once saw an elderly Irishwoman who was a constant user of the clay pipe, in whom the groove formed between the opposing teeth at the angle of the mouth was so deep and large that she had been of late years obliged to wind the stem of her pipe with a strip of linen to make it large enough to be gripped by the worn teeth.

Abrasion from chewing tobacco is quite common among old sailors and the negroes in the tobacco-raising districts of the South, while among the native low-caste Hindoos and Burmese, who mix lime with their betel-nut to form a pungent "quid," abrasion is very common. Tobacco and betel-nut chewers, as a rule, always chew the quid upon the same side of the mouth, and as a consequence the abrasion always occurs upon that side. The constant friction of the tobacco—which always contains more or less grit, particularly so when the unprepared leaf is used, as by the negroes of the South—and of the betel-nut mixed with lime rapidly wears away the morsal surfaces of the teeth employed in masticating the quid.

The writer has seen several cases in which the teeth had been worn to such an extent by this process that they did not meet by a fourth of an inch.

The treatment of an abrasion is the same as that employed in erosion and attrition.

CHAPTER XXIII.

DISEASES AND INJURIES OF THE DENTAL PULP AND THEIR TREATMENT.

In a preceding chapter the various stages of caries were described, and in the following chapters the treatment of the *superficial*, *progressive*, and *deep-seated* stages have been discussed. It now remains to take up the last or *complicated stage* of the disease; that stage in which the carious process has penetrated so deeply into the dentin that it may have nearly or quite exposed the pulp and produced irritation and pain in this organ, and possibly jeopardized its vitality.

The pathology of the dental pulp has been most completely studied by Wedl, Salter, and Black, and nearly all of the knowledge now possessed upon this most interesting and important topic has come to us as a result of their researches. The subject, however, still remains a fruitful field for further investigation, for many problems are still unsolved and many questions need further elucidation.

The pathologic changes in the pulp which have been most carefully studied and described are those in connection with hyperæmia, inflammation, secondary deposits, calcareous and fatty degenerations.

HYPERÆMIA OF THE DENTAL PULP.

Definition.—Hyperæmia (Greek, ὑπέρ, over; αἷμα, blood), a condition of plethora or congestion. Hyperæmia of the dental pulp is a condition in which the vessels of the pulp are dilated and excessively filled with blood.

Hyperæmia may be considered as the most important pathologic condition to which the pulp is subject, for the reason that it is a common affection and often terminates in the destruction of the organ. Hyperæmia may be *transient* or *persistent*, its character depending upon the nature, degree, and duration of the irritation which induces it.

Irritation is the state of a tissue or an organ in which there is an excess in vital movement, commonly manifested by increase of the circulation and of the sensitivity. Irritation in some form always precedes hyperæmia and inflammation; or, in other words, these conditions are always caused by some form of irritation. When the irritation is confined to a particular portion of the body it is termed *local irritation*. When it affects the whole system it is termed *general* or *constitutional irritation*. Hyperæmia is therefore an expression of a state of irritation which may be either local or general.

Hyperæmia, however, may be a physiologic or a pathologic condition. Flushing of the cheeks as a result of mental excitement produced by joy, shame, or anger is an illustration of a physiologic hyperæmia; while the redness following a local irritation would more nearly express a pathologic hyperæmia.

Transient hyperæmia may be induced as an accidental condition in sound teeth by thermal shock, by diminution of atmospheric pressure, such as is experienced in high altitudes, or by injuries which are not of a serious nature but sufficient to produce a congested condition of the pericemental membrane and, by association therewith, transient hyperæmia of the pulp.

This condition rarely produces more than a mild and fleeting sensation of pain, but yet is a sufficient reminder of what might ensue if the irritation were long continued, and to warn the individual not to unnecessarily expose himself to its influence.

Persistent hyperæmia of the pulp is of two forms,—*active* or arterial and *passive* or venous.

Active hpyeræmia is a condition in which the arteries and capillaries of the pulp are excessively filled with blood, and, as a result, abnormally dilated.

Passive hyperæmia, or venous hyperæmia of the pulp, is a condition in which the veins and venules suffer engorgement by reason of compression at the apical extremity of the pulp-canal. This condition is induced by irritation and a consequent increased flow of blood through the arteries, followed by their dilatation and the immigration of the leucocytes. Thus the arteries occupy more than their normal space in the canal, while the leucocytes fill the meshes of the connective tissue and thus produce compression upon the veins or vessels of exit.

The susceptibility of the pulp to external irritation varies greatly in different individuals, while age, temperament, and diathesis play an important part. Susceptibility to irritation is much greater in youth than in adult life, and in persons of high-strung nervous temperament than in the phlegmatic. Persons of a tuberculous or syphilitic diathesis are very susceptible to all forms of irritation and prone to degenerative tissue changes.

Irritation, on the other hand, is well known to be a prolific cause of new formations, provided the irritation is not too intense in character. Slight irritations, if of a continuous character, often result in hyperplasias of tissue, as, for instance, in the increased development of cement-tissue at the apices of the roots of teeth which have been subjected to the irritation of malocclusion, the strain of carrying a plate which has been clasped to them, or of supporting a bridge; while if the irritation is excessive it is liable to produce resorption or other destructive pathologic changes. This is often seen in the roots of devitalized teeth which are in a septic condition or are the seat of chronic abscess.

Again, it is a well-known fact that owing to slight irritations of the dental pulp from such causes as produce a slow and gradual loss of the hard structures of the teeth, like the abrasions of mastication or of metal clasps or the erosion of the enamel at the cervical margins or upon the labial surfaces of the anterior teeth, or from slowly progressing caries, secondary deposits are formed in the pulp-chamber opposite the point of irritation, and proceed synchronously with the destruction of the external tissues until the entire coronal portion of the pulp-chamber is filled and the crowns of the teeth are worn down to the gum. If, however, the process of destruction is rapid the pulp is soon exposed, and hyperæmia and inflammation supervene, thus putting an end to all chances of protecting the pulp by new formations, as such growths are never formed when acute inflammatory symptoms are present.

Causes.—Hyperæmia of the pulp may be induced by many and varied forms of irritation, both *local* and *constitutional.*

Local Causes of Irritation.—These may be divided into *external*, or those which operate from without, and *internal*, or those which operate from within, the pulp.

External Local Causes.—Caries in its various stages; traumatic injuries; abrasions; erosions; chemic reactions from sweets, acids, etc.; excessive thermic changes; instrumentation; mechanic irritation from metallic fillings; incompatibility of fillings; pressure from fillings and other foreign substances upon the thinned walls of the pulp-chamber; galvanic shock; septic infection.

Internal Local Causes.—Dentinal tumors; pulp-nodules.

Constitutional Causes.—Nervous irritability; plethora; pregnancy.

Hyperæmia from External Causes.—*Caries* in the deep-seated stage is the most common of all the causes of irritation which produce or excite a determination of blood to the pulp, resulting in hyperæmia. Acute hyperæmia may occur from caries in any of its stages, but most frequently when the disease has progressed so far as to nearly expose the pulp, or it has been nearly uncovered by a traumatic injury or by abrasion or erosion. External irritants, like thermal shock and chemic reactions, are usually the exciting causes of hyperæmia. There are, nevertheless, certain individuals in whom *general nervous irritability* and local *hyperæsthesia* may be so greatly exalted at times that trivial forms of irritation become unbearable. Under such circumstances hyperæmia of the pulp may be induced by the most superficial cavities of decay, particularly when they are located at the cervix of the tooth. In such persons the introduction of metal fillings, even in the most shallow cavities, are frequently productive of a persistent active hyperæmia and severe odontalgia, necessitating the removal of the filling before relief can be obtained, while if the filling is permitted to remain inflammation of the pulp supervenes. Irritability of this character results sooner or later, according to the intensity of the hyperæmia produced, in either death of the pulp, the formation of secondary deposits in the form of dentinal tumors, or pulp-nodules, or in a general fatty or calcareous degeneration.

On the other hand, secondary formations or deposits are not infrequently found within the pulp-tissue, which can in no wise be accounted for as resulting from external agencies, and which are sometimes productive of a most persistent form of irritation, accompanied by severe neuralgic pains, while at other times the irritation may assume a low chronic form, resulting in various obscure reflex symptoms.

Chemic reactions from sweets, acids, salt, etc., taken into the mouth as food or condiments, when coming in contact with the exposed dentin of vital teeth, may, even in the case of superficial caries, in the recession of the gums which exposes the cervices of the teeth, in chemic erosion and mechanic abrasions, produce a persistent hyperæmia of the pulp, the nature of which is determined by the severity and duration of the irritation, the excitability of the dentinal fibrillæ, and the general nervous irritability of the individual.

Excessive thermic changes and chemic reaction, operating upon the exposed or carious dentin of vital teeth, are the most frequent exciting causes of hyperæmia of the pulp. The thermic or heat sense of individual teeth is often augmented by the action of caries, or by other processes or injuries which denude the dentin of its natural protecting covering, so that temperatures which had been readily tolerated when the tooth was in a normal state become under these abnormal conditions painful or absolutely intolerable; while, upon the other hand, in neurasthenic individuals, certain sound teeth, and sometimes, though rarely, all of the teeth, become hypersensitive, so that the pressure of mastication is no longer borne with comfort, and contact with foreign substances occurring at the cervices of the teeth or at points unprotected by the enamel is exceedingly painful, but in which the degree of pressure exerted or the form of contact does not seem to hold any relation to the amount or the character of the pain induced. The same is true of thermic changes; the differences in the degree of heat and cold beyond the point of toleration do not seem to make any especial difference in the intensity of the pain. In the former condition hyperæmia may be induced as a consequence of irritation, and the pulp, if examined at the time, will be found to be passing into a state of disorganization; while in the latter, if the offending tooth is extracted, macroscopic and microscopic examination may fail to discover any structural changes whatever in the pulp or the calcified tissues of the tooth.

Instrumentation, such as is employed in the excavation of a hypersensitive cavity of decay, is often very painful, and the irritation induced by the process will, in certain individuals of exalted nervous irritability, produce an active hyperæmia of the pulp. A common form of irritative instrumentation, and one which more often results in producing active hyperæmia, is that caused by the friction of rapidly revolving engine burs and disks, which are permitted to heat the tooth beyond the limit of normal toleration. The friction induced by the rapidly revolving bur may be prevented by causing a stream of tepid water to flow over it from a syringe, while the friction and consequent heating of the tooth in finishing a filling with sand-paper and cuttle-fish disks may be greatly lessened by lubricating the surface with toilet soap or vaseline.

Incompatibility of metal fillings with the structures of the teeth is often productive of serious annoyance from the irritation produced by the presence of the foreign body in the hard structures of the tooth, for such it must be considered under these circumstances.

Hyperæmia of the pulp which is induced by the presence of metallic fillings in the tooth is due, as already intimated, to a peculiar and exalted general nervous susceptibility of the individual to various forms of irritation, and to an excessive excitability or irritability of the dentinal fibrillæ, which makes them intolerant of all foreign substances used as filling-materials, which are very far removed from the dentin in their power to carry caloric impressions and electric currents. This is proved by the fact that such teeth which have been filled with metals are soon made entirely comfortable by the removal of the metallic fillings and substituting gutta-percha or porcelain inlays.

Pressure of fillings is sometimes a cause of irritation of the pulp, and is rapidly followed by acute or active hyperæmia. Pressure sufficient to cause irritation can only occur in those cases in which the layer of dentin covering the pulp is very thin, or so considerably decalcified as to cause it to bend under the stress of the force used in packing the filling into the cavity.

Hyperæmia which is caused by this form of irritation rapidly progresses to congestion and partial stasis, accompanied by excruciating throbbing pain, and later ending in strangulation of the apical vessels and death of the pulp, unless the filling is immediately removed and the irritation allayed by local applications to the pulp of soothing or anodyne drugs, like the tincture of opium, morphine, or cocaine.

If, however, continuous pain has been present for more than two or three days, conservative treatment of the pulp will usually prove unavailing for the reason that the irritation has been so violent as to completely overcome the resistive powers of the pulp and render recuperation nearly, if not quite, impossible. Devitalization then becomes the only means of giving comfort to the patient and preserving the tooth.

Galvanic shock is another and not infrequent cause of irritation and hyperæmia of the pulp. This form of irritation is produced in the mouth by the contact of dissimilar metals, the surfaces of which are bathed with saliva having a slightly acid reaction, as, for instance, the contact of gold and amalgam fillings in occluding teeth, or in the approximating surfaces of teeth which are not in close contact, but which by the occasional suspension of food *débris* or the oral secretions *make* and *break* the circuit during the acts of mastication, speech, deglutition, or in other movements of the jaws, tongue, and the muscles of mastication. Metal plates occasionally produce the same effects when in contact with fillings of a different potential. Fillings composed of metals of a different potential placed in the same cavity do not—even when moisture can penetrate between them—produce galvanic shock, for the reason that the galvanic current established between them is continuous, and without the presence of moisture it would be very slight indeed, except upon the exposed surfaces, and this soon ceases from the gradual oxidation of the surface of the baser metal. When gold and amalgam are placed in the morsal surface of the same tooth, but in cavities separated by a more or less thin wall of dental tissue, painful galvanic shock sometimes occurs during the act of mastication, by the current being completed and broken by the contact of masses of food which are so placed at the time as to form a connection or circuit between the two fillings.

Another source of galvanic shock is the contact of a table fork, knife, or spoon with a gold or a bright amalgam filling; such shock is sometimes very painful.

The character of the hyperæmia produced by galvanic shock will depend in large measure upon the intensity and the frequency with which the shocks occur and the susceptibility of the individual to such form of irritation. In the one case it may result in acute hyperæmia and severe attacks of odontalgia, while in another it may develop a passive or chronic hyperæmia with calcareous deposits or other degenerative changes.

The treatment of this form of irritation should be, invariably, the removal of one of the offending fillings and replacing it with a metal like the other, or with a material possessing no conducting or electric properties, like gutta-percha or zinc phosphate.

Septic infection is often a source of acute hyperæmia of the pulp. This is commonly caused by the invasion of the pulp-chamber by the disintegrating processes of caries. It, however not infrequently occurs in those cases in which the pulp has not been exposed, but is still covered with a layer of decalcified and softened dentin (pseudo-exposure), the tubuli of which are filled with saprophytic and pyogenic organisms which readily penetrate to the pulp and establish septic irritation, inflammation, suppuration, and devitalization. A thin layer of *sound* dentin is a positive external protection against the infection of the pulp with the pyogenic organisms.

It is nevertheless possible for suppurative conditions to be established in the pulp without direct external infection. The presence of pyogenic organisms in the blood-current which may have gained an entrance through some abrasion of the skin or mucous membrane, or through a wound, or pre-existing abscess, has long been recognized. These are capable when they become arrested in a vessel of rapidly propagating and overcoming the *vis naturæ* of the surrounding tissues and establishing suppurative conditions. This explains the presence of abscesses of the pulp which are occasionally found in perfectly sound teeth, the contents of the pulp-chamber having the appearance of the pus found in cold abscesses, and which, like the cold abscesses found in the bones and soft tissues of tubercular individuals, have not and do not present any acute symptoms until they are opened, when, if the utmost aseptic precautions are not observed, they sometimes take on most violent inflammatory conditions which may, in extreme cases, terminate in the loss of the tooth and in establishing acute septicæmia.

Symptoms.—The symptoms of active or acute hyperæmia of the pulp are sharp, lancinating pains, produced by hot or cold substances coming into contact with a vital tooth which has been partially destroyed by caries, traumatic injury, abrasion, or erosion, or which contains a metal filling, or by the contact of sweet or acid substances with the denuded surface. So long as the shock of irritation of these agencies produces a quick, sharp, and transient paroxysm of pain, which reappears only upon an application of the irritation, it may be safely inferred that no serious vascular disturbance is present; but when the paroxysms of pain are not only sharp and lancinating, but prolonged for several minutes or even hours after contact with these irritating agencies, it may be suspected that serious disturbances are taking place in the vessels of the pulp.

Slight tenderness to percussion or to forcible occlusion is often a subjective symptom. This is due, in all probability, to an associated sympathetic hyperæmia of the pericemental vessels surrounding the apex of the root. The pain, in the absence of active irritation, is usually diffused over the entire side of the jaw and but vaguely located, and may be referred by the patient to an adjoining tooth or to one in the immediate neighborhood. Sometimes the pain is reflected to a tooth upon the same side of the jaw but remote from the seat of trouble, or it may be reflected to the corresponding tooth or some other in the opposite jaw. Occasionally this symptom will assume a neuralgic character, the pain being located in the ear, or it may manifest itself in the ophthalmic division of the fifth nerve and produce lachrymation, hyperæmia, or inflammation of the conjunctiva, and even amaurosis. When the pain is neuralgic in character the "points douloureux" of Valliex are often well marked in the trifacial nerve. In the *ophthalmic division* these tender points are located at the supraorbital foramen, the upper eyelid at the line of union of the nasal bone with the cartilage, at the inner angle of the orbit, and in the globe of the eye. Another point is near the parietal eminence.

In the *superior maxillary division* the tender points are situated at the infraorbital foramen, at the point over the most prominent part of the malar bone, an uncertain point upon the gum of the superior maxilla, a similar point upon the upper lip, and another upon the palate.

In the *inferior maxillary division* the tender points are found over the auriculo-temporal branch just in front of the ear; another is located over the inferior dental foramen, and still another over the mental foramen.

Diagnosis.—Diagnosis in even the most obscure cases of hyperæmia of the pulp can usually be made by forcing a jet of cold air into the cavity from a chip-blower, or by the application of a jet of cold water having a temperature not lower than 60° F., thrown from a syringe upon the suspected tooth. In the absence of a cavity, fillings should be sought for and tested by the same means. Failing with these, hot water may be used in the same manner. Or the positive pole of the galvanic current may be applied. As a rule, the application of any one of these methods will render the diagnosis sure by immediately stimulating a responsive twinge of pain. More rigorous means will excite a severe paroxysm of pain in the offending tooth and aggravate the neuralgic symptoms.

Pathology.—The principal and characteristic pathologic change which takes place in active hyperæmia of the pulp is an *irregular dilatation of its blood-vessels.* Salter* (1875) was the first to discover this peculiarity of the vessels of the pulp while studying the pathology of suppurating and sloughing pulps. He describes the condition as an irregular dilatation of the smaller vessels into ampullæ filled with clots, and which he believed to be due to engorgement of the vessels, loss of vital contractility, passive yielding of the over-distended and thinned walls, and coagulation of the

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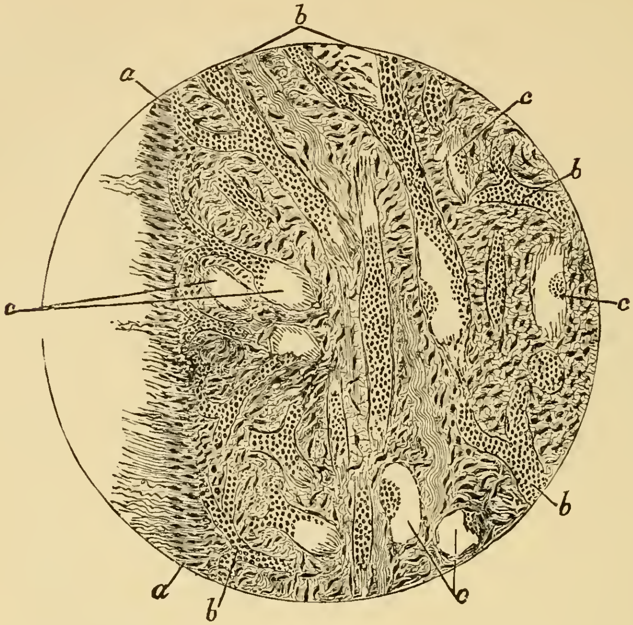
* Dental Pathology and Surgery.

blood. Albrecht * (1858) called attention to the notable increase in the volume of the blood-vessels and to their tortuous course. Wedl † (1870)

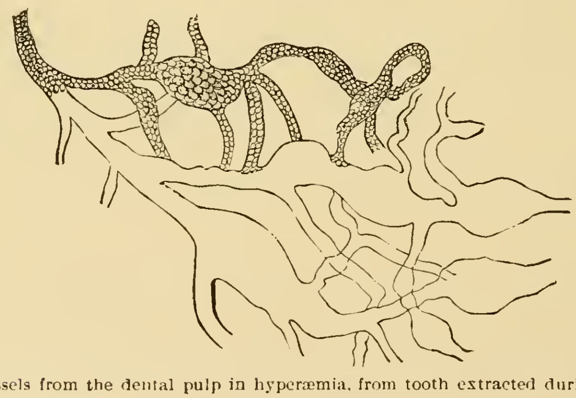
FIG. 484.



Hyperæmia of the dental pulp, showing the natural injection of the vessels. (After Black.) *a, a,* membrana eboris, or layer of odontoblasts; *b, b, b, b,* vessels distended with blood; *c, c, c, c,* points from which the blood has fallen in handling the section.

also describes a swollen and lax condition of the fibrous sheaths of the small arteries and veins.

FIG. 485.



Dilated blood-vessels from the dental pulp in hyperæmia, from tooth extracted during a paroxysm of intense pain. (After Black.)

Black ‡ (1886) found the dilated and varicosed condition of the vessels of the pulp (Fig. 484) to be so constant as to form a characteristic patho-

* Krankheiter der Zahnpulpe. † Pathology of the Teeth.
‡ American System of Dentistry.

logic feature of the acute form of the affection. Fig. 485 was made by Dr. Black from a section of the pulp of a tooth which was extracted during a paroxysm of acute pain. The tooth had been troubling for several weeks, the paroxysms of pain being excited by very trivial changes in temperature and lasting for an hour or more. He also found in other cases of a similar character, but which were extracted during an interval between the paroxysms of pain, that nothing of a remarkable character was presented. The veins of a bulbous portion of the pulp may be abnormally large and engorged with blood, while the arteries will be almost or quite empty and the injection of the capillary system wanting. Black looks upon the increased susceptibility of the pulp to thermal shock as "in a large degree due to nervous phenomena. The tension of the blood-vessels and their degree of contractibility are phenomena which are controlled by the vasomotor system, and in the dental pulp these are prominently affected by thermal changes in such a way that the vessels expand passively before the pressure of the circulation."

The dilatation of the vessels is due to a paralysis of the vaso-constrictor fibres, and the varicosed condition to an irregular paralysis of these fibres. The effect of painful stimulation or irritation upon the vasomotor system of nerves is to cause an immediate contraction of the vasoconstrictor fibres of the walls of the vessels and narrowing of their lumen; this is followed by reaction and stimulation of the vasodilator fibres, which cause a dilatation of the lumen of the vessel, and permit a greater quantity of blood to flow through it than is normal, which constitutes a transitory hyperæmia. In persistent hyperæmia of a pronounced type the vasoconstrictor fibres suffer paralysis for a time, resulting in a continued expansion of the vessels, which may become permanent if the irritation is of a continuous character.

Black found as a result of his researches that the vessels of the pulp possessed a wonderful degree of recuperative power, and that the vessel walls frequently recover their normal tonicity.

In the more advanced stage of arterial hyperæmia another phenomenon is sometimes presented. This is the escape or migration of the red blood-corpuscles through the walls of the vessels, forming areas of a reddish hue, and in other instances of deeper color, having the appearance of extravasations of blood. These are in all probability due to embolism and the formation of an infarct. An infarct is a dark-red, wedge-shaped area in an organ due to the occlusion of a vessel by an embolus, with the subsequent extravasation of blood into the tissues beyond the point of obstruction. The base of the wedge is towards the periphery of the organ, and the apex towards the point from which the blood-clot entered the obstructed vessel.

Passive or *venous hyperæmia* can only be inferred from the character of its symptoms, which are dull, heavy, gnawing pains, accompanied by a sense of fulness, the intensity of the pain often being steadily maintained for many hours. These symptoms are probably due to the dilatation of the arteries which enter at the apical foramen, causing pressure upon the veins and preventing the escape of the blood from the pulp by these channels. In teeth possessing two or more roots, the hyperæmia may be somewhat lessened by the escape of the blood through the veins of a second root. In single-rooted teeth this cannot occur, and if the congestion extends to the apex of the tooth, the pain will continue until strangulation or general infarction takes place.

Prognosis.—Hyperæmia from external irritants, if unrelieved, usually leads to diffuse inflammation of the pulp, probably as a result of infarction and the extravasation of the red blood-corpuscles. Cohnheim's experiments seem conclusive that inflammation does not result from even the most extreme hyperæmia that can be induced by the paralysis of the vasomotor nerves. Black* was not able to determine whether diffuse inflammation would occur before infarction and extravasation had taken place or not, but was inclined to believe with Cohnheim that it would not. His own observations, however, show conclusively that in every case of extravasation a mild form of inflammatory action had been induced, by which new elements were thrown out which acted the part of absorbents in the removal of the extravasated blood, and in this way he believes a general diffuse inflammation of the pulp may be set up as a result of hyperæmia. He thinks this will explain those cases of diffuse inflammation of the pulp which often occur without the exposure of the organ to any of the forms of external irritation.

Absorption of the extravasated red blood-corpuscles takes place through the phagocytic action of the leucocytes.

The progress of active hyperæmia will depend upon the temperament and the general health of the patient, the duration and character of the irritation, the severity and frequency of the paroxysms of pain, and the extent to which the crown of the tooth has been destroyed by caries or other causes.

The power of the pulp to recover after repeated attacks of hyperæmia points strongly to a favorable prognosis in those cases which have escaped infarction and septic infection; provided the temperament, age, and the general health of the individual do not operate against it.

Conservative treatment should therefore be adopted in all cases in which a favorable prognosis may be hoped for. It is not to be expected, however, that every case so treated will prove successful, any more than that one should expect every case in which the pulp is removed to prove successful. A certain number will prove failures in either case, but the percentage of successes and failures will depend (after the individual equation of the patient has been eliminated from the proposition) very largely upon the diagnostic ability and manipulative skill of the operator, coupled with good judgment in the selection of the particular method of treatment to be employed.

The writer maintains that inasmuch as the pulp of the fully calcified tooth is its organ of nutrition and sensation, it has *two important functions* to fulfil,—functions which should be preserved as long as possible, that the tooth may perform to completion its many offices as nature intended; and

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* American System of Dentistry.

furthermore, that the pulp should never be ruthlessly destroyed, because, forsooth, it has sounded an alarm on the too near approach to its citadel of the arch-enemy, dental caries.

Many operators look upon all efforts to conserve the vitality of the pulp, after it has given evidence of being the seat of hyperæmia, as largely experimental, with the chances of failure very greatly in the ascendency, and for this reason advise devitalization and extirpation as the surest way of rendering the tooth comfortable.

Other equally skilful and conscientious operators attempt the conservation of the pulp even after it has been the seat of hyperæmia for several days, and succeed in a good per cent. of cases in preserving their vitality, as proved by their responding to the usual tests many years afterwards.

The *age* and the *general health* of the patient are important factors in the recuperative powers of the pulp. Conservative treatment of the pulp is much more likely to prove successful in youth and early adult life than in middle life or old age, while in the debilitated or those suffering from tuberculosis or other infectious diseases the prognosis is very unfavorable.

Treatment.—The rational treatment of any surgical disease or injury comprehends two general principles: first, the removal of the cause; and second, rest of the organ or part which should approach complete physiologic rest as nearly as possible. These principles should always be carried out in the treatment of dental diseases, for they can be as readily applied in this class of diseases as they can in the more serious surgical diseases or injuries.

In the treatment of hyperæmia of the pulp, the first effort should be directed towards giving relief from the pain, and this can best be accomplished by the removal of the cause of irritation. When the disturbance to the pulp arises through a carious cavity in the tooth, this should be freed from food *débris* by carefully syringing the cavity with tepid water to which has been added in proper strength a suitable alkali or an antiseptic. Bicarbonate of soda is the best alkali for the purpose, and listerine, pasteurine, borolyptol, thymolene, and formol are the best of the prepared antiseptics. The simple removal of the *débris* and neutralizing the acid condition of the disorganized dentin will often be all that will be required to give immediate relief from the pain. The next step is to remove the disorganized dentin, care being taken not to expose the pulp, as an accident of this character complicates the treatment and renders the prognosis of the case somewhat more doubtful.

The writer believes with many other practitioners of somewhat extended experience that it is better practice to leave a layer of decalcified dentin over a living but hyperæmic pulp than to remove this covering and substitute for it a foreign substance, which can by no possible stretch of the imagination be thought to be as compatible to the pulp as the tissue—though partially disorganized—which nature formed for its protection; and for the further reason that such practice gives better results, in conserving the organ, than does capping with a foreign substance.

The cavity should now be dressed with some remedy possessing sedative and antiseptic qualities, like the oils of cloves, cinnamon, thyme, gaultheria, peppermint, etc., applied upon a pledget of cotton and sealed in with temporary stopping or zinc oxyphosphate. Carbolic acid is recommended by some operators, while others object to its use because of its coagulating effect upon the albuminoids of animal tissue. The object in sealing the dressing into the cavity with these substances is to secure rest to the pulp by preventing or lessening thermal shock, and also to prevent its further contamination with septic material, as by this method only can one expect to succeed in permanently allaying the irritation of the pulp and reducing its hyperæmic condition. Plugs formed of cotton saturated with gum sandarach cannot fulfil these requirements, for they soon become saturated with the secretions of the mouth and filled with myriads of organisms, and should, therefore, never be employed in any case where the maintenance of aseptic conditions are desirable.

The dressings should be allowed to remain undisturbed for two or three days or longer if the tooth continues comfortable, otherwise they may be changed every day. Care should be exercised in applying the dressing, and in each after-treatment, to prevent the entrance of moisture from the mouth. To insure this condition it is better to resort to the rubber dam than to rely upon napkins or other means for excluding moisture. If after a week's treatment the tooth remains in a comfortable condition, the pulp may be protected from thermal shock by varnishing the cavity and placing a layer of softened gutta-percha in the bottom of the cavity, and filling the balance with zinc oxyphosphate, or thin zinc oxyphosphate may be flowed over the bottom of the cavity and the balance filled with gutta-percha.

The treatment of exposed pulps is given in a following chapter upon this subject.

In those cases in which the hyperæmia is associated with abrasions, erosions, or superficial cavities the surfaces may be treated with carbolic acid (deliquesced crystals) or caustic potassa when located in the anterior part of the mouth, or with silver nitrate when located in unexposed positions. Or a retentive form may be given to the denuded surface, the cavity thus made being first treated with carbolic acid and then dried, varnished, and filled with zinc oxyphosphate.

When the irritation and hyperæmia are due to the presence of large metallic fillings or to galvanic shock from contact of fillings of dissimilar metals, these should invariably be removed and replaced with non-conducting materials.

Hyperæmia from Internal Local Causes.—Hyperæmia of the pulp may be induced by certain internal causes,—viz., the formation of secondary growths within the pulp-chamber or within the parenchyma of the pulp itself.

These growths are designated as *dentinal tumors* and *pulp-nodules.*

Calcifications of the pulp resulting from the irritation of caries and other destructive loss of the hard tissues, and calcareous degeneration, are rarely, if ever, causes of hyperæmia of the pulp, but are quite often the results of hyperæmia.

These formations have, however, been frequently found in teeth which had given no history of irritation or pain; it has, therefore, been questioned whether they are ever sources of hyperæmia. Some have thought them to be the result of irritation and hyperæmia, while others have believed they may sometimes not only be the cause of this disturbance, but the more serious condition of facial neuralgia.

This form of hyperæmia is sometimes termed *idiopathic*, for the reason that there seemed to be no other disease upon which it was dependent for its origin or progress. In a certain number of these cases there is not the slightest evidence of any external form of irritation whatever. In fact, the teeth are perfectly sound, the most careful examination failing to reveal the minutest trace of a break in the continuity of the enamel, either from caries, abrasion, erosion, or other injury. We must, therefore, in these cases, look for internal causes of irritation which are to be found in the presence of dentinal tumors and pulp-nodules. There are, however, no symptoms which are particularly or peculiarly diagnostic of these forms of irritation. The *diagnosis* must therefore be reached by a process of exclusion.

The *prognosis* is decidedly unfavorable in this class of cases so far as the vitality of the pulp is concerned, for sooner or later the pulp succumbs to the irritation and devitalization takes place.

Treatment.—The treatment of hyperæmia due to irritation produced by the presence of secondary deposits within the pulp-chamber to be curative *must be radical.* This consists of devitalizing and extirpating the pulp and filling the canals with suitable materials.

Hyperæmia from Constitutional Causes.—*General nervous irritability* or *neurasthenia* is a term which has come into general use to indicate certain states of the nervous system—often inherited—the anatomic basis of which is still unknown, but which are characterized upon the one hand, as pointed out by Putnam, by a series of *negative* symptoms manifested by a lack of vigor, efficiency, and endurance, affecting usually a large number of nervous functions, and, upon the other hand, by signs of active derangement, which in part seem to occur as *positive* symptoms, and in part are due to a failure of the mutual support and control which the different parts of the nervous system afford each other in health. These conditions are often manifest in the mentally and physically overworked, in low conditions of the general health, particularly in anæmic states of the blood, and in those suffering from prolonged wasting diseases, like tuberculosis and cancer, or from digestive or intestinal derangements and from nervous shock.

Neurasthenic patients are also subject to various sensory disorders like neuralgic attacks and periodic headaches, irritability of the spinal cord, which upon pressure produces painful peripheral sensations in the region of the thorax or abdomen, according to the level at which the pressure is made. Another quite common variety of painful sensation, not precisely neuralgic in character, is a distressing sense of pressure and tenderness at the vertex or occiput, with stiffness of the muscles of the neck. Occasionally the pain is very severe, and entirely unfits the individual for the time for any form of physical or mental labor.

Dr. Allbutt, in speaking of this class of individuals, says, "They are heirs of every true neurosis, from insanity to toothache."

Hyperæsthetic conditions of the peripheral terminations of the nerves, especially of the skin, are frequently met with in neurasthenic individuals. These conditions are characterized by an exalted or exaggerated sensibility of the skin, which is unattended by any observable structural changes whatever. In mild cases there is manifested an undue sensitiveness to contact with foreign bodies, such as the clothing, while in the severer cases the greatest distress is occasioned by even the passage of a feather over the surface. This disease is properly classed with the neuroses of the skin, and may be either idiopathic or symptomatic in its origin, but little is known of its etiology or pathology.

Conditions similar to this are sometimes manifested in teeth which give no other evidence of disease; teeth in which the integrity of the enamel has not been broken; but it is an open question whether the sensation of pain is primarily due to an exalted sensibility or hyperæsthesia of the dentinal fibrillæ, and located in them alone or in the pulp, the susceptibility of which has been abnormally increased to all forms of external irritation.

Although the exact anatomic and histologic character of the dentinal fibrillæ have never been positively demonstrated, yet there is no good reason for doubting that they are terminal nerve-fibres, for they seem in many respects to possess in a high degree the functions of nerve-tissue. It is, therefore, not a severe strain upon the imagination to suppose the dentinal fibrillæ capable of assuming an excessive sensibility or hyperæsthetic condition as an expression of the neurasthenic state of the patient, or that such expression may be primarily manifested in the pulp itself, which becomes abnormally sensitive to external impressions that under other conditions would cause no pain or uneasiness whatever.

In those cases in which loss of substance has occurred in the crown of the tooth from caries or traumatism sufficient to expose the dentin, it would seem that the hyperæsthesia begins in the dentinal fibrillæ and extends through them to the pulp. This view receives support from the fact that if these cases are treated with silver nitrate applied to the exposed dentin, the hyperæsthesia rapidly disappears and the tooth regains its normal sensitivity.

General *plethoric* conditions of the system and *pregnancy* are often productive of hyperæmic states of the dental pulp, by reason of the increased arterial pressure which accompanies these conditions. Some of the most obscure cases of odontalgia that the writer has ever had to deal with have been finally traced to one or the other of these conditions.

Plethora may be defined as a condition in which the volume of the blood in the body is in excess of the normal amount (*polyæmia*), and in which the vessels of the body generally, or of any part, are over-distended with blood. It is made manifest in flushing of the face, a sense of fulness in the head, buzzing in the ears, and full pulse, caused by the increased arterial tension and fulness or engorgement, particularly of the capillary system of blood-vessels.

Plethora is more common in men than in women, and is most frequently seen in middle life. It has been stated by Jacobi that plethoric conditions are present in women just before the menstrual periods.

Osler is of the opinion that the conditions which are denominated plethora are the result not of an actual increase in the volume of the blood, but rather to its distribution and certain local peculiarities of the vessels or of their innervation.

Individuals of this dyscrasia are prone to capillary hyperæmia; to rupture of the arterioles and capillary vessels and extravasations of the blood, by reason of the continued increased blood-pressure, and the consequent weakening of the walls of the vessels. This is illustrated by the fact that this affection furnishes a fair proportion of the otherwise healthy individuals who suffer from a general distention of the superficial vessels, hyperæmia, and hemorrhagic conditions of the mucous membrane of the upper air-passages, as well as that more serious and often fatal affection known as cerebral apoplexy.

The tendency in plethoric individuals to general distention of the superficial blood-vessels and engorgement of the capillaries the writer believes sometimes results in hyperæmia of the pulp in perfectly sound teeth, accompanied by pulsating sensations, a sense of fulness or throbbing pain which may be referred to one or more teeth. In other cases it may result in rupture of the vessels, extravasation of blood, inflammation, and death of the pulp.

The *diagnosis* of hyperæmia of the pulp caused by plethora is quite readily made from the general condition of the patient, the absence of any discoverable external cause of irritation, and the previous history of the case, which is invariably a sense of fulness, accompanied with occasional pulsating or throbbing sensations in the tooth, which are augmented by vigorous exercise or the recumbent position; later the pulsating or throbbing sensations become painful, which indicates the establishment of the hyperæmic state.

Treatment consists in reducing general and local arterial tension. This may be accomplished in the first instance through a general depletion of the system by the administration of saline cathartics, a restricted diet, and regular exercise. Local arterial tension may be relieved by the hot foot-bath, keeping the extremities warm, the bowels open, and the skin free. If general treatment fails to give the desired relief and the pain continues, the only recourse is the devitalization and extirpation of the pulp.

Pregnancy.—Pregnancy, although a physiologic process, is often productive of various disordered states of the system. It will be sufficient in this connection, however, to dwell simply upon those abnormal conditions of the oral cavity which are referable in a greater or less extent to the usual augmentation in the volume of the blood during this period, and to a plethoric state of the upper half of the body, which is not an infrequent accompaniment, and to those nervous phenomena which are productive at this period, of neuralgic conditions of the trifacial nerve.

Changes both quantitative and qualitative occur in the blood during pregnancy. The quantitative change in the blood is proved by the increased area of the circulation brought about by the enlargement of the uterus and by the fulness of the vessels, a fulness which is sometimes productive of varicose veins or of serous effusion. This increase in the volume of the blood was first demonstrated by Spiegelberg and Gescheidlen * in experiments upon pregnant bitches.

Authorities, however, are not agreed as to the qualitative changes which take place in the blood. Andral,† Nasse,‡ Meyer,§ and others claim that the watery elements and the white corpuscles are increased and the red corpuscles diminished. Ingerslev || was unable to detect any diminution in the number of red corpuscles, while, upon the other hand, Fehling ¶ found the hæmaglobin and the red corpuscles increased.

Temporary hypertrophy of the left ventricle sometimes occurs as a result of increased labor thrown upon the heart as a consequence of the augmentation of the blood mass. This was first made known by Larcher ** in 1828.

Venous congestion, varices, and swelling of the lower extremities, and arterial hyperæmia of the upper half of the body, are a frequent accompaniment of pregnancy. The causes of these conditions are not fully understood, but they were attributed by Christoforis †† to pressure of the gravid uterus upon the iliac veins, which prevented the normal return of the blood to the *inferior vena cava*, and to pressure upon the descending aorta, thus obstructing a normal flow of blood to the lower extremities, and causing plethora or arterial hyperæmia of the upper portion of the body.

An increase in the salivary secretions is often a noticeable symptom. Ptyalism when present manifests itself early, and usually disappears spontaneously between the third and fourth months. It occasionally persists, however, in an exaggerated form during the entire period of gestation, and even for several weeks thereafter, while the amount secreted may be so great as to endanger the life of the patient. The qualitative changes in the saliva during pregnancy are sometimes quite marked. The water is increased, while the organic and inorganic elements are diminished. Schramm reported one case in which the pytalin was entirely absent. In those cases in which an excessive flow of saliva is manifest the buccal mucous membrane is more or less inflamed, the parotid, submaxillary, and sublingual glands are swollen, tender, and quite painful when their secretory functions are especially excited. Fœtor is not present, and the absence of this symptom distinguishes it from mercurial ptyalism.

The cause of this disorder is generally thought to be due, in all probability, to a reflex neurosis, though the writer is inclined to the opinion that it is due to over-stimulation of the glands resulting from the general hyper-

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* Hirst's American System of Obstetrics, p. 353.

† Annales de Chimie et de Physique, Juillet, 1842.

‡ Archives of Gyn., Bd. ix. S. 338.

§ Untersuchungen über die Veränderungen des Blutes in der Schwangerschaft.

|| Centralb. f. Gyn., 1879, p. 635.

¶ Archives f. Gyn., Bd. xxviii. Heft 3, S. 454.

** Hirst's American System of Obstetrics, p. 346.

†† Ibid.

æmic condition of all the tissues of the upper portion of the body during this period. The affection frequently reappears in successive pregnancies.

Gingivitis is another common oral symptom in pregnancy, and is often present when there is no indication of salivation. These cases are characterized by redness and tumefaction of the gums and a tendency to bleed on slight pressure or friction, while the secretions of the mucous glands are often decidedly acid in reaction.

Phagedenic pericementitis is occasionally an accompaniment of pregnancy, and is frequently associated with rheumatic affections, diabetes mellitus, and albuminuria, but just how it is associated in relation to cause and effect with the kidney affections is not positively known, but the writer has suggested * that "it is due in these cases to the accumulation of effete products in the system, possibly of uric acid, urea, and other waste material."

Neuralgic affections are also quite common during pregnancy, and most frequently affect the face and head. Odontalgia is a not infrequent accompaniment of pregnancy in teeth which, so far as external conditions are presented, appear to be perfectly sound. This affection is due to hyperæmia of the pulp induced by the augmentation in the volume of the blood, the increased arterial pressure, and general hyperæmia of the upper portion of the body.

The proof of this statement is in the fact that a brisk cathartic will often relieve or entirely control an attack of odontalgia when due to these causes. It operates in a general way by depleting the circulation, thus relieving the arterial tension and hyperæmia ; while it acts locally by reducing the blood-pressure in the pulp, and restoring for the time being a normal circulation.

On the other hand, anæmic states of the blood are prone to establish general and local neuralgic conditions. Anstie has graphically epitomized the definition of neuralgia as "*the cry of the hungry nerves for food.*" The trifacial nerve is frequently the seat of neuralgia, the pain often being located in one or more teeth. Cases are on record in which tooth after tooth has been extracted under the belief that hyperæmia or inflammatory conditions were present in the pulp of such teeth, when in reality the cause of the affection was a general one, due to an impoverished condition of the blood, which in many cases could undoubtedly have been relieved by appropriate general tonic treatment.

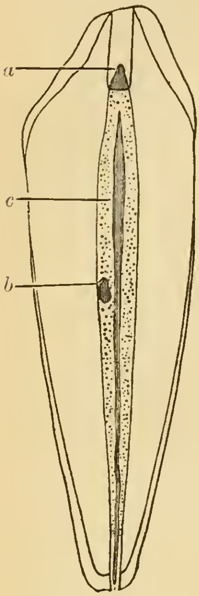
Reflex neuralgic phenomena in the teeth are occasionally encountered as a result of diseased conditions of remote organs, or of hyperplastic or hypertrophic enlargement of portions of tissue or organs, or of new growths, which cause pressure upon important nerve-trunks, or upon the nerves directly supplying the teeth. Consequently in the diagnosis of all obscure cases of odontalgia due weight should be given to the possibility of the affection having its origin in some one of these remote causes.

* Paper on "The Teeth of Pregnant Women," Transactions of the American Medical Association, 1889.

NEW FORMATIONS.

Calcic Formations within the Pulp-Chamber.—The formation of secondary growths of dental tissue within the pulp-chamber and calcic degenerations of the tissues of the pulp have never been satisfactorily classified.

Fig. 486.



Salter was the first to attempt to classify the various forms of new growths within the pulp-chamber, and for many years it was the only classification used. Black has since made a more minute and comprehensive classification, but this, he thinks, is still far from complete or satisfactory.

Salter divides secondary growths of dentin into three different forms,—viz., *dentin of repair, dentin excrescence, intrinsic calcification, or osteodentin.* The accompanying illustration (Fig. 486), borrowed from Salter,* represents these forms of secondary growths in the pulp-chamber: *a* represents a mass of dentin of repair formed to compensate for the wear at the summit of the cusp; *b*, an excrescence or tumor projecting from the side of the cavity into the pulp; *c*, represented by the dark cylinder in the axis of the pulp, indicates where the formation of osteodentin or intrinsic calcification begins.

Dr. Black † classified the secondary deposits within the pulp-chamber under six different forms,—viz.:

"1. *Secondary Dentin.*—A new growth of dentin more or less regular in formation, excited by abrasion, decay, or other injury, by which the dentinal fibrils are subjected to irritation at their distal ends.

"2. *Dentinal Tumors within the Pulp-Chamber.*—An erratic growth of dentin into the pulp-chamber united to the wall by a pedicle. The structure is very irregular.

"3. *Nodular Calcifications among, but not of, the Tissues of the Pulp.*—These are the irregular nodulated masses so frequently seen either as very small stones or irregular masses. They contain many calcospherites.

"4. *Interstitial Calcifications of the Tissues of the Pulp.*—These are the counterpart of calcifications elsewhere in the body, as in the arteries, etc.

"5. *Cylindrical Calcifications of the Pulp.*—The tissues in this form are probably in a state of fibrous degeneration, which is usually seen in the pulp-canals.

"6. *Osteodentin.*—Erratic formations showing both the lacunæ of bone and the dentinal tubes."

Calcospherites were seen by Black in connection with many of these forms. Other irregular formations are found that are scarcely assignable, he thinks, to any of these varieties, and it is not unusual to find the various forms intermixed with each other.

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* Dental Pathology and Surgery. † American System of Dentistry.

FIG. 487.—Secondary dentin on wall of pulp-chamber. (V. A. Latham.) × 100.

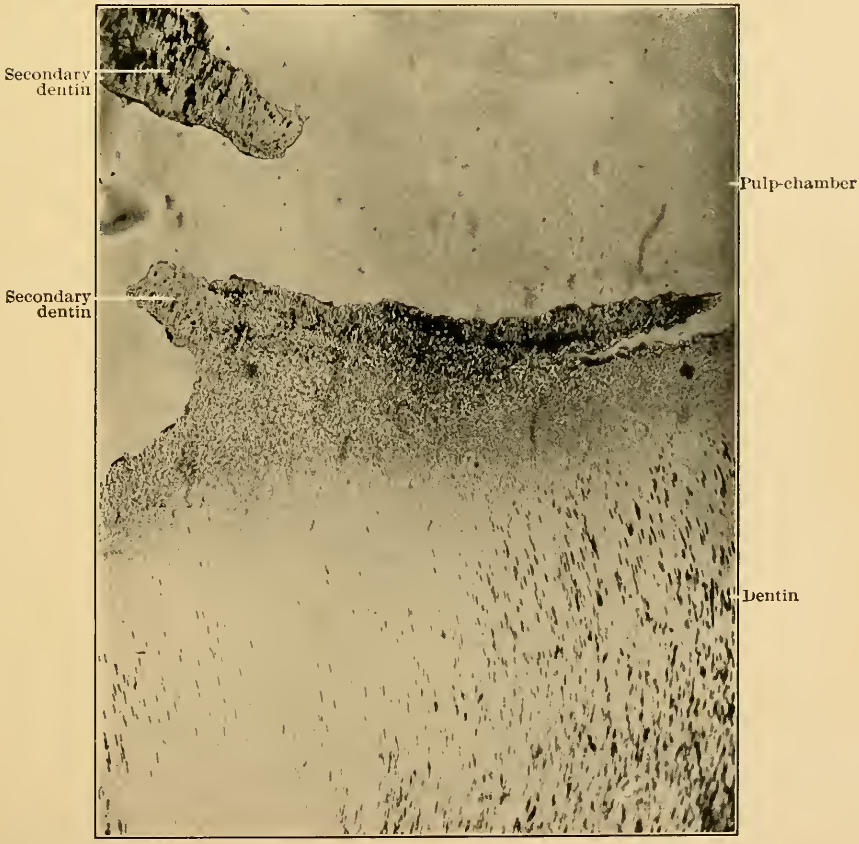


FIG. 488.—Secondary dentin on wall of pulp-chamber. (V. A. Latham.) × 96.

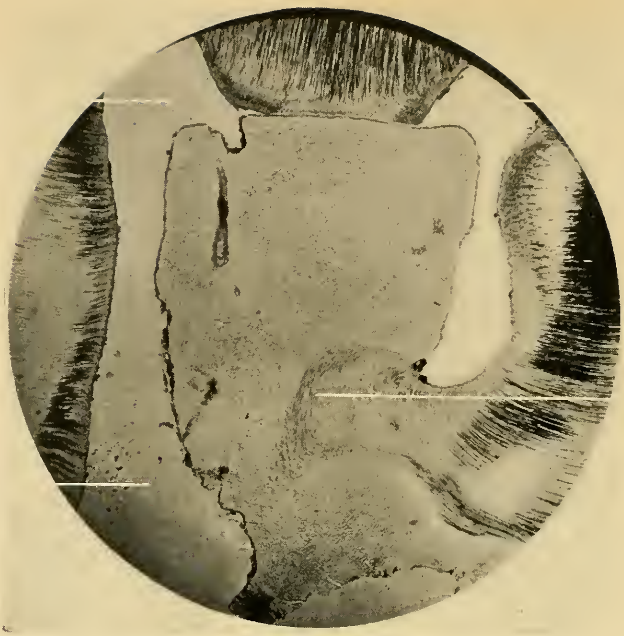


FIG. 489.—Secondary dentin in base of pulp-chamber. (V. A. Latham.) × 50.

FIG. 491.—Section of dental pulp containing a pulp-nodule. (V. A. Latham.) × 23.

Secondary dentin, or *dentin of repair*, may be distinguished from the other forms of secondary deposit by the fact that it is always located opposite some lesion of the external tissues of the tooth, whereby a loss of continuity has occurred ; that it is adherent to and in direct structural continuity with the primary dentin ; that the pulp is not attached to, nor is its structure involved in, the newly formed mass, but may be easily removed.

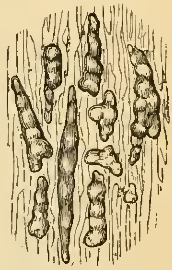
This process may be regarded as physiologic, having a similar significance to the process of repair exhibited in bone-tissue.

For further discussion of this subject, see chapter on "Conservative Treatment of the Pulp."

Dentinal Tumors.—These are rare forms of secondary growths within the pulp-chamber. They are composed of calcific material of notably irregular structure, formed in masses of varying size, and attached by a pedicle to the primary dentin, or occasionally to masses of secondary formation. They are confined entirely to the pulp-chamber. The dentinal tubes within the mass are continuous with the tubules of the primary dentin (Fig. 487).

Dr. Black is of the opinion that they are the result of the same causes as those leading to the formation of secondary dentin generally. With this opinion the writer cannot fully agree, for the reason that such growths have been occasionally found in teeth in which there were no evidences of any external cause of irritation. Of the circumstances which determine the erratic tumor-like form of the growth nothing whatever is definitely known. Figs. 488 and 489 show two very erratic forms. Wedl and Heider believe it is due to an *inversion of the layer of dentinal cells*, and that the space formed within the surface of the pulp by the inversion is later occupied by new dentin. They say, "These formations are by no means of rare occurrence, and that they are found attached to the original dentin by means of a pedicle, and in cases where there is no connection with a pedicle detachment has ensued."

FIG. 490.



After Dr. Black.

Nodular Calcifications, or Pulp-Stones.—These are found in globular masses (Fig. 490) and spindle-shaped masses scattered through the substance of the pulp, particularly in the teeth of adults. They may be found in any part of the pulp-tissue, but most often in the coronal portion. In form they are irregularly nodulated, appearing to be made up of an aggregation of smaller nodules. In structure they appear to be masses of calcific material composed of the same elements as dentin, but lacking its peculiar structure. Embedded within the calcific material are numerous bodies made up of concentric rings, which are calcospherites. Various irregular lines are seen running through the mass, which may be tubules or only faults in the structure.

The formation of pulp-nodules is thought to be due to the deposition of masses of calcoglobulin within the pulp, and which is known to form the base of the pulp-nodule,—the calcospherite, enamel, dentin, and bone,—the lime-salts entering into combination with the calcoglobulin to form calcospherites, and these uniting in larger masses form the pulp-nodules.

Wedl, Salter, Black, and other writers look upon their presence in the tissues of the pulp as a result of some form of peripheral irritation of the dentinal fibres, as they are found in increasing numbers in the teeth of those who have suffered from caries, abrasion, erosion, inflammatory conditions of the pericementum, or other injury or disease. Figs. 491 and 492, which show a pulp-nodule *in situ*, are made from a pulp removed from a tooth which was the subject of pyorrhœa alveolaris. Tomes does not quite agree with this view, as he found globular masses in three out of five specimens of perfectly sound molar teeth removed *post mortem* from subjects in the hospital morgue. Robin and Magitot called attention to the presence of isolated calcareous granules of globular form which were scattered through the substance of the pulp in the early stages of dentin formation. Henle and others have likewise described them as present in the teeth of man, ruminants, and rodents. C. S. Tomes found them in the developing teeth of ruminants, scattered freely through the dentinal pulp, and finally becoming embedded at various depths within the substance of the dentin.

The fact, therefore, remains that many cases of calcific nodular formations within the pulp have their origin in other than external causes of irritation. Black looks upon the presence of a few pulp-nodules in the tooth as of no special pathologic significance as far as the future health of the tooth is concerned.

Calcification of the Tissues of the Pulp.—This is a condition often seen in the teeth of elderly persons, as the result of senile change or degeneration of tissue. Fibroid degeneration (Fig. 493) is one of the most common precedents of calcareous deposits in the pulp.

Calcareous deposits formed within the structure of the tissues, according to Ziegler, usually occur in localities where the tissues have already lost their vitality or are in a process of degeneration or necrobiosis. It appears as if dying tissue which has undergone more or less modification possesses a kind of attraction for the lime-salts which are in solution within the body, and enters into intimate combination with them. The tissues which are most prone to calcareous degeneration are connective tissue which has undergone hyaline degeneration or sclerosis, the walls of blood-vessels, tumors, and other portions of the body which are undergoing hyaline or fatty degeneration, degenerating cartilage, dead cell-bodies, and cheesy areas of considerable size.

Tissue-calcification is uniformly associated with degenerative changes in the structures of the pulp. Calcification may affect small or large areas, causing in the latter case a distinct hardening of the tissue and a whitish coloration.

The process is characterized by the formation of numerous minute islands of calcification scattered through the tissue of the pulp, of regular outline, and presenting a smooth surface.

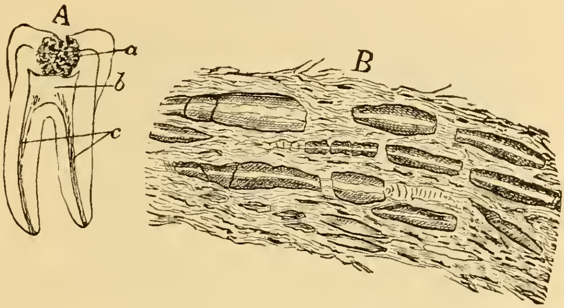
There is considerable difference in the microscopic appearance of these islands of calcification. In some of them are seen on section the calcified tissue elements of the pulp, others appear to be of granular structure, with a few irregular and wavy tubes scattered through them, and still others appear to have no structure at all.

FIG. 492.—Vertical section of dental pulp, showing pulp-nodule. (V. A. Latham.) × 70.

FIG. 493.—Section of tooth-pulp undergoing fibroid degeneration. (V. A. Latham.) × 110.

Salter and Black both describe a peculiar form of degenerative calcification occurring in the radial portion of the pulps of teeth, particularly in the roots of the molars, which they have termed *cylindrical calcification.*

FIG. 494.



Cylindrical calcification of the pulp, early stage. (After Dr. Black.)

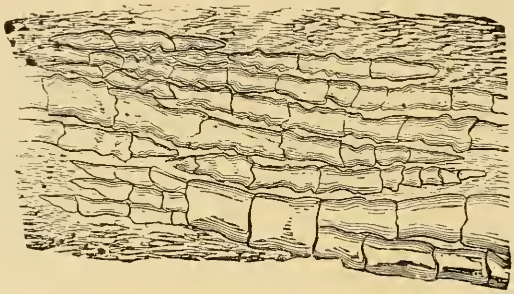
From the appearances exhibited in sections of cylindrical calcification, it is evident that it is a calcareous degeneration of a previous fibrous degeneration of the pulp. This is shown in the accompanying illustrations by Dr. Black. Fig. 494 shows an early stage of the degenerative process;

FIG. 495.

Cylindrical calcification of the pulp, early stage; nodules teased apart. (After Dr. Black.)

Fig. 495 is a similar section in which the nodules have been spread out to show the attachment of the cylindrical masses to the fibrous elements of the pulp; while Fig. 496 shows a more advanced stage of the disease in which the cylinders run together and join end to end, forming jointed rods, but do not coalesce. In this stage of the disease the radial portion of the pulp becomes stiffened and may be bent at various angles, and will retain its bent position. Salter says—and Black agrees with him—that ultimately "the whole of the tissues, cells, nuclei, connective tissue, blood-vessels, and multitudes of nerves are swallowed up and obliterated in the calcific process. The process of calcification is clearly not interstitial in the sense of being between the fibres." This variety of calcification is usually associated with other forms, and there is generally more or less calcification of the coronal portion of the pulp, either in the form of secondary dentin or

FIG. 496.



Cylindrical calcification of the pulp, advanced stage. (After Dr. Black.)

interstitial calcification. Figs. 497 and 498 illustrate such a condition, the coronal portion of the pulp being completely calcified.

Osteodentin is a secondary formation of rare occurrence in the human teeth, but it is common in the teeth of animals, particularly in very large

FIG. 497.

FIG. 498.

animals, like the elephant. These formations are the result of long-continued or chronic irritation. As its name implies, it is a form of secondary growths which combine the elements of both dentin and bone, or, more correctly, of cementum (Fig. 499). It is developed, according to Salter, by the general conversion and intrinsic calcification of the several tissues of the pulp. It is usually vascular, frequently arranged in systems around vessels, like the Haversian systems of bone, and it sometimes has true lacunæ. It has fewer dentinal tubules than any other form of dentin, and is usually very transparent. It is made up of various calcification islands or systems of secondary dentin, which are finally fused together and adherent to the primary dentin (Fig. 500). The mass may contain any number of Haversian systems and numerous true bone lacunæ, especially resembling those found in the cementum.

These masses of osteodentin are found in teeth which show marked evidences of a former resorption of dentin, and although in many cases the tissues increased in amount, a considerable portion was found to occupy

Fig. 499.

Section of osteodentin. (After Salter.)

the situation of the normal dentin which had been removed by the process of resorption.

Bödecker* has also described this form of new growth as secondary dentin with forms analogous to Haversian systems.

Fig. 500.

Section of osteodentin. (After Smale and Colyer.)

Occasionally the resorbed dentin will be replaced by bone. Fig. 501, which is taken from the "Transactions of the Odontological Society of Great Britain," 1893, shows a section made from a partially erupted tooth,

* Dental Cosmos, 1879.

the root of which had apparently been about two-thirds formed, and appeared as though it had been fractured, but upon microscopic examination it was found that this appearance was due to resorption. The bone-tissue occupies the cavity formed by the process of resorption.

Fig. 501.

Section of dentin showing resorption area occupied by bone-tissue. (After Smale and Colyer.)

Irritation and hyperæmia of the pulp, it will be seen from the foregoing descriptions, could hardly occur from any of the various forms of secondary deposits except those mentioned under the head of internal local causes,—viz., dentinal tumors and pulp-stones,—by reason of the fact that all the other forms of secondary deposits are conversions of tissue, while these are erratic growths, occupying space in the pulp-chamber or in the tissue of the pulp, where they produce pressure upon the nerve-filaments, causing irritation.

CHAPTER XXIV.

INFLAMMATION OF THE DENTAL PULP.

Definition.—Inflammation (Latin, *inflammatio*, from *inflammare*, to inflame; *inflammo*, I set on fire), is a condition of nutritive disturbance, characterized by hyperæmia, with proliferation of the cells of a tissue or organ, and attended by one or more of the symptoms of pain, heat, swelling, discoloration, and disordered function. Inflammation is a series of changes in a part identical with those which are produced in the same part by injury from a chemic or a physical irritant.

Pulpitis is the term applied to inflammation of the dental pulp. (Latin, *pulpa*, pulp, and *itis*, a suffix used to indicate inflammation.)

Physical Signs.—The physical signs or cardinal symptoms of inflammation, as described by Celsus, are four in number,—viz., rubor, tumor, calor, and dolor, redness, swelling, heat, and pain; a fifth symptom has since been added to complete the description of the physical phenomena as presented in the tissues,—viz., *functio læsa*, disturbance of function in the part.

Inflammation is a symptom of disturbed function, but not a disease. It is an effort upon the part of the system to eliminate or render inert or harmless the primary cause of the disturbance.

All forms of inflammation are the result of the action of certain forms of irritation. Irritants are classed under four general heads,—viz., *mechanic*, *chemic*, *septic*, and *nervous*.

Mechanic irritants produce irritation through their mechanic action. Examples: the presence of foreign bodies, pressure from external sources, pressure from new growths, traumatisms, accidental or surgical, etc.

Chemic irritants are substances which irritate by virtue of their chemic reaction upon the tissue elements with which they come in contact. Examples: alkalies, acids, and escharotics, like chromic acid, or certain coagulants, like carbolic acid and silver nitrate, or violent irritants, like croton oil and cantharides. Other examples are found in drugs which through their constitutional exhibition produce peculiar effects upon certain tissues and organs, and which if administered in toxic doses will cause inflammation. Mercury acting upon the tissues of the mouth and salivary glands produces stomatitis and salivation. Cantharides will cause irritation of the urinary organs, ergot of the uterus, and uric acid will produce gouty inflammations. The toxic inflammation caused by the poison of serpents and certain insects, the poisonous action of certain plants, like the *Rhus toxicodendron*, and the ptomaines are examples of still other groups of chemic irritants.

Septic irritants are living organisms,—parasites or micro-organisms,—which cause irritation by their presence in the tissues or by the elaboration of toxic substances—ptomaines—as waste products and their introduction into the system by absorption. The pus-microbes and the saprophytic germs belong to this class.

Nervous irritants are those which produce irritation through the medium of the nervous system by disturbing the normal functions of the part. The influence which is exerted by the nervous system over the functions of nutrition, both generally and locally, in the production of inflammatory symptoms has long been recognized.

Impairment of the nutrition of the skin is sometimes observed to follow injury of the nerves supplying the part. Degenerative changes have been known to take place in the pulps of the lower teeth following exsection of the inferior dental nerve. Reflex nervous conditions are also recognized as being productive of inflammatory phenomena. An instance in point is the nervous irritation sometimes caused in the dental pulp by a misplaced uterus or the condition of pregnancy. Herpes zoster is an example of a pustular eruption following the course of a nerve, the inflammation being accompanied with infiltration of leucocytes around both the terminal branches and the trunk of the nerve.

Inflammation is a process which may affect any tissue of the body having a vascular circulation or which is connected with blood-vessels. Enamel which has no vascular circulation and is in no way connected with blood-vessels cannot be the seat of inflammation. Dentin, which occupies a position midway between enamel and bone in the evolution of the calcareous tissues, presents conditions which are thought by certain authorities—Heitzmann, Abbot, Bödecker, and others—to be inflammatory in their nature, the peculiarities of the symptoms being due to the low state of vitality and the small percentage of organic matter contained in its structure.

Inflammation in vascular tissues usually begins with the phenomena of hyperæmia, and progresses to exudation or to suppuration; sometimes resolution takes place, at others leading to the production of new formations, or to metamorphoses of various kinds, or to devitalization and destruction of tissue, and creating a more or less serious disturbance of the functions of the parts. The inflammatory process may vary greatly in its character and in its location.

The histologic character of inflammations depends upon two factors,—the *nature* of the *exudation* and the *changes* in the *tissues*. Both are used to classify the various forms of inflammation, according as the one or the other seems to be most pronounced.

Exudation.—Exudation or diapedesis is the process by which during partial stasis of the blood-current the corpuscular elements of the blood (the leucocytes and phagocytes) and the *liquor sanguinis* pass through the walls of the blood-vessels into the tissue spaces beyond. This process is the result of changes in the vessel walls, which permit the passage or leakage of the elements of the circulating fluid through the walls of the vessels. Ziegler says, "It may be accepted as an established fact that in inflammation the vessel wall is affected, but it is still questioned by some whether the affection is of the nature of a chemic alteration or a mere widening of pre-existing intercellular spaces." Burdon Sanderson believes "it is due to the loss of the power by the vessels of resistance to dilatation, and the loss of vital power, in consequence of which leakage takes place." Rupture or rhexis of the vessel walls sometimes takes place, which permits the red blood-corpuscles to escape into the tissues.

Tissue Changes.—The cellular and fluid exudates which pass through the vessel walls collect first in their immediate neighborhood, but rapidly spread out and involve surrounding healthy tissue by occupying the lymph-spaces of the tissues. When this tissue infiltration is considerable it is liable to produce other disturbances of circulation and nutrition, and thus increase the area of the inflammatory exudation and tissue degeneration.

Among the earliest changes which take place in the inflamed tissue is the coagulation of the fibrinous elements of the exudate, which prevents the further movement of the migrated corpuscles by enclosing them in the coagulated mass.

One of the functions of the leucocytes is to take up solid particles and portions of broken down and disintegrated blood-corpuscles. Metchnikoff (1884) and his followers claim that they have also the power of englobing and destroying the invading pathogenic bacteria which have gained an entrance to the blood and other tissues of the body. And that by this phagocytic power of the leucocytes immunity was established in the organism. He found in certain observations made upon a species of daphnia, which is subject to infection by a *torula* resembling the yeast fungus that gains access to its body through its food, that the fungus penetrates the walls of the intestines and invades the tissues. In certain cases the infection was not fatal, and this he believed was due to the fact that the leucocytes which accumulated around the invading fungi seized upon these organisms, and eventually destroyed them. If the leucocytes were successful in overpowering the parasites, the animal recovered; if not, the infection proved fatal. From this he argued that the pathogenic bacteria, when introduced into the body of an immune animal, are destroyed in a like manner, while they play an active part as prophylactic agents and in the metamorphosis of tissues and organs in inflammation.

Metchnikoff explained that the leucocytes gathered up the bacilli and destroyed them by a process of internal digestion. This power of the leucocytes to destroy foreign substances was first suggested by Surgeon-General Sternbergh, of the United States army, in 1881.

There is still a difference of opinion as to the power of the leucocytes to destroy living bacteria. Koch found in 1878 that the bacteria multiplied within the body of the leucocytes, and that many of these cells were destroyed by the bacteria.

Sternbergh, Weigert, Baumgarten, and others, have maintained that the bacteria found in the leucocytes were already dead when taken up by these cells, their vitality having been destroyed by some agency outside of the leucocytes, namely the blood-serum, and that there is abundant experimental evidence to prove that the blood-serum has decided germicidal power.

Sternbergh says (1892), "Numerous experiments have been made during the past two or three years with the view of determining whether pathogenic bacteria are, in fact, destroyed within the leucocytes after being picked up by them, and different experimenters have arrived at opposite conclusions. In the case of mouse septicæmia, and in gonorrhœa, one would be disposed to decide, from the appearances and the arrangement of the pathogenic bacteria in the leucocytes, that they are not destroyed, but that, on the other hand, they multiply in the interior of these cells, which in the end succumb to this parasitic invasion. In both of the diseases mentioned we find leucocytes so completely filled with the pathogenic micro-organisms that it is difficult to believe that they have all been picked up by a voracious phagocyte which has stuffed itself to repletion, while numerous other leucocytes from the same source and in the same microscopic field of view have failed to capture a single bacillus or micrococcus. Moreover, the staining of the parasitic invaders and the characteristic arrangement of the gonococcus in stained preparations of gonorrhœal pus indicate that their vitality has not been destroyed in the interior of the leucocytes or pus-cells, and we can scarcely doubt that the large number found in certain cells is due to multiplication *in situ* rather than to an unusual activity of these peculiar cells. But in certain infectious diseases, and especially in anthrax, the bacilli included within the leucocytes often give evidence of degenerative changes, which would support the view that they are destroyed by the leucocytes, unless these changes occurred before they were picked up, as maintained by Nuttall and others."

Nuttall (1888) has shown that the destruction of virulent micro-organisms in the blood of animals was not dependent alone upon the immediate presence of living leucocytes, but that the serum of the blood, when freed from all cellular elements of any kind, still possessed the power of destroying the vitality of bacterial forms equal to that of the blood in its normal state when all of its constituent elements were present.

Buchner (1890) demonstrated that the serum was robbed of its germicidal properties by exposure to a temperature of 55° C. for half an hour. Its efficiency, on the other hand, was not impaired by alternately freezing and thawing it, but dialysis or extreme dilution with distilled water diminished its germicidal power or completely destroyed it. If, however, it was diluted with an equal amount of water containing from 0.6 to 0.7 per cent. of sodium chloride, its germicidal action was in no way diminished. From this he concluded that the active agent in the blood which gave it this germicidal power is a living albumin, and that an essential constituent is sodium chloride, the removal of which, either by dialysis or dilution, robbed the blood of its germicidal power. These elements or constituents of the blood which possess the power of destroying pathogenic micro-organisms he termed "alexins."

Hankin, Martin, and Ogatta (1891) have succeeded in isolating ferment-like "globulins," which in solution possess active germicidal powers.

Later, Vaughn, Novy, and McClintock have found in their observations that the nucleins are the most important germicidal and protective agents possessed by the body; that this bacterial constituent of the blood-serum is not a serum albumin, but that it is a proteid, for it is destroyed at 60° C ; and that it is probably a nuclein, for it is not destroyed by gastric digestion.

The nuclein which they isolated was found to possess most powerful germicidal properties when tested upon Koch's *comma bacillus*, the *streptococcus pyogenes aureus*, and the *bacillus anthracis*.

If *resolution* now takes place the blood-current gradually resumes its natural flow, resorption of the exudates begins, the induration and swelling disappear, the pain ceases, and the tissues regain their normal color and functions.

If, on the other hand, stasis becomes complete in a limited inflamed area, *suppuration* is established, first, by the death or necrosis of the exuded blood-cells and of the embryonal and fixed tissue-cells,—necrobiosis,—and secondly, by the liquefaction and complete dissolution of the tissue elements, the leucocytes and embryonic cells formed from the fixed tissue-cells —phagocytes—being converted into pus-corpuscles and the intercellular substance of the tissues liquefied.

Complete stasis occurring in larger areas may result in death of tissue *en masse;* when this occurs in soft tissues it is termed *gangrene;* when occurring in bony tissues it is termed *necrosis.*

Another change which may take place in the inflammatory exudates is that of *fatty degeneration.* This is a process of retrograde change by which the albuminoid elements of the tissues and the exudates are converted into granular fatty matter.

Pus, tubercles, etc., are sometimes converted into soft, cheese-like masses by a degenerative change known as *caseation.*

Hyperplasias, or *hypertrophies of tissue*, are not uncommon sequelæ of inflammation. Hyperplasia is an increase of the elements which compose a tissue or an organ, resulting in an increase in the volume of the tissue or organ, and may be due either to over-stimulation, over-nutrition, irritation, or a low form of inflammation. Polypus of the pulp, enlargement of an irritated gum festoon, and hypercementosis are examples of this condition.

New formations resulting from inflammations are due to a proliferation of embryonic cells and their organization into new tissue, sometimes similar in kind, but often of a different character from the tissue in which they originate, resulting in the formation of tumors of various kinds, some benign, others malignant.

Examples of the former variety are the calcareous formations developed within the pulp-cavity ; and of the latter, good examples of the benign tumors are found in the fibromas which sometimes occur upon the gums, and the malignant varieties are well shown in osteosarcomas of the jaws and in epitheliomas of the lips.

Inflammation is usually divided into two forms,—viz., *acute* and *chronic*, —and these again into many varieties, according to the anatomical location of the process, as taught by Virchow, such as catarrhal, fibrinous, parenchymatous, phlegmonous, indurative, degenerative, scrofulous, and infective.

In acute inflammation the process runs a more or less rapid course and the symptoms are marked, while in the *chronic form* the symptoms are all less prominent, and any one or all of the cardinal symptoms may be so slightly developed as to escape notice altogether. A form between these two conditions has been denominated *subacute* inflammation.

TABLE OF INFLAMMATORY PHENOMENA.

Summary of steps:

1. Irritants.
   - *a.* Traumatic
   - *b.* Chemic.
   - *c.* Bartoric or septic.
   - *d.* Electric.
   - *e.* Thermic.
2. Irritation.
3. Determination or active hyperæmia.
4. Disturbance of circulation.
5. Increased motion and retardation or oscillation.
6. Stasis (partial).
7. Vascular dilatation.
8. Exudation,—diapedesis, rhexis.
9. Swelling,—œdema.
10. Terminations.
    - *a.* Resolution, or absorption or organization.
      - *a.* Vascularization.
      - *b.* Granulation.
      - *c.* Scar-tissue.
    - *b.* Fibroid thickening or chronic inflammation.
      - Hyperplasia.
      - New formations.
    - *c.* Suppuration.
    - *d.* Abscess,—necrosis.
    - *e.* Ulceration.
    - *f.* Gangrene.

INFLAMMATION OF THE PULP.

Etiology.—Inflammation of the pulp may be either acute, subacute, or chronic in form, and each of these varieties may involve only a limited area of the pulp, when it is termed *circumscribed* inflammation, or it may involve the whole of the organ, when it is termed *diffuse* or *general* inflammation.

Acute pulpitis is in a very large majority of cases due to exposure of the pulp, either from caries, fracture of the crown, mechanical abrasion, or erosion. About ninety-six per cent. of the primary cases, according to the records of the writer, are due to exposure from caries; about three per cent. to fractures, abrasions, erosions, and other injuries of a traumatic nature involving a loss of tissue; and one per cent. to constitutional conditions, such as plethora, pregnancy, nervous irritability, and kindred affections.

These figures accord very closely with those of Tomes,* who says that "ninety-nine out of every one hundred cases are due to exposure of the pulp."

* Tomes's Dental Surgery, 4th edition, p. 380.

In those cases which develop after the carious cavity has been filled,—secondary cases,—minute exposures of the pulp involving one of the cornua,—*incomplete exposures*, or *pseudo-exposures*,—which permit pressure to be exerted upon the pulp by reason of the thinness and decalcified condition of the wall of the pulp-chamber, and thermal shock aggravated by the presence of metallic fillings are the principal causes; the latter, however, are the most prolific of inflammatory conditions, by reason of the fact that in incomplete and pseudo-exposures the pulp has generally been protected by some form of non-conducting capping, which in a measure prevents or lessens thermal shock in these cases.

Exposure of the pulp to the fluids of the mouth permits the entrance of the pyogenic micro-organisms and establishes septic inflammation, which almost invariably terminates in suppuration. It is possible, however, for a septic inflammation to occur in the pulp without direct exposure of any part of this organ: first, by the penetration of the softened and decalcified dentin by the pyogenic or pus-producing micro-organisms which in their growth follow the dentinal tubuli, thus gaining access to the tissues of the pulp; secondly, by the presence of these organisms in the blood, which have gained access to this fluid through some external wound or abrasion of the skin or mucous membrane, or from some pre-existing suppurating wound or abscess, forming secondary abscesses just as metastatic abscesses are formed in other portions of the body by the lodgement of these organisms in the capillary blood-vessels or glandular structures, forming a nidus, where, under favoring conditions of a weakened local vitality, they rapidly propagate.

Pathology.—Inflammation of the dental pulp is in no way different from inflammation as observed in other connective tissues. It follows the same course, by the establishment of hyperæmia, the exudation of leucocytes and their proliferation, the formation of infarcts, the escape of red blood-corpuscles, the coagulation of the fibrinous elements, and either resorption ending in resolution, the organization of the escaped cells into new tissue, the liquefaction of the exudates and the formation of pus, the death of the pulp *en masse*, followed by putrefaction—*moist gangrene*—and the formation of mephitic gases in those cases in which the pulp has been exposed to septic influences, or by mummification—*dry gangrene*—in those cases in which the pulp has not been exposed to septic infections.

Acute Circumscribed Pulpitis.—Acute circumscribed inflammation of the pulp is usually found in those cases in which the walls of the pulp-chamber has been perforated, exposing the surface of the pulp at this point to external irritating and septic influences. The area thus affected is sometimes very minute; at others it involves a considerable portion of the surface of the pulp. The microscope reveals in the early stage of the inflammation a more or less extensive area immediately beneath the inflamed surface, occupied by the inflammatory exudates, and smaller areas, which are colored red, the result of the formation of thrombi and infarcts and the escape of the red blood-corpuscles.

Suppuration is later established upon the surface, and minute collections of pus-corpuscles may be found in the deeper structures of the organ.

The character of the inflammation now depends upon the extent of the opening in the pulp-chamber, the activity of the phagocytes, and the dyscrasia or diathesis of the patient. When the perforation in the wall of the pulp-chamber is so small as to prevent a free escape of the pus which is formed at the point of exposure the suppurative inflammation becomes more acute, and the entire pulp is soon involved, ending in its speedy destruction. But when the perforation is so large that the pus formed upon the surface finds a ready exit, the suppurative process is apt to be prolonged for an indefinite period, the character of the process becoming subacute or chronic in its manifestations with the formation of an ulcerating surface.

On the other hand, if the patient is of a scrofulous, tuberculous, or syphilitic diathesis, or is suffering from malaria, diabetes mellitus, or albuminuria, the suppurative inflammatory process will run a rapid course, ending in a few days at most in the destruction of the pulp; while if the individual is in fair health and of good constitution, the tendencies are towards resolution or a subacute or chronic inflammation.

Acute Diffuse or General Pulpitis.—Acute diffuse or general inflammation of the pulp is the most common result of all forms of irritation of whatever nature, whether mechanic, chemic, septic, or nervous. It may occur, as already pointed out, with or without perforation of the pulp-chamber.

The character of the inflammation is such that it speedily causes stasis of the blood-current by general infarction or thrombosis, unless the perforation in the wall of the pulp-chamber is sufficiently large to permit expansion or swelling of the tissues to a degree that will relieve the pressure upon the blood-vessels at the apical end of the pulp-chamber.

The result of general infarction is death of the pulp *en masse*. Inflammation, however, both acute, *circumscribed*, and *diffuse*, may be induced by infarcts in limited areas within the body of the pulp, caused by intense hyperæmia, as pointed out by Black.* Extravasation of red blood-corpuscles and their disintegration frequently occurs as a result of infarction. The disintegration of these corpuscles and the dissemination of their coloring matter through the substance of the dentin explains the pinkish hue which often obtains after the death of the pulp, and which, from the gradual decomposition of the hæmoglobin thus disseminated, progressively changes the color of the dentin to brown, blue, and blue-black.

Symptoms and Diagnosis.—The symptoms of *acute pulpitis* must be studied from two aspects: first, those cases in which there is no exposure of the pulp; second, those which present exposure and are necessarily septic. The symptoms of inflammation of the pulp are so nearly like those of hyperæmia that differentiation between them becomes extremely difficult. Black thinks that in pulpitis the pain is less paroxysmal and more inclined to be prolonged.

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* American System of Dentistry, vol. i. p. 846.

On account of the unyielding nature of the walls of the pulp-chamber the symptoms of acute pulpitis are generally active and violent, and are characterized by sharp, stinging, lancinating, throbbing pain, at times continuous; in other cases the pain may be paroxysmal in character, increasing in intensity until it becomes almost unbearable, then slowly subsiding, the exacerbations occurring with short intervals of a few minutes or with larger intervals of an hour or two. In those cases presenting without exposure of the pulp the inflammation runs a rapid course, and the vitality of the pulp may be destroyed in a few hours from venous congestion, terminating in complete stasis, induced by pressure upon the arteries entering the apical foramen. In those presenting exposure of the pulp, the inflammatory symptoms may be prolonged for several days, and finally end in complete stasis and death *en masse* by the same mechanic obstruction to the circulation, or the inflammatory symptoms may assume a chronic form and be prolonged indefinitely. Exercise or the recumbent position increases the violence of the pain in the acute form of inflammation, as does also excessive changes in the temperature, pressure from foreign substances in the cavity, or the irritation from sweets, acids, or salt.

In those cases where there is no exposure of the pulp the symptoms are usually most severe but brief in their duration, and they are much less liable to suppuration or decomposition by reason of the exclusion of the micro-organisms from external sources.

On the other hand, in those cases presenting an exposure of the pulp, the symptoms are generally less severe, but are more prolonged, the course of the inflammation being modified by the opportunity for expansion and protrusion of a portion of the pulp—*hernia*—under the pressure of the distended blood-vessels, which is made possible by the break in the continuity of the walls of the pulp-chamber.

The exposure of the pulp to the influence of the septic conditions of the carious cavity and of the secretions of the mouth introduces a complication which renders any attempt at conservative treatment much more difficult than would be the case if micro-organisms from external sources had not come in contact with it.

The break in the continuity of the walls of the pulp-chamber causes another complication which often greatly aggravates the suffering endured in acute inflammation by permitting the pulp, which is often greatly distended with blood, to press upon the sharp and irregular edges of the perforation, producing *strangulated hernia* of the pulp. Relief is only obtained after depleting the organ by puncturing or scarifying its surface.

Prognosis.—The prognosis of acute pulpitis has generally been considered as extremely problematic, and therefore efforts at conservation of the organ under such conditions have never received much support from the profession at large. That the dental pulp may under the favorable circumstances of good general health and hygienic surroundings finally recover from acute inflammation which has not progressed to the stage of suppuration there is not the least doubt, as can be attested by numerous cases and the clinical experience of many operators. And yet the fact remains that in many of these seeming cases of recovery supplementary pathologic changes have occurred, usually of a degenerative type, like calcareous deposits or fatty metamorphosis, which have finally, after months, or perhaps years, terminated in devitalization and decomposition, or dry gangrene.

Treatment.—The treatment of acute pulpitis may be both local and systemic. As a rule, however, local treatment will usually be sufficient to control the symptoms, but when these measures fail, as occasionally happens, systemic treatment may prove of inestimable value.

Local treatment consists in first freeing the carious cavity from all foreign substances and irrigating it with an alkaline solution, like soda bicarbonate, one drachm, tepid water, one fluidounce, to neutralize the acid condition of the disorganized dentin. The cavity is then dried and the same local measures employed as indicated in the treatment of hyperæmia of the pulp. The most efficient means which can be employed to give relief in those cases complicated with exposure of the pulp is depletion by direct puncture or incision of the exposed organ. Cocaine hydrochlorate—ten to twenty-five per cent. solution—should be applied to the pulp after adjusting a rubber dam, and in from two to five minutes the pulp will have been sufficiently anæsthetized upon the surface to permit of its puncture or incision without pain. Chloretone solution, made by mixing equal parts by weight of ether and chloretone, may be applied to the exposed pulp upon a pledget of cotton for the same purpose. After the vessels have been depleted the pulp may be dressed with some efficient sedative and antiseptic remedy like the following: morphine sulphate, one-tenth grain, atropine, one-hundredth grain, dissolved in a drop of oil of cloves. The hypodermic tablets of morphine and atropine in these proportions can always be procured and kept on hand ready for use, and may be prepared for application to the cavity by first crushing the tablet upon a glass or porcelain mixing-slab and then adding a drop of oil of cloves. It is then gathered upon a pledget of cotton, placed in the bottom of the cavity, and sealed in with zinc oxyphosphate, mixed thin, and inserted in this condition, so that no pressure will be brought to bear upon the exposed pulp. Temporary stoppings which permit the percolation of the septic oral secretions through or around them should be avoided, as success in the treatment of these cases will depend largely upon maintaining aseptic conditions of the cavity and the pulp. Another efficient remedy for relieving the pain in acute pulpitis is a paste made of cocaine hydrochlorate in glycerol, applied as above. Saturated solutions of menthol and thymol are also recommended for the same purpose.

Another method of relieving the congested condition of the pulp is the abstraction of blood from the engorged veins and capillaries of the gums, directly over the affected tooth, by scarification, and promoting the flow of blood by the application of warm water held in the mouth. The abstraction of blood by the application of leeches is an old method, and still advocated by some authorities. The dangers from infection, however, are so great from the use of this method that its application is inexcusable in these days of enlightened aseptic surgery.

Counterirritation is sometimes useful in relieving the congestion of the vessels of the pulp by drawing the blood to the surface. This may be accomplished by the continued use of capsicum plasters applied to the gum over the affected tooth; painting the gum with tincture of aconite and tincture of iodine, equal parts, or by drying the gum and painting it with cantharidal collodion, which raises a blister. Care should be taken to paint only a small area, as the irritation induced by the blister renders the gum very sensitive for several days.

Systemic treatment consists of the administration of general sedative and analgesic remedies. Ten grains of Dover's powder administered at bedtime, or five to ten grains of antikamnia, or ten grains of ammonol, will usually insure a quiet night. A hot foot-bath just before retiring may be supplemented with advantage, as this is a useful means of equalizing the circulation and relieving arterial tension in the upper portion of the body. A brisk saline cathartic is also a valuable additional means of relieving the determination of the blood to the affected part.

After the inflammatory symptoms have been relieved and the pulp becomes quiescent, the question of the after-treatment must be settled,—viz., whether conservation shall be attempted or the pulp extirpated. The settlement of this question calls for a clear insight into the local and constitutional conditions which surround the case, and good judgment is required in the final decision, for if the operator would render his patient the best possible service in each individual case he must be free from all bias or prejudice and ready to act as his best judgment dictates.

SUPPURATION OF THE DENTAL PULP.

Definition.—The term suppuration comes from the Latin *suppuratio*, from *suppurare*, to form pus. The formation of pus.

Suppuration is the most frequent termination of acute inflammation. An inflammation which terminates in this manner is termed suppurative inflammation.

Suppuration is a process by which the morphologic elements found in the inflammatory exudates—the leucocytes and the embryonic cells formed from the fixed tissue-cells—are converted into pus-corpuscles and the intercellular substance of the tissue is liquefied.

The conversion of the leucocytes and embryonic cells and the liquefaction of the intercellular substance to form pus are produced by a peculiar peptonizing or digestive action of the pyogenic micro-organisms.

The causes of suppuration may be divided into *indirect* and *direct*.

The *indirect causes* of suppuration are the inflammatory phenomena of exudation, the crowding of the connective-tissue spaces with the corpuscular elements of the blood, and the consequent pressure upon the capillary blood-vessels, resulting in complete stasis and death of the tissues involved. Death of the tissues, however, is not always necessary to produce suppuration, but the changes which take place in the affected parts are those which are expected to follow intense irritation,—viz., hyperæmia, exudation, coagulation of the fibrinous elements, and partial stasis.

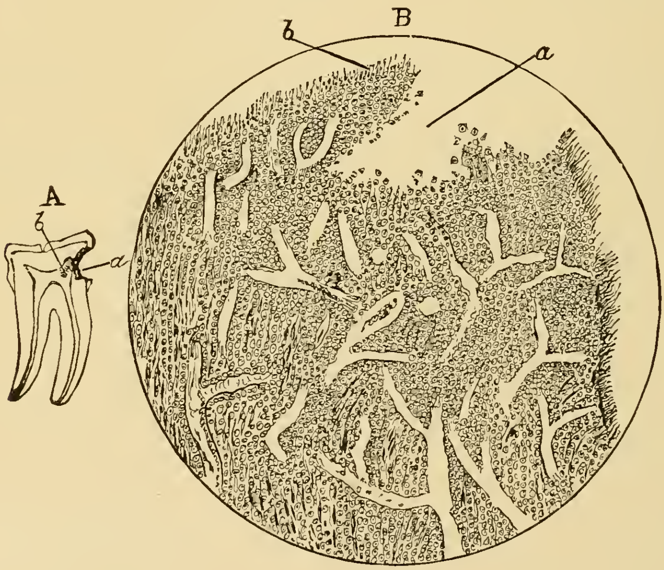
The *direct causes* of suppuration are certain specific micro-organisms—

the pyogenic bacteria—and their peptonizing effect upon the leucocytes, embryonic cells, and intercellular substance of the tissues.

In the suppuration due to the presence of the pyogenic bacteria—infectious inflammations—the direct cause which produces it multiplies in the tissues. Consequently its tendency is to become progressive, while from the pus produced by this form of inflammation the pathogenic micro-organisms—the staphylococci and streptococci—can be cultivated, and if introduced into another organism will produce inflammation and suppuration.

Pus may be produced, however, under certain circumstances without the presence, aid, or intervention of micro-organisms, as, for instance, by the introduction beneath the skin of certain irritating chemical substances. Councilman was the first to prove the fact that croton oil when injected beneath the skin of rabbits would produce suppuration without the action of micro-organisms. The early experiments in this line gave very conflicting results. Some investigators succeeded in producing an aseptic pus which would not cause suppuration when introduced into another organism, while others produced a septic product with the same chemic agent. These conflicting results were due in some cases to imperfect aseptic methods; in others to the fact that the same chemic substance would produce suppuration in one species of animal and not in another, as pointed out by Christmas, who was unable to produce suppuration in rabbits with turpentine or mercury, but succeeded with dogs.

Fig. 502.



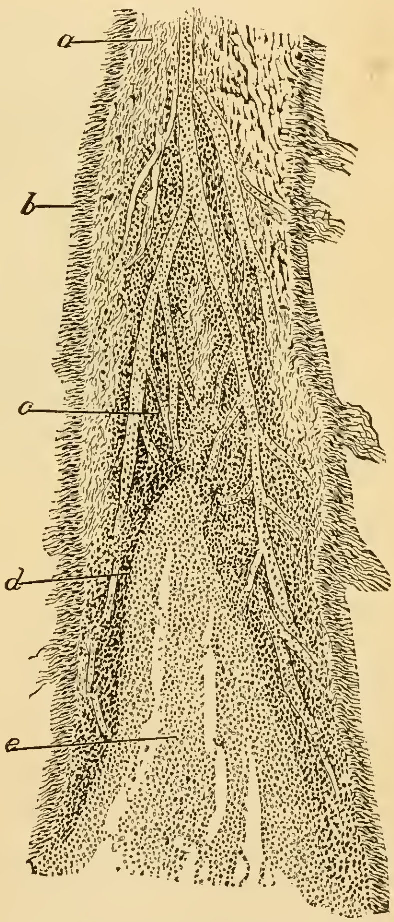
Suppuration of the dental pulp is in nowise different from suppuration as observed in other connective tissues, except that which relates to its location and peculiar environment. It is found most commonly associated with exposure of this organ and under large fillings, the pulp of the tooth having been previously inflamed.

Suppuration of the pulp presents in two forms, *superficial* and *parenchymatous*, and may be either *acute* or *chronic* in its manifestations.

Acute superficial suppuration of the pulp, or *ulceration*, is a destructive loss or solution of continuity of the exposed surface of the organ ; a molecular death of tissue, which will not permit of repair by primary union, and owes its existence to the fact that the retrograde changes or metamorphoses are in excess of those of repair. Change the relationship between these conditions and the ulceration will heal by granulation, just as is seen in ulcerations upon the free surfaces of the body. If unchecked, the ulcerative process tends to gradual but final destruction of the whole organ.

Fig. 502 shows a section by Black taken from an inflamed area. The blood-vessels are represented as empty to bring them more prominently into view, but in reality they are filled with coagulated blood. It will be further noticed that the normal cells have nearly all disappeared, and that their places have been occupied by the inflammatory products of exudation. Opposite the point of exposure (*a*) the odontoblastic layer has been destroyed and a pus-pocket formed in the deeper substance of the pulp, while at *b* the odontoblastic layer has been considerably undermined. This undermining of the odontoblastic layer Dr. Black found to be the general rule in progressive suppuration or ulceration of the pulp.

FIG. 503.

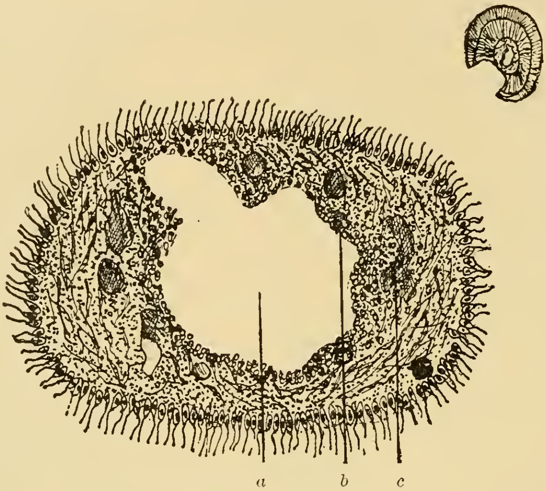


Progressive suppuration of the pulp. (After Black.) × 100. *a*, healthy tissue ; *b*, odontoblastic layer ; *c*, inflamed tissue showing dilated veins ; *d*, line of demarcation of suppurative process ; *e*, pus.

Fig. 503 represents a longitudinal section taken from a case of progressive suppuration or ulceration of the pulp of an incisor, and shows that the destructive process follows the course of the veins, progressively destroying the tissue as it advances from the point of exposure to the apex.

Acute parenchymatous suppuration of the pulp, or *abscess*, is an accumulation of pus in the parenchyma of the organ surrounded by a wall of lymph. It owes its existence to the action of an excessive and continuous irritation which has caused a copious exudation, the filling of the connective-tissue spaces, pressure upon the capillary blood-vessels causing stasis, followed by coagulation of the fibrinous elements. The leucocytes lose their vitality, while pressure upon the connective-tissue cells involved in the affected area produces a like result in them, and by the action of the pyogenic bacteria which have gained access through external channels, or through the avenue of the circulation, the exudates and the tissues are converted into pus. These abscesses are usually situated near the point of exposure, and are rarely found singly. Black says it is not uncommon to find several minute pus-pockets at a little distance from the point of exposure. The abscess may, however, occupy the central portion of the pulp. Burchard removed such a pulp, the abscess involving nearly its entire structure, but leaving the peripheral portion unbroken, as shown in Fig. 504.

Fig. 504.



Transverse section of pulp of inferior bicuspid, partly diagrammatic. (After Burchard.) *a*, abscess cavity; *b*, embryonic cells at periphery of abscess cavity; *c*, occluded blood-vessels.

Black has found abscesses in the deeper structures of the pulp, most frequently in the molars. Fig. 505 shows such an abscess in a central incisor, about midway of its length, the coronal portion of which was suppurating, while the evidences of inflammation within the deeper structures was rather more extended than is common.

Suppurative inflammation of the pulp under cappings and large fillings used to be a frequent occurrence before the introduction of antiseptics in the treatment of surgical wounds. To-day, however, such occurrences are much more rare by reason of the improved methods of treatment which have been based upon this great scientific discovery.

Symptoms and Diagnosis.—The formation of an abscess in the soft tissues of the body causes considerable swelling, and when the swelling is hindered by overlying and unyielding fascia the pain becomes very intense, and the pus burrows along courses which offer the least resistance, often forming long and tortuous channels in the effort to reach a point of exit.

In suppuration of the pulp with a minute perforation of the wall of the pulp-chamber, or under a capping or a large filling, the pus is held back, and as it accumulates, causes pressure upon the tissues of the pulp, which either give way or are destroyed. The pain which is induced by this process is different from that caused by hyperæmia, in that the onset of the attack is not so sudden nor so violent. It begins with a dull, heavy, gnawing sensation, which gradually increases in intensity to the most violent and almost unendurable pain. The duration of the pain is governed by the amount and rapidity with which the pus is formed. Sometimes the accumulation of the pus is so rapid that the vitality of the pulp is destroyed in a few hours; at others devitalization may not occur under twenty-four to forty-eight hours. Death of the pulp is induced by the pressure upon the apical blood-vessels, causing general infarction. Evacuation of the

Fig. 505.

Abscess within the tissues of the pulp. (After Black.) × 250. The field includes about one-half of the little pocket of pus.

pus by opening the pulp-chamber gives almost instant relief from the severe symptoms. Sometimes when the pus is deep-seated it becomes necessary to puncture the abscess with a probe. The amount of pus which is occasionally contained in a pulp-chamber is surprisingly large, at times welling up in such quantity as to nearly fill a large cavity of decay. The pressure under such circumstances must have been very considerable indeed, and thus accounts for the intense character of the pain. In from six to twenty-four hours after the cessation of the pain symptoms of apical irritation begin to be manifest unless the pulp-chamber has been opened and the pus is evacuated.

The presence of small abscesses within the parenchyma of the pulp are not always productive of severe pain, and they may be retained for an indefinite period, and finally absorbed. (Black.)

Accumulations of pus within the pulp may, as in other locations of the body, undergo fatty degeneration, as pointed out by Salter. Decomposition of the retained pus may take place with the generation of mephitic gases. Black says upon this point, "Warm liquids when taken into the mouth should increase the pain by expanding the gases, while cold would relieve it by the opposite effect." This is a diagnostic fact of considerable importance, and should always be borne in mind in diagnosing the various forms of acute pulpitis.

Treatment.—The treatment of this class of cases requires the immediate opening of the pulp-chamber, the evacuation of the pus, and antiseptic treatment of the suppurating pulp. Although it is possible under favorable circumstances to control the suppurative process and relieve the inflammatory symptoms, efforts at conservation of the pulp are not favorable, for the reason that they so rarely succeed. It is, therefore, the wiser plan, as soon as the inflammatory symptoms are under control, to devitalize or cocainize the pulp and remove it.

CHRONIC INFLAMMATION OF THE DENTAL PULP.

Chronic pulpitis is usually a sequel of the acute form of inflammation, but it may occasionally be due to a low grade of irritation which has never been of sufficient severity to produce other than a mild but continuous hyperæmia of its blood-vessels, such an irritation as would accompany the gradual wearing down of the teeth from mechanic abrasion or chemic erosion with the formation of secondary deposits, as already pointed out in Chapter XXII.

Chronic pulpitis, which is the sequel of the acute stage, may present itself in either of three common forms,—viz., *chronic suppurative inflammation*, *hypertrophic inflammation*, and *degenerative inflammation.*

Chronic suppurative inflammation of the pulp is almost always confined to the surface of the pulp in connection with perforations of the wall of the pulp-chamber, which are small or moderate in extent, but which allow of the free escape of the pus as rapidly as it forms. If for any reason the accumulations of pus are retained, active symptoms usually supervene, and acute abscess of the pulp is the result.

Chronic suppuration of the pulp tends sooner or later to cause its destruction either by molecular death (ulceration) and devitalization of its tissue, or by death *en masse* (gangrene) of extensive portions and sloughing of the gangrenous areas. Severe pain is rarely present in this form of inflammation, unless the opening into the pulp-chamber becomes stopped up with food *débris*, or the cavity is filled with a septic dressing. The removal of these obstructions to the escape of the pus gives immediate relief.

The heat sense is greatly lessened, as is also its general sensitiveness to chemic irritants and to pressure or instrumentation.

The only *reliable treatment* in this form of inflammation of the pulp is devitalization or cocainization and extirpation. Conservative treatment based upon the possibility of the suppurating surface becoming cicatrized and the pulp being capable afterwards of performing its normal functions rests upon such meagre clinical evidence that it cannot be recommended except as a purely experimental study.

Hypertrophic inflammation, or polypus of the pulp, can occur only when the walls of the pulp-chamber have been perforated to a considerable extent, for when they are intact there is no possibility of enlargement, by reason of the fact that there is no room in the pulp-chamber for such growth.

The size of the perforation in the walls of the pulp-chamber determines to a certain extent the size and the character of the new growth. In small perforations the pulp protrudes but slightly, except when acute inflammatory symptoms are present, as already indicated upon a previous page.

When the perforation in the wall of the pulp-chamber is large, the pulp may bulge from the opening, forming a large fleshy mass (*polypus of the pulp*), which may be so large as to fill the entire cavity of decay, and even protrude beyond it. This condition is more commonly seen in young persons at the period of adolescence and in scrofulous and tuberculous individuals.

In the early stages of the growth or hypertrophy of this tissue it is very sensitive, but later, as it increases in size, it gradually becomes less and less sensitive until, comparatively, it is no more sensitive than the gum-tissue.

The hypertrophied mass is composed of vascular distentions, granulation-tissue, and connective-tissue fibres, the whole mass being covered with a thick epithelium. In general appearance it is so like gum-tissue that it is with extreme difficulty that it can be distinguished clinically from that tissue. It may be differentiated from a gum festoon which has grown into the cavity of decay by the fact that it is connected to the pulp by a narrow constricted pedicle, and that a probe can be made to pass beneath it and completely around the whole circumference of the cavity of decay, while a gum festoon which occupies the cavity can be lifted out, and will be found to be connected with the gum at the cervical margin by a broad pedicle.

Hypertrophied tissue will be found to be quite difficult to destroy with arsenic or other escharotics. Before attempting devitalization the mass should be amputated at the bottom of the cavity by severing the narrow pedicle, and as soon as hemorrhage has ceased arsenic may be applied to the stump and the case treated as an ordinary exposure.

Calcification of an hypertrophied pulp has been known to occur. Tomes* mentions a case reported by Rogers, in which hypertrophy of a pulp took place after the crown of an upper molar tooth was removed in an unsuccessful attempt to extract it, leaving the pulp exposed. Some months afterwards the roots were removed, and the hypertrophied pulp was found to have extended over the sharp edges of the pulp-chamber and to be completely calcified. Black † described a somewhat similar case occurring under a metallic capping, and Heider and Wedl ‡ figure a case in their atlas of a similar condition occurring in an incisor tooth of an antelope.

Another result of hypertrophic inflammation of the pulp is the resorption of the dentin surrounding the pulp, causing enlargement of the pulp-chamber. Such conditions are, however, very rarely met with in clinical practice. Black mentions a case of this character occurring in a first lower molar which he had capped for exposed pulp ten years before and had inserted a large gold filling. Irritation of the pulp had persisted for the last two or three years. On removing the filling the pulp-chamber was found to be enormously enlarged, and an opening to the peridental membrane had occurred at the bifurcation of the roots.

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* Tomes's Dental Surgery, 4th ed., p. 367.

† American System of Dentistry, vol. i. p. 859.

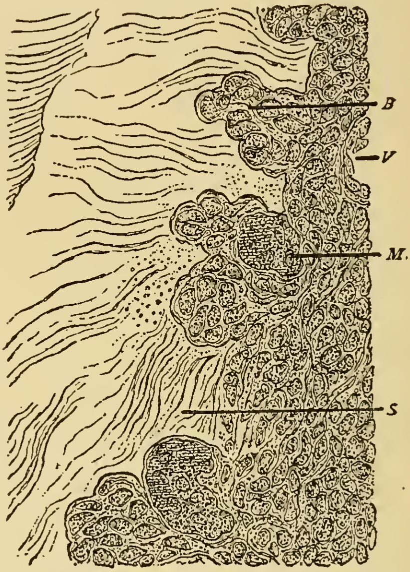
‡ Atlas of Pathology of the Teeth.

In another case, a central incisor, the enlargement of the pulp-chamber was not so great, but was unmistakable.

The writer saw a similar case in consultation with the late Dr. W. W. Allport, occurring in a first superior bicuspid, the pulp of which, according to the record, was not exposed when the tooth had been filled five years before, but which was found upon removing the filling not only exposed, but the pulp-chamber was enlarged to more than twice its normal size. This case occurred in a lady aged about forty, who had been suffering for more than a year with reflex neuralgia and dimness of vision which threatened blindness.

Fig. 506.

Fig. 507.



Pulpitis. (After Bödecker.) × 300. *S*, secondary dentin; *B*, bay-like excavations filled with medullary or inflammatory corpuscles; *M*, multinuclear body; *V*, blood-vessels in transverse section.

Fig. 506 is made from a photograph of a superior central incisor in the private collection of the writer, and shows the pulp-chamber greatly enlarged.

Bödecker* presents a figure illustrating the resorption of secondary dentin (Fig. 507), which seems to indicate the manner in which resorption of the dentin forming the walls of the pulp-chamber takes place in this class of cases. At *M* will be noted a large multinucleated cell (giant cell) which has invaded the area of resorption and is evidently performing the function of the odontoclasts by removing the dentin.

Degenerative inflammation of the pulp, involving structural changes in the tissues, is usually caused by a long-continued and low form of inflammation, such as would be likely to be produced by a pseudo- or by an incomplete exposure of the pulp, or by a pulp-capping. The most common form of degeneration of structure is atrophy of all the normal elements of the pulp except its fibrous tissue, which becomes greatly increased in amount, forming areola which are filled with fluid. (Black.) The changes in the structure usually take place at or near the point of exposure, but they are not always confined to this location. The bulb of the pulp suffers most, while the balance of the organ may appear to be in a more or less normal condition. Fig. 508 illustrates this condition, and was made from the bulbous end of the pulp of a tooth which was the subject of *pyorrhœa alveolaris*.

* Morphology and Histology of the Dental Tissues, p. 645.

Black * says of this affection, "The original cells of the pulp for the most part disappear or lose their nuclei and become converted into very fine fibres. Areola develop in the matrix, and all the histologic characters of the tissue are profoundly changed."

Fig. 508.

Section of dental pulp. Bulbous end. Fibrous degeneration. (V. A. Latham.) × 50.

Arkovy has described this affection as *reticular atrophy* of the pulp. Black found in his studies of this condition every possible grade of change, from an occasional appearance of areolæ to complete areolation of large portions of the pulp. He thinks it is possible that the œdema noticed in the affection may be the result of hyperæmia which has produced effusion, and yet in all the cases examined he found the evidences of inflammatory action unmistakable.

The symptomatology is not well marked, although the sensitivity of the organ is greatly diminished to all the tests applied.

Treatment.—The only treatment that can be recommended is devitalization or cocainization of the pulp and its extirpation.

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* American System of Dentistry, vol. i. p. 859.

CHAPTER XXV.

EXPOSURE OF THE DENTAL PULP AND ITS TREATMENT.

EXPOSURES of the dental pulp are either the result of caries or of traumatic injuries of an accidental nature which produce a loss of tissue by fracture, thus uncovering the pulp, or as a result of surgical injury in the preparation of the cavity to receive a filling.

Deep-seated caries is the most common cause of exposure of the pulp. By the processes of decalcification and disintegration of the dentin it sooner or later *exposes* the pulp and renders it subject to painful irritation, hyperæmia, inflammation, and finally devitalization.

In the consideration of the subject of *pulp exposure from caries* and *traumatic injuries* it may, for the convenience of description, be divided into three stages or degrees,—viz. :

Pseudo-exposure.

Incomplete exposure.

Complete exposure.

Pseudo-exposure, or *false* exposure of the pulp, is that condition which prevails when the carious process has so far progressed as to have nearly reached the pulp, leaving only a thin layer of partially decalcified and infected dentin to protect it from mechanical injury, but which is, however, more or less readily penetrated by the oral secretions, the bacteria of the mouth, the soluble chemic substances which enter the mouth in the form of food, condiments, and medicines, and by the influence of changes of temperature of even a moderate degree.

These irritating influences often render the pulp highly sensitive, and cause it to respond very acutely whenever they are brought to bear upon it through the carious cavity, while if prolonged, they end, sooner or later, in inflammation and finally death of the pulp.

A traumatic injury which nearly exposes the pulp, leaving the protecting surface so thin as to cause the pulp to respond painfully to the above-mentioned irritating agencies, should be classed as a pseudo-exposure.

The pain which is produced by active hyperæmia is generally acute and paroxysmal in character, but, as a rule, is only of a few minutes' duration. It comes on most frequently while eating, especially sweets and acid fruits, or drinking hot or very cold fluids, or breathing very cold air. If the pulp becomes infected with the pyogenic organisms, efforts to conserve its vitality will usually prove futile.

Treatment.—Two methods may be employed in the treatment of pseudo-exposure of the pulp,—viz., *conservation* and *devitalization*.

Conservation.—Conservative treatment of the pulp should in these cases be employed under all circumstances which present a fair prospect of maintaining the organ in a normal condition. The pulp being the organ which supplies nutrition and sensation to the dentin, its vitality should for these reasons be carefully preserved, while, upon the other hand, after the vitality of the pulp has been destroyed, the tooth loses its translucency, becomes more or less discolored and brittle, presents a greater susceptibility to caries, and is liable to periodic attacks of pericemental irritation from the decomposition of the organic elements of the dentin, while occasionally the pericemental irritation may increase in severity or become chronic, resulting finally in the loss of the tooth. It therefore becomes for the latter reasons also very important that the vitality of the pulp should be preserved whenever it is possible to do so. Certain operators have, on the other hand, advocated the conservation of the pulp in all cases. Witzel advocates conservative treatment of even small portions of the living pulp remaining in the canals, and Belisario and Henry advocate the same course.

Devitalization should be practised only as a *dernier ressort.* The writer is aware that this teaching is in opposition to some very good authorities, who have frequently stated "that when a tooth has been fully formed it has no further need of the pulp, and it may, therefore, be destroyed without damage to the integrity of the tooth;" but he, nevertheless, desires in these pages to enter a protest against such teaching, and against the practice of destroying by wholesale dental pulps which he believes could, with the same degree of care and skill exercised in their devitalization, have been preserved to fulfil their normal function for many years, or even for a lifetime.

Opening the Cavity.—In the opening of the cavity and the excavation of the disintegrated dentin great care should be exercised not to expose the pulp. The relations of the pulp-chamber and of its cornua must be kept constantly in mind, and even then it may be that by an unlucky sweep of the excavator or an excessive prolongation of the pulp cornua the pulp-chamber may be entered and the difficulties of the conservation of the pulp thereby greatly increased.

After all of the disintegrated and decalcified tissue has been removed —and this should not be commenced, for prudential reasons, until the rubber dam has been adjusted—the cavity may be carefully wiped with an efficient antiseptic, like the oil of cloves, oil of cassia, oil of peppermint, or carbolic acid, ninety-five per cent. The surface of the cavity lying nearest to the pulp should then be carefully scrutinized with a magnifying lens for the slightest exposure of the pulp or of its cornua, and if the integrity of the pulp-chamber is found to be intact, the pulp may be protected from pressure and thermal shock by the interposition of a rigid and non-conducting material—that will possess no irritating qualities—between the bottom of the cavity and the filling.

Temperature Sense.—The "temperature sense," as shown by Dr. Louis Jack,* varies greatly in different individuals, and this fact must always be taken into consideration in all efforts of conservative treatment of the pulp.

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* Dental Cosmos, January, 1899.

Dr. Jack has found that the variation in the heat-rate stands, in normal teeth, between 120° and 135° F., while the normal cold-rate varies between 40° and 70° F.

The teeth of each person seem to possess an individual tolerance of a certain degree of heat and cold which will not produce pain, but whenever these limits are passed pain is the result. The average *range of tolerance* was found to vary between forty-eight and seventy-five degrees. It therefore becomes evident that if the vitality of the pulp is to be preserved in this class of carious teeth the pulp must be thoroughly protected against any degree of temperature that might cause irritation.

Dr. Jack also observed that marked intolerance to degrees of temperature that are within the average normal range indicated a serious condition of the pulp, and that after the pulp had been protected for a time from thermal shock, the temperature range gradually increases until normal tolerance is reached.

Materials for Capping.—*Gutta-percha* is, perhaps, by reason of its non-conducting qualities, the very best material that can be used for the purpose of protecting the pulp against thermal shock. The cavity may be entirely filled with it, or it may be used as a simple non-conducting lining, and the balance of the cavity filled with zinc oxyphosphate cement. Metal fillings should never be introduced into such cavities until the normal tolerance to heat and cold have been restored. The metallic filling may be inserted after removing a portion of the gutta-percha or cement. Its entire removal and substitution of a metal filling often proves disastrous to the vitality of the pulp. Such teeth can be made, however, more comfortable by the insertion of porcelain inlays than by metallic fillings, as the porcelain is a poorer conductor of caloric than the metals.

Zinc oxysulphate cement to which a drop or two of oil of cloves has been added is frequently used as a capping or protector of the dental pulp because of its non-irritating and non-conducting properties.

Whenever the layer of dentin covering the pulp is very thin and there is danger of producing pressure upon it in packing the filling, or from the pressure of mastication, a metallic cap may be employed (Fig. 509), or one may be fashioned from sheet lead or tin. The metal should be so concaved that when it is placed in position in the cavity it will touch only at its edge. To protect the pulp from thermal shock and to secure the cap in position thick zinc oxysulphate may be flowed upon the bottom of the cavity, the cap placed in this and covered with a layer of the same material or of gutta-percha stopping,—after the cement has set,—and the balance of the cavity filled with zinc oxyphosphate.

Fig. 509.

Zinc oxychloride cement is sometimes used as a pulp capping, but the dangers of irritation and devitalization due to the irritating and escharotic action of the zinc chloride has caused it to be looked upon as an unsafe material to employ when the conservation of the pulp is the object in view. It was formerly employed to a considerable extent not only in the treatment of such cases as are now under consideration, but in cases of actual or complete exposure of the pulp, and statements were made by enthusiastic operators as to its wonderful *conserving* effect upon the pulp; but a few years later it was discovered that the term *preserving* better suited the condition which resulted from its application as a pulp capping, for nearly all the cases which had been so treated were found to be in a devitalized and mummified condition.

As an obtundent of hypersensitive dentin in shallow cavities it is of great value; but its application to deep-seated caries, or where the pulp is almost exposed, its use is to be deprecated for the reasons given above.

Zinc oxyphosphate cement is employed by some operators to the exclusion of all other materials for capping the pulp in this class of cases. To prevent the irritation and pain which would follow its direct application to the dentin various substances are used to line the cavity,—viz., solutions of chlora-percha, varnishes, Canada balsam, and zinc sulphate.

As a further protection against thermal shock the bottom of the cavity may be covered with a disk of sheet asbestos, blotting-paper, writing-paper, horn, quill, cork, vulcanite, or ivory, which may be secured in place with chlora-percha, copal varnish, or Canada balsam, and zinc oxyphosphate flowed over it.

Incomplete Exposures due to Caries.—*Incomplete exposure of the pulp* may be described as that condition in which a single *cornu* or horn of the pulp is exposed as the result of caries or from traumatic injury. This class of exposures occurring as the result of caries, the exposure of recent origin, and in which the irritation and pain have not been manifested for more than twenty-four hours, are many times amenable to conservative treatment.

Exposures of this class, if caused by traumatic injury during the excavation of the cavity, give better prospects of successful conservation than those produced by caries, for the reason that the latter are generally more or less infected with the pyogenic micro-organisms; while in the traumatic cases, if treated upon surgical principles, infection can be prevented and the pulp maintained in a normal condition by the exclusion of the micro-organisms and other sources of irritation and protecting it from pressure.

Symptoms.—Incomplete exposure of the pulp, due to caries, sometimes presents a history of intervals of irritation and pain, more or less severe, covering a period of a few hours or days. Finally the patient is robbed of a night's sleep by the severity of the pain, and next morning seeks professional advice. The pain is described as sharp, stinging, or burning in character, and the affected tooth is exceedingly sensitive to heat and cold, sweets and acids, or pressure of food within the cavity. Paroxysms of pain are induced by contact with any of these irritating substances, while it is aggravated by vigorous exercise, by lowering the head, as in stooping to pick something from the floor, or by assuming the horizontal position. Exercise and the positions mentioned increase arterial tension in the head, and thus by the increased pressure of blood in the pulp, pain is induced or augmented. The pain in the early stages of irritation is never very severe. but as the case progresses towards inflammation it becomes more and more intense, with shorter intervals of respite, until finally the pain becomes of a sharp, deep-seated, throbbing character and well-nigh continuous, which denotes a high degree of congestion. These symptoms are doubtless due, in a majority of instances, to septic infection from the pyogenic bacteria found in the oral secretions and food *débris* lodged in the mouth and between the teeth. With proper treatment following antiseptic lines even a case of this character is not entirely beyond hope of successful conservation, provided, as already mentioned, these symptoms have not been manifest more than twenty-four hours.

Treatment.—The treatment consists, *first*, of efforts to allay the pain by removing the causes of irritation and subduing the hyperæmia, and *secondly*, of protecting the pulp against the further influence of these exciting causes of incipient inflammation.

The cavity should first be carefully syringed with tepid water to which has been added a little soda bicarbonate and an antiseptic like listerine, pasteurine, or borolyptol, to remove the food *débris*, neutralize the acid condition, and correct to a certain degree the septic condition. Many times this procedure will relieve the severity of the pain in a few minutes, or entirely control it. The rubber dam should then be adjusted, the cavity carefully dried with bibulous paper or amadou, and the carious matter deftly removed, care being exercised not to wound the pulp, as such wound would endanger the vitality of the pulp by furnishing an open gateway for the entrance of the pyogenic bacteria to its deeper structures.

If the pulp is accidentally wounded, the bleeding point should be touched with oil of cloves or other efficient but non-escharotic antiseptic. The walls of the cavity may now be saturated with oil of cloves, oil of cassia, or the volatile extract of eucalyptus, and the exposed cornu of the pulp protected with a metal cap or other suitable rigid covering, the concavity of which has been filled with a paste composed of oil of cloves and zinc oxide, or zinc oxysulphate cement. The object of the paste or the cement is twofold,—first, to furnish an antiseptic dressing for the exposed crown of the pulp, and secondly, to seal the perforation of the pulp-chamber with a non-irritating substance, which would effectually prevent any protrusion of the pulp beyond its normal limits.

Over the cap should now be flowed a thick solution of chlora-percha or zinc oxysulphate, and after this has set the cavity may be filled with gutta-percha stopping or zinc oxyphosphate.

Prognosis.—The prognosis in these cases will depend upon the local condition of the pulp when capped, the surgical care with which the cavity has been prepared and sterilized, the dexterity with which the antiseptic dressing has been applied, the methods used to prevent pressure upon the exposed portion of the pulp, the protection afforded against thermal shock by the overlying filling-material, and the constitutional condition of the patient at the time of the operation and for some months thereafter.

If the inflammatory symptoms have not passed beyond the stage of hyperæmia—and this may be known by the character and duration of the pain as already indicated—and the surgical and antiseptic technique has been carefully carried out, the prognosis will be fairly favorable, provided the health of the patient is good at the time of the operation and so continues. Anæmic conditions, plethora, pregnancy, nervous debility, tuberculosis, and syphilis are contraindications for the conservative treatment of the pulp.

It must be remembered, however, that whatever form of capping is employed to conserve the vitality of the pulp, its ultimate success as an operation depends upon the formation of secondary dentin at the point of injury which shall remove the dangers of the devitalization of the pulp caused by the disease or the injury, and this cannot be assured until after the lapse of a considerable period of time, usually from one to two or three years.

Although it is true that a large proportion of these cases will do well under favorable circumstances, yet it is equally true that at the end of this time a certain number will be found to have lost their vitality, even though little discomfort or none at all had been experienced.

Incomplete Exposures of the Pulp due to Traumatism.—Traumatic incomplete exposures of the pulp are usually the result of accidents during the excavation of a carious cavity, or from mechanic abrasions or chemic erosions, but occasionally it may occur from an external injury which fractures a portion of the crown and leaves one of the cornua exposed.

In traumatic exposures of the pulp due to accidents in excavating, the cornu of the pulp is usually wounded, and is followed by hemorrhage and acute pain, which, however, soon subsides. The bleeding point may be treated as just described, or irrigated with a five per cent. warm solution of carbolic acid,—escharotics should be avoided,—and as soon as hemorrhage has ceased the extent of the injury can be ascertained, when, if it does not extend beyond the involvement of the cornu of the pulp or a very small opening into the chamber, the excavation may be completed and the case treated by capping upon the lines already indicated. If, however, the pulp has been seriously wounded by the instrument slipping into the bulbous portion and causing a complete exposure, devitalization or immediate extirpation, is the only remedy.

In exposures due to abrasions, erosions, and external traumatisms which fracture the crown, conservative treatment is out of the question, as there is no means of adequately protecting the pulp against the irritating influences which surround it. Devitalization or immediate extirpation must therefore be resorted to in order to relieve the patient of the suffering incident to an exposure of this character.

SECONDARY DENTIN, OR DENTIN OF REPAIR.

One of the main objects sought in the conservative treatment of the exposed pulp is to stimulate nature to repair the breach made in the walls of the pulp-chamber by disease or traumatism, or to protect the pulp against a threatened breach of its walls by the interposition of a new-formed tissue laid down by the odontoblasts. In the study of the formation and calcification of the dentin (Chapter II.) it has been shown that the chief function of the odontoblasts, which are arranged in a continuous layer over the entire periphery of the pulp, was that of forming or building the dentin, and that upon the completion of the formative process the function ceased.

The function, however, of the formative cells is not lost, for it frequently happens that under the stimulation of irritation occurring at any period of life, produced by mechanic abrasion, chemic erosion, caries, and other forms of *external* irritation, the odontoblasts again become active and deposit calcific material within the dentinal tubuli, termed *tubular calcification*, or lay down at the point of irritation a peculiar calcific material, termed *secondary dentin*, the *dentin of repair* of Salter, in a seeming effort to build a barrier against the encroachment of the disease or injury upon the territory of the pulp (Fig. 510). These deposits are always found opposite, or rather at the base of, the dentinal fibrillæ involved in the irritation. Calcific material is also laid down by the odontoblasts in temporary teeth retained beyond their normal period, and as a senile condition in the teeth of elderly people (Fig. 511), the pulp-chamber and canal being sometimes almost obliterated by this process.

Secondary dentin has sometimes a very close resemblance to normal dentin, but it is by no means a perfect example of this structure. In the new formation as found in persistent temporary teeth, in the senile calcification of elderly persons, and in cases of chronic irritation, the new-formed tissue often approaches the perfection in structure of normal dentin, while in those cases which are dependent upon some form of external irritation like mechanic abrasion, chemic erosion, or caries, the new-formed tissue which has been developed to shield the pulp against these irritating influences often presents a low grade of structural organization, the tubules being scanty, very irregular in their course, and the tissues more dense than normal dentin, while occasionally it will be almost structureless.

Dr. Black * is of the opinion that the formation of secondary deposits within the pulp-chamber, in cases of exposed pulps which have been capped, do not permanently conserve the vitality or the health of the pulp, but that they usually produce exhaustion, degeneration, and finally death of the organ.

He looks upon those cases of capping as the most hopeful which have passed on for years without the formation of any deposit whatever, very many of which seem to remain indefinitely in a perfectly healthy condition.

Dr. Truman † says new formations are usually expected from capping pulps; but this expectation is rarely realized, as here the irritation is excessive and becomes a destructive force.

Complete exposure of the pulp is that condition in which the invasion of caries has penetrated the pulp-chamber and laid bare, to a greater or less extent, the body or bulbous portion of the pulp, or a traumatic injury has caused the loss of a sufficient amount of the crown to open the pulp-chamber and expose its vital contents. Complete exposures of the

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* American System of Dentistry. † Ibid.

FIG. 510.—Vertical section of human cuspid, showing formation of secondary dentin in the coronal portion of the pulp-chamber as a result of loss of tissue at the morsal edge. × 100.

FIG. 511.—Vertical section of human central incisor, showing formation of secondary dentin in the coronal portion of the pulp-chamber. × 102.

pulp, due to caries, are rarely amenable to conservative treatment by reason of the inflammatory symptoms which are always present. These symptoms may be *acute* or *chronic* in their character. When the symptoms are acute and the opening into the pulp-chamber is small, so that the pulp is confined within the pulp-chamber, the swelling which takes place causes pressure upon the blood-vessels, which results in stasis, general infarction, and death,—gangrene of the organ. If, on the other hand, the opening into the pulp-chamber is large, so that the pulp in swelling finds relief from the pressure by a portion of its congested tissue escaping through the opening into the cavity of decay, stasis and infarction are sometimes avoided, and the inflammatory symptoms assume a low form or chronic type. In either case devitalization or immediate extirpation of the pulp is the only satisfactory method to pursue, as efforts to conserve its vitality usually prove futile. Traumatic exposures of a like character are likewise not amenable to conservative treatment, and in all such cases the pulp should be extirpated by the immediate method under local or general anæsthesia.

DEVITALIZATION AND EXTIRPATION OF THE PULP.

Three general methods are employed for the devitalization and extirpation of the dental pulp: first, by the *chemic action of drugs;* second, by *instrumentation;* and third, by *local or general anæsthesia.*

The drugs which have been used for devitalizing the pulp by means of their chemic action are arsenous acid, zinc chloride, cobalt (arsenical ore), caustic potassa, and chromic acid.

The requirements of a devitalizing agent are,—

1. That it act painlessly.
2. That it destroy vitality promptly.
3. That the action of the drug shall not discolor the dentin.

Devitalization of the pulp is generally accomplished by the application of arsenous acid (arsenic trioxide), which destroys the vitality of the organ *en masse.* No other remedy used for this purpose possesses the above requirements in so large a degree, or is so prompt, certain, and complete in its devitalizing effect upon the dental pulp; and yet, as the result of accident or in careless hands, it is capable of doing great damage to the surrounding tissues, and on this account some operators who have witnessed its destructive effects upon the gingival tissues and the alveolar processes have discarded its use altogether. It still, however, remains the "sheet-anchor" of the profession for this purpose despite the ill effects which sometimes follow its use.

Arsenic trioxide was first introduced for the purpose of devitalizing the dental pulp by Spooner (1836), and when employed with proper care there is no remedy which gives such universally good results. Arsenic trioxide is usually combined with acetate of morphine in various proportions, and creosote, carbolic acid, and oil of cloves, or other essential oil, added to form a creamy paste.

The earliest combination of this character was the formula of Dr. J. D. White (1855):

℞ Arsenous acid,
Morphiæ sulph., āā gr. x to xv;
Carbolic acid, q. s. ft. paste.

A later formula is that of Dr. J. Foster Flagg (1877):

℞ Arsenous acid, gr. v;
Morphiæ acetas, gr. x;
Ol. caryophylli, q. s. ft. paste.

A more recent combination substitutes cocaine hydroclorate for the morphine:

℞ Arsenous acid, gr. x;
Cocainæ hydrochl., gr. xx;
Ol. cinnamomi, q. s. ft. paste.

Miller (1894) recommended the following formula as possessing advantages over those containing morphine, as the thymol which is substituted for the morphine exceeds it in its local anæsthetic action, and has the decided advantage of possessing a considerable antiseptic quality:

℞ Thymol,
Arsenous acid, āā gr. x;
Ol. caryophylli, q. s. ft. paste.

Morphine.—The object in adding this drug to the paste is to utilize its narcotic properties to relieve the severity of the pain, which is often induced by the irritating effect of the arsenic upon the tissues of the pulp.

Carbolic acid (deliquesced crystals) is a notable escharotic, while it also possesses antiseptic and local anæsthetic or analgesic properties, which make it a valuable ingredient of a devitalizing paste. Carbolic acid alone is capable of devitalizing the pulp.

Creosote is not so vigorous an escharotic as carbolic acid, while it possesses about the same degree of antiseptic and local anæsthetic power.

Oil of cloves is but very slightly escharotic, while its antiseptic and local obtunding effect is very considerable.

Cocaine hydrochlorate is substituted for the morphine because it possesses such strong local anæsthetic powers.

Oil of cinnamon is added for its antiseptic qualities.

Thymol is used for its local anæsthetic and antiseptic action.

Chloretone is also used for its local anæsthetic effects, and is preferred by some operators to cocaine, as it is non-poisonous. (See chapter on anæsthesia.)

PHYSICAL EFFECTS OF ARSENIC UPON THE PULP.

The application of arsenic trioxide to the living pulp produces certain definite phenomena which are irritative in their character, and represent the earlier physical phenomena of acute inflammation,—viz., arterial hyperæmia, pain, increasing from a low grumbling, gnawing character to acute, violent paroxysms, followed by acute congestion of the blood-vessels, exudation, and finally apical strangulation, or general infarction, which effectually prevents egress or ingress of the blood-stream, causing complete stasis and death of the organ. Fig. 512 is made from a section of a pulp which had been treated with arsenic, and shows the congestion and enlargement of the blood-vessels.

Fig. 512.

Section of dental pulp. Blood-vessels congested from application of arsenic.

Flagg* describes the phenomena as follows: "A minute portion of the arsenic being introduced into the circulation of the pulp acts as a dynamic, vital irritant, which causes, *first*, a determination of blood to the organ, resulting, in from fifteen to twenty minutes, in uneasiness and throbbing pain; *secondly*, congestion, which causes a cessation of the throbbing character of the pain; *thirdly*, usually, complete cessation of pain, leaving like the going down of a wave; this condition has a varied length of duration, dependent upon the extent and frequency of the previous pulp irritation, extent of pulp exposure, temperamental impressibility,—*nervous irritability*,—systemic ability to resist and react,—*vital resistance*,—and such like considerations. The death of the pulp *en masse* being due to strangulation of the vessels at the apex in consequence of the congestion."

Animal tissue when thoroughly impregnated with arsenic trioxide, even in small amount, is rendered proof against putrefaction, but dental pulps which have been devitalized by this drug are only very exceptionally rendered proof against the putrefactive process. Arsenic in large quantity, locally applied, is an energetic and powerful escharotic or caustic, but its action is somewhat slow as compared with carbolic acid, zinc chloride, caustic potassa, and chromic acid. Its escharotic effect is more marked and rapid upon tissues of low vitality—abnormal growths—than upon normal tissue. Absorption, however, takes place much more rapidly in healthy

* J. Foster Flagg, Dental Cosmos, July, 1877.

than in highly inflamed or dead tissue. This fact explains why, in comparatively healthy pulps, devitalization with arsenic is so much more rapid and effective than in those which are inflamed, partially calcified, or otherwise diseased. In the former a single application is usually all that is necessary to effect complete devitalization, while in the latter two, three, and even four applications are sometimes required.

Arsenic when used in large quantities upon an extensive surface, as in the treatment of *cancer of the breast* and *lupus* in which the application has been intentionally permitted to include surrounding healthy tissue, absorption of the drug by the healthy tissue may take place—before its devitalizing action renders the tissue incapable of conveying it to the circulation—in such quantities as to produce constitutional effects or endanger life. That such a condition could be possible as a result of pulp-devitalization seems beyond the possibilities of peradventure, while, upon the other hand, irritation of the *apical space or the tissues beyond*, resulting from the application of an arsenical dressing to a vital pulp in other than deciduous teeth, and in the permanent teeth of young children before the completion of calcification of the roots in which the foramina are very large, could only occur, if intelligently used, as a rare and accidental circumstance.

The violent irritating action of arsenic when coming in contact with the surface of the pulp immediately causes arterial hyperæmia, while the devitalizing effect produced upon the tissue lying in immediate contact with it renders the devitalized tissue incapable of absorbing the drug, and thus prevents it being carried into the circulation except in an infinitesimal quantity, too small to provoke irritative inflammation at the apical spacé.

Flagg,* in experiments instituted by him to ascertain the amount of arsenic absorbed by the pulp, found it "almost incomprehensively minute, never more than one millionth (?) of a grain." He further maintains that the apical irritation which often follows upon the fourth to the seventh day after arsenical devitalization is not due to the effects of arsenic which has passed to the apical foramen, but to inflammatory conditions extending to the apical portion of the pulp, and are the last stages of the process of devitalization, as may be readily shown by microscopic examination of the apical extremity of a pulp removed at this time, and which is further proved by the subsidence of the pericemental symptoms in a few hours, or at most in twenty-four to forty-eight hours.

Arkovy presented an elaborate study of the action of arsenic upon the dental pulp at the International Medical Congress, 1881, which may be briefly summarized as follows: arsenic trioxide (As_2O_3) when applied to a vital dental pulp induces:

"1. Hyperæmia, partial or complete, depending upon the amount of the drug used; expansion of the blood-vessels, with a tendency to thrombosis and capillary embolism.

"2. It does not produce coagulation of the tissue.

* Dental Cosmos, July, 1877.

"3. It seems to possess a specific influence upon the blood-corpuscles, combining with the hæmoglobin to form a compound of arsen-hæmoglobin, which produces a yellowish tinge of the pulp-tissue and affects the color of the blood.

"4. The drug is conveyed *in substantia* into the blood-channels, where it produces, besides the changes already mentioned, disintegration of their contents—granular detritus—and shrinkage or anæmic collapse of the vessel walls. This being most noticeable where large doses had been used.

"5. The connective-tissue fibres and the odontoblasts undergo no change, but the connective-tissue cells are increased from three to four times their normal size.

"6. The effects upon the neurilemma is to somewhat increase the number of its nuclei, while in the axial part granular destruction of the myelin sets in and the axis-cylinder begins in various locations to disappear; while in others the notchy tumefaction of the axis-cylinder, usually seen only in cases of central lesion, can be plainly made out.

"7. These alterations are found scattered throughout normal-looking tissue.

"8. The pulp, in whole or in part, and the neighboring dentin and cementum, are tinged a brownish red when large doses of the drug are employed. This discoloration is most marked in the pulp at the top of the bulbous portion and at the apical fourth or third."

Miller in experimenting upon the tails of mice found that "the action of the arsenic appeared to be somewhat accelerated when a glass ring was applied close to the root of the tail. This was done to simulate the surroundings of the apical vessels. In more than forty cases there was not one in which the action of the arsenic extended beyond the ring, and the action was not appreciably affected by enclosing the tails in plaster casts. The action of the arsenic is of a progressive nature, beginning at the point of application and extending gradually in each direction."

Miller denies that arsenic trioxide produces escharotic effects upon the pulp like that of zinc chloride or carbolic acid, etc., and states, "The local application produces no immediate visible effect whatever."

Method of Application.—In the application of arsenic for the destruction of the vital pulp certain important considerations are presented.

1. *Dosage.*—The amount of the drug that may be safely applied is from one-sixteenth of a grain (0.001 gramme), or from that to one-thirtieth of a grain (0.002 gramme). The writer has found, however, in his experience, that one-hundredth of a grain (0.0006 gramme) was just as effective as a larger amount, provided it was permitted to remain in contact with the pulp for from three days to one week. The larger the dose the quicker the death, and *vice versa*, but the large dose is usually very painful, while the small dose will devitalize with absolutely no pain at all.

The one-hundredth part of a grain is an exceedingly small quantity, and yet it can be approximated as readily as the one-sixteenth of a grain after the actual amount has once been weighed out and observed. The approximate amount is all that is aimed at, for no one would think it necessary to weigh out each dose to be applied.

For many years the writer has not used morphine, cocaine, or other obtunding drug, except carbolic acid, in combination with arsenic for devitalizing the pulp, and has found it exceedingly rare that pain has been produced by the application, or that he has failed to painlessly remove the pulp at the end of a week or ten days. The exceptions have been cases in which severe irritation and hyperæmia were present before the application was made. The text-books usually warn the student not to use any coagulating drug in combination with arsenic, as the coagulum prevents the arsenic from taking effect. Clinical experience upon the part of the writer does not substantiate this teaching.

2. *Placing the Dressing.*—The cavity should first be syringed with tepid water containing an antiseptic or an alkali like soda bicarbonate. Next the rubber dam should be adjusted,—and this is wise in all cases before making an application of arsenic,—the cavity carefully dried, and the dressing, which should be composed of a piece of cotton the size of a pin-head, may be moistened with ninety-five per cent. carbolic acid, and the dry arsenic, which has been previously measured out, gathered up with the moistened dressing and then laid carefully over the point of exposure.

A somewhat larger dose is necessary in cases of pseudo-exposure, as the drug is slow in penetrating the dentin even though completely decalcified.

3. *Sealing the Cavity.*—It has been customary to seal the cavity containing an arsenical dressing with cotton and sandarach or with temporary stopping. Neither of these materials are really suitable for the purpose, as the first soon gets foul and very offensive, while from swelling of the cotton fibre or compression from the force of mastication painful pressure upon the pulp is induced. The temporary stopping is also liable, especially in crown cavities, to be compressed by mastication and produce painful pressure upon the pulp; while, both of them are open to the serious objection of forming leaky stoppings, which, if employed in approximal, labial, or buccal cavities extending beneath the gum, might lead to the escape of a portion of the arsenic and destruction of the soft tissues and alveolar process immediately surrounding the tooth. Zinc oxyphosphate mixed to a creamy paste and introduced so as to avoid pressure is the only safe material with which to seal a cavity containing an arsenical dressing. If this material were universally used for this purpose, sloughing of the gum, necrosis of the alveolus, and loss of the tooth, as a result of the escape of the arsenic, would become, except in rare cases due to accidental causes, a bygone experience.

In those cases which give evidence, by pain, of considerable hyperæmia, palliative treatment should first be employed to relieve the suffering and reduce the congested state of the pulp-vessels, as by this means devitalization may be rendered more sure and at the same time nearly if not quite painless. The cavity should first be disinfected with a tepid carbolic acid solution—two per cent.—or a solution of *formol*, two to five per cent.

Formol is composed of forty volumes of formaldehyde and sixty of water. The former per cent. is made by adding one volume of formol to nineteen volumes of water, the latter by adding one volume of formol to seven volumes of water.

Formol owes its value as a disinfectant to its great diffusibility in the strengths above mentioned ; it, however, possesses coagulating power.

The application of formol to an exposed pulp is at first slightly painful, but this immediately passes away and the effect is eminently soothing.

The pulp may now be dressed with morphine and one of the essential oils, and the cavity sealed for several days with temporary stopping or zinc oxyphosphate ; the latter being preferable from the fact that pressure is avoided and the pulp given complete protection against all external irritating agencies.

Some operators prefer to dress the pulp with cocaine hydrochlorate and oil of cinnamon.

Pulps which have been exposed for some time usually show evidences of suppuration. These cases should be treated by first removing as much as possible of the decalcified dentin around the exposure as can be done without producing much pain, and carefully syringing the cavity to remove the *débris* and wash away the pus. The arsenical dressing should be placed in *direct contact with the pulp* and sealed in by the method above described.

After the arsenical dressing has been removed, it is well to follow this treatment with a dressing of tannic acid for a few days, as the tannin hardens the pulp and facilitates its removal.

Dr. Harlan has recommended swabbing the cavity with the sesquioxide of iron, as this unites with the arsenic, forming an insoluble compound, and thus prevents any further action of this agent.

Occasionally a small fragment of living pulp will be left in the apical portion of the canal, which is still very sensitive. It is better to destroy this by repeated applications of ninety-five per cent. carbolic acid than to reapply arsenic, for fear of it going beyond the apical foramen. Danger also exists of mistaking an enlarged apical foramen for a piece of vital pulp remaining in the canal.

Errors of this character have been made by some of the very best and most careful practitioners. In all such cases it is better to err upon the safe side rather than to cause the loss of a tooth by a careless or mistaken diagnosis.

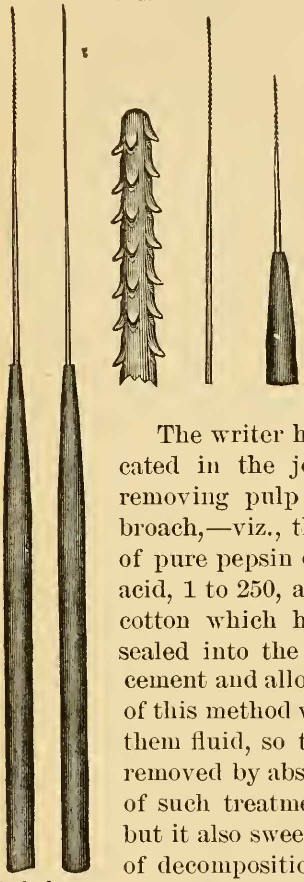
Discoloration of the Dentin.—This condition often follows a violent congestion of the pulp, which has been caused by external irritants. The discoloration is produced by the disorganization of the blood-corpuscles and the distribution of the hæmoglobin through the dentinal tubuli. Arsenic applied in large quantity for the devitalization of the pulp usually produces a violent congestion, and more often results in producing discoloration of the dentin than when the drug is used in small quantities.

It is therefore important in all cases of highly congested pulps to relieve this condition by palliative treatment or local depletion before applying the arsenic.

Extirpation of the Pulp.—The devitalized pulp should be removed at the end of a week or ten days after the application of the arsenical dressing, for the reason that at this time it can be done without pain or hemorrhage, as the natural process of separation or exfoliation has taken place between the dead and the living tissues at the apex of the root. If it is allowed to remain much beyond this period, pericemental irritation is likely to follow as a result of putrefactive decomposition and local septic poisoning.

The removal of the dead pulp-tissue may be accomplished by first thoroughly opening the pulp-chamber with burs or excavators upon lines which will give the most direct access, and then passing a fine barbed broach (Fig. 513) to the apex of the canal, rotating it once or twice in the same direction, and upon withdrawing it the pulp will be found entangled upon the barbs of the broach. If, however, the tissue of the pulp has been softened by decomposition and does not come away with the instrument, it must be broken up and removed by constant rotation of the broach, or fibres of cotton may be wrapped upon a plain Swiss jeweller's broach and rotated in the canal. This is the very best method of removing the remains of a pulp which has become liquefied by decomposition.

Fig. 513.



Barbed nerve-broaches.

The writer has sometimes adopted a method that was advocated in the journals several years ago (1872 or 1874) for removing pulp *débris* which could not be extracted with the broach,—viz., the introduction into the pulp-cavity and canals of pure pepsin dissolved in water acidulated with hydrochloric acid, 1 to 250, and carried into them by the means of fibres of cotton which had been saturated in the solution. This was sealed into the tooth with gutta-percha or zinc oxyphosphate cement and allowed to remain for twenty-four hours. The object of this method was to digest the remnants of the pulp and render them fluid, so that they could be washed out by irrigation or removed by absorbent cotton wound upon a broach. The result of such treatment is not only the removal of the pulp *débris*, but it also sweetens the canals and completely removes the odor of decomposition.

Papain.—Papoid is also used for the same purpose, and by many operators is thought to be superior to pepsin as a digestive ferment. Papain has the power of converting albuminoids into peptones, starch into maltose, and emulsifies the fats. It also possesses antiseptic virtues. Its digestive power is greater than that of pepsin or pancreatin. Papain is soluble in water, though not in alcohol, but it is active in either an acid or an alkaline solution. An aqueous solution of papain soon spoils, but when dissolved in glycerol it keeps for an indefinite period.

As a digester of pulp *débris* it may be mixed into a creamy paste by the addition of glycerol and introduced into the root-canals and pulp-chamber with a fine broach and sealed into the tooth with gutta-percha or zinc oxyphosphate cement and allowed to remain for twenty-four hours. At the end of this period the remnants of the pulp will be found to have been liquefied and the canals aseptic.

CHAPTER XXVI.

PULPLESS TEETH AND FILLING PULP-CANALS.

Definition.—A tooth which contains a devitalized pulp is said to be *dead;* a better term to designate this condition is *pulpless*, for the reason that the tooth cannot be correctly designated as dead so long as it maintains a vital connection through its pericementum with the alveolus of the jaw; but when this membrane has lost its vitality or has been destroyed, the tooth may then be correctly termed *dead* or *necrosed*, for it has no further vital connection with the economy.

All devitalized or pulpless teeth may be classed, from the surgical stand-point, under two heads,—viz., *aseptic* and *septic*. Inasmuch as the septic cases are the most common they will be considered first.

Septic pulp-canals are those which are invaded by the pyogenic and saprophytic micro-organisms, and contain decomposing or putrefying tissue in greater or less quantity, food *débris*, the fluids of the mouth, or other material which forms a suitable soil for the growth and propagation of this class of organisms. (See Chapter V.)

Devitalization of the pulp is usually the result of caries and exposure of this organ, followed by septic infection, inflammation, and suppuration; consequently the great majority of the cases of pulpless teeth which are presented for treatment are in a septic condition. Another class of septic cases are those in which the pulp of a perfectly sound tooth has lost its vitality from some traumatic injury or from embolism, but which perhaps for months or years thereafter has given no evidence of its condition except by the change in the color of the tooth. Suddenly, however, symptoms of a septic inflammation of the pericemental membrane become unmistakably manifest; and as there is no external communication with the devitalized pulp through a carious cavity by which the infection could have entered from the outside, it is fair to presume that the organisms which have established the suppurative process found a lodgement at the apical space, having been brought there through the avenues of the circulation. On the other hand, teeth of this class, when opened for the purpose of removing the dead and mummified pulp, often take on the most violent septic inflammation as the result of the admission of pathogenic organisms from the atmosphere or the fluids of the mouth. In all such cases the greatest care should be taken to prevent septic inflammation by the use of the rubber dam, and keeping the cavity through which the pulp-chamber is to be reached flooded with a strong antiseptic, like carbolic acid (ninety-five per cent.) or a sublimate solution (1 to 1000 or 1 to 500), so that when the pulp-chamber is opened an antiseptic of sufficient strength will be carried into it to prevent the growth and propagations of the micro-organisms. Devitalized pulps which have not been infected either from external sources or through the avenues of the circulation dry up and become mummified.

The sequelæ of septic infection of devitalized pulps are *pericementitis, dento-alveolar abscess, septicæmia*, and *pyæmia*.

Pulpless teeth which present septic canals are rarely ever entirely free from a certain amount of pericemental irritation, which is due to the toxic effect of the ptomaines developed from the action of the micro-organisms upon the gangrenous pulp, and which has been forced into the apical space by the pressure of gases, gravity, or by instrumentation.

If the organisms which have attacked the gangrenous pulp are of virulent type, active inflammation of the pericementum and alveolar abscess are likely to follow. The severity of the inflammatory symptoms is governed in part by the character of the infecting organisms, and in part by the local resistance of the tissues and the diathesis of the individual. In those persons affected with tuberculosis and syphilis, either inherited or acquired, or who are suffering from general debility, diabetes, or albuminuria, inflammation is prone to run a rapid and severe course.

Aseptic pulp-canals are those in which for various reasons, like persistent hyperæmia due to caries, abrasion, or fracture, but which has not exposed the pulp, or for the purposes of grafting a crown or setting a bridge, devitalization of the pulp by the application of arsenous acid has become a necessity. The removal, under antiseptic precautions, of such pulps as soon as separation or sloughing has taken place at the apex leaves the canals in an aseptic condition, and no other treatment is required than that of filling the canals at the same sitting and before the rubber dam is removed. The septic cases, however, often require several treatments before they are in a suitable condition to warrant the filling of the canals; in fact, this should never be done while there is any mephitic odor emitted from the canals, or there is any pericemental soreness, as these are unmistakable evidences that septic conditions still prevail. Immediate root-filling of crooked septic canals is to be most strongly deprecated, as the inevitable result is an alveolar abscess.

If, however, the canals can be rendered aseptic by a single treatment,—and this is possible in some cases, as, for instance, in the anterior teeth when the canals are straight and of large size,—immediate filling of the root is the only correct practice. Many practitioners make the mistake of *over-treating* such cases, thus keeping up an irritation which might be avoided by sterilization and immediate filling of the root-canal.

Preparation and Treatment of Pulp-Canals.—In the treatment of septic pulp-canals the object aimed at is that of so changing the conditions as to render them *aseptic*. This is accomplished by *first* excluding the secretions of the mouth by applying the rubber dam and maintaining absolute dryness of the field of operation in all subsequent treatments. When the treatment has once been commenced, from that time onward to the completion of the final operation the secretions of the mouth should never be allowed to again contaminate the pulp-canals. Failure to observe this rule often renders the treatment of the case tedious and unsatisfactory. The application of the rubber dam as the first step in all the subsequent treatments is the only way to insure positive aseptic conditions.

FIG. 514.—Superior left central incisor. Labio-lingual longitudinal section, showing pulp-canal.

FIG. 515.—Superior right central incisor. Mesio-distal longitudinal section, showing root-canal.

FIG. 516.—Superior left lateral incisor. Labio-lingual longitudinal section, showing root-canal.

FIG. 517.—Superior left lateral incisor. Mesio-distal longitudinal section, showing root-canal.

FIG. 518.—Inferior left central incisor. Labio-lingual longitudinal section, showing root-canal.

FIG. 519.—Inferior right central incisor. Mesio-distal longitudinal section, showing root-canal.

FIG. 520.—Inferior left lateral incisor Labio-lingual longitudinal section, showing root-canal.

FIG. 521.—Inferior right lateral incisor. Mesio-distal longitudinal section, showing root-canal.

FIG. 522.—Superior right cuspid. Labio-lingual longitudinal section, showing root-canal.

FIG. 523.—Superior left cuspid. Mesio-distal longitudinal section, showing root-canal.

FIG. 524.—Inferior left cuspid. Labio-lingual longitudinal section, showing root-canal.

FIG. 525.—Inferior right cuspid. Mesio-distal longitudinal section, showing root-canal.

FIG. 526.—Peculiarities in inferior cuspids and bicuspids. *A*, bifurcated inferior cuspid ; *B*, bifurcated canal, inferior first bicuspid ; *C*, bifurcated canal (middle third), inferior second bicuspid.

FIG. 527.—Superior right first bicuspid. Bucco-lingual longitudinal section, showing bifurcation of root and canals.

FIG. 528.—Superior left first bicuspid. Base of pulp-chamber, showing entrance to root-canal.

FIG. 529.—Superior right second bicuspid. Bucco-lingual longitudinal section, showing root-canal.

FIG. 530.—Superior right second bicuspid. Base of pulp-chamber, showing entrance to root-canal.

FIG. 531.—Inferior right first bicuspid. Bucco-lingual longitudinal section, showing root-canal.

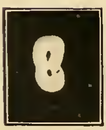


FIG. 532.—Inferior left first bicuspid. Base of pulp-chamber, showing entrance to root-canals.

FIG. 533.—Inferior right second bicuspid. Bucco-lingual longitudinal section, showing root-canal.

FIG. 534.—Inferior right second bicuspid. Base of pulp-chamber, showing entrance to root-canal.

The *second* step in the treatment is to open the pulp-chamber and root-canals and remove all pulp *débris*.

This is a simple matter in the superior incisor teeth, which have straight roots and normal canals, as shown in Figs. 514, 515, 516, and 517, which are longitudinal sections cut labio-lingually and mesio-distally.

The canals of the *inferior incisor* teeth are more difficult to enter, by reason of the mesio-distal flattening of their roots and the corresponding narrowing of the canals. This is shown in Figs. 518, 519, 520, and 521, sections cut in the same manner as those preceding.

The *cuspids*, both *superior* and *inferior*, when the roots are straight, are as easily entered as the superior central incisors. Figs. 522 and 523 are sections of the superior cuspids, and Figs. 524 and 525 are sections of the inferior cuspids. Fig. 526 represents some of the peculiarities met with in the inferior cuspids and bicuspids.

The *superior bicuspids* usually offer no serious difficulties in gaining access to their canals. It must be remembered, however, that the superior *first* bicuspid has usually a bifurcated root and two canals, as shown in Fig. 527 ; these are sometimes very small,—the labial root being the smallest,—and for that reason some difficulty may be experienced in following them to the apical foramen. Fig. 528 shows the location of the pulp-canals at the base of the pulp-chamber.

The superior *second* bicuspid has generally a single root and a single canal, which is of good size, as shown in Fig. 529, but it is often flattened mesio-distally. Fig. 530 shows the form and size of the pulp-canal at the base of the pulp-chamber.

The *inferior bicuspids* are almost invariably single-rooted teeth, having a single canal, as shown in Fig. 531, which usually gives free access to the apex. Fig. 532 shows an inferior first bicuspid having two distinct root-canals. Their position, however, is sometimes such—being curved inward—as to make it difficult to readily open the canal, except with drills carried in the right-angle hand-piece. This difficulty is more often experienced in the first bicuspid than in the second. Figs. 533 and 534 show the form of the canals in the inferior second bicuspids.

The *superior molars* offer somewhat greater difficulties to thorough opening of their canals, by reason of the angles of inclination of their roots and the differences in the size of the roots and their canals. The difficulties of gaining access to the canals increase from tooth to tooth in a distal direction, not so much from the shape and direction of the canals as from the position of the teeth, which makes it impossible to use straight instruments or to gain a view of the field of operation except by the reflected image.

In the superior *first* and *second molars* the disto-buccal root is the only one which, as a rule, offers any considerable difficulty in locating and following the canal. Fig. 535 is a longitudinal section of the disto-buccal and lingual roots of a superior first molar, and Fig. 536 of a similar tooth cut so as to show the buccal roots. This canal is often so small that the finest Donaldson bristle cannot be made to enter it for more than a small fraction of the length of the root. Fig. 537 shows the size and form of these canals at the base of the pulp-chamber. The pulp-canals of the superior second molars are shown in Figs. 538, 539, and 540. The superior *third molars* are the most difficult to treat, but this is due more to their position than to any other reason. Fig. 541 is a longitudinal section of the mesio-buccal and lingual root of a superior third molar, and Fig. 542 of the buccal roots of a superior third molar. Fig. 543 shows the size and form of the canals at the base of the pulp-chamber. Fig. 544, *A* and *B*, presents abnormal root-canals sometimes found in these teeth.

The *inferior molars* when the canals are normal present no difficulties, as a rule, which are not readily overcome by a little skill and ingenuity. The difficulties, of course, are increased in operating upon the *second* and *third* molars over those of the *first*. Fig. 545 shows the pulp-canals in a mesio-distal longitudinal section of an inferior first molar. Fig. 546 shows the size and form of the canals at the base of the pulp-chamber.

It should be borne in mind that the roots of the inferior molars are considerably flattened mesio-distally, that the canals are constricted in the centre, and that the mesial root and its canal are usually much smaller than the distal root and canal.

Fig. 547 represents a mesio-distal longitudinal section of an inferior second molar, and Fig. 548 shows the size and form of the canals at the base of the pulp-chamber. Fig. 549 represents a mesio-distal longitudinal section of an inferior left third molar, and Fig. 550 shows the size and form of the canals at the ball of the pulp-chamber. Fig. 544, *C*, illustrates a not uncommon abnormality of the root-canals of an inferior third molar.

The abnormalities in the number and the form of the roots and pulp-canals are so many and so varied that a separate description of them would occupy too much space in a volume of this character. The accompanying illustrations, Figs. 551, 552, 553, 554, 555, 556, and 557, and Plate VII., will, however, indicate the multiplicity and divergence of such abnormalities, and will be a guide and a warning to the student that he will encounter an uncertain number of teeth that will defy all efforts to follow their pulp-canals to the apex.

Opening the Pulp-Chamber and Canals.—In opening the pulp-chamber and the root-canals of the teeth one general principle should be observed,—viz., *to obtain access to the pulp-chamber in a direct line with the axis of the tooth.* This rule holds good for any tooth in any part of the mouth. The operator should never attempt to gain access to the pulp-canals through an approximal, buccal, or lingual cavity of decay without extending it to a point which would give direct access, as it is impossible to thoroughly cleanse the canals or properly fill them through cavities of decay in these locations unless the above rule is observed. It is better practice many times to drill an opening in that portion of the tooth which will give direct access to the pulp-canal, treating it through this opening, and filling the cavity of decay without reference to its proximity to the pulp-canal.

The superior and inferior incisors and cuspids should always be opened through the lingual surface, as this gives direct access to the canal, while the canals of the bicuspids and molars, both superior and inferior, should for the same reason be opened through the centre of the morsal surface.

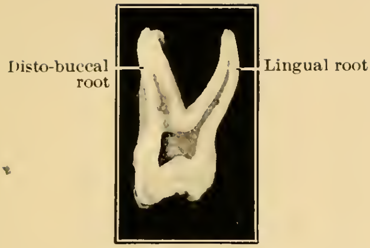


FIG. 535.—Superior left first molar. Bucco-lingual longitudinal section, showing root-canals.

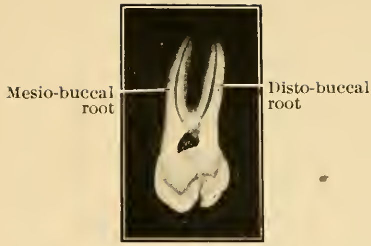


FIG. 536.—Superior left first molar. Mesio-distal longitudinal section, showing buccal root-canals.

FIG. 537.—Superior left first molar. Base of pulp-chamber, showing entrance to root-canals.

FIG. 538.—Superior right second molar. Bucco-lingual longitudinal section, showing root-canals.

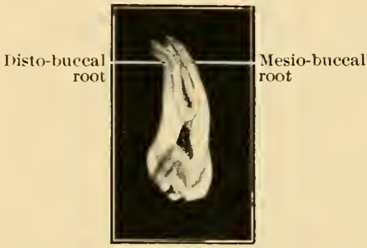


FIG. 539.—Superior right second molar. Mesio-distal longitudinal section, showing buccal root-canal.

FIG. 540.—Superior left second molar. Base of pulp-chamber, showing entrance to root-canals.

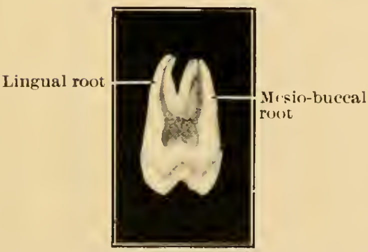


FIG. 541.—Superior left third molar. Bucco-lingual longitudinal section, showing root-canals.

FIG. 542.—Superior right third molar. Mesio-distal longitudinal section, showing buccal root-canals.

FIG. 543.—Superior right third molar. Base of pulp-chamber, showing entrance to root-canals.

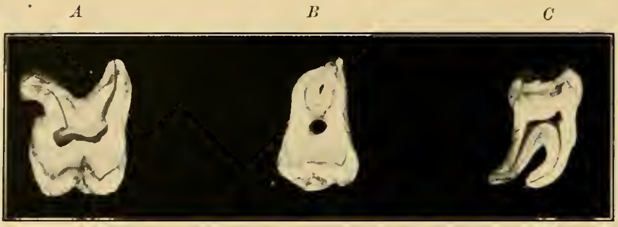


FIG. 544.—A, superior third molar; B, superior third molar; C, inferior third molar.

FIG. 545.—Inferior left first molar. Mesio-distal longitudinal section, showing root-canals.

FIG. 546.—Inferior left first molar. Base of pulp-chamber, showing entrance to root-canals.

FIG. 547.—Inferior left second molar. Mesio-distal longitudinal section, showing root-canals.

FIG. 548.—Inferior left second molar. Base of pulp-chamber, showing entrance to root-canals.

FIG. 549.—Inferior left third molar. Mesio-distal longitudinal section, showing root-canals.

FIG. 550.—Inferior left third molar. Base of pulp-chamber, showing entrance to root-canals.

A B C D

FIG. 551.—*A*, double-rooted superior lateral incisor; *B*, united superior central and lateral incisors; *C*, superior cuspid; *D*, double-rooted superior bicuspid.

A B C D E

FIG. 552.—*A*, *D*, superior cuspids; *B*, *C*, double-rooted superior cuspids; *E*, multiple-rooted superior bicuspid.

FIG. 553.—Superior bicuspids.

FIG. 554.—Superior bicuspid and molars.

FIG. 555.—Inferior first bicuspids.

FIG. 556.—Inferior molars and bicuspids.

FIG. 557.—Inferior molars.

PLATE VII.

Abnormal root-canals.

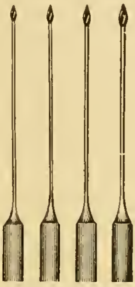
The most satisfactory instrument for making these openings is the spear-pointed drill, care being taken not to drive the drill beyond the floor of the pulp-chamber in those teeth which have multiple roots, as by so doing it might penetrate the bifurcation. In the superior first bicuspids and the molars generally this opening needs to be considerably enlarged in order to enter their root-canals, as they usually form divergent angles to the floor of the pulp-chamber. This enlargement may be accomplished with cross-cut fissure burs or cone burs.

Enlarging the Pulp-Canals.—The question of the propriety of mechanically enlarging the pulp-canals is one upon which there is a considerable difference of opinion. Some operators claim that a perfect cleansing of the canals cannot be accomplished without it, nor the canals perfectly filled except by such preparation. Others maintain that any canal which will admit a Donaldson bristle (Fig. 558) can be perfectly cleansed without enlarging it, and those cases in which the canals are so small that they will not permit the bristle to enter need no cleansing or filling.

FIG. 558.

Donaldson Bristles.

FIG. 559.



Gates-Glidden drills.

FIG. 560.

Donaldson pulp-canal cleansers.

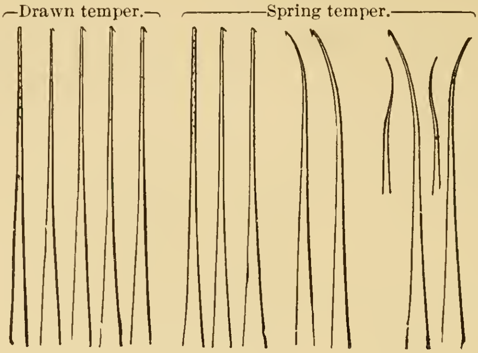
The writer prefers a middle ground between these two extremes. There is always danger in extremes, both of theory and practice; it is, therefore, better to try to avoid the errors of over-enthusiasm, but keep so alert for the truth that it does not escape us.

Nearly every pulp-canal that will permit the passage of a broach or a Donaldson bristle is placed in better condition for cleansing and filling by being opened and enlarged with a reamer or Gates-Glidden drill (Fig. 559) for at least a part of its extent; but the dangers are so great, if the root is curved or very much flattened mesio-distally, of making an aperture through the side of the root, or near its apex, or of forcing septic material through the apical foramen, or breaking off the head of the drill and leaving it lodged in the canal, that these instruments should be used with the greatest caution. Breaking the drill while reaming the canal is much more liable to occur if the burring engine is used than when hand instruments are employed. Swiss jewellers' broaches of spring temper are very valuable instruments for enlarging the pulp-canals and cleansing them of *débris*, and are much less liable to be broken and lodged in the canal than any other form of instrument. They cut much slower and do not clog so readily as the Gates-Glidden drill, and for these reasons, in small and constricted canals they are much the safest instruments to use. The breaking of an instrument in a pulp-canal is an exceedingly vexatious accident,

Fig. 561.

Nerve extractor, with holder.

Fig. 562.



Nerve extractors.

as its removal often entails no inconsiderable amount of labor and the consumption of much valuable time.

After the orifice of the pulp-canal has been sufficiently enlarged to suit the purpose, it should be thoroughly cleansed of all *débris* by the aid of the Donaldson pulp-canal cleansers (Fig. 560) or the nerve extractors shown in Figs. 561 and 562.

Hydrochloric and sulphuric acids are recommended by Callahan and others for chemically enlarging the pulp-canals. These agents in twenty-five to fifty per cent. solutions are conveyed to the canals upon a platinum bristle or probe and carefully insinuated. The affinity of these acids for the lime-salts is such that the walls of the canals are rapidly softened and disintegrated. The softened material is then readily removed with the Donaldson pulp-canal cleanser. The action of the acid may be limited by saturating the canals with a solution of sodium bicarbonate.

The *third* step in the operation is the local application of such therapeutic agents as possess *germicidal*, *antiseptic*, and *disinfectant* properties. These agents all have in common the property of destroying pathogenic and saprophytic micro-organisms, preventing the development of their spores, or of rendering inert or innocuous their waste products. They differ, however, very markedly in other respects; for instance, some of them coagulate albumin, while others do not. The former are therefore classed as *coagulants*, the latter as *non-coagulants*. To the first class belong all of the salts of metals and the alcohols, to the second very many of the essential oils. The non-coagulants possess, in a great degree, the power of diffusion, and maintain their antiseptic properties for a longer period than the coagulants; hence in the treatment of pulpless teeth these agents are considered by many operators to be more valuable for this purpose than the coagulants.

The *metallic salts*, which possess decided germicidal antiseptic and disinfectant properties, are the zinc chloride ($ZnCl_2$), aluminum chloride (Al_2Cl_6), mercuric chloride ($HgCl_2$), auric chloride ($AuCl_3$), sodium sulphite (Na_2SO_3), cupric sulphate ($CuSO_4,5H_2O$), and the argentic nitrate ($AgNO_3$). These have all been tested as germicidal agents in the treatment of septic pulp-canals, but all except the zinc and aluminum chlorides and the sodium sulphite have been discarded on account of the discolorations which they produce.

The *alcohols* which are commonly employed in the treatment of septic pulp-canals are the ethylic or commercial alcohol, phenylic alcohol,—viz., carbolic acid,—and creosote, with the coal-tar derivatives, the cresols.

Formol is also a very valuable therapeutic agent for disinfecting septic pulp-canals. The forty per cent. solution is reduced to a solution of two to three per cent. for dental use. Stronger solutions are irritating and coagulating.

The *essential oils* which are most in favor for the treatment of septic conditions of the pulp-canals are those of cloves, cinnamon, cassia, thyme, and eucalyptus. They are not, however, so powerful in their germicidal action as the coagulants.

Certain mineral acids have also been recommended for this purpose,—viz., the hydrochloric and sulphuric acids. They destroy micro-organisms by their intense chemic action, while the *alkalies* which have been employed are a combination of potassium and sodium,—Schreier's alloy, known under the name of kalium-natrium, sodium carbonate ($Na_2CO_3,10H_2O$), and sodium dioxide (Na_2O_2). These agents act by saponifying the fatty matter formed by the decomposition of albuminous substances and dissolving the albuminous substances contained in the pulp-canal.

Oxygen and chlorine gases in the nascent state have also been employed for the purpose of rendering the pulp-canals and the dentin sterile. Oxygen is still extensively used. These agents are also employed for the purpose of bleaching discolored teeth, the process of sterilization, however, progressing with the penetration of their bleaching action.

Oxygen gas is obtained by the introduction into the pulp-canals of aqueous and etherial solutions of hydrogen dioxide (H_2O_2) or solutions of sodium dioxide (Na_2O_2). These agents when placed in contact with decomposing albuminous substances give up one atom of their oxygen; the liberated oxygen acting as an oxidizer. The former is decomposed into water and nascent oxygen, the latter into sodium hydroxide and nascent oxygen.

Chlorine is usually employed in the form of hypochlorites, usually in solutions made by the electrolytic action of powerful electric currents upon sea-water. These preparations have the name of electrozone and meditrina.

Iodine and bromine and their preparations are also powerful sterilizing agents. Iodine is usually employed in the form of the tincture. Iodol and iodoform are objectionable for use about the mouth on account of their disagreeable odor.

Bromine is objectionable for the same reason, and also for its intense irritating effects.

Aristol, which is a combination of thymol and iodine,—dithymol biniodide,—is a favorite remedy with many operators for sterilizing putrescent pulp-canals. Hydronaphthol and a number of similar agents have been recommended from time to time, and have been used with considerable success.

Authorities differ as to the diffusibility of the coagulants. Some have maintained, notably Harlan,* that zinc chloride and carbolic acid, by their coagulating effect upon albumin, did not become diffused through the dentin; while, upon the other hand, such authorities as Truman,† Kirk,‡ and York § have maintained an opposite view.

Formol coagulates albumin, mucin, and gelatin, the coagulum maintaining its form for an indefinite period, and appears to be rendered permanently sterile so far as the action of the organisms of decomposition are concerned.

MATERIALS EMPLOYED FOR FILLING PULP-CANALS AND METHODS OF INTRODUCTION.

The pulp-canals having been properly prepared and sterilized are now ready for the introduction of the material which is to occupy the space in the canals formerly held by the dental pulp. The main object sought in filling the pulp-canal is to hermetically close or seal the apical foramen, and thus to prevent the egress of septic material, mephitic gases, microorganisms, or their waste products from the canal into the apical space, and also to preclude the possibility of the entrance by transudation of fluids from the apical tissues into the canal. These materials should be of such a character that they will remain unchanged by any influence which may be brought to bear upon them in such an environment. They must be unirritating to the soft tissues, impervious to moisture, susceptible of such ready adaptability to the walls of the canal as to insure a moisture-tight filling, and should possess antiseptic properties, or at least be capable of being rendered absolutely sterile when introduced.

The materials which are used for this purpose may be divided into three classes,—viz., *solids*, *plastics*, and *fluids*. These materials are, however, often combined, the solids being used as the medium whereby the plastic and fluid substances are introduced into the canal. The solid materials comprise gold-foil in various forms, tin-foil in shreds or pellets, gold and copper wire, lead and wood points, the latter made of hickory or orangewood and saturated with creosote.

The base metals, which are readily oxidized, have never been extensively employed on account of their liability to cause discoloration of the dentin, though from the therapeutic stand-point this quality sometimes renders them very valuable. The plastic materials which are most commonly employed are zinc oxychloride and softened gutta-percha points. Cotton, silk, and asbestos fibre are sometimes used as the vehicle for introducing zinc oxychloride and other plastic materials into the pulp-canal. The

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* Dental Review, vol. x. p. 44.

† Proceedings Academy of Stomatology, Philadelphia, 1894.

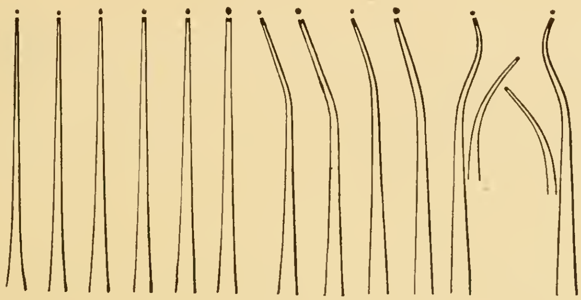
‡ Dental Cosmos, vol. xxxvi. p. 181.

§ Transactions Illinois State Dental Society, 1897.

objection to the use of a vegetable fibre like cotton as a filling for pulp-canals is overcome when it is employed in conjunction with the zinc chloride, "as it converts the cellulose of the cotton fibre into a pectous substance called amyloid, which is colorless and unchangeable in the conditions existing at the apex of a pulp-canal." *

The fluid substances used for this purpose are gutta-percha—either the red base-plate or the white stopping—dissolved in chloroform, the familiar chlora-percha, and salol, and paraffin. The two latter substances are rendered fluid by heat before being introduced. On cooling they become hard.

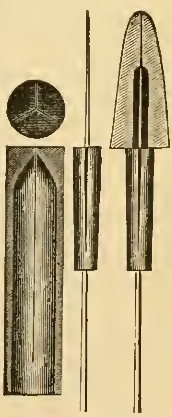
Fig. 563.



Pulp-canal pluggers.

Gold-foil was the first material used for the purpose of filling root-canals, and was introduced by the late Dr. Maynard, of Washington, D. C., about the year 1838. His method was to use narrow strips of heavy non-cohesive foil, and to pack this into the canal with delicate pluggers (Fig. 563) made for the purpose. When skilfully done it could be made to hermetically seal the apical foramen, but its removal, if circumstances required, was well-nigh impossible. For many years the older operators relied entirely upon this method of filling the pulp-canal. Tin is thought by some authorities to be superior to gold, for the reasons that it is more easily introduced and when oxidized possesses antiseptic properties.

Fig. 564.



Canal probe gauge.

Dr. W. S. How recommended the use of shredded tin for sealing the apical foramen. To avoid the danger of forcing the tin beyond the apical foramen a series of fine probes are used to measure the depth of the canal, as shown in Fig. 564, the clutch making it possible to measure it exactly. With these probes the particles of shredded tin-foil are carried to the apex and impacted into position.

This method is open to the same objection as gold, in that it cannot be removed from the pulp-cavity. The advocates of this method of filling pulp-canals assert that this objection is not a valid one,

* Kirk, American Text-Book of Operative Dentistry, p. 325.

for if the canal has been properly prepared and sterilized and the material skilfully introduced such a necessity never arises.

Gold, copper, and lead points are made by shaping sections of these metals to fit the caliber of the canal, the right length being ascertained by measuring the depth of the canal with a suitable probe or pulp-canal bristle. The late Dr. W. H. Morrison, of St. Louis, was the first to suggest the use of gold points for filling pulp-canals, which he recommended should be made from very soft pure gold wire shaped to fit the canal and of such length as not to pass the apical foramen when driven home. When introduced in conjunction with the plastic or fluid materials used for this purpose they can be made to perfectly seal the apical foramen as well as the entire length of the canal.

Wood points are but little used at the present day, although thirty to thirty-five years ago they were for a time quite extensively employed. They had the advantage, when saturated with creosote, of remaining permanently antiseptic, but there was no assurance that the apical foramen was hermetically sealed unless used in conjunction with the plastic materials, or that when the point was driven into the canal it did not project beyond the apical foramen.

Cotton saturated with creosote or carbolic acid was recommended many years ago as a permanent filling for pulp-canals by Dr. J. Foster Flagg, and for a long time it was extensively employed. It, however, did not fulfil the expectations of some of its most ardent advocates, especially when carbolic acid was used as the antiseptic, for pericementitis and alveolar abscess was not an infrequent sequel after a few months or years. When creosote was used the results were much better, as the antiseptic properties of this agent are more permanent. But neither carbolic acid nor creosote retain their antiseptic properties very long in such an environment. At the present time this material is rarely used as a permanent pulp-canal filling unless combined with zinc oxychloride. Since the dentist is now supplied with materials which are so much more reliable for this purpose, there seems to be no excuse for using a material whose only qualification is that it can be easily introduced.

The writer has removed many of the cotton fillings, and with few exceptions—and these had been saturated with creosote—they were vile-smelling and disgusting, while some of them were saturated with septic matter, discolored, and positively rotten.

Zinc oxychloride has been demonstrated by abundant clinical experience to be one of the most valuable of the materials employed for filling pulp-canals. When mixed to the consistency of a creamy paste it can be readily introduced into any accessible canal by the aid of a fine pulp-canal bristle and using a gentle pumping motion. Or it may be introduced upon fibres of cotton or silk. After it has set it is very hard, and has the advantage of remaining antiseptic for a considerable period thereafter, on account of the excess of the zinc chloride which is usually present in this cement. Care must be exercised not to allow the cement to pass the apical foramen, as it is very irritating to the soft tissues. Its peculiar coagulating and mummifying effect upon any remnants of the pulp and the contents of the tubuli prevents decomposition of these tissues and preserves the normal color of the dentin.

If the removal of the cement become necessary, it may be accomplished with Callahan's method of enlarging pulp-canals with sulphuric acid.

Gutta-percha is also one of the most valuable materials for filling pulp-canals, many operators preferring it to the zinc oxychloride.

Gutta-percha cones of proper shape and length, made from either the base-plate or the white stopping, when rendered plastic by heat or the action of chloroform, the volatile extract of eucalyptus, or the oil of cajuput, are most easily and successfully introduced even into tortuous and very fine canals. If the pulp-canals are first filled with a thin solution of chlora-percha and the material worked as far towards the apex as possible with a fine Donaldson bristle, or if moistened with the volatile extract of eucalyptus, or the oil of cajuput, the surface of the gutta-percha point will be rendered plastic and antiseptic. After being carefully placed in position and warmed by a blast of heated air directed upon it from a hot-air syringe, it will, under a little pressure from the pulp-canal plugger, readily slip into place, sealing the apical foramen, and by adding other cones the entire caliber of the canal may be filled to the orifice. In tortuous canals, by a little extra pressure the fluid gutta-percha can be made to penetrate to the very apex. If the canal has been thoroughly dried before the introduction of the filling, the gutta-percha will adhere very closely to the walls of the canal. This material is unchangeable in such an environment, and is the most bland and non-irritating to the soft tissues of any of the materials which are used for this purpose. It may be removed by first softening it with chloroform, and then thrusting a barbed broach into it and twisting the broach as is done in extirpating a devitalized pulp.

In the introduction of gutta-percha points care should be taken not to use so much force in packing them into place as to cause any portion to escape into the apical space. To prevent air being forced into the space by the introduction of the cone, the canal should be first filled with fluid chlora-percha and carefully worked to the apex with a fine probe. If the pressure is made gently and the patient warned to give notice as soon as the least sensitiveness is felt at the apex of the root, this accident may be avoided. This suggestion is applicable to the introduction of all forms of pulp-canal fillings. Pressure of the filling upon the tissues of the apical space, or the presence of air or septic *débris* forced through the foramen in front of the filling, always induces more or less pericemental irritation, and not infrequently results in alveolar abscess.

Ottolengui suggests the preparation of gutta-percha points or cones with a strand of silk in the centre, so that if it become necessary to remove the filling it can be more readily done if the cones have been prepared in this manner. His method of preparing the cones is as follows: "Take floss-silk and wax it thoroughly, after which dip it into chlora-percha and cut it into pieces about an inch long. These when dry give gutta-percha cones which have a strand of silk through them. They are readily packed into the canal, and the end, being allowed to extend beyond the orifice of the canal, is readily grasped, in case of need, with a pair of tweezers, whereupon the whole root-filling is easily withdrawn."

Theo. von Beust,* of Dresden, Germany, suggests the following method of preparing cones for root-fillings: "Take fine silver wire of from 0.02 to 0.05 millimetre in diameter, and cut from the different thicknesses of wire lengths to correspond to the different sizes of root-canals. These are tapered and roughened and surrounded with a film of gutta-percha, making the point cylindrical or cone-shaped, very like the root-canal points bought at the depots. A hook is then turned at the end of the point which is to occupy the coronal portion of the pulp-cavity. This makes an ordinary root-canal point of gutta-percha with a core of wire in the centre and a hook at the large end." By this method it is possible to remove the root-filling entire, should occasion require, by simply grasping the hook with a pair of dressing forceps. The point is inserted in the canal after the manner already described for other gutta-percha points.

Chlora-percha has its chief value in that it is capable, while in the fluid state, of being introduced into portions of certain canals in which solid materials could not be made to enter on account of their extreme smallness or their tortuous course. It is valuable, also, as a lubricant for the gutta-percha and metal points, and for closing the interstices between these materials and the walls of the canal.

In introducing chlora-percha into tortuous and very small canals, it should be made quite thin and worked towards the apex as far as possible with fine Donaldson bristles; then, by the aid of the How probes or other suitable instruments, fine threads of base-plate gutta-percha may be warmed and packed into the canals until they are full, when, if the patient has given no response to the forcing of the gutta-percha into the canals, a large piece of gutta-percha base-plate may be warmed and packed into the bottom of the cavity, and this covered with a pledget of cotton large enough to fill the cavity; then, with as large a plugger as will enter the cavity, pack the cotton, gently at first, and gradually increasing the force until the patient feels a slight pressure at the apex, when all further forcing of the material should cease, as this indicates that the chlora-percha has reached the apex of the canal.

Dr. W. C. Barrett,† of Buffalo, some years ago most convincingly demonstrated that not only would the chlora-percha travel by this method to the very apex of the canal, but that it might also follow certain minute canals which sometimes connect the pulp with the pericementum at some distance from the apex of the root.

Salol and *paraffin* have been so recently recommended as materials for filling pulp-canals that it is too early to pass judgment upon their utility or permanent value. They are both introduced in the same manner. A fine probe is first passed into the canal to the apex; a portion of the agent to be used is then taken up between the points of a pair of dressing pliers and heated over an alcohol flame until it is melted. While still hot the pliers are inserted into the cavity of the tooth, beside the probe, and then

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* Items of Interest, October, 1900, p. 713.

† Independent Practitioner.

opened. The fluid material immediately follows the probe to the apex of the canal, and on slowly withdrawing the probe while the material is still fluid it occupies the space of the probe and completely fills the canal. Some operators are in the habit of inserting a gutta-percha or a metal cone into the canal while the material is still fluid, thus insuring the material reaching the apex and perfectly filling the whole canal. This method has another advantage which gives it importance,—viz., if it become necessary to remove the filling, a blast of hot air from a chip-blower, or the contact of a hot instrument with the filling, will melt the material and permit the cone of gutta-percha or metal to be easily withdrawn.

Paraffin does not change its conditions in such an environment; but this does not seem to be the case with salol, as several reliable observers have claimed that it has disappeared from the canals in which it had been placed, probably by volatilization and diffusion through the dentin.

If *pericemental soreness* should follow the permanent filling of the pulp-canal, and this not infrequently happens, it may be relieved by painting the gum over the affected tooth with a counterirritant like tincture of aconite and tincture of iodine, equal parts of each; or chloroform may be added in the same proportions.

Mummification of the Pulp.—It has been frequently noticed, as far back as the days when arsenous acid was employed to relieve hypersensitiveness of the dentin, that after a time the tooth became slightly discolored and all sensitiveness disappeared; later, when occasion offered to open the pulp-chamber, the pulp was found not only dead, but completely desiccated or mummified, although in many of these cases no pericementitis was ever manifest. It has also been noticed, when portions of a pulp, devitalized by arsenous acid, had been left in the apex of the root, that very often such remnants, after having been treated with creosote or zinc chloride solutions, gave no further trouble whatever. The same conditions often occurred under fillings and cappings made of zinc oxychloride, and when the pulp-canals were opened, perhaps years afterwards, the pulps were found in a complete state of mummification.

This was noticed also under amalgam fillings made of cadmium or containing large quantities of this metal. These facts have led many operators to experiment with various antiseptic agents in the hope of discovering some method whereby it would be possible to render such remnants of pulp-tissue, as must often be left in tortuous and crooked pulp-canals, permanently aseptic, and thereby insure the possibility of its never causing pericementitis or alveolar abscess.

Witzel (1874), according to Miller,* was the first experimenter to institute systematic observations upon the subject. Witzel's method was to devitalize the bulbous portion of the pulp by means of arsenous acid, extirpate that part, and leave the portions in the canals undisturbed, treating these portions as freshly exposed pulps. This is the method followed later by Herbst, the only difference being that Herbst used native arsenic—cobalt—instead of the regular arsenous acid.

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* Proceedings Columbian Dental Congress, 1893.

A few cases treated after this manner do well, but the great majority of them sooner or later develop pericementitis and alveolar abscess.

Miller found that only a very small number of the antiseptic agents have any permanent sterilizing action upon the pulp. These are the cyanide, bichloride, and salicylate of mercury, sulphate of copper, and the oil of cinnamon. The preparation which gave the best results was composed of mercuric chloride, 0.0075 gramme, and thymol, 0.0075 gramme, made into tablets.

The method of employing this preparation is to devitalize the pulp and remove all that is readily accessible, then place one of the tablets in the pulp-cavity, crush it with an amalgam plugger, working it down into the canals as far as possible, and cover it with gold-foil. The great objection to this preparation is that the mercuric salt discolors the tooth.

This same experimenter expresses great faith in the power of the oil of cinnamon to permanently sterilize any fragments of pulp-tissue that may from necessity be left in the pulp-canals. The only objection to the use of this agent, and also of oil of cassia, is their liability to produce a greenish discoloration of the tooth.

Continuing the same line of experimentation, Söderberg has found the following formula to be very efficacious as a means for permanent pulp sterilization:

℞ Alum exsic.,
Thymol,
Glycerol, āā equal parts;
Zinc oxide, q. s. to make a stiff paste.

Frith claims good results from the following formulæ:

℞ Tannic acid,
Thymol, āā equal parts;
Glycerol, q. s. to make a stiff paste.

℞ Mercuric chloride,
Thymol,
Acidi carbolici, āā 2 grammes;
Acidi tannici,
Morph. mur., āā 1.5 grammes;
Ol. menth.,
Ol. cassiæ, āā q. s. to make a stiff paste.

With the latter "a tannate of mercury is formed; it is insoluble, and but little pain is caused by its absorption."

The method of applying these sterilizing agents is to remove all of the pulp-tissue that is possible, then to place a portion of the paste in the pulp-chamber and with a root-canal plugger carry it into the canals, and then add enough more to fill the pulp-chamber, cover it with zinc oxyphosphate, and fill with gold or amalgam as the conditions require.

Söderberg has more recently suggested that a small quantity of cocaine be added to the paste to prevent the pain incident to the action of the dried alum upon the pulp-tissue.

Objections have been raised to the employment of such methods of treatment, for the reason that it was feared it would tend towards slovenly methods of operation, as it would be much easier to apply the paste than to carefully follow the pulp-canals until all remnants of pulp-tissue that skill and patience could reach were removed. The advantages of the method lie in the possibility of so sterilizing the remnants which cannot with the utmost skill be removed that there will be little or no probability of their ever causing future trouble.

CHAPTER XXVII.

BLEACHING DISCOLORED TEETH.

DISCOLORATION of a tooth is the result of the death of its pulp, the disorganization of the red blood-corpuscles, and the dissemination of the hæmoglobin through the dentinal tubuli. It should be understood, however, that in this connection no reference is made to those metallic stains resulting from the oxidation of amalgam fillings containing large amounts of silver or cadmium, or from other conditions which may be operative in the mouth, like the chromogenic action of certain bacteria, tobacco, medicines containing iron, etc. Chemistry has not as yet discovered any reliable and effective method of removing the metallic stains caused by the oxidation of metal fillings, etc.

The death of the pulp does not of necessity result in discoloration of the tooth, but loss of its translucency or vital appearance is always a resultant of pulp devitalization. This appearance once lost can never again be restored by any means known to chemistry or dental art. Discoloration may be removed and the tooth whitened, but a natural appearance in color or translucency can never be obtained. The removal of discoloration may be accomplished by two methods: *first*, by chemic agents, and *secondly*, by the color effect obtained by the introduction of a white filling-material into the enlarged cavity and pulp-canal. By such means it is possible to greatly improve the color, and this improvement is most marked in those teeth which are most discolored.

The first noticeable change in the color of a tooth which has had its pulp devitalized by any of the various causes which may produce this condition is that of a pinkish tint.

The discoloration in devitalized or pulpless teeth ranges from a pinkish tint to black. These gradations in color pass rapidly "from the original pinkish hue, which becomes yellow; this, growing darker, passes into brown, and after the lapse of considerable time the tooth may become a permanent slaty gray or black." (Kirk.)

It is a notable fact, however, that the character of the agency which has caused the devitalization of the pulp determines to a considerable degree the rapidity with which discoloration of the tooth ensues. Traumatisms which produce severe injury to the pulp, rupturing its blood-vessels and causing extravasation of blood into its tissues, result in almost immediate discoloration of the tooth. Intense *irritation*, such as is produced by the application of arsenic trioxide, zinc chloride, or other violent irritants which cause infarction, embolism, or thrombosis, sometimes result in discoloration in less than twenty-four hours after their application. A severe pulpitis, lasting for two or three days before the vitality of the pulp is destroyed, does not cause discoloration nearly so readily; while if the inflammation has been of a mild type and the devitalization of the pulp has progressed slowly, the initial discoloration may be so slight as to escape notice except by reflected light.

If, however, the devitalized pulp is permitted to remain in the tooth for any length of time the color gradually grows darker, and although it may never become so unsightly as those which have been devitalized by more violent irritants, they will in time assume a color which will call for treatment to render them less conspicuous. Teeth, however, in which the pulp has been removed immediately after devitalization, or while it is in a state of irritability, but before stasis, embolism, or thrombosis has occurred, do not, as a rule, become discolored. The only change noticed in them is the loss of translucency.

Pathology.—Black has found the coloring matter of the red blood-corpuscles in a crystalline form in the blood-clots found in devitalized pulps, and that while the clots are in a state of solution from disintegration the coloring matter may enter the tubules in large amount and cause the discoloration of the entire dentin, giving it a red color.

The decomposition of the proteid elements of the pulp exerts a profound modifying influence upon the extent and the intensity of the discoloration by the formation of hydrogen sulphide and its action upon the hæmoglobin.

Healthy blood contains on an average twelve per cent. of hæmoglobin. (Vaughn.)* The crystals of hæmoglobin have the bright red color of arterial blood; this explains the initial pinkish hue or the red color which obtains in certain teeth immediately after devitalization of the pulp. Hæmoglobin has the power of forming rapid association and dissociation with oxygen without affecting the molecular arrangement of the hæmoglobin itself. In fact, it is the oxygen carrier of the red blood-corpuscle. Hæmoglobin is a proteid body combined with hæmatin, a body of known composition containing iron ($C_{34}H_{35}N_4FeO_5$).

The term *oxyhæmoglobin* is used to designate the hæmoglobin while it carries the oxygen, and in contradistinction to the hæmoglobin from which the oxygen has been removed. Arterial blood contains a considerable quantity of oxyhæmoglobin, but very little reduced hæmoglobin; while venous blood is poor in the former and rich in the latter. (Vaughn.)†

The association of oxygen with hæmoglobin, although a chemic combination, is of such a nature that the oxygen is readily given up and replaced without detriment to the hæmoglobin molecule. The red blood-corpuscle is therefore able to receive its oxygen as it passes through the pulmonary circulation, and give it up again in its passage through the capillary system, without material change in the corpuscle itself.

No accurate formulæ have been found for the proteids. Bunge gives the following analysis as the range of variation in their composition:

Carbon	50.0 to 55.0 per cent.
Hydrogen	6.6 to 7.3 per cent.
Nitrogen	15.0 to 19.0 per cent.
Sulphur	0.3 to 2.4 per cent.
Oxygen	19.0 to 24.0 per cent.

* Chemical Physiology and Pathology.

† Ibid.

According to Wurtz their composition is as follows:

Carbon	52.7 to 54.5 per cent.
Hydrogen	6.9 to 7.3 per cent.
Nitrogen	15.4 to 17.0 per cent.
Oxygen	20.9 to 23.5 per cent.
Sulphur	0.8 to 2.2 per cent.

It will be seen, therefore, that according to the analysis of Bunge the albumins contain approximately from 6.6 to 7.3 per cent. of hydrogen and from 0.3 to 2.4 per cent. of sulphur, while those of Wurtz place the percentage of hydrogen at 6.9 to 7.3 and sulphur at 0.8 to 2.2 per cent.

In the putrefaction of the animal albumins these substances are decomposed into fat, tyrosin, leucin, ammonia, hydrogen sulphide, carbon dioxide, hydrogen, and nitrogen. The hydrogen sulphide is formed by the union of two atoms of hydrogen with one of sulphur. This gas acting upon the hæmoglobin and certain of its compounds, formed by decomposition,—viz., methæmoglobin, hæmin, hæmatin, and hæmatoidin,—present various chromogenic features which explain the color changes that take place in the tooth during the decomposition of the albuminoid substances of the pulp, the organic material of the dentin, and the hæmoglobin of the blood contained in this organ at the time of its devitalization. These compounds form various colors. The crystals of *hæmoglobin* are bright red; those of *methæmoglobin* are reddish brown; those of *hæmin* are dark brown or black; those of *hæmatin* are bluish black; and those of *hæmatoidin* are reddish or orange-colored.

"Extravasations of blood quickly undergo changes which are visible even to the naked eye. In the skin they are at first brownish, then blue-green and yellow. When small hemorrhages have occurred in the substance of a tissue, as the periosteum, pleura, or lung, reddish-brown or blackish spots will be visible long afterwards. In bodies which are rapidly putrefying these areas may be slate-colored.

"Larger hemorrhages into the tissues—for example, in the brain or the lung—come to have a rusty color after a time, and still later the affected spots show ochre-yellow, yellowish-brown, or brown pigmentation. Corresponding with all these changes in color are physical and chemical changes in the hæmoglobin and in the iron contained in it." *

During the process of disintegration of the red corpuscles of the blood the hæmoglobin breaks up into "two groups of substances, one containing iron and the other not; the former is called *hæmosiderin*, the latter *hæmatoidin*." †

Hæmatoidin is chemically identical with *bilirubin*, the chief coloring matter of the bile; and, as already noticed, it is reddish or orange-colored in its crystalline form. "It appears to be more abundant when the blood-pigment is not much exposed to the action of living cells, as in the centre of large extravasations, and in hemorrhages into preformed cavities of the body, as, for example, into the pelvis of the kidney or into the subdural space." ‡ For this reason it would seem that the same conditions would obtain in a closed cavity like the pulp-chamber, which had not been penetrated by caries or traumatism, and which would, upon the devitalization

* Ziegler, General Pathology, 1899. † Ibid. ‡ Ibid.

of the pulp, be devoid of living cells in contact with it, and would thus explain the reddish or reddish-yellow discoloration of the teeth.

"*Hæmosiderin*, the derivative of hæmoglobin containing *iron*, is met with in the tissues for the most part in the form of yellow, orange, or brown masses and granules, which deepen in color with time. . . . If hæmosiderin comes in contact with ammonium sulphide (or hydrogen sulphide, both of which are derivatives of the putrefactive decomposition of the animal albumins), it becomes black by the formation of iron sulphide." *

The conditions for the formation of iron sulphide are present in a tooth containing a dead and putrefying pulp, and it may be safely inferred that this process takes place within the tooth as the result of the chemic changes which are brought about through the agency of the saprophytic micro-organisms acting upon the proteid elements of the pulp-tissue, the blood, the contents of the tubuli, and the hæmatin contained in the red corpuscles, the sulphur combining with the iron in the hæmatin to form iron sulphide. Kirk † is of the opinion that "while iron sulphide as such cannot be held wholly accountable for the final bluish-black color of a tooth which has reached the stage of permanent discoloration, the pigmentation is almost certainly due either to it or to some allied compound in which iron and sulphur, with some organic constituents, largely enter, and which by a further slight decomposition would yield true iron sulphide."

PREPARATION OF THE TOOTH FOR BLEACHING.

Various chemic agents have been suggested for the purpose of bleaching discolored teeth and restoring them to their normal color. The majority of these agents are more or less irritating and escharotic, and more or less injurious to the surrounding soft tissues; it is therefore important that the tissues of the apical space should be protected by the introduction of a filling that will hermetically seal the apical foramen, and at the same time of such material that it will not be acted upon by the chemic agent employed. The only material used for filling teeth that possesses these qualities is gutta-percha. To protect the gums, lips, and other soft tissues of the mouth, and the adjoining teeth, from the destructive action of these chemic agents the rubber-dam is of the greatest value; in fact, it is indispensable.

The first step in the preparation of a tooth for the bleaching process—a superior central incisor, for instance—is to freely open the pulp-canal and remove any remaining portions of the pulp and other *débris* by means of a Donaldson pulp-canal cleanser. This is to be followed with repeated irrigations with sterilized water rendered alkaline by the addition of a small quantity of sodium bicarbonate. The cavity of decay, if one exists, should now be cleaned of all deeply stained softened dentin, and the pulp-chamber and canal enlarged with suitable burs and reamers. If pericemental irritation exists, this condition must first be abated.

The rubber dam should now be adjusted, but to the tooth only that is

* Ziegler, General Pathology, 1899.

† American Text-Book of Operative Dentistry.

to be operated upon, as by this means there is less danger from leakage than when two or more adjoining teeth are included in the dam, while the adjoining teeth are protected against injury from any disintegrating or solvent action upon the enamel which might be possessed by the chemic agents used for the purpose of bleaching. To secure the dam from slipping off the tooth, and to guard against every possibility of leakage, a waxed ligature should be wrapped three or four times about the tooth at the cervix and tied with the surgeon's knot. Added security may be obtained by coating the ligature,—after it is in place,—the cervix of the tooth, and the rubber dam at this point with liquid chlora-percha.

The cavity and the pulp-canal should now be dried with bibulous paper and amadou as thoroughly as may be with these absorbent agents, and further dehydrated by means of a Wooley or an Evans root-dryer or the hot-air syringe. The root-canal should now be filled with gutta-percha, which should not include more than the apical third or half of the canal, for the reason that the discoloration of the tooth is most intense at the cervix and immediately beyond towards the apex, and if, as frequently happens, there is recession of the gum, it is important that the bleaching process be carried beyond this point.

All fillings of every kind which may be present in the tooth-crown should be removed before the bleaching process is commenced. This is especially necessary if the bleaching agent to be employed is one that contains chlorine, as this element readily combines with iron, gold, platinum, and other metals, forming soluble chlorides which, if permitted to penetrate the tubular structure of the dentin, will cause permanent discolorations that are well-nigh impossible to remove. For this reason, also, the instruments which are used for mixing and introducing bleaching agents of this character should be made of wood or ivory. Another advantage in removing the fillings from such a tooth is the increased surface which is thus exposed to the action of the bleaching agent.

The cavity should next be thoroughly prepared by removing all remains of softened dentin, thin walls of enamel, and any septic or other foreign substance. Kirk recommends washing the cavity after it is prepared with dilute ammonia water, or a hot solution of borax in distilled water in the proportion of one drachm to one ounce, to saponify and remove by solution all fatty matters which might otherwise obstruct the entrance of the bleaching agent to the tubular structures of the dentin. The surplus moisture should next be removed, and the tooth is then in condition for the bleaching process.

Method of bleaching Teeth.—The chemic agents which have been most successfully used for the purpose of bleaching discolored teeth are of two classes,—*oxidizing* agents and *reducing* agents. The former destroy the color molecule by virtue of their power to evolve oxygen in a nascent state. The latter act in an opposite manner by virtue of their great affinity for oxygen, seizing upon the oxygen element of the color molecule to form by-products, the character of which depends upon the chemic composition of the reducing agent employed.

The oxidizing agents are divided into two forms,—viz., *indirect oxidizers* and *direct oxidizers*.

The *indirect* oxidizing agents which are employed for bleaching teeth are chlorine in the form of chlorinated lime, chlorinated soda (Labarraque's solution), aluminum chloride, free chlorine gas, and *iodine* and *bromine;* the latter being used to remove various special metallic stains.

The *direct* oxidizing agents are hydrogen dioxide, sodium dioxide, and potassium permanganate.

The *reducing* type of bleaching agents is represented by *sulphurous acid.*

Chlorine Methods.—Chlorine (Cl) has a strong affinity for all metallic substances, and under favorable circumstances enters with great energy into direct combination with them, forming compounds which are generally soluble in water.

One of the chief characteristics of chlorine is its strong affinity for hydrogen (H) wherever found. This peculiarity is utilized in the operation of bleaching teeth by liberating the chlorine which is held in combination with the calcium, sodium, and aluminum of the above-mentioned compounds. The bleaching power of the chlorine is exerted upon the color molecule by seizing upon its hydrogen element and liberating the oxygen (O) contained in it. The oxygen thus liberated is in the nascent state, and in this form it acts most powerfully as an oxidizing agent. By the union of the chlorine with the hydrogen element of the color molecule, or other molecules containing hydrogen, chlorhydric acid (HCl) is formed, and the identity of the substance acted upon is destroyed.

The Truman Method.—Dr. James Truman (1864) introduced the first successful method of bleaching discolored teeth. His method consists substantially of liberating chlorine from *chlorinated lime* by the addition of a weak solution of acetic, tartaric, or oxalic acid. Dr. Truman has suggested several ways by which the chlorinated lime and the acid may be brought together. "One process is to saturate the entire canal and the pulp-chamber with the acid before inserting the chlorinated lime; another is to dip the instrument in the weak solution of acid, and then in the lime, and pack it rapidly into the cavity; and still another is to make a paste by the use of distilled water, and pack this into the tooth, and then apply a stronger acid solution by means of cotton wrapped around the point used." *

The cavity is then quickly sealed with gutta-percha, zinc oxychloride, or zinc oxyphosphate. This method to be repeated every two or three days until the required shade is obtained.

The failures which occur by the use of this method are due, in the opinion of Dr. Truman, to defective manipulation, principally in the employment of steel or any metal instruments,—as by their use metallic compounds are formed with the chlorine and permanent discolorations result,—and in the non-employment of distilled water in the various manipulations, for reasons that are manifest.

After the desired color is obtained, the tooth must be filled with some material which will by its antiseptic and coagulating qualities prevent the future decomposition of the contents of the dentinal tubuli. Dr. Truman

* American System of Dentistry.

thinks zinc oxychloride possesses these qualities in a remarkable degree, and experience proves it to be a most satisfactory substance for this purpose. After the cement has set it should be protected with a gold filling.

In the employment of *chlorinated soda* for the purpose of bleaching a tooth, the dentin is dehydrated as thoroughly as possible by the usual means, and afterwards saturated with the solution. A piece of absorbent cotton may then be saturated with a weak acid solution, placed in the cavity, and sealed in. The chemical action is substantially the same as when chlorinated lime is employed,—viz., the liberation of chlorine which combines with the hydrogen element of the color molecule, and sets free the oxygen element in a nascent state.

Another method of bleaching teeth with chlorine is that invented by Dr. Wright, of Richmond, Virginia. This method consisted of forcing a continuous stream of chlorine gas—previously prepared in the laboratory—into the pulp-canal and cavity of the tooth by an elaborate apparatus made especially for the purpose. The method was very efficient and rapid in its action, but the complications of the apparatus and the trouble of preparing the gas were obstacles which prevented its general adoption, and it was therefore abandoned.

Dioxide Methods.—*Hydrogen dioxide* (H_2O_2) is one of the class of *direct* oxidizing agents. Its value as a bleaching agent lies in the fact that one of its atoms of oxygen is bound to the water molecule by such a weak chemic combination that it is readily disrupted, and one of its atoms of oxygen liberated, as nascent oxygen. Many substances are capable of disrupting this compound and converting it into water (H_2O) and free oxygen (O). Contact with fresh blood, pus, salivary secretions, inspissated mucus, albumin, and nearly every form of dead organic matter, causes disruption of the compound, the evolution of oxygen, and the decomposition, wholly or in part, of the organic matter with which it comes in contact. These characteristics make it not only a very valuable means for bleaching discolored teeth, but also as a cleansing agent and germicide in all operations upon the teeth and in diseased conditions of the mouth.

The ordinary three or four per cent. aqueous solutions of hydrogen dioxide are of little value for the purpose of bleaching the teeth, as they are very unstable if kept for any length of time.

Since the introduction of the ethereal solution prepared by McKesson and Robbins, of New York, known as "caustic pyrozone," which contains twenty-five per cent. of hydrogen dioxide, the question of bleaching by the *direct* method has been solved, and this preparation is now largely used when this method is employed.

The process of bleaching by this method is to apply the twenty-five per cent. ethereal solution to the pulp-canal and the cavity by means of loosely twisted wisps of cotton, and following each application with blasts of heated air from the hot-air syringe until complete evaporation of the menstruum is obtained. This process is repeated two or three times at the same sitting, or until the desired restoration of color is secured. Failing in this, an application of pyrozone may be sealed in the cavity and permitted to remain for one or two days, when upon removing it and making another application and evaporating it to dryness the color will usually be restored.

The pyrozone seems, from experience, to act more rapidly and its results to be more permanent if it has been rendered alkaline before applying it "by the addition of a few drops of *ammoniæ fortior*, or by the solution of one of the caustic alkalies,—*e.g.*, sodium or potassium hydroxide or sodium dioxide." *

Dr. D. N. McQuillen, of Philadelphia, has suggested the treatment of the pulp-canal and cavity with Schreier's kalium-natrium preparation to secure the alkaline effect in the process. The *débris* caused by the action of the kalium-natrium is then carefully removed with instruments and pellets of cotton, the usual washing omitted, and the pyrozone applied as above.

This method gives most excellent results, both in the greater rapidity with which the bleaching process takes place and in the permanency of the results. As soon as the desired restoration of color is obtained the tooth should be filled temporarily with some material which can be easily removed, so that if discoloration returns the bleaching process may be again applied with little loss of time. No tooth which has been bleached should be permanently filled for at least two or three months, or even longer, that the permanency of the restored color may be assured before this operation is undertaken.

Dr. A. W. Harlan, of Chicago, introduced the use of aluminum chloride in connection with hydrogen dioxide. His method is to pack the aluminum salt into the cavity and then to moisten it with hydrogen dioxide. This was originally thought to be a chlorine process, whereby the chlorine in the aluminum salt was liberated by the action of the hydrogen dioxide; but later experimentation has shown that the reaction is due to the catalytic action of the aluminum salt, and that the hydrogen dioxide compound is disrupted by contact with the former and nascent oxygen is set free. Kirk suggests that inasmuch as aluminum chloride is an active coagulant, it is contraindicated in the bleaching of teeth until the process has reached the stage where a fixative is needed to prevent further decomposition in the tubular structure of the dentin.

Sodium dioxide (Na_2O_2) is another of the class known as *direct* oxidizing agents. It is similar to hydrogen dioxide in that its combination with one of its atoms of oxygen is so weak that it readily gives it up when subjected to the same conditions that cause hydrogen dioxide to part with one of its atoms of oxygen. The essential difference, however, lies in the character of the by-products which are formed after its decomposition.

Sodium dioxide is a strong caustic alkali, and after the loss of one of its atoms of oxygen it becomes Na_2O, still retaining its caustic and alkaline properties. When combined with water it is the ordinary caustic soda. The value which is possessed by sodium dioxide as an oxidizing or bleaching agent lies not only in the fact that its liberated atom of oxygen attacks the color molecule, but that it possesses great saponifying powers, which reach the oils and fats contained in the structures of the tooth and dissolve any organic matter still remaining.

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* Kirk, American Text-Book of Operative Dentistry.

"For use as a bleaching agent it is applied to the dentin in a saturated solution. In making the solution especial care is necessary in order to avoid elevation of temperature, by reason of the energy with which it enters into combination with the water. If the solution is allowed to become heated in the making, decomposition of the compound with loss of oxygen occurs and its bleaching power is destroyed. The solution is best made by pouring into a small beaker, of about one ounce capacity, two drachms of distilled water and immersing the beaker in a large vessel or dish containing ice-water or pounded ice. The can containing the dioxide powder should then have its lid perforated with a number of small holes similar to the lid of a pepper caster, and the powder be slowly dusted into the distilled water in the small beaker. The powder is added to the water until the solution assumes a semi-opaque appearance, indicating the point of saturation. On removing the beaker from the cooling mixture, the dioxide solution will in a few minutes assume a transparent straw-colored appearance and be ready for use." *

The method of application is similar to that employed when hydrogen dioxide is used, with the exception that pieces of asbestos felt are used instead of cotton with which to make the application, as the cotton fibre is acted upon by the sodium dioxide and converted into an amyloid substance which interferes with the bleaching process of the solution.

After the dentin has been thoroughly saturated with this solution a ten per cent. solution of sulphuric acid is applied, which neutralizes the alkaline condition, causing effervescence and the formation of sodium sulphate and hydrogen dioxide.

The particular value of this method lies in the fact that it not only destroys the integrity of the color molecule, but the caustic alkali exerts a solvent action upon the organic material remaining in the dentinal tubuli, while the reaction which causes effervescence in the tubuli completely removes the *débris* by mechanically forcing it out of the tubuli.

It may be necessary to reapply the sodium dioxide, as one application does not always restore the color. Before doing this, however, the tooth should be thoroughly washed with hot distilled water. In the second application the acid should be omitted. After the color is restored the tooth should be again thoroughly washed with hot water to remove all *débris*, and after thorough desiccation the tooth is ready for the filling. Kirk recommends varnishing the walls of the cavity before introducing the filling. Zinc oxychloride and zinc oxyphosphate cements are the best for these fillings on account of their better color, while the zinc chloride by its coagulating effect will effectually prevent putrefactive changes taking place in any portions of organic matter which might remain in the tubuli.

Kirk claims for this method that it not only restores the color of the tooth but normal translucency as well, and he thinks the opaque, white effect which results from other methods is due to the bleached organic *débris* remaining in the tubuli, while in the sodium dioxide method this is removed by the solvent action of the strong caustic alkali.

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* Kirk, American Text-Book of Operative Dentistry, p. 437.

Sulphurous Anhydride Method.—*Sulphurous acid* (sulphurous anhydride, SO_2) is the only one of the class of reducing agents that is used in the operation of bleaching teeth. Its value as a bleaching agent resides in its strong affinity for oxygen. When applied to a discolored tooth, it decomposes the color molecule and combines with its oxygen element, thus destroying the identity of the molecule and of the color. Various methods have been suggested for utilizing the bleaching property of sulphurous acid by the direct application of the gas to the root-canal of discolored teeth.

One of these methods comprehended making a solution of the gas in water and applying the solution to the pulp-canal and the cavity. Another was to ignite, by means of the electric cautery, a small piece of sulphur which had been placed in the pulp-canal. Both of these methods are open to serious objections from the disagreeable odor and from their limited efficiency. To be efficient the gas must be confined within the cavity for some time, and with neither of these methods is such confinement possible.

Kirk * has devised a method whereby it is possible to generate the gas from compounds placed within the pulp-cavity, and confine it there as in the chlorine process of Dr. Truman. The bleaching compound is made as follows: "One hundred grains of sodium sulphite and seventy grains of boric acid are separately desiccated and afterwards ground together in a warm, dry mortar. The powder is then to be transferred to a tightly stoppered bottle. For bleaching purposes the powder is packed into the root-canal and cavity of the tooth, and then moistened with a drop of water, and the cavity immediately closed as tightly as possible with a stopping of gutta-percha, previously prepared and warmed. A reaction ensues between the boric acid and the sodium sulphite whereby sulphurous acid is liberated. The process is effective in many cases where the chlorine methods have failed, but is slow in its action, and is largely superseded by the dioxide-of-hydrogen and dioxide-of-sodium methods."

Dr. E. A. Bogue has devised a method of bleaching teeth which he describes as follows: "The first procedure is to close the apical foramen with oxychloride of zinc and cotton. Oxalic acid is then applied and followed by a current of hot air, after which dry chalk is packed into the canal and sealed in and left over night, repeating the process if necessary. Finally, pyrozone—25 per cent.—is applied until the color returns. The canals and cavity are then dried, the inner surface of the cavity coated with copal varnish, and over this is placed oxyphosphate cement."

Cataphoric Method.—In the bleaching of the teeth by the cataphoric method the power of the continuous galvanic current to disseminate, diffuse, and carry remedies into and through animal tissues is taken advantage of to bring about a more complete and perfect dissemination of the certain bleaching fluids used to restore the color of devitalized teeth.

The same electric apparatus and appliances employed in the treatment of hypersensitive dentin are used in this method of bleaching teeth. The principles involving the application of the current and its control are also the same (see Chapter XIII.), the only difference being that the resistance

* American Text-Book of Operative Dentistry, p. 439.

offered by a devitalized tooth is much greater than that of a vital tooth, which necessitates a much higher voltage (pressure) to carry the bleaching agent into the dentin. While a current pressure of ten volts is all that can be utilized in the treatment of hypersensitive dentin, twenty-five to thirty, and even sixty volts, are sometimes required to drive a current of one and one-half milliamperes through devitalized dentin.

The bleaching fluid which is used in connection with the galvanic current is a twenty-five per cent. aqueous solution of hydrogen dioxide to which has been added a small quantity of sodium chloride, sufficient to give it the strength of the normal salt solution used in transfusion,—one drachm to a pint of warm sterilized water,—as the addition of this salt increases the conductivity of the fluid. The ethereal solution of hydrogen dioxide is too resistant to the current to be utilized in this connection.

To prepare a twenty-five per cent. aqueous solution of hydrogen dioxide, place in a test-tube one volume of normal salt solution and two volumes of twenty-five per cent. ethereal solution of hydrogen dioxide, and mix by shaking the test-tube. To remove the ether, place the solution in a small porcelain evaporating dish and gently heat over a water-bath until the ether is all evaporated, care being used not to allow the flame of the lamp to ignite the ether vapor. The hydrogen dioxide is thus dissolved in the water and the ether dispelled. Dr. Hollingsworth recommends adding one per cent. of zinc sulphate to the solution, which diminishes the resistance and exerts a coagulating effect upon the organic matter of the dentin, which gives translucency to the dentin and enhances the permanency of the operation.

Fig. 565.

Syringe electrode.

The same care must be exercised in isolating the tooth by the rubber dam, and securing it against leakage of moisture or leakage of the electric current, that is exercised in the treatment of hypersensitive dentin as already described in detail in the chapter previously referred to.

The tooth being ready for the bleaching process, the aqueous solution of hydrogen dioxide is applied to the tooth-cavity on a pledget of cotton, which must at all times be kept moist with it, and the platinum point of a suitable anodal electrode placed in contact with it. The cathodal electrode, covered with sponge and moistened with the sodium chloride solution, may be held in the hand or applied to the side of the face or neck, and the current turned on, the same precautions being taken as when treating hypersensitive dentin.

Short circuiting of the current is liable to occur if great care is not taken to keep the external surfaces of the tooth dry.

Some operators apply the cathode to the external surface of the tooth, and claim that more rapid effects are obtained on account of the shorter distance which the current has to travel. There is, however, considerable danger of short-circuiting the current if the external surface of the tooth should become moistened, or by a movement of the patient the electrodes should accidentally come in contact with each other.

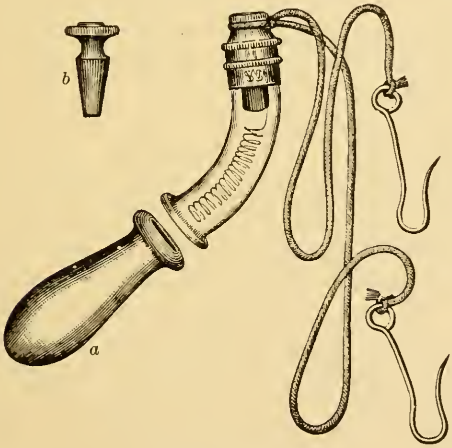
The Hollingsworth syringe electrode (Fig. 565) may be used to keep the cotton moist with the bleaching fluid.

To successfully employ the aqueous solution of hydrogen dioxide with the electric current, it is necessary to use a device which will permit the whole crown of the tooth to be enveloped in the bleaching fluid.

Such a device has been invented by Dr. Hollingsworth, and described by him as follows: "The bleaching electrode consists of a curved glass tube, with a metal top at one end, connecting with a spiral platinum wire in the tube (Fig. 566) and a rubber nipple (*a*) at the other end to enclose the tooth to be bleached. A metal cap plug (*b*) prevents the bleaching fluid from escaping, and the tip is provided with a groove for the attachment of the connecting cord. The appliance is held in place by the hooks attached to the metal tip of the tube, which are caught over the top of the rubber dam.

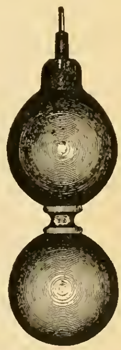
"The duplex syringe (Fig. 567) is for the purpose of filling the tube and nipple with the bleaching fluid. The nozzle connects only with the rear

FIG. 566.



Bleaching electrode.

FIG. 567.



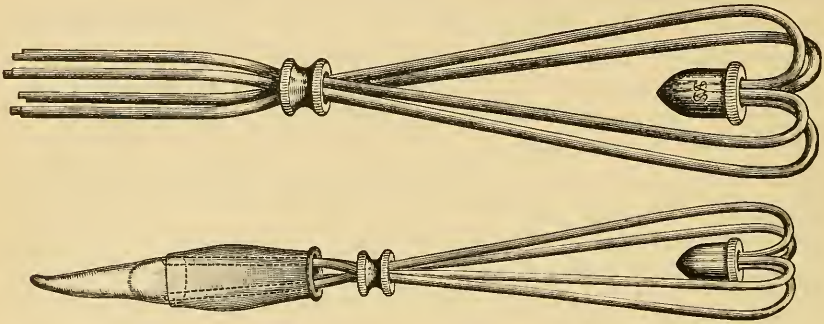
Duplex syringe.

bulb. When this is charged with the bleaching fluid the nozzle is inserted in the tube of the bleaching electrode, first compressing the forward bulb and allowing it to expand to exhaust the air in the tube and nipple, when pressure upon the rear bulb forces the bleaching fluid into the electrode.

"The nipple-expander (Fig. 568) is for adjusting the rubber nipple to the tooth that is to be bleached. The closed end of the nipple is first perforated with the rubber-dam punch, and when placed upon the tooth and ligated forms a close-fitting and tight holder for the bleaching fluid."

Before adjusting the bleaching electrode, the tooth should be prepared as for bleaching by any of the methods already described; the pulp-canal and the tooth-cavity are then loosely packed with cotton previously saturated with the bleaching fluid. The object of this is to form a conductor that will carry the fluid to the remote recesses of the cavity and canal, and also to exclude air-bubbles which would act as insulators of the electric current.

Fig. 568.



Nipple-expander.

The first step in the adjustment of the electrode is the placing of the rubber nipple in position by means of the nipple-expander (Fig. 568) and securing it firmly by a ligature passed around it at the cervix of the tooth, varnish or chlora-percha to be flowed over it as an added precaution against leakage.

The free end of the nipple is now forced over the shouldered end of the glass tube and the hooks adjusted to hold the opposite end of the tube in position. The tube is now to be filled with the bleaching fluid by inserting the nozzle of the duplex syringe—which has been previously charged—into the metal tip of the tube, compressing the forward bulb to exhaust the air. If air finds its way into the tube at the cervix of the tooth beneath the margins of the rubber nipple, varnish may be again applied, and suction will draw it into and fill any little interstices which might give access to air. The rear bulb is compressed and the tube filled with the bleaching fluids, thus submerging and surrounding the crown of the tooth in the fluid. The positive pole is now connected with the metal end of the tube and the negative pole with the hand electrode, and these with the source of the current.

Fig. 569.

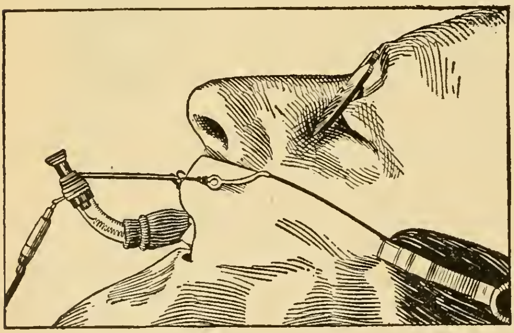


Fig. 569 shows the bleaching electrode in position and connected with the positive pole.

The current should be turned on slowly and the milliampere-meter closely watched; a leak in the current is indicated by the registration of a greater amperage than is usually employed in such operations,—viz., one-tenth to one-half a milliampere upon vital teeth, which is increased to one and sometimes one and one-half milliamperes in bleaching devitalized teeth.

CHAPTER XXVIII.

DISEASES OF THE PERICEMENTUM.

THE pericementum or peridental membrane is often the seat of various diseased conditions, both nutritive and functional. Among these are several distinct forms of inflammation, all arising from different causes, some local in origin, others constitutional, and each requiring, according to their origin, a different line of treatment for their cure.

Bödecker classifies the diseases of the pericementum under two heads,—viz., *purulent* and *non-purulent.* Burchard thinks this is misleading, as cases may be due to septic causes without pus-formation, while pus-formation represents but one form of sepsis. Burchard * classifies them as *septic* and *non-septic.*

Black † classifies the disorders of the pericementum under three heads: first, diseases which begin at the apex of the root; second, those which begin at the border of the gingivæ; third, those beginning at some intermediate portion of the membrane. These are again divided into septic and non-septic, general and localized, acute and chronic.

PERICEMENTITIS.

Definition.—Pericementitis (from the Greek περι, around; Latin, *cæmentum*, cement; Greek, ιτις, itis, the ending, signifying inflammation), inflammation of the pericementum or peridental membrane and the tissues immediately surrounding the tooth.

Inflammation of the investing membrane of the roots of the teeth is therefore termed *pericementitis*, *periodontitis*, or *dental periostitis.*

Next to hyperæmia and inflammation of the pulp, pericementitis is the most prolific cause of toothache. It therefore calls for a careful study of its pathology and its symptoms, that it may with certainty be differentiated from other affections which cause odontalgia.

Causes.—Pericementitis may be divided into two distinct forms, one dependent upon *local* causes for its existence, the other upon general or *constitutional* conditions, and these forms may be either *acute* or *chronic*, septic or non-septic, in their character.

Local pericementitis is a condition of inflammation of the investing root membrane caused by *traumatic injury* or *septic poisoning.*

Traumatic pericementitis may be induced in vital teeth by blows, falls, or malocclusion, either from the natural movement of the teeth incident to the loss of supporting neighbors or by fillings which have not been prop-

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* Dental Pathology, Therapeutics, and Pharmacology.

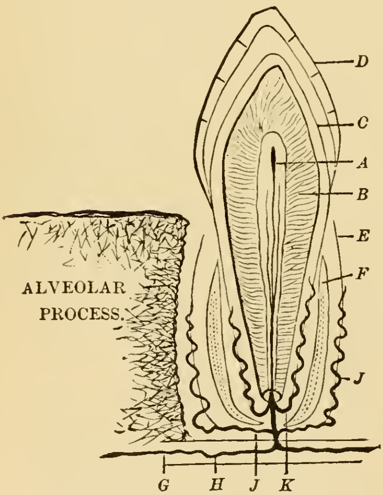
† American System of Dentistry, vol. i. p. 921.

erly shaped to give a perfect occlusion with opposing teeth ; by the pressure of an ill-fitting partial set of artificial teeth ; by an ill-fitting crown or by an improperly adjusted clasp ; by excessive malleting and wedging ; by ligatures and rubber-dam clamps ; by the rapid movement of teeth in the operation of regulating ; by the presence of a rubber band used in regulating, and which has been allowed to cut its way towards the apex, as shown in Fig. 570 ; by the irritating presence of salivary calculus upon the roots ; by an imperfect root-filling, or by puncturing the side of the root with drills or reamers.

Fig. 570.

In traumatic pericementitis the inflammatory condition is of an acute diffused character, seemingly involving the whole of the membrane at the same time, but presenting symptoms which, as a rule, are much less severe in their manifestations than those associated with septic conditions. In a majority of cases of traumatic pericementitis the inflammatory symptoms never reach the stage of suppuration and involvement of surrounding tissues. In the severer forms of injury, such as blows and falls upon the teeth, accompanied by laceration of the overlying tissues or partial luxation of the teeth, induration and swelling are often very considerable, sometimes ending in suppuration from infection of the injured tissues. Perforation of the lateral wall of the canal often establishes a pericementitis which resists all efforts at treatment. Injuries, however, which do not cause a break in the continuity of the tissues do not, as a rule, suppurate unless the pyogenic organisms are already in the system and are deposited at the point of injury from the blood-current. Under such circumstances the injured tissues, by reason of their lowered vital powers of resistance, would furnish a favorable soil for the growth and propagation of the pyogenic organisms, and the formation of pus would be the result.

Fig. 571.



A, dental pulp and its artery ; *B*, dentin ; *C*, tunica propria ; *D*, enamel ; *E*, pericementum ; *F*, cementum ; *G*, canal in lower jaw ; *H*, dental artery ; *J*, branch of dental artery supplying pericementum ; *K*, branch of dental artery supplying tunica propria. (After Black.)

Septic pericementitis may be either *acute* or *chronic*, and is usually the sequel of inflammation and gangrene of the pulp, the exceptions being such cases as those just mentioned. Septic pericementitis always begins as a *circumscribed inflammation*, located at the apex of the root of the tooth, occasionally involving one or more teeth upon either side of it ; the tissues first involved are those of the apical space, and for this reason it is often spoken of and described as *apical pericementitis*.

Acute apical pericementitis sometimes accompanies pulpitis ; when this dual condition is manifest in double- or multiple-rooted teeth, it is possible for one of the roots to contain a devitalized pulp while the other portions are vital; but when this dual condition occurs in teeth having a single root, another explanation is needed to account for the phenomenon. It seems probable, therefore, that inasmuch as the vessels of both the pulp and the pericementum arise from a common branch located at the apical space (Fig. 571), and the connective tissue which enters the foramen with the vessels and nerve-trunk is continuous with the pericementum at the apical space, the inflammation has spread by continuity of structure.

Acute apical pericementitis, however, is not always of septic origin, for it may be the result of chemic irritation from the escharotic action of arsenous acid, zinc chloride, carbolic acid, or other irritating agents which have been applied to the pulp or to the canal and have escaped into the apical space. Or it may be due to the mechanic irritation of portions of filling-material which project beyond the foramen and press upon the apical tissues.

Pathology.—Acute apical pericementitis due to septic infection from a gangrenous pulp does not differ materially in the pathologic changes which take place in its tissues from those which are observed in any other tissue which may be the seat of a septic inflammation.

Irritation at the apex is produced by infection of the apical tissues with the micro-organisms of suppuration or of their waste products, or with the ptomaines of decomposition produced by the action of the saprophytic organisms upon the gangrenous pulp. At the beginning the irritation produces hyperæmia of the vessels of the pericementum, especially near the apex of the root; this is followed by exudation of the *liquor sanguinis* and the migration of white blood-corpuscles, and later by proliferation of the connective-tissue cells. The pericementum now becomes thickened, and presents areas of cloudiness. Later as the inflammation progresses this cloudiness may extend over the entire surface of the membrane.

At this stage, if the cause of the irritation is removed, resolution takes place and the tissues return to their normal state. Failing in this, the inflammatory process progresses, and the morphologic elements surrounding the inflamed part—the leucocytes and the embryonic cells formed from the fixed tissue-cells—lose their vitality and are converted into pus-corpuscles, and through the digestive and peptonizing action exerted by the pyogenic organisms upon the intercellular substance of the tissues it is liquefied and pus is formed, resulting in dento-alveolar abscess. Occasionally the inflammatory process is confined to the apex; at others it becomes diffused over the entire membrane.

Symptoms and Diagnosis.—The first symptom noticed in acute pericementitis of septic origin is a gnawing, uneasy feeling of tension in and about the tooth, with a desire to bite upon it. This feeling of tension is produced by the hyperæmic condition of the blood-vessels of the peridental membrane, and is relieved for the time being by forcibly biting upon the tooth. Forcible pressure upon the teeth drives the blood out of the vessels and relieves the tension for a few minutes, but the gnawing feeling and tension again return in a slightly increased form. Lateral percussion of the tooth reveals slight tenderness. The tooth now begins to feel longer than the others, as though it were raised from the alveolus, and is slightly loose. This is actually the fact, for as the congestion of the blood-vessels goes on the membrane becomes thickened and the tooth is slightly raised from its alveolus. The gum around the tooth becomes swollen and tender, and the free margins assume a red or purple hue. Pain of a deep, dull, constant character will now be present. Lateral percussion is painful, and forcibly biting upon the tooth, instead of giving relief, now causes intense pain. The swelling slowly increases and the pain is still deep-seated, but gradually changing to a dull, throbbing character, while the tooth grows more and more sensitive to percussion.

The swelling now becomes more defined and palpation will discover a softening at some one point with fluctuation, which indicates the formation of pus, the penetration of the bone, and an early spontaneous evacuation of the pus by natural pointing, or it may escape by burrowing along the side of the root, finding an exit at the margin of the gum. The intensity of the symptoms will depend somewhat upon the character of the infection and upon the diathesis of the patient.

Differential Diagnosis.—It has already been stated that pericementitis, next to pulpitis, was the most common cause of toothache. It therefore becomes important to be able to make a diagnosis between them. Attention has also been called to the fact that pulpitis and pericementitis may occasionally exist at the same time in an individual tooth having more than one root, but it is not impossible for this dual condition of inflammation to exist in a tooth with a single root. Under such circumstances the sharp, stinging, lancinating pain of a pulpitis may be present and associated with soreness to percussion and elevation of the tooth in the alveolus.

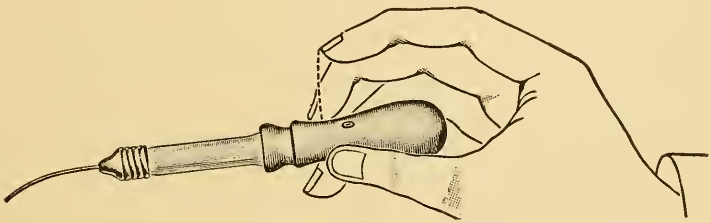
In a large majority of cases, however, pericementitis is not developed until after the vitality of the pulp has been destroyed and the saprophytic germs have begun their work of reducing the gangrenous pulp to its original elements.

The pain from pulpitis is of a sharp, stinging character, and inclined to be paroxysmal and reflected to various parts of the face, making it often difficult to locate the tooth which is causing the pain. The normal heat sense is also greatly *lowered*, so that temperatures which can be borne by a healthy tooth become intolerable in one affected with pulpitis. While in pericementitis the pain is always located in the affected tooth, and is of a dull, heavy, gnawing character. The heat sense in pericementitis is *raised* somewhat above that of the tooth affected with pulpitis. In the early stages of an inflammation cold is soothing, as it contracts the blood-vessels and retards the progress of hyperæmia and exudation; while in the stage of congestion and partial stasis heat is more beneficial, as it tends to promote the movement of the blood, particularly in the congested veins, and thus relieves the tension upon the hypersensitive nerve-fibres of the inflamed tissues. A rigor and elevation of temperature indicate the formation of pus.

Prognosis.—The usual duration of acute septic apical pericementitis is from three days to two weeks. In a majority of these cases the inflammation ends in suppuration and the formation of a dento-alveolar abscess, occasionally they terminate in resolution, while in others the cell proliferation results in the formation of new cement-tissue,—hypercementosis. The latter condition is the result of a continuation of the irritation that developed the acute attack, but which is of a milder type, assuming a subacute or chronic form.

Local Treatment.—The local treatment of acute pericementitis of either the traumatic or septic form is, *first*, to remove the cause of the irritation if it still exists. This comprehends, in the traumatic variety, the relief of malocclusions, the discarding of ill-fitting plates or crowns and improperly adjusted clasps, the removal of salivary calculus, or of root-fillings which are causing pressure upon the apical space. In the septic variety it means the opening of the pulp-canal and the removal of its decomposing contents, either by chemic means—treatment with sodium dioxide solution—or by mechanic means, in the use of broaches, barbed cleansers, etc., exercising the greatest care not to allow the broach or Donaldson cleanser to pass the apical foramen or to force the septic material into the apical space. Frequent irrigation with antiseptic

Fig. 572.



Dunn capillary or drop syringe.

solutions should accompany the process of cleansing the canals, followed by the application of hydrogen dioxide, either upon a pledget of cotton or by the aid of the Dunn syringe (Fig. 572). After the canals have been thoroughly cleansed, they should be dressed with one of the essential oils or Dr. Black's one-two-three mixture :

℞ Oil of cinnamon, 1 part ;
Carbolic acid, 2 parts ;
Oil of wintergreen, 3 parts ;

or,

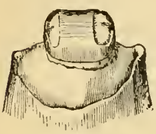
℞ Eugenol, 1 part ;
Carbolic acid, 2 parts ;
Eucalyptol, 3 parts ;

or with some other suitable antiseptic.

In opening the canals of teeth which are very sore the tooth should be supported with the thumb and index-finger of the left hand while drilling through the overlying dentinal tissue or the filling, as the case may be. Or a ligature may be tied around the cervix of the tooth, the ends being left long enough to extend well beyond the mouth, and traction made upon it, as suggested by Dr. J. Foster Flagg, to counteract the pressure of the drill. The immediate opening of the canals is imperative in all cases where the pulp has died under a filling, otherwise the accumulation of the mephitic gases will force the septic material contained in the pulp-canal into the apical space and establish an acute alveolar abscess. Such teeth do better if left open for from twenty-four to forty-eight hours than they do if dressings are applied. If left open, the gases of decomposition readily escape, while if the opening is closed, they rapidly accumulate and keep up the irritation.

Secondly, to secure rest for the tooth by preventing the opposing tooth from occluding with it. This may be done by moulding a piece of base-plate gutta-percha to the crowns of the lower bicuspid and molar teeth upon the opposite side of the mouth, or the adjustment of a metal cap, as shown in Fig. 573, so that when the teeth are closed they rest upon the gutta-percha splint or the metal cap. Or, if there are no teeth remaining upon the opposite side, a tooth in front or behind the affected one may be utilized for the purpose. Or a hollow rubber crown, made by the S. S. White Company, may be placed upon a tooth in a suitable location. A still more simple and efficient method is to dry the morsal surface of two or three teeth upon the same side of the mouth, preferably the lower teeth, and cover them with zinc oxyphosphate cement. The writer prefers Ames's metaloid for this purpose to any other, on account of its great adhesive qualities.

Fig. 573.



Metal cap.

After rest has been secured, the *third* step in the treatment is the exhibition of topical remedies for the relief of the pain and controlling or aborting the inflammatory symptoms. The local congestion may be relieved by freely scarifying the gum over the affected tooth, and promoting the bleeding by the free use of warm water. Or counterirritation may be employed by painting the gum with cantharidal collodion or with the following combination of remedies:

℞ Tincture of aconite,
Tincture of iodine,
Spirits of chloroform,
Spirits of camphor; āā f ʒ i. M.

Darby's capsicum and sinapin dental plasters will also be found beneficial in deflecting the blood to the surface, if applied to the gum directly over the affected tooth. The hot-water bag applied to the side of the face is often very soothing in the more advanced stage of the inflammation. It should be wrapped in a towel or covered with several thicknesses of flannel, to conserve the heat and to furnish an agreeable surface upon which to rest the face.

Constitutional Treatment.—The throbbing pain may often be greatly relieved by the use of a hot foot-bath to which a tablespoonful or two of mustard has been added. This equalizes the circulation by causing a determination of blood to the lower extremities, and relieves arterial tension in the upper part of the body, and by that process mitigates the pain. A brisk saline laxative is also beneficial in many cases.

In the more severe cases, accompanied with febrile symptoms, full, bounding pulse and high temperature, coated tongue, constipation, headache, and chilliness, efforts are still to be made to abort the inflammation. Quinine in doses of from five to ten grains may be administered, or some of the coal-tar derivatives, like phenacetine or antikamnia, may be employed in five- to ten-grain doses until the excessive rapidity of the pulse is controlled and the pain rendered less severe. If the inflammatory symptoms are not markedly less by bedtime, ten to fifteen grains of Dover's powder may be administered with a hot lemonade or other hot drink, and the patient, after a hot foot-bath, placed in bed and covered with an extra blanket in order to promote copious diaphoresis.

Or bromide of potassium, fifteen to twenty-five grains, combined with tincture of veratrum viride, five minims, may be administered, and repeated in four hours if needed.

Constipation may be relieved by taking in the morning before breaking the fast a glass of Hunyádi water or one-half ounce of sulphate of magnesia in a glass of water, or a grain of calomel may be administered at bedtime, omitting the lemonade, and following it in the morning with a Seidlitz powder.

Some operators have great faith in the constitutional effect of calcium sulphide in limiting the suppurative process. Its use is, however, somewhat empirical, as there is no definite knowledge of its physiologic action upon the tissues. The theory has been advanced, and the results seem to prove the theory, that it has, *first*, a stimulating effect upon the blood-current and glandular elements of the mucous membrane and the skin; *secondly*, this stimulating effect is noticed in the increased movement of the blood-current and in the amount of normal glandular secretions, while it checks that due to venous congestion and blood stasis; *thirdly*, it is thought to produce H_2S in the system, which has a controlling or restraining influence upon the amæboid movements of the wandering cells or leucocytes.

SUBACUTE AND CHRONIC PERICEMENTITIS.

These conditions present all of the characteristics of the acute form of the disease, but in a less severe form.

The most common cause of subacute and chronic pericementitis is a septic condition of the pulp-canals, sometimes resulting in pericemental soreness only, or in the formation of pus. These forms of pericementitis are usually the sequelæ of acute attacks of the affection. They may also occur in teeth in which the pulps have been removed and the canals filled, but this condition is usually found associated with crooked roots or contractions of the caliber of the canals which have prevented the complete removal of the pulp to the apical foramen; or they may be caused by septic conditions from a pulp which has died under a filling; and occasionally they are found associated with apparently sound teeth that have suffered from some traumatic injury which caused death of the pulp, but which for a long period gave no trouble; or with teeth whose pulp vitality has been lost through the plugging of the artery of supply by a thrombus, and fatty degeneration has taken place in the tissues of the pulp. In a considerable number of cases of subacute and chronic pericementitis there is no evidence whatever of the formation of pus, or even of swelling of the overlying gum-tissue. This is true of even some of the septic cases. It would seem, therefore, from this that the character of the septic organisms was less virulent than during the acute attack, or that the tissues are more resistant to the action of the organisms or their waste products, or perhaps both of these suppositions are true, and for that reason the inflammatory process runs a less vigorous course.

Symptoms.—In chronic apical pericementitis the patient usually complains of periodical soreness, which lasts for a day or two, or perhaps for three or four days; the soreness then disappears to return again after a shorter or longer interval. In some of these cases the gum will be markedly congested, in others no discoverable change in the color of the gum takes place. Percussion is more or less painful, and palpation over the apex of the root often gives evidence of tenderness. The tooth is not sensitive to changes of temperature.

Marked sensitiveness to changes of temperature would indicate hypersensitive dentin or inflammation of the pulp, and should exclude pericementitis from the diagnosis. Upon close examination of some of these cases a very slight discharge of pus may be discovered at the cervix of the tooth, and if a fine probe is passed into the opening from which the pus can be pressed, it will follow a sinus or open track which the pus has made for itself at the side of the root down to the apex.

Treatment.—Many cases of chronic pericementitis are dependent for their origin upon traumatic injuries like malocclusions due to the natural movement of the teeth towards each other after a supporting neighbor has been lost. The malocclusion may be one in which the pressure upon the tooth is too great, or it may be in a wrong direction, forcing it into an abnormal position. The tooth is often slightly loose and sore to pressure or percussion. Or the malocclusion may be caused by a filling which has not been properly occluded to the morsal surface of the antagonizing tooth. In either case the tooth or the filling should be cut away until a natural or comfortable occlusion has been restored, when, by the aid of the local application of the aconite and iodine preparation to the gum over the apex of the tooth, the soreness and looseness will soon disappear.

Devitalized teeth which have had their pulp-canals filled furnish a considerable number of mild septic cases which result in chronic pericementitis. This is due sometimes to imperfect sterilization of the dentin, or of fragments of pulp left in tortuous canals and crooked roots; at others to imperfect methods of cleansing and filling the canals, or of forcing portions of the filling-material beyond the foramen. In all such cases the root-filling should be removed, and the operation of cleansing the canals, sterilization, and filling done over again, as this is the only way in which it is possible to secure restoration of health to the tooth.

The difficulties are such sometimes, however, on account of the malformation of the roots, that it becomes impossible to completely sterilize the canals and restore the tooth to a healthy condition, even after repeated trials of resterilization and filling. Under such circumstances the extraction of the tooth is the only way out of the difficulty, and this is to be advised rather than to allow the tooth to remain as a constant source of irritation.

GENERAL NON-SEPTIC PERICEMENTITIS.

General or constitutional non-septic pericementitis is an inflammation of the pericementum involving a number of teeth at the same time in one or both jaws, and dependent upon certain specific systemic conditions, such as rheumatism and gout, tubercular conditions, scorbutus, diabetes mellitus, and albuminuria, or to the local toxic manifestations of certain drugs like mercury, iodine, and phosphorus, and the preparations of gold, copper, antimony, arsenic, etc.

The pathologic changes which take place in non-septic pericementitis due to systemic conditions are in general the same as are found in those cases which are dependent upon local causes for their origin. But the exudations are much more liable to become organized into new tissue, resulting in hypercementosis.

The tendency of acute local pericementitis is, from the severity of the inflammation, to produce *death* of the exuded leucocytes and the embryonic cells formed from the fixed tissue-cells—necrobiosis—and the formation of pus. While in certain forms of systemic or general pericementitis the tendency is strongly to the formation of new tissue, through the *organization* of the escaped leucocytes and the embryonic cells. This tendency is most often noticed in that form of pericementitis due to the specific action of gout and rheumatism. On the other hand, when the inflammation is due to certain other systemic conditions like tuberculosis, scorbutus, diabetes mellitus, albuminuria, and mercurial ptyalism, the tendency is in the direction of necrobiosis and the formation of pus.

Pericementitis, associated with the rheumatic and gouty diathesis, is rarely general in its character. Its most frequent manifestations are decidedly local in the sense that only a few teeth are involved at the same time, although occasionally all of the teeth may be the seat of inflammatory symptoms due to these causes.

Clinical and post-mortem experience teaches that the *Materies morbi* of rheumatism and gout have a predilection for the fibrous structures of the body, especially the synovial membranes, the aponeuroses of muscles, the dura mater, the cardiac tissues, and the periosteal and pericemental membranes. The structure most commonly affected is the synovial membrane, resulting in inflammatory conditions of the joints.

It not uncommonly happens, however, that there is associated with the inflammatory phenomena of the joints enlargements of the long bones and nodular formations in other localities, while conditions somewhat analogous are often presented in the pericementum.

The predisposing and exciting causes of certain irritative conditions of the pericementum seem to have their origin in the same conditions which bring about the phenomenon of rheumatism and gout, and they have also proved by experience to be amenable, in many cases, to the same specific treatment adopted in these diseases. It is a notable fact, also, that in persons suffering from this form of pericementitis the urine, saliva, and perspiration nearly always give a decidedly acid reaction. Serumal deposits sometimes form upon the root of the tooth near the apex when there is no connection between the deposit and the mouth. Under such circumstances suppuration often supervenes, and produces a form of pyorrhœa alveolaris. (See Chapter on "Pyorrhœa Alveolaris.")

The pericementum seems to be very susceptible to the irritating effects of an acid condition of the blood, whether from an excess of lactic or uric acid retained in the system or from such acids as are found in sour wines and malt liquors. The habitual use of sour wines and malt liquors by those having the rheumatic and gouty diathesis greatly aggravates these conditions, and some individuals are so susceptible to their irritating influence that a slight indulgence will often precipitate an attack of acute articular rheumatism, of gout, or of pericementitis.

General pericementitis of a mild form is often the forerunner of an acute attack of rheumatism or gout; while, upon the other hand, a general or a local pericementitis, involving a number of teeth in different parts of the mouth, may be the only manifestation or expression of the presence of the rheumatic or gouty diathesis.

Congestion and thickening of the pericementum and temporary loosening of the teeth, and occasionally death of the pulp, accompanied by dull, gnawing pains and more or less soreness, are a not infrequent occurrence in attacks of rheumatism and gout.

Symptoms and Diagnosis.—In rheumatic and gouty pericementitis soreness and pain in the teeth are early symptoms, and generally associated with an acid condition of the salivary secretions, of the perspiration, and of the urine; while it is not at all uncommon to find the individual at the same time suffering from muscular pains which are unmistakably rheumatic in character, or from an acute arthritis of one or more joints of the extremities. Sometimes, however, the only manifestations of the rheumatic and gouty conditions are the soreness and painful condition of the teeth and the acid condition of the saliva and the urine.

Rheumatic and gouty pericementitis, like rheumatism and gout in general, may be acute or chronic in their manifestations. The acute form is usually established as the result of taking cold or of over-indulgence in the pleasures of the table, and like those general conditions is greatly aggravated by bad weather, a low barometer, and excesses in eating and drinking. The chronic form of the disease is the result of repeated attacks of the acute form, and most often terminates in hypercementosis.

Soreness of the teeth to pressure, as in mastication, is the first symptom of acute rheumatic and gouty pericementitis. This condition is at first relieved by continued pressure, and the individual desires to close the teeth together and keep them in this position. After a few hours the teeth become painful to such pressure, and constant effort is made to prevent the teeth from coming forcibly in contact. Mastication then becomes very painful or impossible, and liquid food only can be taken. The gums become more or less congested and purplish in color, but *suppuration rarely takes place except where concretions have been formed upon the roots.* When the disease is confined to a few teeth in a single location or in different parts of the mouth, they have the feeling of being loose and considerably elongated. This is due to the congestion and thickening of the pericementum, which lifts the teeth from their alveoli and makes them loose.

Differential Diagnosis.—Difficulty is sometimes experienced in diagnosing between a rheumatic or gouty pericementitis and an incipient or chronic apical pericementitis due to septic conditions. These difficulties arise from the fact that pulpless teeth are much more liable to become the seat of rheumatic symptoms than normal teeth, consequently, when several devitalized teeth become the seat of pericementitis, it is almost impossible in the early stage to diagnosticate between them except by inference. The fact, however, remains that in a rheumatic pericementitis several teeth are almost invariably affected at the same time, while in septic apical pericementitis a single tooth is usually at fault. Should three or four devitalized teeth be in a state of septic apical inflammation at the same time, the diagnosis could be proved by the absence of the other symptoms which usually accompany an attack of rheumatic pericementitis. The duration of the symptoms will vary from three or four days to as many weeks, depending upon the severity of the attack and the success of the constitutional treatment.

Prognosis.—The prognosis in this form of pericementitis is generally good, for the reason that the acute symptoms are usually controlled by systemic treatment. In the chronic form of the disease the prognosis is less favorable, as hypercementosis is the usual sequel, and systemic treatment has little or no effect upon the progress of new-tissue formation.

Treatment.—The treatment of these forms of pericementitis is largely systemic, and is comprehended in the regular methods employed in general rheumatic and gouty conditions,—viz., the exhibition of such remedies or combination of remedies as have for their base salicylic acid or colchicum, or both, mercurial and iodine compounds, lithia, various mineral waters, hot mineral baths, and Turkish baths. A restricted diet which reduces the quantity of meat consumed and cuts off all game, wine, and malt liquors, is also beneficial.

Local treatment in the form of depletion to directly relieve the congested condition of the gums, and indirectly of the pericementum, often gives relief after a little time. This may be obtained by scarifying the gums and promoting bleeding by the use of tepid water held in the mouth. Or these symptoms may be relieved by counter-irritation, as already described upon a preceding page. If suppuration be present, the pockets should be explored for calcic deposits, and if discovered, they should be removed and the pockets treated with dilute sulphuric acid, trichloracetic acid, or other stimulating and antiseptic applications. For further methods of treatment of this form of the disease the reader is referred to the chapter on "Pyorrhœa Alveolaris."

TUBERCULAR PERICEMENTITIS.

Pericementitis occurring in an individual of tubercular diathesis runs such a peculiar and rapid course that it deserves separate mention. Although, strictly speaking, the term as above applied may not be, perhaps, correctly used, it nevertheless serves to describe a condition by no means uncommon, and which sometimes has serious consequences.

In using this term it is not intended to imply that the form of pericementitis to be described is due to the presence of, or originates in, the tuberculous condition, or that the tubercle bacilli are the cause of the peculiar and rapid course of the disease.

In all of the cases which have come under the observation of the writer, the primary cause of the affection was a traumatic injury of the pericementum, produced by either excessive malleting, as in large contouring operations, the rapid movement of the teeth, or a malocclusion. In all of the cases the patient gave unmistakable evidences of having a tuberculous diathesis. It is generally conceded to be a clinical fact that injuries occurring in tubercular subjects are much more prone to end in suppuration than are like injuries in other persons, and that the inflammatory process is much more acute than in other individuals.

The following case, which is introduced by way of illustration, occurred in the practice of the writer. The patient was a college student for whom he had made two large countour fillings with gold in approximating cavities in the right superior bicuspids. The operations had consumed four hours of time in the preparation of the cavities and inserting and finishing the fillings. The teeth were vital, and the hand-mallet was used in condensing the gold. In a few hours after the operation the teeth became very sore and painful, and at the end of twenty-four hours the face was greatly swollen and the gums tumefied, soft, and boggy from the lateral incisor of the right side back to and including the second molar. The teeth thus involved were all loose and exceedingly sensitive to pressure or percussion. On lancing the gums, which was done in several places, thick creamy pus was discharged in great quantity, and upon irrigating the pus-cavity it was found to be continuous through the whole extent of the inflamed area. The periosteum was also lifted from the external plate of the alveolar process, but higher up over the bicuspids than the other teeth. The abscess continued to discharge for several weeks, but finally closed without necrosis of the bone. The teeth all became firm in their alveoli and remained vital.

Other cases of a similar nature occurring from various injuries in which necrosis of the external alveolar plate resulted from the inflammation might be described, but this is sufficient for the purpose of illustration.

SCORBUTIC PERICEMENTITIS.

This form of pericementitis is one of the marked symptoms of scurvy. It is the result of long exposure to a cold and damp atmosphere, coarse diet, insufficient vegetable food, and fatiguing labor. It most frequently occurs among sailors of the Arctic regions, particularly whalers. It is also seen among soldiers and the men of lumber camps. It is not infrequently seen in our large cities among the very poor, who are housed in damp basements and cellars, and whose food-supply is very scanty and of the least nutritious varieties.

Occasionally little children under two years of age are victims of the disease, and this is an evidence of malnutrition.

Symptoms and Diagnosis.—Scorbutic pericementitis, as a rule, attacks all of the teeth in rapid succession, and is therefore a general pericementitis. In a typical case of scurvy the teeth are all loose, sore, and painful, making mastication impossible. The gums are swollen and spongy, purplish in color, and bleed easily, while pus exudes around their margins and from the dental alveoli. The breath is fetid and sometimes there is an increased flow of saliva. Associated with the oral symptoms there are certain manifestations of the disease upon the skin in the form of livid spots intermixed with spots of a less vivid color. These spots are small and resemble flea-bites. They sometimes occur in patches or in strips and are usually located at the roots of the hair; they are scattered over the chest, thighs, arms, and trunk, and are occasionally seen upon the mucous membrane of the mouth and nasal passages. The disease is accompanied by extreme weakness, general debility, and depression of spirits. Occasionally there is severe pain in the extremities, particularly in the wrists and ankles. In the severer form of the disease, hemorrhage occurs from the livid spots found upon the skin (*purpura hæmorrhagica*), and from the spots found upon the mucous membrane of the mouth and nose. In many of these cases there is a considerable deposit of salivary calculus about the cervices of the teeth.

Treatment.—The treatment of scurvy calls for a radical change in the sanitary surroundings of the patient. A generous diet, supplemented with green vegetables and acid fruits, is generally all that is required in the way of general treatment. In the severer cases tonics are called for, like the elixir of calisaya, strychnine and iron, or quinine.

The local treatment for the inflammatory conditions of the teeth and gums would be to cleanse the mouth by the use of hydrogen dioxide, remove all deposits of soft *débris* and salivary calculus from the teeth, relieve the congestion of the gums by painting them with the tincture of aconite and iodine, equal parts, or by scarifying them with a sharp lancet, and prescribing an antiseptic and astringent mouth lotion. In indolent and ulcerative conditions the gums may be painted with a ten per cent. solution of zinc chloride in water.

General pericementitis is often a progressive symptom in *diabetes mellitus*, *Bright's disease*, and *locomotor ataxia*. The conditions which are presented are similar to those which will be described later under the head of pyorrhœa alveolaris, with the exception that the roots of the teeth when finally exuviated do not usually show any signs of serumal deposits.

MERCURIAL PERICEMENTITIS.

This form of the disease is due to the constitutional impression of mercury. Mercurial ptyalism with its attendant evils has been so common in the past that almost every practitioner of twenty-five years' experience saw many cases in the early days of his practice. But happily in these later years the use of the drug has been greatly restricted, so that at the present time such cases are rarely seen except in the Southern States.

The effects which are produced by mercury upon the general system, and locally in the mouth, depend upon the quantity administered and the susceptibility of the individual to the action of the drug. Children between the ages of five and ten years are peculiarly susceptible. There is, however, a very great difference in the susceptibility of various individuals; in one an ordinary dose of blue pill or of calomel will produce a severe general pericementitis, inflamed gums, profuse salivation, and swollen tongue, while another seems to be almost proof against its action, even in large and repeated doses.

Garretson records a case of mercurial poisoning in a child seven years of age in which the administration of three grains of calomel resulted in the loss by necrosis of the left half of the lower jaw.

The writer has recorded a case* of a woman thirty years of age in which fifteen grains of calomel taken in three-grain doses at bedtime produced necrosis of both jaws, accompanied by extensive sloughing of the gums of the inferior maxilla and of the soft tissues covering the roof of the mouth, swollen tongue, intolerable fetid breath, excessive salivary secretion, loosened teeth, and an uncontrollable diarrhœa, the case ending in death from exhaustion.

Various other drugs, such as potassium iodide, pilocarpin, the preparations of gold, copper, antimony, arsenic, etc., are capable of producing ptyalism; and if this condition is maintained for any considerable period, the pericementum becomes involved, resulting in inflammation of this membrane, suppuration, and possible loss of the teeth.

All of these drugs are in some degree eliminated from the system by the salivary glands, and during their elimination they seem to perform the functions of active irritants. A moderate degree of salivation may cause a considerable amount of soreness and tenderness about the gums and the roots of the teeth, but this soon subsides, and no permanent injury has been wrought. But if this condition is repeatedly induced or maintained for a considerable period, pathologic changes are established in the pericementum, which permanently injure the organs of mastication and hasten their destruction.

Symptoms and Diagnosis.—Pericementitis due to the toxic effect of mercury upon the general system usually involves all of the teeth. The condition generally begins with an increased flow of saliva and a metallic taste in the mouth. Later pericemental irritation is developed, followed by thickening of the membrane and extrusion of the teeth, which become loose and painful. Pus is formed in the alveoli and discharged at the margins of the gums. The gums become inflamed, swollen, and turgid, and bleed upon the least provocation. The breath is offensive, and the saliva, which is mixed with pus and blood, has the odor of decomposing animal matter. The tongue is swollen and often fills the mouth, pressing upon the teeth, which leave their imprint upon its edges. The secretion of the saliva is so great that it constantly drips from the mouth, and in the severer cases the amount may reach several pints in twenty-four hours. The salivary glands, as a result of their excessive secretion of saliva, frequently become swollen and painful. Diarrhœa is often a prominent symptom.

The excessive flow of saliva distinguishes this form of ptyalism from

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* Injuries and Surgical Diseases of the Face, Mouth, and Jaws, p. 272.

all others, and although it were impossible to obtain a direct history of the administration of mercury, this particular symptom alone would strongly indicate the nature of the affection.

Prognosis.—The prognosis in the milder form of the affection is favorable to a complete recovery of the tissues to a normal condition. In the severer cases the teeth are not only endangered, but the gums, alveolar processes, and even the jaws may be seriously affected. Gangrene and sloughing of the gums, necrosis of the alveolar processes, and loss of the teeth are common sequelæ, and, as already indicated, necrosis of the body of the jaw may sometimes be added to the category of evil results which have followed the administration of even small doses of mercury. Fibrous or cicatricial anchylosis of the jaws sometimes follows as a result of sloughing of the gums and mucous membrane of the cheeks, which upon healing bind the jaws together with cicatricial bands.

Treatment.—The treatment of this form of pericementitis must be directed to the systemic condition; the first step being to cut off the administration of the drug and hasten its elimination from the system. This may be accomplished by means of potassium iodide, purgative mineral waters, diuretics, and diaphoretics. The diet should be generous and composed of the most nutritious food. The local conditions may be treated with solutions of potassium chlorate, silver nitrate or hydrochloric acid, and astringent deodorant mouth-washes. Especial care should be given to the cleanliness of the mouth. Hydrogen dioxide will be found a most efficient remedy for this purpose sprayed into the mouth and between the teeth.

CHAPTER XXIX.

DENTO-ALVEOLAR ABSCESS.

Definition.—Abscess, from the Latin *abscedere*, to depart.

An abscess is an accumulation of pus in the tissues of the body, resulting from a localized inflammation, and which is surrounded by a wall of *lymph* (formerly termed the pyogenic membrane, from the erroneous notion that it secreted pus). An abscess may also be termed a hollow ulcer.

A *dento-alveolar abscess* is an accumulation of pus within a dental alveolus, or associated therewith, and dependent upon a septic inflammation of the tissues of the apical space or the pericementum, the former resulting from a gangrenous pulp, the latter from various forms of irritation or injuries resulting in suppurative inflammation.

Causes.—Suppurative inflammation always precedes the formation of an abscess, and the presence of pyogenic bacteria is necessary to establish a suppurative inflammation; hence it may be stated that an abscess is the result of the infection of the tissues with the pyogenic micro-organisms which produce the destruction of the exuded leucocytes and the cellular elements of the tissues at the point of infection, and the liquefaction of the intercellular substance, thus forming pus.

It is possible, however, to produce pus without the agency of micro-organisms, as, for instance, by the injection of croton oil and other violent irritants beneath the skin; but the pus so formed is aseptic, and if other animals are inoculated with it, it does not produce inflammatory symptoms, while a septic pus produced by the action of the pyogenic organism will invariably cause suppurative inflammation if a sufficient quantity is introduced into the tissues.

Exciting Causes.—The exciting causes of dento-alveolar abscess are found in septic conditions resulting from the death of the pulp and from certain inflammatory affections of the pericementum considered in the chapters just preceding.

The most common exciting causes of dento-alveolar abscess are the organisms of suppuration and of decomposition,—viz., the pyogenic and saprophytic bacteria. These organisms are constantly found in the mouths of even the most cleanly persons, and are an ever-present menace to all operations upon soft tissues which break the continuity of their surface, and the pulps of teeth which have been exposed by caries or by surgical traumatism.

The ptomaines or waste products of these organisms, and the mephitic gases formed (hydrogen sulphide, H_2S) as the result of the decomposition of the tissues of the pulp, passing through the apical foramen and coming in contact with the tissues of the apical space, cause irritation and a lowered vitality of the tissues as a result of their poisonous effect. The inflammation which follows, however, is not always of the same character or intensity, the difference in these respects being controlled, seemingly, by certain predisposing causes,—viz., the virulence of the organisms, the local resistance or stamina of the tissues, and the general condition of the individual.

Predisposing Causes.—The character of a septic inflammation depends in great measure upon the virulence of the organisms which have been introduced into the system. This is a well-established law in both pathology and animal toxin therapy, and has been abundantly demonstrated by experiments upon animals and upon man, as, for instance, in the treatment of anthrax with the attenuated virus, and of malignant inoperable sarcomas with the toxins of the *bacillus prodigiosus* and with the *streptococcus erysipelatus*.

The effect of an infection with the pyogenic cocci will always vary with the number of the organisms which have entered the tissues. Watson Cheyne found in his experiments with the *proteus vulgaris* of Hauser—a bacterium commonly associated with putrefaction—that a dose of one-tenth cubic centimetre of an undiluted culture contained about two hundred and fifty million bacteria, and when injected into the muscular tissue of a rabbit quickly proved fatal; while a dose of one-fortieth cubic centimetre, containing about fifty-six million, caused very extensive abscesses, and resulted in death of the animal in from six to eight weeks. Doses which contained less than eighteen million very rarely produced any effect. These experiments demonstrated the fact that the system when in a healthy condition has wonderful resistive power against the organisms of disease.

He further demonstrated with cultures of the *staphylococcus pyogenes aureus* that it was necessary to inject a dose sufficient to include at least one billion cocci into the muscle of a rabbit to produce a speedy fatal result, while a dose containing two hundred and fifty million caused the formation only of a small circumscribed abscess.

The *staphylococcus pyogenes albus* produced the same results, but required somewhat larger doses.

Another fact of great interest was discovered by this investigator,—viz., that concentration of the septic material in a certain locality was necessary to produce the most marked results. Dividing the dose and injecting it at different times, or in different localities at the same time, did not produce the same results as when it was all injected into a single locality.

The tone, resistance, or stamina of the tissues play an important part in the predisposition to infection. Tissues whose vitality or resistive powers have been lowered by traumatism, either accidental or surgical, or by disease, succumb more readily to a septic infection than do tissues in a normal condition. Healthy protoplasm is possessed of great resistive power to the action of disease-producing bacteria, and this is the salvation of the human race. But for this every member of the human family would become diseased, and the race soon swept from the face of the earth.

The general condition or tone of the individual is an important factor in the predisposition to infection. Persons who are debilitated from illness, overwork, anxiety, debauchery, and other causes are far more susceptible to the invasion of pathogenic organisms than are those in robust health. The same is true of individuals who have inherited syphilis and that condition generally known as struma. In these cases the evidence of a lack of vital resistive power is often strongly marked, and when children possessing these diatheses are attacked by disease, they more readily succumb than do those children born of healthy parents. In this class of individuals all inflammatory conditions of the tissues of the mouth and the teeth run a violent course, and suppurative conditions which involve the pericementum, the periosteum, the alveolar processes, or the body of the jaw are prone to result in phlegmonous conditions of the soft tissues, involvement of the lymphatic glands, and not infrequently in septic intoxication.

Certain acquired cachexiæ like syphilis and tuberculosis also predispose the individual to a more virulent manifestation of a septic inflammation than in persons of good constitution, for the reason that these diseases markedly lower the power of resistance of the tissues and decrease the phagocytic power of the leucocytes. These predispositions are most pronounced in early life, and, as a rule, grow less and less prominent with the advancement of age; but sometimes they persist throughout the whole lifetime of the subject.

Varieties.—Dento-alveolar abscess presents in two forms,—viz., acute and chronic. In the *acute* form the symptoms are often very severe and sometimes alarming, resulting in extensive necrosis of bone, gangrene and sloughing of soft tissues, acute septicæmia, pyæmia, and death. In the *chronic* form of the disease the symptoms are of a much milder type, but necrosis of bone, septicæmia, and pyæmia are not unheard-of conditions in connection with chronic alveolar abscess.

Dento-alveolar abscess is sometimes described as open or patulous, and blind. An open or patulous abscess is one which has a fistula through the gum or other location, from which the accumulated pus discharges. A blind abscess is one which has no opening, except the pulp-canal, through which the pus could escape. Blind abscesses are usually of the chronic or subacute variety.

Fig. 574.

Shreddy sac or lymph-wall of tooth abscess as met with in dento-alveolar abscess.

Pathology.—When the pyogenic bacteria gain an entrance to the tissues of a living body they accumulate very rapidly, forming a minute colony which by their concentrated action, or that of their chemic product, causes coagulation of the serum and of the contiguous tissue,—"coagulation necrosis,"—thus forming a nidus or central point for the development of the process of suppuration. Around this central point, composed of necrotic tissue and containing a colony of micro-organisms, the leucocytes accumulate in great numbers, completely enclosing it by forming a wall of lymph, as shown in Fig. 574 (the pyogenic membrane of the older writers).

According to the theory of Metchnikoff, certain cells, known as phagocytes, play an important part in limiting the action of the bacteria. The phagocytes are of two varieties, *fixed* and *free*. The *fixed* phagocytes are the endothelial cells and the fixed connective-tissue cells, while the *free* phagocytes are the wandering cells or leucocytes. It is claimed that the phagocytes attack the micro-organisms which are found in the tissues and destroy them. These organisms under certain circumstances are found within the body of phagocytes, and for this reason it has been believed that the phagocytes devour bacteria. This theory has also been advanced by Metchnikoff and others in explanation of immunity to disease. Immunity or susceptibility, it is claimed, depends upon the ability or inability, respectively, of the phagocytes to destroy micro-organisms. This theory may be entirely correct, but as yet it is not universally adopted. One of the strongest arguments against it is the fact that infectious diseases can be produced by the peculiar poisons or waste products elaborated by the bacteria and without the presence of the organisms which elaborated the peculiar poison.

Formation of Pus.—Through the agency of the peptonizing power of the micro-organisms lodged at the point of infection the central mass of dead tissue, formed by the process of coagulation, and the contiguous intercellular substance are liquefied. This process liberates the exuded leucocytes which were entangled in the meshes of the intercellular substance, and they become mixed with the liquefied material and break down into a granular detritus, which, with the dead leucocytes, forms pus. This process continues with greater or less rapidity, according to the character of the inflammation and the diathesis of the individual, the quantity of the pus steadily increasing in amount; tension of the surrounding tissues results, and both the bony and soft structures are destroyed by molecular necrosis until the surface is reached, following that course which offers the least resistance. This is termed *pointing*, and through this opening the fluid contents of the abscess are discharged. During the process of the formation of the abscess active cell proliferation in the fixed tissue-cells is going on in the outer portion of the wall of leucocytes; while upon the inside of the abscess-cavity a new tissue is formed, known as *granulation-tissue*, which by its growth repairs the damage caused by the death and liquefaction of the tissues involved in the abscess. This tissue is composed chiefly of small, round cells with scanty intercellular substance, but very rich in capillary blood-vessels, each granulation-point being occupied by minute capillary loops.

Location.—According to the common acceptation of the term, an alveolar abscess is an accumulation of pus located in the apical space, the result of septic inflammation induced by a decomposing gangrenous pulp; and for various reasons it would seem best to restrict the use of the term to this particular form of dento-alveolar abscess. It is true, however, that abscesses are formed within the dental alveolus which have no connection with a gangrenous pulp; in fact, they are frequently found in the alveoli of vital teeth, as, for instance, in pyorrhœa alveolaris and inflammatory conditions arising from various forms of irritation and traumatisms of the pericementum.

In the formation of a dento-alveolar abscess the pus is at first confined to the apical space, where it is surrounded by bony walls. As the pus accumulates pressure is brought to bear upon the surrounding walls; this pressure, together with the dissolving or peptonizing action of the bacteria, causes a rapid cell-necrosis and disintegration of the surrounding cancellated bone, and a gradually increasing cavity is formed at the apex of the root. The tendency of the accumulated pus, assisted by the pressure within the cavity, is to seek an exit in a direction that offers the least resistance.

The external or buccal wall of the alveolar process is the thinnest, and offers the least resistance to the progress of the accumulated pus; for this reason the abscess usually points upon the buccal aspect of the alveolar process, opposite the apex of the root.

Dento-alveolar abscesses point in three distinct ways after penetrating the bony walls: *first*, directly through the soft tissues; *secondly*, by separating the periosteum from the bone and forming a secondary pus-cavity; *thirdly*, by following the pericementum along the side of the root and discharging at the margin of the gum.

Dento-alveolar abscesses which point directly through the gum-tissues are the most common, and rarely present any complications. The second form is often complicated with necrosis of portions of bone, and by penetrating the external tissues of the face or burrowing downward into the tissues of the neck. For these reasons such an abscess should receive prompt attention. in order that the destructive process may be confined to the narrowest limits and disfiguration and other more serious consequences be prevented.

The relations of the roots of the incisor and cuspid teeth to the floor of the nose are such, in many instances, that alveolar abscesses may point through the floor of the nasal fossa and produce a purulent discharge that might readily be mistaken for chronic nasal catarrh. The relations of the roots of the bicuspid and molar teeth to the floor of the antrum are such as to make it even less difficult for an abscess connected with one of these teeth to penetrate the floor of the sinus.

Abscesses in connection with the teeth of the lower jaw may penetrate the alveolar process, but fail to penetrate the gum, and by force of gravitation and the pressure of the accumulating pus make paths for themselves between the periosteum and the soft tissues, or between the periosteum and the bone, and finally discharge upon the face beneath the chin or the jaw. Or they may burrow through the body of the jaw. Abscesses in relation with the third lower molars often penetrate the external tissues at the angle of the jaw, or they may occasionally burrow downward into the neck, forming large pus-cavities in the submaxillary triangle. The writer has operated upon several cases of this character, from which pus varying in amount from four ounces to a pint had been removed. In some of these cases the tissues were so infiltrated with the pyogenic cocci that for weeks after the original abscess had healed, and the offending tooth had been removed, crop after crop of phlegmonous abscesses appeared in the neighborhood, located in the cellular tissue immediately beneath the skin.

Another form of dento-alveolar abscess is one which has no external sinus for the discharge of the pus. These cases have been for this reason designated as *blind abscesses.* The term is, however, hardly a correct one, for the pus discharges through the pulp-canal, which becomes its sinus, and it is therefore not a blind abscess. These abscesses are usually small, and, as a rule, have not been very painful; in fact, all of the acute symptoms have been greatly modified by reason of the ready exit of the pus from the beginning of the suppurative process.

Abscesses which discharge along the side of the root and find exit at the margin of the gum are sometimes confounded with the so-called blind abscess, but in these cases a careful examination will reveal the fact that there is no discharge through the pulp-canal. Many times this form of abscess is associated with pulpless teeth whose roots have been filled, but in which there is sufficient septic irritation to keep up a chronic discharge of pus through the sinus which has been formed by the side of the root.

Acute dento-alveolar abscesses rarely heal spontaneously; there is, however, a partial filling up of the pus-cavity by the growth of the granulation-tissue which lines it. But there is usually a sufficient amount of decomposition of tissue and the growth of micro-organisms within the abscess cavity and the pulp-canal to keep up a continuance of the suppurative process and a discharge of pus. A chronic dento-alveolar abscess is one which has passed through the acute stage, but in which the after-symptoms have been greatly modified.

Occasionally a dento-alveolar abscess may present chronic symptoms from the very beginning of the suppurative process, as, for instance, in *blind abscess.* In many of these cases no marked inflammatory symptoms have developed at any time, and yet there is often a prolonged and obstinate irritation at the apical space and a persistent accumulation of pus, which finds an exit through the pulp-canal.

Abscesses which have pointed through the external tissues of the face are nearly always of a chronic type, particularly those which have had their origin in ancient traumatisms, perforation of the cementum, broken instruments within the root-canal, or from an impacted position of a tooth.

Fig. 574½ is a radiograph of a chronic dento-alveolar abscess of ten years' standing, which was the result of an injury to the superior right central and lateral incisors caused by a fall which fractured the crowns of both teeth so as to expose the pulps. The pulps were extirpated, the root-canals filled, and the pivot teeth set upon the roots. Abscesses formed at the apices of the roots soon afterward, which became chronic, and had discharged through the gum, intermittently, ever since. The radiograph shows the abscess cavity to be of considerable size and the apices of both roots involved in the abscess.

Symptoms and Diagnosis.—The symptoms of acute dento-alveolar abscess in its early stage are the same as in acute septic apical pericementitis. If inflammation of the pericementum of a pulpless tooth with the pulp-chamber open has continued for from twenty-four to thirty-six hours, pus has doubtless been formed. With the formation of pus the symptoms become more aggravated. The gums in the region of the affected tooth assume an inflamed condition; the pain is of a deep *throbbing* character, which at times is almost intolerable. With the formation of pus there is often a rigor, or chilly sensations are experienced, lasting for an hour or two. This is followed by an elevation of temperature; the more severe the rigor the higher the fever will run. The temperature may vary from 101° to 103° or 105° F., according to the virulence of the infection and the susceptibility of the individual to septic irritation.

As soon as the pus penetrates the bony walls of the abscess and escapes into the soft tissues the severity of the pain is abated, but the tissues begin immediately to swell, and the swelling may be so great when the affected tooth is located in the upper jaw, as to close the eye, or when

Fig. 574½.

Dento-alveolar abscess of ten years' standing, associated with the superior right central and lateral incisors.

located in the lower jaw to cause great swelling of the neck, especially in the submaxillary triangle. The cervical lymphatic glands may also become swollen and tender, and sometimes suppuration takes place in them. The pus occasionally collects in great quantity, and under such circumstances it is not uncommon for such abscesses, when located in the upper jaw in connection with the incisors and cuspids, to rupture into the nasal cavity, and for the bicuspids and molars to discharge into the antrum of Highmore, or through the external tissues of the face, while those in the lower jaw may rupture through the external tissues of the jaw or burrow downward, following the fascia of the neck, and rupture at any point above the clavicle. Cases are on record where abscesses in connection with the lower third molars have burrowed downward and discharged into the larynx and at points upon the chest as low down as the mammary glands. Infection and swelling of the lymphatic glands of the neck is a frequent accompaniment of alveolar abscesses, while metastatic abscesses have been formed in various parts of the body as a result of the invasion of the blood-current by the organisms of the abscess.

Dento-alveolar abscesses which discharge into the nasal fossa have been mistaken for cases of chronic nasal catarrh, while such abscesses discharging into the maxillary sinus are productive of the most troublesome cases of empyema of this sinus.

The diagnostic signs of acute dento-alveolar abscess are discoloration of the tooth, no response to the thermal test, showing that the pulp is dead, tenderness to percussion, elongation of the tooth, looseness in its alveolus, tenderness to palpation over the apex of the root, swelling and inflammation of the gum, and fluctuation at that location where the abscess is about to point. The character of the pain is more intense during the formation of the pus than at any other time, and is relieved as soon as the swelling of the external tissues begins.

In the *differential diagnosis* it must be remembered that a sequestrum of necrosed bone or an impacted tooth would produce symptoms so nearly like those of dento-alveolar abscess as to be readily mistaken for that condition. In fact, sometimes the only way that a differential diagnosis can be made out is by tracing the sinus to the sequestrum or to the impacted tooth.

Prognosis.—The prognosis of simple uncomplicated dento-alveolar abscess is generally good if proper antiseptic methods of treatment are instituted. Occasionally, however, no method or amount of treatment will avail to save some of these teeth. In certain individuals the death of the pulp means the speedy loss of the tooth from chronic septic pericementitis and resorption of its alveolus. Fortunately these cases are not very common, but when they do present themselves they cause an untold amount of anxiety during the effort to preserve them, and deep chagrin when these efforts prove futile and the tooth has to be extracted.

When the alveolar abscess is *complicated with necrosis* of the alveolar process surrounding the tooth it is commonly lost with the necrosed bone; but when the external plate alone or the mesial or distal septum only are lost, the tooth may in many instances be retained and restored to health and usefulness.

When it is *complicated with perforation* of the floor of the nasal cavity or of the maxillary sinus a somewhat serious problem is presented. It would at first thought seem that the only treatment that would be required to cure such cases was to properly sterilize the pulp-canals and to fill them. Such treatment does not, however, always succeed, for the reason that there is very great difficulty experienced in properly sterilizing them, on account of the constant draining of the fluids of the nasal cavity and of the antrum into the canals; in fact, in some of these cases it is impossible to ever get them in such a condition of dryness as to warrant the introduction of a root-filling. Again, it is not at all uncommon to find the apices of the roots of these teeth more or less eroded; and when the abscess has become chronic, if they are not eroded they are covered with concretions of calcific matter, which makes it impossible for the roots of these teeth to ever again assume a healthy condition. The prognosis is, therefore, unfavorable, and the sooner such teeth are removed the better. Their extraction often becomes imperative as a means of correcting the discharges from the nose and from the maxillary sinuses.

When the alveolar abscess is *complicated with a sinus which discharges* *upon the face* it becomes a matter of considerable interest to the patient as to whether the offending tooth can be saved and the disfiguration of the face corrected if the tooth be permitted to remain. Such cases do not ordinarily present any serious difficulties in their treatment. One such case associated with a cuspid tooth, which was referred to the writer by a medical friend, discharged by the side of the nose just below the inner canthus of the right eye, and resisted all efforts to puncture the apical foramen or to force antiseptic remedies through it; and as no improvement could be seen in the case after repeated treatments extending over a period of more than two weeks, it was thought advisable to remove the offending tooth, when, upon extracting it, a steel broach was found in the upper fourth of the canal, and projecting beyond the foramen a full half-inch. Comment is unnecessary. The discharges immediately ceased, and the sinus closed in less than a week. Later the discolored tissue was removed by an elliptical incision, the skin loosened from the fascia and brought together with very fine silk sutures; the wound healed by first intention, and the only scar left was a delicate straight line following the natural line of the face.

Dento-alveolar abscess is sometimes *complicated with perforation of the cementum.* Perforations of the pulp-canal which involve the pericementum may be caused in several ways: *First*, by caries which has operated from within the pulp-canal; *secondly*, the absorptive action of the osteoclasts which, as a result of inflammation, have attacked the cement-tissue at various locations upon the side of the root and penetrated to the pulp-canal; and *thirdly*, by the injudicious use of the reamer or drill in enlarging the pulp-canal preparatory to filling, or forming it to receive a post for an artificial crown. Such cases often present a condition of chronic abscess which may discharge through the pulp-canal, by the side of the root at the margin of the gum, or through a sinus in the external tissues.

The effect of such a perforation is to establish inflammation of the pericementum and sometimes ulceration. Perforations which are the result of caries or absorption are irregular in outline, and the edges are sharp and rough. These conditions present an added source of irritation which aggravates the inflammation already existent and stimulates the growth of granulation-tissue. This new tissue enters the perforation and extends into the pulp-canal, sometimes completely filling it, and by its appearance and hypersensitive condition has misled some of the most careful observers into the belief that they were dealing with an hypertrophied pulp. Under such circumstances the application of arsenic for the devitalization of what appeared to be pulp-tissue might prove exceedingly disastrous. The utmost care should be exercised in reaching a diagnosis in these cases.

Perforations which are the result of a surgical traumatism have well-defined edges, as a rule, and if immediately treated upon scientific principles will, in a considerable number of cases, respond kindly to such treatment and the tooth be finally conserved. But when the case is permitted to run along without proper treatment inflammation of the pericementum follows, and the conditions which have just been described may develop, or chronic suppuration may be established.

In those cases located in the lower jaw where the abscesses burrow through the body of the jaw and open upon the face or beneath the chin, or extend into the soft tissues of the submaxillary triangle, or into the deeper tissues of the neck, immediate extraction should be recommended in the former and imperatively demanded in the latter. In the former the prognosis is considered *unfavorable*, for the reason that in a majority of these cases the apices of the roots will be found more or less eroded as a result of the continued inflammatory conditions. While in the latter the prognosis is considered *grave* by reason of the tendency to diffuse cellulitis and the great danger that acute septicæmia may be developed by the absorption of the ptomaines, or that pyæmia may be established by the invasion of the pyogenic organisms or the entrance of pus into the blood-current, and the formation of metastatic abscesses in remote portions of the body.

Treatment.—The treatment of acute dento-alveolar abscess often demands vigorous *constitutional treatment* to abort the inflammatory process, to allay the suffering incident to the process of pus formation and the penetration of the bone for the escape of the pus, and to control the high temperature induced by the severe irritation and the absorption of certain waste products of the micro-organisms.

The constitutional measures which are usually employed in the treatment of alveolar abscess have already been indicated in the preceding chapter on Pericementitis.

Local Treatment.—The treatment of acute alveolar abscess in its early stages, *before a fistula has been established*, comprehends,—

1. Efforts to abort the inflammation by the employment of local therapeutic measures, surgical and medicinal.

2. Limiting, as far as possible, the destruction of tissue by controlling the suppurative process.

3. The earliest possible evacuation of the pus.

4. The promotion of the healing process.

Inasmuch as the primary seat of the infection which establishes the suppurative process in the apical space is the pulp-canal, efforts should be *first* directed to gaining an entrance to this seat of infection and thoroughly removing all infectious material. It is an axiom in general medicine and surgery that to *cure* a disease the *cause must first be removed.* Having removed, as far as may be, by mechanical means, the gangrenous and putrefying pulp, the *second* step is to render the canals aseptic by saturating or irrigating them with antiseptic drugs, and *thirdly*, by local depletion, induced by scarification of the gums in the neighborhood of the affected tooth, to promote bleeding by warm water held in the mouth or by counter-irritation of the gum over the diseased tooth, as indicated in the chapter on Pericementitis.

If these measures fail to abort the suppurative process by reason of the escape of the infectious material and pyogenic bacteria into the apical space, it becomes necessary, in order to *limit the destruction of tissue*, to reach this focus of infection by surgical means. This may be accomplished in some cases through the apical foramen and the pus evacuated through this channel; but if this is not possible, it may be reached by trephining the alveolar plate, or by the extraction of the tooth. In all cases where the tooth is valuable and the general conditions of the health of the individual do not contraindicate, every effort should be made to save the tooth. But in certain conditions of the system, as in tuberculosis, syphilis, continued fevers, anæmia, general debility, nervous prostration, and pregnancy, the conservation of the tooth is contraindicated, as in all but the latter the vital resistance of the tissues is so reduced that great destruction of tissue is likely to attend all suppurative processes; while in the latter, if the period of confinement is near, it is imperative that all suppurative conditions be abated before parturition sets in, on account of the great danger of septic infection at this period, and the establishment of puerperal fever or acute septicæmia from the presence of suppurative foci in other portions of the body, and the infection being carried in the blood-current.

Blind abscesses should be permitted to drain through the pulp-canal for forty-eight hours or longer, in fact, until pericemental irritation ceases, before dressings are applied to the root-canal.

In trephining the alveolar plate two methods have been suggested. Dr. Black's method is to perforate the gum-tissue by the escharotic effect of carbolic acid, full strength, carried upon a serrated plugger of suitable size, and applied to the gum at the point selected for the perforation, and the instrument gently rotated. As the carbolic acid penetrates the tissue it renders it anæsthetic, while the rotation of the serrated instrument cuts away the tissue which has been destroyed by the escharotic action of the drug. In this way the gum is penetrated without causing pain. A sharp, spear-pointed drill is now substituted for the plugger, and the bony plate perforated in the same comparatively painless manner. The only objection to this method is the necessarily slow procedure, as the instrument cannot be advanced more rapidly than the penetration of the carbolic acid renders the tissues anæsthetic.

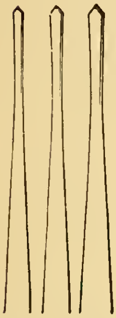
A second method is to inject subgingivally a two per cent. solution of cocaine hydrochlorate over the root of the affected tooth; make a triangular flap in the gum, the point towards the crowns of the teeth; then, with a spear-pointed drill (Fig. 575) or a small trephine (Fig. 576), penetrate the alveolar plate at the apical space with the engine-drill (A) or hand-drill (B), as shown in Fig. 577, as suggested by Garretson. By this method the operation may be done entirely without pain, except from the injection of the cocaine solution, which is only momentary. On reaching the apical space, the focus of infection may be broken up and the abscess-cavity irrigated with suitable warm antiseptic solutions, and the opening in the gum and the alveolar plate kept patulous by the introduction of a few strands of antiseptic silk or cotton. The wound and the abscess-cavity should be irrigated two or three times per day until the inflammatory symptoms are abated, when the case may be treated after the usual manner, and as soon as the conditions are favorable the pulp-canals should be filled.

"*Ubi pus ibi evacuo,*" when there is pus evacuate it, is as wise a surgical rule for to-day in the treatment of acute abscesses as when it was first enunciated centuries ago. The expectant treatment, which has until recent years been the general practice, is quite rapidly giving way to the more rational method of cutting down upon the seat of suppuration and giving immediate exit to the accumulated pus, as by this method the disease is cut short and much suffering saved the patient.

A safe rule to follow in all cases of acute alveolar abscesses which have not yet pointed is to apply the knife and give immediate exit to the accumulated pus, for by so doing great relief is afforded the patient, while the destruction of tissue is thereby limited, and the dangers from general septic infection are greatly reduced.

The promotion of healing is accomplished by thorough antisepsis of the

Fig. 575.

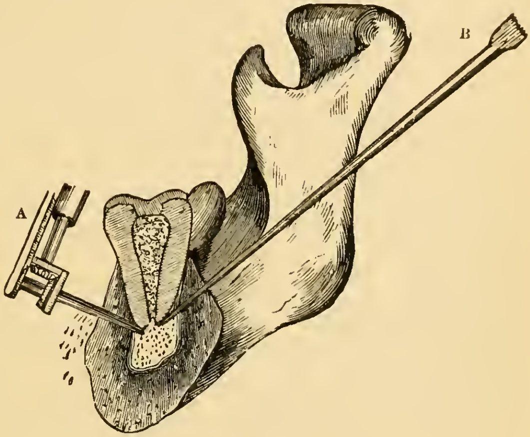


Spear-pointed drills.

Fig. 576.

Trephines.

Fig. 577.



pulp-canals and the abscess-cavity, and securing rest for the tooth during its restoration to health.

In the treatment of abscessed teeth which have discharged into the nasal fossa or the antrum of Highmore, extraction is the only satisfactory method of treatment, while in those which have penetrated the external tissues of the face it is also generally the safest practice, especially in those cases which do not respond to the ordinary methods of treatment, such as sterilization of the pulp-canals, abscess-cavity, and fistulous tract, and the employment of such escharotics as creosote and carbolic acid pumped through them, or drawn through them by the cupping device recommended by Drs. T. M. Hunter* and Burchard.† This device is formed of the ordinary rubber polishing-cup mounted upon a mandrel, and used by first moistening the inside of the cup and pressing it over the fistulous opening until the air is excluded, when the vacuum which has been created by allowing the cup to assume its natural shape will empty the pus-cavity, and if creosote, carbolic acid, or other fluid substance has been placed in the pulp-canal, it will be drawn through the fistulous tract and appear at its exit.

In the treatment of abscesses arising from devitalized or impacted teeth located in the lower jaw which have not pointed, but in which the pus

* Dental Cosmos, vol. xxxiv. p. 82.

† Burchard's Dental Pathology, p. 379.

has accumulated in considerable quantities and burrowed downward into the submaxillary and carotid triangles, the immediate extraction of such teeth and the evacuation of the pus by external incision is imperatively demanded. In opening such abscesses the incision should be made at the lowest point of the pus-cavity, and, on account of the danger from wounding the important blood-vessels located in these parts, the incision with the bistoury should only be carried through the skin, when, with a pair of hæmostatic snap-forceps with the blades closed, the point may be insinuated between the fibres of the muscles and carried into the abscess, and as they are withdrawn the blades may be opened and the fibres of the muscles still farther separated. By this method of tunnelling the tissues all danger of wounding the blood-vessels is entirely obviated.

After the evacuation of the pus the cavity is thoroughly irrigated, a drainage-tube inserted, and the external wound dressed with several layers of absorbent cotton liberally sprinkled with powdered boric acid or iodoform, and a bandage applied.

Of course it is understood that so formidable an operation will require a general anæsthetic and the confinement of the patient to the bed for several days.

Chronic Alveolar Abscess.—The treatment of the ordinary chronic alveolar abscesses with fistulous openings should follow the same line of procedure as that just laid down for the treatment of acute abscess with fistulous opening.

Abscesses which are associated with perforations of the walls of the root communicating with the pulp-canal are in a very large majority of instances in a chronic state when presented for treatment. In those cases which are the result of a surgical traumatism of recent date, occurring at any point above the middle of the root (the morsal half), the chances for successful treatment are very good indeed, provided resorption of the root in the immediate neighborhood has not begun.

The perforation may be closed in the following manner: after having arrested the hemorrhage with tannin and glycerol, phénol sodique or adrenalin chloride solution, and the cavity thoroughly sterilized and maintained in that condition during the balance of the operation, a disk of No. 60 gold-foil, or, better, a disk of tin cut from a sheet of No. 4 tin-foil which had been doubled upon itself four times, or sixteen thicknesses, may be dipped in chlora-percha and laid over the opening and carefully pressed into place, the canal filled with gutta-percha, and the cavity in the crown sealed with zinc oxyphosphate.

In those cases which are the result of pathologic states the treatment becomes much more difficult. When the pulp-canal is filled with granulation-tissue, this can be removed by first applying a local anæsthetic like cocaine or eucaine, which in many instances can be employed cataphorically. Or an ethereal solution of chloretone—equal weights of each—may be applied upon a pledget of cotton. As soon as it is thoroughly anæsthetized it can be removed with a small sharp-pointed lancet, delicate enough to enter the pulp-canal for at least half its depth. After the bleeding has been arrested, the cavity may be packed with cotton dipped in powdered boracic acid and sealed with gum sandarach. These dressings should be renewed every day for a week, when the canal may be sterilized and the lower half filled with a gutta-percha point, the perforation covered as just described, and the balance of the cavity filled with gutta-percha. If the first treatment is not successful, try again and again, if the importance of the tooth will warrant it. If, however, after repeated trials the tooth remains tender and irritable, it will be the wiser plan to extract it. The same is true of those perforations which occur at that portion which may be termed the apical half of the root. In these cases gutta-percha is the only reliable material which can be used for closing perforations in this part of the canal. The uncertainty attending the adjustment of the metal disk to the perforation in such a location, or even adapting a gutta-percha pellet over it that will not produce pressure, is so great that they rarely prove successful. A perforation such as would be made by a drill passing through a curved root is usually so clean cut that it can be readily closed by a pellet of tin-foil or gutta-percha, but the septic material still remains in the curved extremity of the root, where it will become a menacing source of infection and irritation. It is better, therefore, under such circumstances, to extract the tooth at once rather than to attempt its conservation.

In those cases, however, which present an obstinate suppurating condition, which persists after the most thorough antiseptic treatment of the pulp-canals, the abscess-cavity, and the fistulous tract, *radical treatment* becomes necessary. This may comprehend, first, the curettement of the fistulous tract and the abscess-cavity; second, the amputation of the apical end of the root *in situ;* third, the extraction of the tooth, amputation of the apical end of the root, sealing of the canal, and replantation of the tooth.

Curettement of the abscess-cavity and the fistulous tract is often employed to stimulate the healing process in indolent ulcerations and abscesses. The object of this procedure is to change the indolent character of the granulating process into one of an active character, and thus promote the healing process.

The procedure is as follows: first inject a few minims of a two or four per cent. solution of cocaine hydrochlorate, eucaine, or chloretone into the pus-cavity through the fistulous tract. As soon as the parts have become anæsthetic, which will be in from three to five minutes, slit open the fistula to its base or connection with the abscess-cavity; enlarge the opening in the alveolar plate sufficiently to admit a good-sized straight spoon excavator. Carefully examine the apex of the root for any rough or denuded points, and if none exist the case may be considered as offering a fair chance of being cured. The next step is to thoroughly curette the whole surface of the abscess-cavity with the spoon excavator, after which the *débris* and blood may be washed away and the cavity packed with a strip of boric acid gauze or carbolized gauze. The root-canal should have been previously sterilized and packed with an antiseptic dressing, or the canal may be permanently filled with gutta-percha. In the opinion of the writer the better plan is to permanently fill the root-canal first, and then at the same sitting, or one arranged a few days later, proceed with the operation of curettement. The after-treatment of the abscess-cavity consists of removing the dressing once each day, thorough irrigation with a saturated boric acid solution, two per cent. carbolic acid solution, or with cinnamon-water, and redressing with a strip of gauze. The gauze should be packed lightly so as not to injure the delicate granulation-tissue which usually begins to form immediately after the operation. As the cavity grows smaller less and less gauze will be required, and finally it may be left out altogether and the external opening allowed to close. Irrigation, however, must be kept up until the wound is entirely healed. Frequent use of the irrigating fluid should be recommended as a mouth-wash, and the patient instructed to use it every two hours during the day and once or twice during the night as a means of controlling the septic condition of the mouth.

If, however, upon examining the apex of the root it is found to be denuded and roughened, or covered with calcific deposits, it will be necessary to amputate the diseased portion of the apex.

Amputation of the Apex in Situ.—Before undertaking this operation the pulp-canal should be thoroughly sterilized and filled with gutta-percha, and the crown-cavity protected with a filling of zinc oxyphosphate. The fistula is then slit open with a small bistoury down to the apex of the root, the edges of the incision held away, and a section of the alveolar plate removed with the trephine in the dental engine sufficiently large to thoroughly expose the apex of the root, or a large fissure-bur may be used for the same purpose, and the opening in the alveolar plate enlarged by sweeping it around the edges. Hemorrhage may be controlled by packing the wound with cotton saturated with phénol sodique or tannin in glycerol. The apex of the root, after the hemorrhage has ceased, can be readily seen through the opening. The eroded portion should now be amputated with a small, sharp fissure-bur, revolved at high speed with the dental engine. The edges of the stump can be smoothed with a fine finishing-bur, or with a sharp excavator or scaler. The cavity should next be thoroughly irrigated, all *débris* and blood-clots removed, and the cavity packed with a strip of gauze and powdered boric acid. The edges of the incision may be brought together at the upper portion and maintained in position by one or two sterilized horse-hair sutures, the end of the gauze being left at the most dependent portion of the incision, where it may be grasped and removed after twenty-four to forty-eight hours, according as the circumstances of the case may indicate. Meanwhile the mouth must be frequently irrigated with a suitable antiseptic lotion. At the end of a couple of days the dressing is removed, the cavity thoroughly irrigated with antiseptic solutions, and the patient instructed to keep the mouth clean by the frequent use of the antiseptic mouth-wash which has been selected. Teeth which have been treated after this method should not be filled with gold for several months after the operation.

A fair per cent. of the cases of amputation *in situ* prove successful, but the writer is of the opinion that the more heroic operation of extraction and replantation (see following chapter) gives a larger percentage of cures in obstinate cases of alveolar abscess than the preceding method of operation.

Alveolar Abscess associated with Deciduous Teeth.—Little children are often great sufferers from alveolar abscesses associated with their temporary teeth. If the child is timid and greatly afraid of being hurt, the difficulties presented by this condition render the duty of the operator to relieve the little sufferer as quickly as possible a somewhat arduous task.

Patience, gentleness, and kindness, however, backed by a little firmness, will usually overcome the timidity of the child, and in large measure banish the fear of being hurt, so that it becomes possible to do all that is necessary to give the desired relief.

The suppurative process occurring in children is never so severe as in adults, as the tissues of children are soft and break down very readily when subjected to inflammatory processes. For this reason the time consumed by the pus in finding its way through the gum is much less than in the adult. And although the pulse and the temperature may run high during the inflammatory process, and the swelling and congestion of the tissues be very considerable, the suffering is not so great as in adults.

The treatment of these cases does not differ from that already indicated. Immediate relief may usually be obtained by opening the abscess by an incision in the gum. This may be done with so little pain to the child, if the bistoury with which the incision is to be made has a keen edge, and the attention of the child is diverted to some pleasing subject when the incision is made, as to hardly attract its notice. When all is over the child usually expresses surprise that it hurt so little. With children who are unmanageable it becomes necessary to use a general anæsthetic, and under certain circumstances it is best to extract the tooth rather than to attempt its conservation.

A very large percentage of pulpless temporary teeth can be rendered healthy and useful so long as nature requires their service for the purpose of mastication by thorough sterilization of the pulp-canals and filling them with gutta-percha. Dr. W. H. White a few years ago introduced a new material for filling root-canals in children's teeth particularly,—viz., *balsam del deserto*, which it is claimed does not in the least interfere with the resorptive process of the roots of these teeth in their exuviation. It is especially useful in filling abnormally large canals.

Occasionally a case will be presented in which root-fillings are not tolerated by the tissues. Such teeth should be extracted at once, as repeated inflammation and the formation of abscesses are liable to cause injury to the advancing tooth.

Chronic alveolar abscesses are prone to cause swelling of, and sometimes metastatic abscesses in, the cervical lymphatic glands of children of the strumous or tuberculous diathesis. Under such circumstances the immediate extraction of these teeth is imperatively demanded.

Constitutional treatment is also demanded in these cases for the building up of the bodily vigor. Much can be done for these children by giving them an abundance of out-door life and plenty of wholesome, nutritious food. Sometimes drugs are indicated, in the form of cod-liver oil, iron, arsenic, beef-peptones, the bitter tonics, etc., but best of all is sunlight, pure air, plenty of exercise, and the institution of a scrupulous hygienic condition of the mouth.

CHAPTER XXX.

REPLANTATION OF THE TEETH.

Definition.—Replantation, from the Latin *replantare*, to plant again. Reimplantation, from the Latin *reimplanto*, to implant again.

The operation of replantation or reimplantation of teeth is the replacing of a tooth in the alveolus from whence it had been removed by accident or by design.

Replantation is practised at the present time for three conditions:

First.—When a tooth has been dislodged by an accidental traumatism, such as might result from a fall or a blow.

Second.—When a tooth has been removed as a result of an accidental surgical traumatism, such as the dislodgement of a tooth by the mouth-prop or mouth-gag during the administration of a general anæsthetic preparatory to the extraction of a tooth, or the slipping of the forceps in the extraction of a tooth, which causes the dislodgement of its neighbor or one in the opposite jaw.

Third.—When a tooth is the subject of a persistent alveolar abscess which does not respond to the ordinary methods of treatment.

The degree of success which attends the replantation of teeth depends upon the presence and healthful condition of the pericementum, the length of time that the tooth has been removed from its alveolus, the physical condition of the patient at the time of the operation, the immobility of the tooth during the process of forming its new attachments, and the hygienic condition of the mouth.

The discussion of the *first* and *second* conditions will be reserved for the chapter on "Dislocation of the Teeth."

The treatment of persistent alveolar abscess by extraction and replantation is generally practised as a *dernier ressort* when all other methods have failed.

Obstinate alveolar abscesses are usually caused by a crooked root, an abnormally small root-canal which makes it impossible to remove or render innocuous the retained septic pulp-material, or it is caused by perforations of the root made in attempts to open small root-canals, calcareous deposits upon the apex of the apical end of the root, or erosion of the apical end of the root, which is accompanied by a more or less persistent discharge of pus, either through the external or internal plate of the alveolar process or through the alveolus at the neck of the tooth.

Occasionally cases will be found in which no discharges are present, but instead a chronic induration of the surrounding tissues; or, as in the superior teeth, the discharges may find their way into the antrum of Highmore or the anterior nasal passages, and possibly mislead the operator into the belief that he has a case of empyema of the antrum or of ozæna to deal with.*

These teeth are usually sooner or later condemned as worthless members of the economy, and are removed.

Many of these teeth with suitable treatment may be rendered healthy and useful for an indefinite period.

Replantation is only admissible in the anterior teeth, including the bicuspids. The molars are capable of being replanted only in exceptional cases when there is fusion of the roots and they assume a conical form, and occasionally a lower molar when the roots are perpendicular to the crown.

It will be generally conceded that attempts to cure such cases as those just mentioned by the ordinary methods usually prove unsuccessful, and that eventually the teeth are lost. This results from the fact that such operations are largely, *per force*, only guesswork. If the root is curved at a more or less acute angle it is difficult to follow the canal with the broach or Donaldson bristle, and many times quite impossible, or if the canal is abnormally small, the finest Donaldson bristle may not enter it at all. Reaming the canal is unsafe, and under these conditions the various antiseptic fluids and liquid filling-materials are unsatisfactory because they do not always penetrate to the end of the canal, and consequently septic material remains in the pulp-canal and keeps up a constant irritation.

In cases of erosion of the apical end of the root, amputation of this portion *in situ* is frequently unsuccessful in curing the disease owing to the difficulties in smoothing the stump and perfectly filling the apical foramen.

The same may be said of attempts to plug perforations in the sides of the root.

Roughened surfaces and foreign substances are not kindly borne by the tissues which surround the roots of the teeth; it is therefore imperative that all such hinderances to a return to the normal condition be reduced to a minimum. For these reasons it would seem preferable to extract and replant such teeth if they do not speedily prove amenable to treatment by the usual methods; for, with the tooth in the hand, the root can be minutely inspected, and any eroded portion amputated and the surfaces finely polished. The pulp-canal can be reamed out and cleansed without the fear of perforating its sides, the canal filled and the apical foramen or a perforation plugged with gold and carefully finished, and the whole thoroughly sterilized. None of these operations are possible with the same degree of perfection while the tooth is *in situ*; they must, *per force*, be more or less imperfect, and just in that degree will they produce irritation and the more serious inflammatory processes.

The question might very properly be asked, Are the operations of replantation and transplantation of freshly extracted teeth having the pericementum attached founded upon physiologic law and sound surgical principles? The answer is, Yes; quite as much so as are the operations of skin and bone grafting, and no one condemns these. Union with the

* Dental Cosmos, vol. xxxiv. p. 464.

tissues with which they are placed in contact is the result of the same vital processes; the surgical conditions are nearly identical in each of them, and success is as certain in the one as in the other, provided the same aseptic conditions can be maintained until union is complete.

The failure of replanted teeth to unite with their alveoli is much less common than with transplanted teeth; at least, the personal observation of the writer bears out this statement. The immediate cause of failure is usually suppurative inflammation, induced either by mobility of the tooth, which constantly breaks up the attachment of the plastic exudate, or septic conditions of the tooth or of its alveolus at the time of the operation, or inoculation afterwards from a septic condition of the mouth.

The failures which occur later—viz., after attachment has taken place—are more difficult to understand.

In these cases the surfaces of the roots are attacked by the osteoclasts, and gradually honey-combed or masses of pericemental tissue and dentin are dissolved at various locations about the apex, leaving large cavernous excavations with sharp edges. Suppuration accompanies or follows the work of the osteoclasts; the tooth becomes loose, and is sooner or later expelled from the jaw as a foreign substance.

In explanation the writer would venture the opinion that these phenomena are due to irritation induced by septic conditions resulting from decomposition of the organic material contained in the dentine, and that in the form of a gas or effluvium it penetrates the cementum, and coming in contact with the pericementum and surrounding tissues, sets up this retrograde metamorphosis.

There are certain individuals for whom it would not be wise to undertake this operation,—viz., those suffering from general anæmia, tuberculosis, and syphilis. Such individuals are never good subjects for surgical operations, as their tissues are very irritable, do not, as a rule, heal readily, and are prone to suppuration; consequently replantation, transplantation, and implantation, if performed upon such persons, are likely to prove unsuccessful.

Many of the failures from these operations have been associated with one or the other of these diseases. Great care should therefore be exercised in the selection of the cases upon which to operate. Carelessness in this regard can only result in failure. Of the more than forty operations of this character which it has been the privilege of the writer to perform, it has been thus far his misfortune to record only a single failure, although they have comprised all grades and durations of the disease, several of very long standing, ranging from five to fifteen years.

The character of the union which takes place between the root of the replanted tooth and its alveolus has not so far been positively demonstrated. The writer therefore feels that he may offer a few thoughts which may tend towards an elucidation of this question.

Applying the methods used in physical diagnosis to these cases, we find that percussion gives the most marked signs.

Taking the percussion note of normal teeth, produced by striking the tooth with a steel instrument, as the standard of pitch, we find that as inflammatory conditions of the alveolus advance the percussion note becomes lower and duller, while, on the other hand, as these symptoms subside the note assumes a clearer and higher pitch. This lowering of the tone is doubtless the result of a thickening of the pericemental membrane and its increased vascularity. The percussion note given by a large percentage of replanted teeth a few months after the operation, or when union is complete, is much clearer and higher pitched than that of the adjoining teeth. This is more noticeable in the superior than in the inferior teeth, on account of the greater resonance of the superior maxillæ.

These facts would seem to indicate a bony union in these cases between the root and its alveolus.

It would also seem probable that the locations at which this anchylosis would most likely occur would be where the pericementum had been destroyed or the cement-tissue partially removed; and there seems no good reason why under these conditions reunion may not take place in a somewhat similar manner to that which occurs in fractured bones.

In some cases the percussion note is normal, this would indicate a normal reunion of the pericementum with the alveolus; but when the percussion note is lower and duller, it would be certain evidence of an indurated pericementum or other inflammatory symptoms.

To insure success in these operations the following suggestions should be observed:

1. Exclude anæmic, tubercular, and syphilitic cases.

2. Secure thorough aseptic conditions of the surfaces of the root and pulp-canal by washing and immersing in bichloride of mercury solution, 1 to 500 of water.

3. Amputate and smooth all eroded surfaces, but sacrifice as little of the pericementum as possible. This is very important.

4. Hermetically seal the pulp-canal and apical foramen, and any perforations that may exist, with gold fillings.

5. Curette the abscess-cavity, remove the blood-clot from the alveolus, and wash both with the bichloride of mercury solution before replanting the tooth. This is the only treatment of the abscess-cavity and of the alveolus that will be required.

6. Secure immobility of the tooth by a ligature or an interdental splint until union has taken place. An impression of the teeth of that part of the jaw to be operated upon should be taken before the tooth is extracted, and a splint of gold made to include one or two teeth upon either side of it. After the tooth has been replanted, the splint is applied and secured in position with zinc oxyphosphate cement, and allowed to remain for from four to six weeks.

CHAPTER XXXI.

TRANSPLANTATION AND IMPLANTATION OF THE TEETH.

Definition.—Transplantation (Latin, *trans*, across; *plantare*, to plant), the operation of grafting tissue from one part of the body to another part of the same body, or from the body of one individual to that of another.

The transplantation of teeth is the operation of transferring a tooth from one alveolus in the mouth of an individual to another alveolus in the same mouth, or of transferring a tooth from the mouth of one individual to that of another.

The operation of transplanting teeth was, during the days of John Hunter, much more extensively practised than it is at the present day. The study of the literature of that period and of the intervening years shows that as far back as 1783 the operation was falling into disuse, and in 1810 it was referred to as being consigned to oblivion. The reasons which were assigned for giving up the operation were (1) the great danger of transmitting specific diseases like syphilis, (2) the frequent occurrence of alveolar abscess, (3) the loss of the tooth after a few years from loosening or resorption of its root, and (4) objections were raised to the operation on moral grounds, as the poor sold their teeth to the rich for a price.

During the last two decades the operation has been revived, and upon the whole has given somewhat better results than those recorded a hundred years ago. The teeth which are used are usually sound teeth or healthy roots that have been removed in the operation of regulating the teeth or to make room for an artificial denture. The introduction of antiseptic methods in operative surgery has made it possible to entirely prevent the inflammatory symptoms and the formation of alveolar abscesses which were before this time so common as a sequel of the operation. The danger of transmitting specific diseases has, however, not been overcome, although no doubt greater care is exercised in the selection of the teeth that are to be used for transplanting by inquiring more carefully into the history and physical condition of the individual from whose mouth the tooth was taken. One case has, nevertheless, been reported recently in which syphilis was said to have been transmitted by the transplantation of a tooth taken from the mouth of a syphilitic subject.

The tendency to ultimate loosening of the tooth and resorption of its root after a few years remains the same, and there seems to be no way to prevent these untoward results. Teeth which have been treated by the most complete aseptic methods are equally liable to be lost by these morbid conditions as those which had not been so treated.

Replanted teeth and teeth transplanted from one alveolus to another of the same mouth give better results, in the observation and experience of the writer, than do teeth transplanted from the mouth of one indivdual to that of another.

The operation is applicable only to the ten anterior or single-rooted teeth. It will be seen, therefore, that the operation is confined to rather narrow limitations, the confines of which cannot, with any assurance of success, be overstepped.

The same general conditions that promote success or failure in replanted teeth are operative in transplanted teeth,—viz., the presence of healthful or morbid condition of the pericementum, the length of time that the tooth has been removed from its alveolus, the physical condition of the patient at the time of the operation, the hygienic or non-hygienic condition of the mouth, the adaptability or non-adaptability of the tooth to its new alveolus, the healthful or morbid condition of the new alveolus, and the mobility or immobility of the tooth during the formation of its new attachment.

The most favorable period in which to perform the operation of transplantation is during youth and early adult life, although it may be successfully performed at any period provided the patient is in vigorous health.

In the selection of a tooth for transplantation, one should be chosen which is as near as possible of the same age as the tooth which is to be replaced. Teeth which are younger than the one to be replaced are, however, more likely to form a healthy union with the new alveolus than those which are older.

The practice of selecting teeth which have been extracted for a considerable time, where nothing is known of their history or of the physical condition of the patient from whom they were taken, should be severely criticised for the reasons already mentioned. Too much care cannot be exercised in this direction. When a suitable sound, fresh tooth cannot be secured, a tooth with a carious crown but healthy root may be selected, and an artificial crown of proper color and form grafted upon the root by any of the various methods of crowning.

It is better, also, in selecting the tooth, to choose one with a slightly larger, rather than a smaller, root than the tooth to be replaced, as it is an easy matter with suitable burs and drills to enlarge, deepen, or change the shape of the alveolus to fit the tooth. When the root is too small to fit the alveolus immobility cannot be secured, and as a consequence a good union does not take place.

The best results are obtained by completing the operation at the same sitting. The tooth to be replaced should first be extracted, care being exercised not to fracture the alveolus or unnecessarily wound the gum. The tooth to be replanted is next extracted, the pulp-canal opened, the pulp extirpated, the canal filled with gutta-percha, and the apical foramen and the opening in the crown plugged with gold. The whole operation should be performed according to the strictest aseptic methods. (See preparation of the tooth for replantation, in preceding chapter.)

The alveolus should then be shaped to receive the new tooth, the alveolus and tooth thoroughly washed with a solution of mercuric bichloride, 1 to 1000 of water. The tooth may now be placed in position and retained, if necessary, with a ligature, an impression taken of this section of the mouth, and a metal splint constructed which will cover the transplanted tooth and one upon either side of it, and cemented in place with zinc oxyphosphate.

The only after-treatment that is necessary is that comprehended in a thoroughly clean condition of the mouth, secured by careful brushing and the frequent use of antiseptic solutions. The splint may be permitted to remain in position for a period ranging from four to twelve weeks.

Method of Union.—The union which takes place between the alveolus and a fresh tooth in which the pericementum is intact over the whole surface of the root would seem to be by a normal process, like that which takes place between these tissues in a tooth which has been dislocated by accident and immediately replanted.

In those cases, however, in which the pericementum has been removed in part by shortening of the root or by disease the union seems in some cases to be bony, in others fibrous.

Mitscherlich transplanted a tooth in a dog, and after six weeks examined it, and found that a considerable portion of the pericementum had disappeared, that resorption had taken place at several locations, followed by calcification of the osteoclasts and the formation of new tissue within the spaces or cavities formed by the resorptive process. This new-formed tissue was continuous with the bone of the alveolus, and held the tooth firmly within its alveolus.

The notion that has been held by some operators that the pericementum of the tooth after it has been extracted for some considerable time and had become dried and dead was after transplantation revivified has no foundation in fact, and is directly opposed to all physiologic law. The attachment which occurs between such teeth and the alveolus is, in all probability, a semi-mechanical one, such as was demonstrated by Mitscherlich in his experiment upon the dog.

Prognosis.—Resorption of the roots of transplanted teeth usually occurs at an earlier or later period, ranging from a few months to four or five years, although in exceptional cases they have remained successful for a considerably longer period; the late Dr. Morrison reported cases which were successful after eleven years.

IMPLANTATION OF TEETH.

Definition.—Implantation (Latin, *implantatio*, from *in*, in, and *plantare*, to set), the act of setting in. Applied to surgery it may be the engrafting of epidermis from the skin of one person upon the body of another, the surgical repair of a wounded intestine by uniting the divided ends, or the setting or transplanting of a tooth taken from the jaw of one person and inserted into an artificial alveolus made in the jaw of another.

Implantation of teeth is an operation of modern times, suggested by Dr. Younger, of San Francisco, California, and when first introduced attracted considerable attention from the profession. Many operations were made with little regard to the physical condition of the persons operated upon or to the hygienic conditions of the mouth. Teeth were implanted for persons suffering with syphilis, tuberculosis, and other constitutional diseases, and certain vicious habits like alcoholic intemperance, which have a tendency to lower the recuperative powers of the tissues and favor the suppurative process. Consequently there were very many more failures than would in all probability have occurred had the cases selected for the operation been more carefully chosen.

The only persons upon whom the operation should be performed are those who are in vigorous health, whose occupations do not call for an unusual expenditure of nerve force, and who are accustomed to keeping their mouths in the very best hygienic condition.

Requirements for the Operation.—The successful performance of the operation of implantation requires upon the part of the operator an intimate knowledge of the anatomy of the parts involved and their relationship to other parts. It must be constantly borne in mind that after resorption of the alveolar process has taken place the depth of the bone is very much less than before the tooth had been extracted. In some cases the bone which intervenes between the apices of the roots and the nasal fossa or the antrum of Highmore is extremely thin, often not more than one-fourth to three-eighths of an inch in thickness, while in extreme cases it rarely exceeds half an inch in thickness.

It is necessary, therefore, to exercise great care, in forming the artificial alveolus in the upper jaw, not to penetrate the nasal fossa or the antrum of Highmore, or to encroach upon the anterior palatine canal, which carries the anterior palatine artery, vein, and nerve, when forming an alveolus for a central incisor. When resorption of the alveolar process has been very considerable, it is often exceedingly difficult to so form the artificial alveolus as to give the tooth its right position and inclination in the arch and preserve a bony wall for the labial surface of the alveolus. This difficulty is more often encountered in the region of the central and lateral incisors than in that of the cuspids.

Should the operator be so unfortunate as to penetrate the nasal fossa or the maxillary sinus, extreme care must be exercised not to infect the sinus. To guard against infection the artificial alveolus should be immediately plugged with a *single* strip of antiseptic gauze, which should remain until the tooth is ready to be inserted into its new alveolus.

To guard against the possibility of the apex of the tooth passing into the nasal fossa or the antrum under these circumstances, the depth of the bony socket should be measured and the root shortened to correspond with its depth.

The preparation of the tooth selected for implantation should be the same as for a tooth which is to be replanted or transplanted.

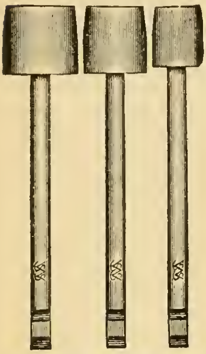
The next step in the preparation for the operation is the construction of a metal splint to secure the tooth in position while union is taking place. This is done by taking an impression of the space to be occupied by the implanted tooth and the teeth upon either side of it. A plaster cast is made from this impression, a bite is taken, and the whole placed in an articulator. A suitable-sized socket is then drilled in the plaster cast, the root of the tooth adjusted therein, and the proper occlusion secured.

From the plaster cast, with the tooth retained in it, a die is made and the metal splint swaged over it.

The tooth is then thoroughly cleansed and placed in a suitable disinfecting solution, 1 to 1000 bichloride, or a saturated boric acid solution, and kept at a temperature of 100° to 110° F. until the artificial alveolus has been made in the jaw.

Method of Operation.—The first step in the operation is to make an incision in the gum-tissue down to the bone. The form of this incision will depend largely upon the individual preference of the operator, the main object being to conserve as much of the firm tissue as possible. Some operators employ a circular incision made with the Rollin circular knives (Fig. 578), others prefer a crucial incision (X), which makes four flaps; others an incision in form of the letter H, which makes two flaps; while still others prefer to employ a U-like or staple-like (⊔) incision, which forms a single flap.

Fig. 578.



Circular knives.

In the X or crucial incision the centre of the cross should correspond with the centre of the alveolar border, and the flaps are to be turned back out of the way of the instruments which are used to form the socket in the bone.

In the letter H incision the upright lines of the incision are made across the alveolar border, close to the approximal surfaces of the teeth upon the mesial and distal sides of the space to be filled by the implanted tooth, while the bar or horizontal incision should connect the upright incisions through the centre of the alveolar border.

In the U-like or staple-like (⊔) incision the upright incisions are made across the alveolar border, close to the approximating teeth, while the curved or the straight incision made to connect the upright incisions are to be made at the lingual border of the alveolus.

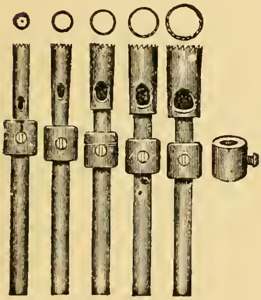
The incisions having been made, the next step in the operation is to lift the flaps from the bone, and in doing this care should be taken to get beneath the periosteum, so that this membrane will be left adherent to the gum-tissue, as by so doing the periosteal layer of the flaps will, when it comes in contact with the root of the implanted tooth, assist in forming a new alveolar border. Delicate periosteotomes for this purpose may be made from selected enamel chisels by rounding the cutting edges.

The flaps, having been lifted from the bone, should be held out of the way by a delicate spring tenaculum-speculum during the forming of the new alveolus. The greatest care should be taken not to bruise the edges of the flaps, otherwise inflammation and sloughing of the borders or of the entire flap may follow.

Various instruments have been suggested for the purpose of forming the socket in the bone. The first instruments made for this purpose were the Younger trephines; these have since been improved by Dr. W. W. Walker, of New York, and are now made with a set-screw collar which slides upon the shaft of the instrument (Fig. 579), and can be set at any point to correspond with the desired depth of the alveolus. Instruments of this character, however, need to be supplemented with others which cut upon the side, as with the trephine alone the alveolus cannot be properly shaped or the core removed.

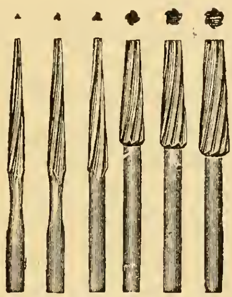
The reamers designed by Dr. Younger (Fig. 580) for this purpose have a serious disadvantage in that they are inclined to clog. The spiral knives of Dr. Rollin (Fig. 581) are a decided improvement over the Younger reamers, in that they are not so liable to clog and cut much more rapidly. The combination drill and reamer instruments (Fig. 582) of Dr. Ottolengui, of New York, are the best of this series of instruments, in that they cut very freely and rapidly, do not clog, and are provided with a safety collar that can be set to suit any depth of alveolus that it may be desired to make.

FIG. 579.



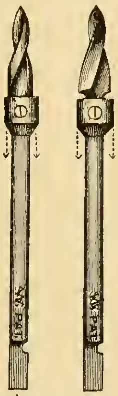
Younger-Walker trephines.

FIG. 580.



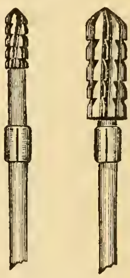
Younger reamers.

FIG. 581.



Rollin's spiral knives.

FIG. 582.



Ottolengui combination instrument.

The Ottofy spiral crib-knife is also a valuable instrument, as it cuts with great rapidity and does not clog. The spiral osteotomes of Dr. M. H. Cryer, of Philadelphia, are designed for the same purpose, and are the most rapid-cutting instrument of the series, and if permitted to run freely they do not clog. Long-shanked, coarse-cut engine-burs are also useful for making any slight changes that may be required in the shape or depth of the alveolus.

During the process of forming the alveolus the parts should be frequently irrigated with an antiseptic solution, preferably a saturated solution of boric acid in water or the Thiersch solution. After the proper depth has been reached, and during the progress of shaping the alveolus, the tooth should from time to time be inserted until the proper adjustment to the socket and the position in the arch has been secured. Another important feature of the operation is to secure a proper occlusion, but it is better to have the tooth a trifle too short than by ever so small a fraction too long, for if the pressure of the jaws comes entirely upon the implanted tooth, inflammation is liable to follow as a consequence of the mechanical irritation.

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As soon as hemorrhage has ceased, the mouth and the socket should be irrigated with a 1 to 1000 mercuric bichloride solution, the tooth washed in the same solution and then placed in position, the parts dried, and the splint cemented in place. As soon as the cement has set the surplus should be removed, the parts again irrigated with the bichloride solution, and the edges of the gum flap nicely adjusted to the cervix of the tooth. If the corners of the flaps are inclined to fall away—evert—from the cervix, a suture of prepared horse-hair may be passed through each labial and lingual corner and tied between the teeth. The sutures should be removed on the third or fourth day. The after-treatment should consist of frequent irrigations of the mouth with antiseptic solutions and careful removal of food *débris* from around the seat of the operation, and such other means as will secure the most perfect hygienic condition of the mouth.

Prognosis.—Implanted teeth, like transplanted teeth, sooner or later are lost by resorption of their roots. Many cases of implanted teeth, however, never formed any kind of union as the result of suppuration which immediately followed the operation; others formed a slight attachment to the alveolus and loosened after a few weeks or months, and dropped out or were removed with the fingers; still others became firmly attached, and remained firm for a year or two, when they became loose from resorption of their roots, and on account of intense irritation had to be extracted; while a very limited number have done good service for periods ranging from three to ten years. On the whole, then, the operation is not one to be recommended except under the most favorable circumstances,—viz., when a freshly extracted healthy tooth can be inserted into the newly formed alveolus of a youth or young adult of the most perfect health and constitution.

CHAPTER XXXII.

DISLOCATION OF THE TEETH.

Definition.—Dislocation, from the Latin *dislocatus*, to put out of place; luxation, from the Latin *luxatus*, to put out of joint. A dislocation or luxation is a displacement of a part from its normal situation.

Two or more bones whose articular surfaces have lost, wholly or in part, their natural relationship are said to be dislocated or luxated, and the condition would be termed a dislocation or luxation.

A tooth which is partially or completely dislodged from its alveolus is said to be dislocated or luxated.

Dislocations of the teeth are of two classes,—viz., *partial* and *complete.*

A *partial dislocation* is one in which the tooth is loosened and partially dislodged from its normal attachments and position.

A *complete dislocation* is one in which the tooth is completely or wholly dislodged from its normal attachment and position.

Dislocations of the teeth are always the result of some form of external violence, such as *direct* blows or falls upon the teeth, accidental dislodgement of a contiguous tooth in the operation of extraction, or violence applied *indirectly*, as a blow or fall upon the chin or the side of the face. Injuries which cause fractures of the jaws almost invariably produce dislocation of one or more teeth at the line of the fracture.

In partial dislocations the tooth may be either dislodged in an *outward* direction or *driven into the alveolus* to a greater or less extent, while in complete dislocations the tooth may be entirely dislodged *outwardly*, or *completely driven through the alveolus* into the nose or the antrum of Highmore.

Treatment.—In the treatment of partial outward dislocations of the teeth the parts should be thoroughly irrigated with antiseptic solutions, cleansed from all blood-clots and foreign substances or loose pieces of fractured alveolar process, the teeth forced back into their normal position and supported by ligatures of silk or wire, or firmly held in place with a vulcanite or metal splint cemented to the adjoining teeth, and allowed to remain until union with the alveolar tissues has taken place. This result may be confidently expected in from one week to ten days, provided suppuration does not supervene. To guard against the establishment of suppuration the mouth and the injured parts should be frequently irrigated with antiseptic solutions.

In the treatment of those cases in which the tooth is partially driven through the alveolus, the crown of the tooth should be grasped by a pair of suitable forceps and drawn down to its normal position. In a majority of these cases, however, it will be found that the attachment of the tooth to the alveolar walls has been entirely broken up, so that when force is applied to draw the tooth into position it will be completely dislocated.

If the tooth still retains a partial attachment to the alveolus, it should be treated as just described, and held in position by means of a ligature or a splint.

As a rule, teeth which have been dislocated even partially have suffered rupture of the nerve and blood-vessels at the apical foramen, so that in a short time, ranging from ten days to a few weeks, the tooth gives evidences of containing a devitalized pulp, and should therefore be opened, the pulp extirpated, and the pulp-canal filled.

Occasionally, however, if the tooth is immediately replaced in its normal position, union of the blood-vessels and the nerve may take place. Numerous cases of this character have been reported from time to time in dental text-books and periodical literature. The writer has had two such cases in his own practice,—one a lower second bicuspid, which responded to the usual tests of heat, cold, and the electric current twelve years afterwards, and the other a second lower molar, which was vital two years afterwards. These cases were both of them in young women of vigorous health and good family history. These results are more likely to follow such accidents occurring in the young, particularly if they happen during the formative period of the teeth, than if they occur at any time thereafter. In tubercular and syphilitic individuals replantation of dislocated teeth is rarely successful, as injuries of even a trivial nature are prone to inflammation and suppuration.

Teeth which have been completely dislocated outwardly should, before being replanted, have the pulp extirpated and the pulp-canal filled with gutta-percha, and the apical foramen and the crown-cavity filled with gold. These operations should be performed under the strictest antiseptic precautions, as suggested in the section of the chapter on Dento-Alveolar Abscess devoted to replantation of the teeth.

Injuries which cause dislocations by driving the teeth into or through their alveoli and into the nasal cavity or the antrum of Highmore usually cause more or less severe fracture and comminution of the alveolar process and superior maxillary bones. Such injuries are generally the result of falls from a considerable height, as from a building, or being thrown from a horse or a bicycle, or from some crushing injury like railway accidents, the overturning of a carriage upon the occupant, or an elevator accident whereby the head is caught between the moving car and the floor. But even under such circumstances it is possible in many cases to bring the fractured bones into normal apposition and to successfully replant the teeth.* It is surprising how readily reunion will take place in these cases, and what good cosmetic results may be obtained by the application of a little skill and patient, intelligent, after-treatment.

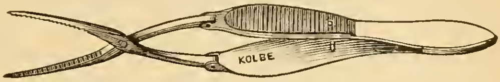
The first thing to be done in these cases after the mouth has been cleansed of blood-clots and rendered as nearly aseptic as the circumstances will permit, by the liberal use of antiseptic solutions, is to search for and remove all of those teeth which have been driven into their alveoli or into the nasal cavity or the maxillary sinus. In nearly all of these cases it will

* Marshall's Injuries and Surgical Diseases of the Face, Mouth, and Jaws, 1897.

be found that the alveolar process is split open, the external plate of the process being the one which is usually fractured and forced outward.

This condition very materially assists in the effort to find and remove the buried teeth. The teeth so dislocated are often completely buried out of sight, or are lost in the antrum. Diligent search must be made for all missing teeth; and if one has been driven into the antrum, this sinus must be opened by enlarging the alveolus of the tooth, and the tooth removed. This is sometimes a difficult problem; but if the opening be made sufficiently large, the tooth can be grasped by a pair of torsion forceps (Fig. 583), or bullet forceps (Fig. 584), and removed; if the forceps will not retain their grasp upon the tooth, it is possible to remove it with a wire-loop snare (Fig. 585) or an écraseur such as is used for the removal of nasal polypi.

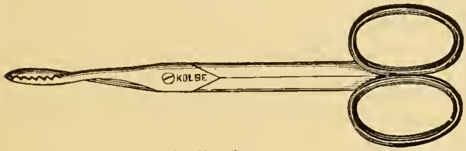
FIG. 583.



Torsion forceps.

After the completely dislocated teeth have been extracted, all loose fragments of bone should be removed from between the alveolar plates and the bones brought into correct apposition.

FIG. 584.

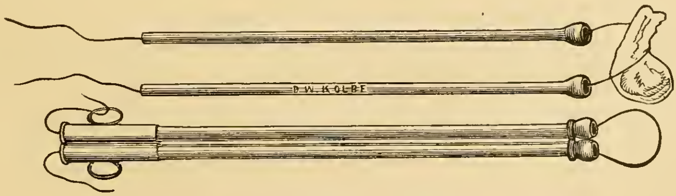


Bullet forceps.

In order to retain them in their normal position it may be necessary to pass silver sutures through the alveolar plates by first drilling holes for their reception at suitable locations. Lead buttons may be used at the termini of the sutures to keep them from cutting into the soft tissues.

After the fractured bones have been adjusted the alveoli should be cleansed from blood-clots, and the teeth, which had been previously cleansed and placed in a tepid three per cent. solution of carbolic acid or a 1 to 1000 bichloride solution, may now be replanted in their normal position and retained by means of ligatures.

FIG. 585.



Gooch's double canula snare.

The first part of the operation would of necessity be of such a painful nature that a general anæsthetic would be required, and the length of time that would be necessary to remove the pulps from the teeth and properly fill them would make it impossible to do this while the patient was under the anæsthetic. While, upon the other hand, the chances of reunion of the replanted teeth with their alveoli is much greater if the teeth are replaced within an hour or two after the injury which has dislocated them. The pulp-canals of such teeth may be opened later, and such treatment instituted as the conditions indicate.

"It is interesting in this connection to note the time required to produce death in the various tissues of the body by the arrestation of the blood-current. The period varies in the different tissues. Brain-tissue, renal epithelium, and intestinal epithelium die in two hours. Skin, bone, and connective tissue continue to live over twelve hours." (Cohnheim.) Tissues which exercise special functions die more quickly than those which do not exercise such functions. These facts should govern all operations for the transplantation or replantation of teeth. Success is more likely to follow the effort of transplanting and replanting of teeth if the operation is completed within an hour or two after the extraction of the tooth.*

Sometimes a single anterior tooth will be driven through its alveolus and into the cancellated tissues beyond, penetrating the floor of the nasal cavity, without fracturing the alveolar process. Under such circumstances the tooth will be so firmly fixed as to require considerable force to dislodge it. The writer saw a case of this character at one time in which a central incisor was driven completely out of sight, and the tooth was supposed by the patient to have been knocked out and lost. The case was so diagnosed, also, by the family physician and the dentist. Careful examination with the probe, however, discovered the crown of the tooth about a third of an inch beyond the border of the alveolus, which was, after considerable difficulty, extracted with a pair of very thin-beaked, straight root-forceps. The tooth, after the removal of the pulp and appropriately filling the canal, apical foramen, and crown-cavity, was replanted and made a good union.

Prognosis.—The prognosis of replanted teeth under the conditions just mentioned is exceptionally good in all healthy subjects. The period of the future usefulness of such teeth may be confidently expected to extend over many years. In some of them, however, there is, after a varying period, a tendency to resorption of the root, and ultimate loss of the tooth.

* Marshall, Injuries and Surgical Diseases of the Face, Mouth, and Jaws, p. 98.

CHAPTER XXXIII.

FRACTURES OF THE TEETH.

Definition.—Fracture (from the Latin *fractura*, a break), the breaking of a bone or a tooth, either by external violence or other form of injury.

Fractures of the teeth, like fractures of the bones, may be divided into three classes,—viz., simple, compound, and comminuted.

Simple fractures are those which involve the hard structures of the crown and do not injure the pulp.

Compound fractures are those in which the fracture is of such extent as to involve the pulp in any portion of the crown or root.

Comminuted fractures are those in which the tooth is broken, crushed, or split into many fragments.

Simple fractures may be of such a nature as to involve only a very small portion of the enamel, or they may be so extensive as to involve a large section of the crown and nearly expose the pulp.

The incisors, from their exposed position, are more liable to fractures of all classes than the bicuspids or the molars, while the cuspids, from their peculiar form and great strength, are the least liable to such accidents, though they are by no means entirely exempt.

The causes which produce simple fractures of the anterior teeth are grinding the teeth and incising such substances as threads, which chip the edges of the enamel, or blows and falls, which cause fractures of larger portions of enamel and dentin, while such fractures occurring in the bicuspids and molars are usually produced by biting hard substances or by blows and falls upon the chin, which drive the jaws together and split off a cusp or produce more serious injury.

Slight fractures confined to the enamel need only to be made smooth with files, stones, or disks, and then polished with pumice. When larger sections of the crown are broken away, the lost portions should be restored with gold or porcelain. It must not be forgotten, however, that injuries which expose the dentin often leave this portion of the tooth extremely sensitive, and not infrequently cause hyperæmia and death of the pulp as a result of the shock induced by the injury, or from thermal impressions upon the exposed fibrillæ.

The application of escharotics to the exposed dentin for the purpose of obtunding its hypersensitiveness is to be deprecated, for the reason that such applications often cause severe irritation and hyperæmia of the pulp, which may result in devitalization. For these reasons it is better to treat such cases by covering the exposed dentin with gutta-percha or zinc oxyphosphate cement and wait for developments. If after a month or six weeks the tooth remains vital and is not hypersensitive to thermal changes, a permanent restoration of the lost portion with gold or porcelain may be undertaken.

Compound fractures are generally the result of severe injuries, such as blows or falls, which bring the anterior teeth in contact with some hard substance, causing fracture of the crown and exposing the pulp, or which drives the jaws forcibly together and splits the crown of a bicuspid or a molar through the pulp-chamber, or carries away a large section of the crown, exposing the pulp. The fragments in fractures which occur through the pulp-chamber, sometimes in such close apposition that the most careful examination is necessary to detect the character of the injury. The writer has seen several cases in which a persistent odontalgia was finally discovered to be due to such a cause.

Bicuspids and molars which have been filled upon the mesio-disto-morsal surfaces are quite prone to be fractured through the pulp-chamber or to have a cusp split off while chewing very hard food, or when accidentally biting upon some foreign substance hidden in the food, like a piece of bone, a shot, a piece of shell or stone.

Compound fractures of the anterior teeth are usually either transverse or oblique, while in the bicuspids and molars the line of fracture is generally oblique or longitudinal, following the line of the pulp-chamber.

Oblique fractures are, however, the most common in both the bicuspids and molars. In bicuspids which have two roots, and in the lower molars, the fracture in the crown may extend in a longitudinal direction, separating the roots, while in the superior molars it usually separates the palatine from the buccal roots. Occasionally the root of an anterior tooth may be fractured transversely at some distance beneath the gum.

Treatment.—Fractures, either oblique or transverse, which open the pulp-chamber, but do not extend beneath the gum, should be treated with a view to finally setting an artificial crown upon the remaining firm root, but in those cases in which the fracture follows the pulp-canal, or in which the root is otherwise seriously involved, extraction is the only treatment to be recommended.

An exposed pulp should be extirpated at once in order to give relief from the severe pain. This should be done under a general anæsthetic.

In devitalized superior molars and in double-rooted superior bicuspids which have been fractured on a line with the pulp-chamber separating the roots it is sometimes possible, after ligating the fragments together with a stout silk ligature, to secure the fractured parts and retain them in a normal position by drilling a hole through the crown bucco-lingually, well towards the gum, counter-sinking the hole upon both the buccal and lingual surfaces and inserting a bolt with a screw-nut made of eighteen-carat gold, filling over the head of the bolt and the nut with gold or with zinc oxyphosphate or amalgam, and replacing any fillings in the line of the fracture through the crown with cement or amalgam, and in very rare instances with gold.

Another method is to fit a gold or platinum band to the outer circumference of the tooth, and retain it in position with zinc oxyphosphate. This method is particularly applicable to the lower molars which have been so fractured as to separate the mesial and distal roots.

Still another method may sometimes be adopted with success in those cases in which the crown is considerably decayed or contains large fillings, —viz., to set a gold shell-crown. This may be accomplished by first securing the fragments in proper apposition by the aid of a piece of fine iron binding wire passed around the cervix of the tooth and twisted tightly. The crown may then be cut to proper shape and length, measured, the band fitted, and the crown made and finished by the usual methods.

Comminuted fractures are always the result of severe injury from concussion or some heavy crushing force, which usually so comminutes the crown and root, together with the alveolar walls, as to destroy the integrity of the tooth and make it necessary to remove the crushed fragments. Occasionally the crown only will be comminuted and the root left intact. Under such circumstances the root may be conserved and an artificial crown set upon it.

Spontaneous fracture sometimes occurs in a tooth which contains a devitalized pulp or a very large metal filling without any seemingly apparent cause. It has been suggested by some writers that in the former the tooth was fractured by internal pressure from the evolution of gas in a closed pulp-cavity as the result of the decomposition of the pulp; while in the latter it was due to the expansion of the metal filling induced by thermal changes. Tomes suggests that it may be due sometimes to a calcified pulp, which acts as an internal wedge when a distorting force is brought to bear upon the tooth. It is possible that such forces as have been mentioned may produce these fractures, but the writer is inclined to the opinion that in each of these conditions the fracture is often due to some unusual force applied to the tooth, either in masticating or in grinding the teeth together while the individnal is asleep. A tooth with a devitalized pulp has usually been weakened by a cavity of decay, while a tooth which contains a large metal filling is also in a weakened condition, and therefore less able to withstand any undue strain that might be placed upon it.

Union of Fractured Teeth.—As a rule, teeth which have been fractured do not become reunited. This is no doubt due to the fact that the dentin has no blood circulation, and that the cementum has but few blood-vessels as compared with bone-tissue, and yet there are several instances on record in which union of fractured teeth has undoubtedly taken place. Fractured bones almost universally reunite, and but for the character of the dental tissues the same result might be confidently expected in the teeth. The union which has taken place in the few instances recorded seems to be due to the active agency of the pericementum, which has thrown out new osseous (cement) material around the fracture, just as is done by the periosteum in fractured bones. It is possible that the pulp in some rare instances may take part in forming the reunion. Reunion of fractured teeth is much more likely to result if the fracture takes place during the formative period of the root, or soon thereafter, than it is if the fracture occurs after adult life is reached. The probability of reunion taking place in a fractured tooth is increasingly greater as the line of fracture nears the apical third of the root.

The conditions which are necessary to promote reunion in the fractured root of a tooth are correct apposition and immobility of the fractured parts, the vitality of the pulp, and a healthy condition of the pericementum. Reunion will fail if the fractured parts are separated by any appreciable space, or if they are in constant motion, or the pulp dies and becomes decomposed, as septic conditions are established at the site of the injury, and by that means the reparative process is arrested or entirely prevented, and if the pericementum is not in a fairly healthy condition the reparative process cannot be established, as this is the most important structure involved in this process.

Wedl * is of the opinion that the pulp takes some part in the process of reunion of fractured teeth, and he figures two reunited fragments in which a deposition of reparative dentin took place,—one was a human superior bicuspid, the other an incisor of an antelope. Tomes † mentions two cases, one a human molar in which union of the fragments had been secured by the formation of new cement-tissue around the fracture. The other was a tusk of a hippopotamus in which the fragments had been considerably separated, but which had been perfectly reunited with new-formed cementum.

Professor Owen mentions a similar case in the tusk of a hippopotamus. ‡

Hyatt describes a specimen of reunited fracture of a central incisor to be found in the Anatomical Museum of Breslau.

Heider mentions a specimen contained in his private collection of a perfectly reunited fracture in a superior bicuspid.

Hohl records fourteen cases found in man and the lower animals, eight of which were human, seven being incisors and one a superior bicuspid. One remarkable case recorded by Hohl in which reunion was perfect is described as follows:

"Professor V., as he was about entering a railway car, fell, striking his mouth upon the sharp edge of an iron step in such a way that the right superior central incisor was fractured lengthwise. The fracture separated the tooth in the middle of the crown so completely that the two fragments diverged from each other, and could be moved back and forth. After the lapse of fourteen days, during which time the intense pain entirely prevented the use of the fractured tooth, a more comfortable condition ensued, and in a few weeks more the tooth completely resumed its normal functions. The two halves of the tooth became firmly adherent to one another, and the line of union was indicated by merely a fine line with a slightly brownish tinge." §

The late Sir E. Saunders has described an incisor belonging to his private collection, which shows a perfectly reunited fracture which had occurred at the junction of the middle and apical thirds of the root. Belisario also reports a case of fracture of a tooth with reunion of the severed fragments. Bennett describes a fractured incisor tooth in which the fragments were apparently considerably displaced and had become reunited in their displaced position.

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* Wedl's Dental Pathology.

† Tomes's Dental Surgery.

‡ Odontography.

§ American System of Dentistry.

CHAPTER XXXIV.

RESORPTION OF THE ROOTS OF PERMANENT TEETH.

Definition.—Resorption (Latin, *resorptio*, from *re*, again, and *sobere*, to absorb), the process whereby formed tissue is converted into its original elements by the action of specialized cells and taken into the blood-current by absorption.

Bone is resorbed through the action of the osteoclast cells. The roots of the permanent teeth are resorbed by a similar process, and is analogous to that observed to take place in the roots of the deciduous teeth prior to their exuviation. The former, however, is a pathologic condition, while the latter is physiologic.

The resorption of dental tissues other than that appearing in connection with the removal of the roots of the deciduous teeth prior to the eruption of the permanent teeth must therefore be considered a pathologic process.

Causes.—The *principal predisposing causes* of resorption of the roots of the permanent teeth are of two classes,—one which is dependent upon conditions associated with the tooth itself, and the other to conditions which are entirely foreign to the tooth.

In the first class of causes are death of the pulp, necrosis of portions of the pericementum, and functional disuse of the tooth due to the loss of its antagonist. In the second class are irritation from an erupting but malposed tooth, as, for instance, a third molar, which presses against the distal root of a second molar, or the presence of a foreign body in contact with the root.

The process of resorption is much more rapid in pulpless teeth and in those in which portions of the pericementum have been destroyed by a suppurative inflammation, such as would attend dento-alveolar abscess. It may be stated as a general fact that the progress of the disease is much more rapid in tissues whose blood-supply or nutrition have been reduced or largely cut off, while, on the other hand, the greater the blood-supply coming to the part so attacked the more successfully will it resist the destructive process. In other words, vital resistance plays an important part in determining the rapidity with which the tissues are dissolved by this process.

When the process attacks a tooth with a vital pulp, its action is more and more retarded as it approaches the pulp, and in some of these cases the cementum and dentin have been removed, leaving only a thin tube-like protection of dentin surrounding the pulp. In those cases of resorption caused by an advancing malposed tooth, it will be noticed that at the point of contact only will the process be active, and the form of the excavation made in the root of the tooth attacked by the resorptive process will correspond to that portion of the surface of the tooth which is advancing towards it.

There is never, however, absolute contact of these surfaces; they are always separated by a mass of multinucleated cells which are doubtless modified osteoclasts. The process of resorption sometimes extends to such depth as to expose the pulp in the root of the tooth, and thus cause a severe and sometimes obscure odontalgia and later on a dento-alveolar abscess.

Exciting Causes.—Continued irritation of almost any form may inaugurate the resorptive process. Among the more common of the exciting causes may be mentioned chronic septic pericementitis, chronic dento-alveolar abscess, a nerve broach broken off in the pulp-canal and projecting through the apical foramen, the presence of a root-canal filling which projects into the apical space, or a severe injury, as from a blow upon the tooth. In certain cases, however, the resorptive process seems to have no discoverable cause whatever.

Pathology.—The *macroscopic appearances* of the roots of teeth which are being resorbed present such a wide difference that it may be safely said that the process rarely attacks any two teeth alike. This will be noticed by reference to the illustrations. Fig. 586 shows the result of a chronic irritation at the apex of a vital superior central incisor. In this case the resorption has produced a smooth, regular, and rounded shortening of the root. Fig. 587 illustrates the same condition occurring at the apices of roots of a devitalized superior molar. Fig. 588 represents two vital superior central incisors in which the process of absorption was most active upon the mesial surface, extending from apex to cervix. The writer is indebted to Dr. Wright, of Chicago, for these latter specimens loaned from his private collection. The surfaces which have been attacked in these teeth present deep, uneven, bay-like excavations and numerous small, rounded openings, which give them the appearance of being worm-eaten. In Fig. 589 the process is shown to have scooped a large, smooth excavation in a devitalized superior bicuspid, well up towards the apex, leaving sharp, clean-cut edges. Sometimes the whole root is absorbed, but this is rare. Fig. 590 shows a devitalized inferior bicuspid in which the disease has extended much farther. This tooth had been crowned with gold several years before the writer saw the case, and no other history could be obtained. In this case the resorptive process had extended into the crown upon one side. Fig. 591, a devitalized central incisor, has lost about one-half of its root; the disease evidently began on the labial aspect of the root near the apex. In this case the dentin has been dissolved much more readily than the cementum, thus causing a very deep depression.

Fig. 592 shows a devitalized superior central incisor in which the process of resorption has gone considerably farther, and has removed almost the entire root and formed a deep depression in the crown.

Fig. 593 was a vital superior cuspid which has a small depression or cup-shaped cavity upon the labial surface of the root near the middle, and shows a very early stage in the resorptive process.

Fig. 594 was another vital superior cuspid in which the disease began at the apex and has destroyed the upper half of the root. The peculiarity of this case lies in the fact that the disease has hollowed out the root

FIG. 586.

FIG. 587.

FIG. 588.

FIG. 589.

FIG. 590.

FIG. 591.

FIG. 592.

FIG. 593.

FIG. 594.

FIG. 595.

FIG. 596.

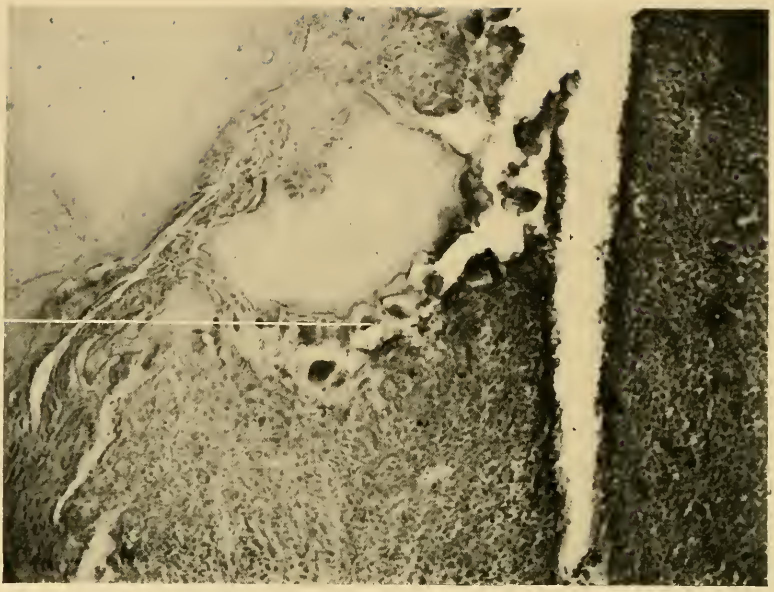

FIG. 597.—Osteoclasts, producing resorption of the root of a tooth. × 45.

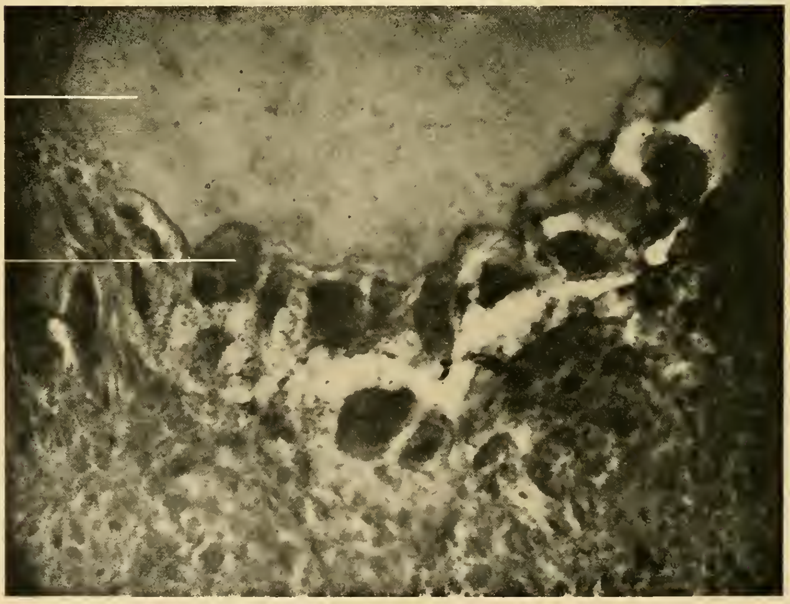

FIG. 598.—Osteoclasts, producing resorption of the root of a tooth.

almost to the cervix, leaving the outer shell of the cementum intact, and preserving a thin tube of dentin around the pulp.

Fig. 595 represents the most interesting case of all. This is a lower second molar, which had been extracted and replanted by a colleague for the cure of pyorrhœa alveolaris. The tooth was supported in position by a gold splint which encircled this tooth, the first molar, and the second bicuspid. The operation was made about two years previously. The tooth had been troublesome for more than a year, but, as there was no discharge of pus, it was thought best to allow it to remain. It finally caused irritation of the gum, and was therefore extracted. In this case the root and a large part of the dentin of the crown was entirely resorbed. The tissue, however, was not removed in the same manner as in the resorption of the deciduous teeth, for in them the surface is left comparatively smooth, while in this case it is full of deep depressions and perforated with holes, as though worm-eaten.

Fig. 596 shows a very peculiar form of resorption in a superior second molar, the result of inflammation of the pericementum induced by drilling through the side of the root in an effort to open the pulp-canal in the disto-buccal root. The probes are passed through the cavity of decay and the opening in the root made by the drill and through two other openings which were the result of the action of the cementoclasts.

Upon *microscopic examination* of the surface which is being resorbed it is found to be covered with cup-shaped depressions of great minuteness, but there appears to be no alteration in the size or of the arrangement of the dentinal tubuli. These minute depressions are Howship's lacunæ, and are doubtless formed by the action of multinucleated cells (Figs. 597 and 598), the osteoclasts, or odontoclasts.

The *modus operandi* by which the roots of the permanent teeth are resorbed seems to be identical with the process by which foreign substances composed of animal tissue, like ivory, catgut, silkworm gut, silk-ligatures, sponge, and decalcified chicken-bone drainage-tubes, etc., are resorbed when buried in the living animal tissues. The success of the process seems to depend upon the character of the inflammation, which must be of a degree that falls short of the suppurative process. This fact has been conclusively proved by numerous experiments (Billroth, Tomes, Krause, Köllicker, and others) with buried ligatures and other animal tissues. It was found that the establishment of the suppurative process immediately arrested resorption. This is doubtless due to the fact that the increase in the degree of the inflammatory process arrests the function of the resorption cells or odontoclasts.

Similar conditions are known to obtain in the exuviation of the deciduous teeth. Resorption in these teeth never progresses while suppuration exists about their roots. This is doubtless true also of the resorptive process in the roots of the permanent teeth.

The examination of the roots of replanted, transplanted, and implanted teeth reveals the fact that where union or attachment has taken place without suppuration, and the teeth were subsequently extracted during some period soon after the operation, resorption must have taken place in various locations, for excavations into the cementum are plainly seen, and these have been refilled by a deposition of new-formed cement tissue. Occasionally the alveolar tissues never become tolerant of these teeth, particularly the transplanted and the implanted ones, and under such circumstances the resorptive process is established and maintained uninterruptedly until the offending members, which act as foreign bodies, are expelled from the jaws.

Symptoms and Diagnosis.—The symptoms are tenderness to percussion, a peculiar looseness of the tooth, which can be moved in a radius shorter than would be expected in a tooth of normal length; later evidences of a mild pericementitis appear, and sometimes a slight discoloration of the tooth. On opening the pulp-canal the pulp is usually found to be devitalized, and upon passing a broach into the canal it encounters midway, or in the upper third of the root, a soft, fleshy mass of tissue. At other times the tooth may contain a vital pulp, and if it has been exposed by entering the canal with a drill, it must be devitalized; but upon its removal and the exploration of the pulp-cavity the tooth will be found to have either undergone shortening of its root, or the probe will reveal the fact that the wall of the pulp-chamber has been invaded, and the cavity so made occupied with a mass of soft tissue.

In vital teeth which are being thus resorbed the pulp will sometimes give evidence of being hyperæmic by the marked increase in the normal heat sense of the tooth, and its intolerance to changes of even a few degrees in the temperature of substances coming in contact with it.

In some of these cases the only symptom is one of discomfort,—not actual pain, but a discomfort which the patient will, perhaps, suggest does not seem likely to be relieved except by the extraction of the tooth.

The diagnosis in the absence of positive signs may be made by exclusion. The Röntgen rays, however, if available, will give a positive diagnosis.

Prognosis.—The prognosis, so far as the conservation of the tooth is concerned, is decidedly unfavorable. When once this process is established in a permanent tooth, it is sooner or later lost. If the diagnosis in these cases could be made early, and the source of irritation removed before the process of resorption had progressed to any considerable extent, it is possible that the process might not only be arrested, but that a redeposition of tissue would take place and the tooth be preserved. But the difficulty lies in the fact that there seems to be no means of diagnosing the disease until it has gone so far as to make it impossible to save the tooth.

Treatment.—Inasmuch as the only symptoms which are manifest in these cases are those of a mild pericementitis, every effort should be made to discover and remove, if possible, the cause or causes of irritation. If the tooth is one that has been devitalized or gives evidence of containing a dead pulp, the pulp-cavity should be opened and cleansed; or the filling removed if one is found; or broken instruments lodged in the pulp-chamber should be searched for and, if discovered, removed. But if, after treating the case antiseptically for a few days longer, there is no improvement in the conditions or abatement of the symptoms, the tooth should be extracted as the only means of giving relief.

CHAPTER XXXV.

HYPERCEMENTOSIS.

Definition.—The term hypercementosis (from the Latin *cœmentum*, coarse stones, and *hyper*, the prefix used to denote superabundance) means an abnormal excess in growth—hypertrophy—of the cement-tissue of the tooth.

Hypertrophy is an increase in the substance of a tissue or an organ, the result of an increase in or the multiplication of its elements, and brought about in such a manner that the structure of the hypertrophied tissue is not materially changed and does not differ essentially from the normal type.

Hypercementosis is therefore a simple increase in the volume of the elements which constitute the cement-tissue of the tooth, which retains in large measure the general character of the structure of the normal tissue. It may be circumscribed or diffuse, and may assume almost any size or shape.

Causes.—The etiologic factors which produce this affection are of two classes, predisposing and exciting.

The *predisposing causes* of hypercementosis are generally the result of those conditions, either constitutional or local, which induce a morbid activity in the cellular elements of the peridental membrane, especially those which increase its blood-supply beyond the normal. This condition may be produced by chronic inflammatory phenomena resulting from septic conditions of the pulp-canals of devitalized teeth or other cause of a low form of inflammation; by malocclusion, or overuse of the tooth, causing congestion; by the death of the pulp, which increases the blood-supply to the pericementum by diverting to it that portion of blood which originally supplied the pulp; by the selective action of such drugs as mercury, iodine, etc., which produce pericemental irritation and gingivitis; by the irritation of mephitic gases contained in the tubuli of devitalized teeth percolating through the cementum and inducing chronic pericementitis, a condition which frequently occurs in teeth whose pulps have been removed and the canals properly filled; while the presence of an excess of uric acid in the blood may also be classed as a predisposing cause, as it favors the deposition of the urates in the pericementum and thereby produces chronic irritation, which causes congestion of this membrane and, under favorable conditions, organization of the inflammatory exudates.

The tendency of the pericementum to develop such excess of cement-tissue is undoubtedly in some instances constitutional, and is especially marked in certain individuals. This tendency seems in some cases to be inherited, and it is fairly good presumptive evidence that if the parents have developed the affection, the children will also suffer from it.

Exciting Causes.—The exciting or active causes of the affection may be any form of irritation which excites a hyperæmic condition of the pericementum, such as excessive thermal changes, a severe strain upon the tooth, as in using great force to crush or incise a hard or tough substance, or the accidental biting upon some hard substance like a piece of bone, a shot, or a piece of stone; or an injury from a blow or fall; caries of the cervix; the projecting edge of a filling; the protrusion beyond the apical foramen of a gutta-percha or other filling-material, and cervical deposits of salivary calculus.

Pathology.—Inasmuch as the formation of cementum is normally a more or less continuous process, beginning with the development of the root and the eruption of the tooth and ending only with its loss or the death of the individual, it becomes very difficult to draw the line at the point where cement formation ceases to be physiologic and assumes pathologic features. An examination of a recently erupted tooth, one with its root developed to the normal length, shows the cementum to be composed of only a few concentric layers, while a tooth from an elderly person shows many such lamellæ. But although the cementum is thin at the cervix and thick at the apex, the number of lamellæ are about the same in all parts of the tissue. The formation of the cementum in lamellæ indicates periods of functional activity and of rest upon the part of the cementoblasts (Figs. 599 and 600). These lamellæ closely follow the general outine of the dentin composing the root and form an even and smooth outer surface. In many pathologic specimens the surface presents a nodular appearance, or larger globular masses are formed at the apex or upon the side of the root, as seen in B and C, Fig. 601. In others, like the bicuspids and molars, the roots may be united, sometimes by simple fusion as shown at A, Fig. 601, at others by a considerable mass; or the roots of two or more teeth may be joined together, as shown in D, Fig. 602. Fig. 602, which is made from a specimen kindly loaned the writer by Dr. Wright, of Chicago, shows a similar condition.

Specimens of hypercementosis often show very great irregularity in the lamellation and in the surface of the dentin. At certain points deep excavations appear in the surface of the dentin, while other similarly appearing excavations are filled with cement tissue which has no regular lamellated structure. Extensive areas of absorption upon one part of the root and large additions of new tissue upon another part may be observed in the same specimen.

The character of the irritation which has stimulated the activity of the formative function of the cementoblasts is indicated by the surface of the new-formed cementum; the smoother and more regularly globular its form (Fig. 603), the more continuously chronic has been the process, while if the surface is irregular or composed of numerous elevations and depressions, it is an evidence of irregularity in the character of the irritation, and indicates intermittent attacks of resorption and deposition.

When such teeth are extracted the pericementum is found to be much thickened and abnormally vascular. Sometimes there will be found adherent to the irregular surface of the new-formed cementum certain flesh-like masses which remind one of the absorbent organ found attached to exuviating deciduous teeth.

Examined microscopically, the new-formed cementum is shown to

FIG. 599.—Transverse section of root of human tooth near the apex, showing dentin and cementum in hypercementosis. × 200.

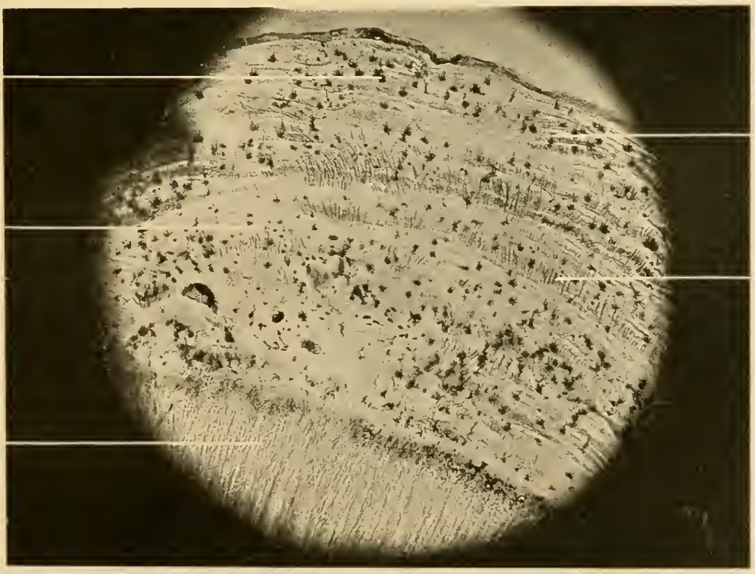

FIG. 600.—Transverse section of root of human tooth near the apex, showing the dentin and the cementum. × 175.

Fig. 601.

A *B* *C* *D*

Fig. 602.

Fig. 603.

FIG. 604.—Transverse section of root of human molar, hypercementosis. × 96.

FIG. 605.—Vertical section of root of human molar, hypercementosis. × 15.

FIG. 606.—Transverse section of roots of human molar, near apex. × 75.

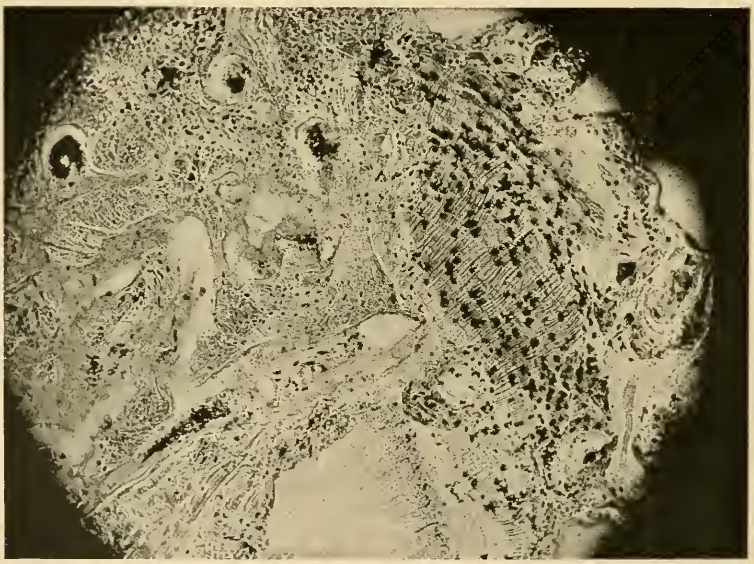

FIG. 607.—Transverse section of root of human tooth, hypercementosed, showing the irregular character of the new-formed tissue. × 75.

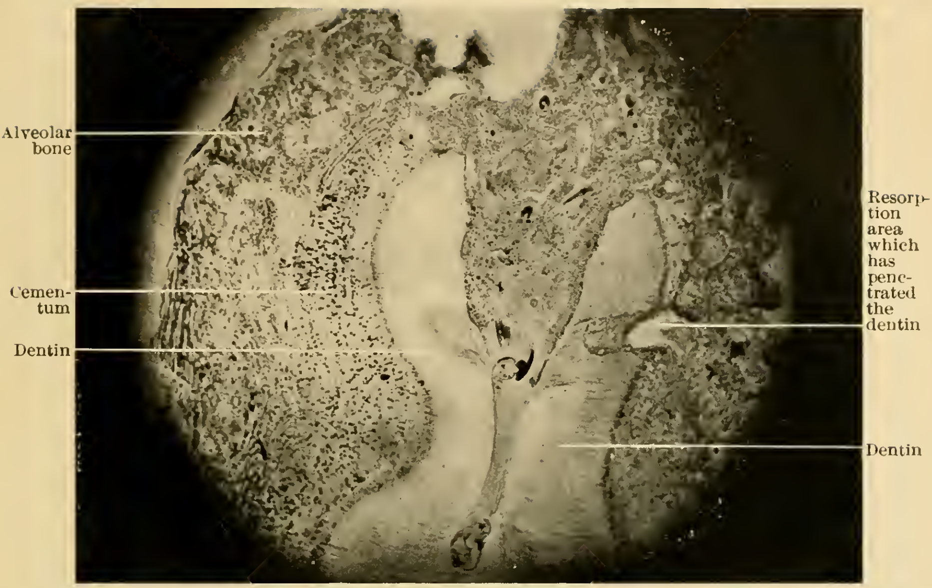

FIG. 608.—Transverse section of alveolus and apex of root of abscessed human molar, showing resorption area partially refilled with a secondary formation of cementum. × 96.

FIG. 609.—Case of inostosis, with formation of a pearl-like globule resembling enamel.

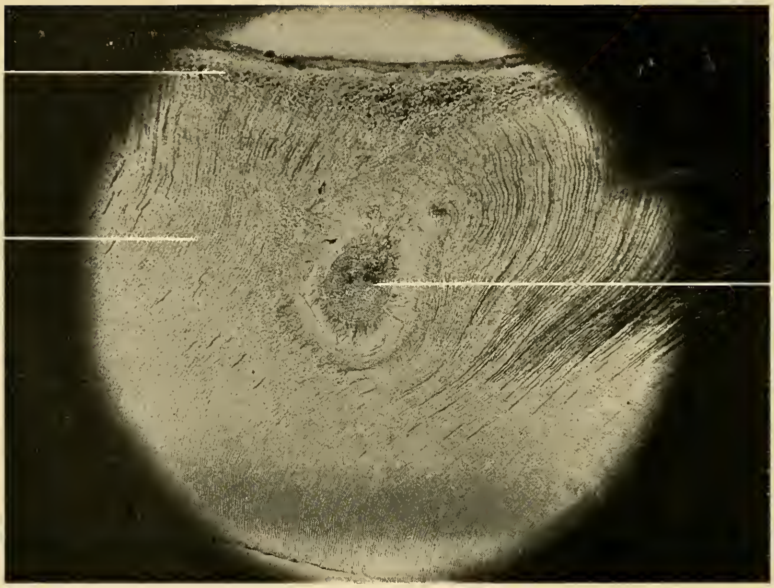

FIG. 610.—Transverse section of root of human tooth, showing case of inostosis. × 80.

possess the characteristic general structure of cementum, but differing in the size, number, and arrangement of the lacunæ and canaliculi, the thickness of the lamellæ, and the distinctness of the incremental lines of Salter (Fig. 604). These differences depend in large measure upon the extent or thickness of the new-formed tissue. In normal cementum the thin laminæ at the cervix of the tooth present no lacunæ, but as the apex is approached they become more and more abundant, as do also the canaliculi. Similar variations occur in the hypertrophied cement tissue (Fig. 605).

Vascular or medullary canals (Haversian canals) are exceptional in normal cementum, but they are frequently found in hypercementosis. The presence of these canals in the cementum is not, however, necessarily an evidence of pathologic conditions, for they are occasionally found in very thick cementum of normal teeth, particularly where two roots are joined together by cement tissue, as shown in Fig. 606.

In hypercementosis having a smooth and regular surface the lamellæ are fairly regular and the incremental lines of Salter generally well marked. The lacunæ are more numerous and slightly larger than in normal cementum, but irregularly arranged and with the canaliculi running in a peripheral direction, as seen in normal tissue.

When the surface of the new tissue is irregular the character of the structure is more or less irregular. The lamellæ are not so distinctly marked and the lacunæ have a more irregular arrangement. These conditions are strikingly shown in Fig. 607.

The density and texture of the various lamellæ often differ considerably; some seemingly are very perfectly calcified, with few or no lacunæ, while in others calcification is quite imperfect and the lacunæ are very numerous. In some cases lamination is not traceable in the new-formed tissue, which fact would indicate that the functional activity of the cementoblasts had been continuous, that there had been no periods of rest, no abatement in the stimulation or irritation.

INOSTOSIS.

A most curious condition is sometimes noticed in the structural arrangement of the new cement tissue, a condition which unmistakably indicates that lamellæ already formed had been partially removed by resorption, and the excavations thus made afterwards filled by a redeposition of cement-tissue, as shown in Fig. 608. The process by which cement-tissue is reformed in the excavations made by resorption has been termed by Henry *inostosis.* The new-formed tissue in inostosis is sometimes of very peculiar character. Occasionally it resembles osteodentin, at other times it has the appearance of enamel. Fig. 609 is a case from the private collection of the writer which shows a pearl-like body in the side of the root of a third lower molar, occupying a cavity apparently formed by resorption. Fig. 610 is a microscopic section of a similar case from the private collection of Dr. V. A. Latham, but lying deeper in the dentin.

These phenomena represent two distinct vital processes, processes which are antagonistic to each other. One is formative, the other destructive. The explanation would seem to lie in the character and degree of the irritation, operating at different periods or in different locations at the same period.

It has already been noticed that a mild and continuous chronic irritation of the peridental membrane favors the production of new cement-tissue through stimulation of the cementoblasts, while it is a recognized fact that another form of irritation, which is perhaps only a little more severe, will establish a retrograde or destructive process in the tissues, as noted in the resorption of bone by the stimulation of the osteoclasts. A similar condition doubtless takes place in the resorption of the cementum, for there are often found attached to such teeth masses of tissue composed of giant-cells which cannot be distinguished from the multinucleated cells found in the "absorbent organ" attached to exuviating deciduous teeth. It has never been definitely determined whether there are two distinct sets of cells—cementoblasts and cementoclasts—or whether the cementoblasts under different stimuli do not perform both functions of formation and of resorption.

Specimens are occasionally exhibited in which well-marked resorption was present upon one side and hypercementosis upon the other, which would indicate that these processes were the result of localized irritations of different degrees.

Although this excessive growth of the cementum may result in the fusion of the roots of a tooth, or of the roots of contiguous teeth, or of the crown of one tooth with the roots of another, as shown in Dr. Wright's specimen (Fig. 602), no authentic evidence, to the knowledge of the writer, has so far been presented of fusion of the cementum with the alveolar process. Bones often become anchylosed by fusion of their surfaces, the result of the healing process, as, for instance, in the temporo-maxillary articulation following traumatisms or inflammation of the joint. Sometimes the new-formed tissue in hypercementosis seems to establish a union with the alveolus, and when the tooth is extracted it not infrequently causes one of the plates of the alveolar process to be fractured and brought away adherent to the root; but upon a closer examination it is found that the bone can be detached from the hypertrophied cement tissue after more or less effort, as the tissues remain separated by a modified pericemental membrane, the fibres of which seem to be very strong and firmly attached to both tissues.

Symptoms and Diagnosis.—The local symptoms of hypercementosis are usually negative, and unless the affection causes pain in the tooth or its surroundings its presence may never be suspected.

Occasionally, however, the patient may complain of symptoms which would indicate pericemental irritation,—viz., slight soreness and elongation, tenderness to percussion, and pain in the region of the tooth. Sometimes tumefaction of the alveolar process over the root may be observable and this may be slightly tender to pressure, but, as a rule, no such positive diagnostic signs are presented.

. When pain is present, it is usually of the reflex, neuralgic order, and generally referred to some remote portion of the face or head or to the eyes or the ears. Numerous cases have been placed on record from time to time, in the periodical dental and medical literature, of persistent neuralgias in these locations and of functional disorders of the eyes and ears, which have been traced to the presence of hypercementosis of the teeth, and the diagnosis has been proved by the cure of these affections following the extraction of the teeth.

Serious derangement of the general nervous system may also result from this form of irritation. Tomes* mentions "two cases in which epilepsy appeared to be dependent upon diseased teeth, the most prominent feature being hypercementosis of the roots."

Chorea has also been traced to the irritation of diseased teeth, particularly to pulp irritation and hypercementosis. These nervous diseases are common in institutions for feeble-minded children, and it was the experience of the writer when serving upon the staff of one of these institutions that many times dental irritation was the cause of these affections, as was proved by the abatement of the symptoms after the extraction of the offending teeth.

The diagnosis of hypercementosis is often a problem which presents the greatest difficulties, and in many cases it can only be reached by a process of exclusion. Pain or other symptoms of uneasiness which are not referable to any other cause may be the only symptoms present. The patient sometimes says the tooth feels enlarged or swollen and sensitive to percussion, but these again may be the only symptoms to guide in the diagnosis.

Many persons are subjects of hypercementosis, sometimes to a considerable extent, without ever having suffered the least inconvenience therefrom, this condition of the teeth not being recognized until, for some other reason, the teeth have been extracted.

The best and most reliable means of diagnosing hypercementosis is by means of the Röntgen rays. The picture thus obtained, if made by an experienced operator, brings out the outlines of the teeth and the position and size of their roots in such a clearly defined manner that the diagnosis of hypercementosis, if it existed, could not help but be correctly made.

It is not necessary for the dental surgeon to go to the expense of buying apparatus for this purpose, for all large cities, and nearly all first-class hospitals, have such facilities for diagnosis and expert attendants ready to photograph any part of the body that may be desired, and thus relieve the dental adviser of all anxiety as to obtaining a good picture, or of the fear of accidents which sometimes come as a result of oft-repeated or long exposure to the effects of the Crookes tube.

Treatment.—The only treatment to be recommended for hypercementosis is the immediate extraction of the diseased tooth as soon as the diagnosis is assured. Immediate relief is not always obtained, but usually, even in the severest forms of *tic douloureux* dependent upon this cause, the pain will abate after a few days. Functional affections of the eyes and ears which have hypercementosis as their cause, rapidly improve after the extraction of the tooth. In the general nervous affections dependent upon the same cause equally favorable results follow.

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* Dental Surgery, 4th edition, p. 471.

CHAPTER XXXVI.

NECROSIS OF THE TEETH.

Definition.—The term necrosis (Greek, νεκρός, *dead*) is generally used in its broadest sense to indicate death in any form, whether death of individual cells, aggregations of cells, or masses of complex tissues.

In its more restricted sense it is used to indicate death of tissue *en masse*, while the term *necrobiosis* is used to indicate death of cells. In surgery the term necrosis is still farther restricted, and is generally applied to death *en masse* of bone and like hard structures, while the term *gangrene* is applied to death *en masse* of soft tissues.

The term necrosis would therefore, when applied to the teeth, indicate death *en masse* of these organs.

The teeth receive their blood-supply and nutrition from two sources,—viz., from the pulp and from the peridental membrane. The character of the teeth is such that the vitality of the pulp of a diseased tooth may be destroyed and the tooth still retained in the jaw for an indefinite period, through its organic connection with the alveolus, by means of the cementum and the pericementum. If, however, the vitality of the pericementum is destroyed, the tooth has no further vital connection with the alveolus, for under such circumstances the same cause which destroyed the pericementum will also destroy the pulp, when the tooth may be termed necrosed, and it is exfoliated as a foreign body. Nature is always intolerant of any useless or dead member and immediately sets in operation certain forces to rid itself of the incubus. The expulsion or exfoliation of a necrosed tooth is attended with more or less local inflammation and suppuration of the surrounding parts, the integrity of which will depend upon the cause of the necrosis and the condition of the surrounding tissues.

When death of the pulp occurs a partial necrosis of the dentin follows, but this from the clinic stand-point does not mean the loss of the tooth, for such teeth, if properly treated by extirpating the devitalized pulp and filling the canals, may remain without untoward symptoms as useful members of the dental arch for many years, though they are not as valuable nor generally so long preserved as teeth with vital pulps. The probabilities are that the dentin may still receive under such circumstances a certain amount of nutrition through the cementum and the granular layer of Purkinje. This, however, is not endorsed by some authorities. A tooth which has lost the vitality of its pulp is, therefore, strictly speaking, in a state of partial necrosis. Some authorities have maintained that in certain debilitated conditions of the pericementum the devitalization of the pulp would prove helpful in establishing more normal conditions in it by diverting the blood, which was originally intended to supply the pulp, to the vessels of the pericementum. It is somewhat doubtful whether the vessels of the pericementum could carry the extra supply of blood without producing an abnormal hyperæmia, and thus defeat the very object that the operation was intended to secure.

Necrosis of the cementum is due to the destruction of the pericementum, as this membrane is its principal means of nutrition during the vitality of the tooth and its only means after the devitalization of the pulp. Necrosis of the cementum may be *partial* or *complete*. Partial necrosis of the cementum is common, but complete necrosis is rare.

Causes.—The causes of necrosis may be divided into systemic, or general, and local; predisposing and exciting.

The *general predisposing* causes are all those conditions which in any way produce debility or disease of the pericementum, while the exciting systemic causes may be such diseases as syphilis, scurvy, mercurialism, iodism, etc.

The *predisposing local causes* are malocclusions, loss of occlusion, local inflammatory conditions of the gums and alveolar process, and death of the pulp.

The *local exciting causes* may be mechanic irritants, like cervical salivary deposits or a rubber band which has been placed upon the crown of the tooth and has been lost beneath the gum; the pressure from an ill-fitting crown, clasp, or plate; root fillings which have passed the apical canal and impinge upon the apical tissues; chemic irritants like arsenic, chromic acid, and caustic potash; septic conditions arising from a devitalized pulp or from unhygienic conditions of the mouth; phagedenic and gouty pericementitis, and severe traumatisms like blows and falls or the too rapid movement of the teeth in regulating.

Partial necrosis of the cementum may vary in extent from a very small area at the apex of a single-rooted tooth to an entire root of a double- or treble-rooted tooth. The cementum is rarely necrosed in teeth having vital pulps, as is evidenced by the fact that in the recession of the pericementum, gum, and alveolus, which sometimes occurs from diseases affecting these tissues, the cementum usually maintains its sensitiveness and responds vigorously to all forms of irritation whenever the influences of these agents are brought to bear upon it. Necrosis of the cementum, either in part or in whole, is therefore dependent upon death of the pulp and upon partial or complete destruction of the peridental membrane.

The most common form of partial necrosis is that which occurs at the apex of the root following alveolar abscess.

In these cases the apex of the root is denuded of its pericementum by the septic inflammation which has been present in the apical space and the denuded portions bathed in pus for a considerable period. This necrosed tissue, however, when not too extensive, may, if the septic conditions are removed, be resorbed, and later a redeposition of cement tissue take place as described in the chapter on "Resorption of the Teeth."

Another but less common form of partial necrosis of the cementum is that in which an entire root of a multirooted tooth, most often the lingual root of the superior molars, may be entirely divested from the cervix to the apex of its pericemental membrane, alveolar process, and gum, or the gum and alveolar process may remain intact.

Such conditions usually occur in pulpless teeth, but occasionally the pulp in the exposed root only will be dead, while in the others it may still be vital and the tooth firmly held in place by the attachment of the buccal roots. If under such circumstances the tooth is opened, the living portions of the pulp devitalized and extirpated, and the root-canals filled, the lingual root may be amputated with engine burs or disks and the balance of the tooth allowed to remain. Teeth treated in this manner have been known to do good service for several years.

Complete necrosis of the cementum may be caused by acute or chronic inflammatory conditions of the pericementum which may be dependent upon general or local conditions.

When complete necrosis of the cementum has occurred as the result of an acute inflammation of the pericementum, the tooth is no longer tolerated by the system, but becomes as a foreign body and is speedily expelled. Under these circumstances the tooth is in a septic condition, and the inflammatory process which is established as a result of septic irritation is often very active, causing great pain, suppuration and discharge of pus at the cervix, considerable tenderness and swelling of the gums and surrounding tissues, and looseness of the tooth, which after a few days or weeks is either picked out with the fingers or drops out.

When complete necrosis occurs as a result of a chronic inflammation, the process of expulsion is usually very slow, chronic suppuration, looseness of the tooth, and periodical soreness being the chief symptoms, and several months or years may be required for its complete exfoliation. Fig. 611 shows a superior central incisor which was completely necrosed and expelled as a result of chronic inflammation induced by drilling through the side of the root and of the protrusion through the opening of a gutta-percha filling. The root is slightly eroded upon the labial surface by the action of the odontoclasts, and a thin scale of calcic concretion has formed upon the lingual surface. Fig. 612 is a crowned superior central incisor which had lost its natural crown by a traumatism while the lad was playing ball. The root had been filled with cotton and the crown set with cement. For several years the tooth had been loose, and was finally extracted with the fingers. Extensive resorption had taken place at the apex, exposing the apical end of the cotton filling.

Fig. 613 is a transplanted superior central incisor which had been crowned before transplanting. For six years the tooth did well, when suddenly it became very sore and loose, and was expelled after a few weeks. On the distal surface at the cervix is a depression caused by resorption which has penetrated to the pulp-canal, exposing the cement with which it was filled. Fig. 614, a necrosed superior cuspid, was the seat of a chronic abscess for many years; the tooth finally became so loose that it was extracted with the fingers; it shows extensive resorption at the apex.

In cases of complete necrosis of the cementum the only treatment is extraction.

FIG. 611.

FIG. 612.

FIG. 613.

FIG. 614.

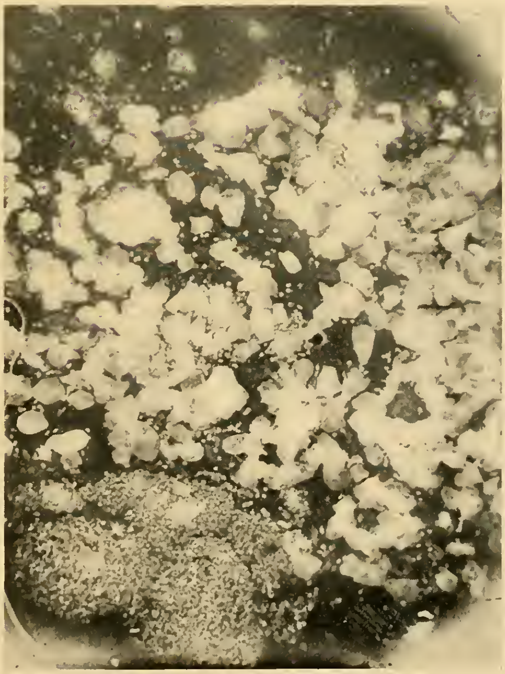


FIG. 615.—Epithelial scales and salivary corpuscles from sordes of the mouth. × 50.

CHAPTER XXXVII.

DEPOSITS UPON THE TEETH. GREEN STAINS. CALCIC DEPOSITS.

Green Stains.—The simplest deposits that are found upon the teeth are the green stains so common at the margin of the gums upon the anterior teeth of children and young people and persons of adult age who pay little attention to the cleanliness of their mouths.

These deposits are probably formed by the growth of the leptothrix buccalis and certain forms of chromogenic mouth-bacteria which have attached themselves to remains of Nasmyth's membrane or a roughened surface of the enamel.

Their continued presence causes a softening and disintegration of the polished surface of the enamel. which leads to decay. It is, therefore, important that they should be removed early, and if the enamel has become eroded it should be ground smooth with fine Arkansas stones and polished with fine pumice and precipitated chalk.

Calcic Deposits.—The calcic deposits which are formed upon the teeth are classed as salivary and serumal, or as "*ptyalogenic*" and "*hematogenic*" (Pierce). The first are formed from the calcic elements of the saliva, the second from the calcic elements of the blood, combined with certain waste or end-products formed from imperfect metabolism.

The formation of *salivary deposits* is usually the result of local causes, but certain general conditions act as predisposing factors. The formation of *serumnal deposits* is largely the result of constitutional conditions, as, for instance, rheumatism and gout, febrile diseases, and certain kidney affections, like diabetes and albuminuria, which may produce local necrobiosis of the pericementum, terminating in pus formation or in caseous or calcic degeneration of the pus and the formation of adherent concretions.

The saliva of the human mouth always contains calcic salts in greater or less quantity. These salts are, under certain conditions, deposited upon the teeth or in the ducts of the glands in the form of concretions or calculi, which are more or less hard and mixed with epithelial scales, leptothrix, and food débris. The deposit or concretion thus formed upon the teeth is called *salivary calculus*, or "tartar," and the concretions formed within the salivary ducts are termed *salivary calculi.*

These deposits are found in greatest abundance upon the surfaces of those teeth which are situated opposite the ducts of the salivary glands,—viz., the buccal surfaces of the first and second superior molars, and the lingual surfaces of the inferior incisors and cuspids, and in those locations where the conformation of the teeth renders the deposits least liable to be disturbed,—viz., upon the proximate surfaces and crevices of the teeth beneath the free margins of the gums.

Composition of the Saliva.—The most important constituents of normal mixed saliva are *ptyalin*,—a diastatic ferment,—*mucin*, and the chlorides of sodium and potassium; in addition to these there are found traces of albumin, fat, *potassium sulphocyanide*, sulphates and phosphates of the alkalies and alkaline salts, principally *calcic phosphate*, also *calcic carbonate* and oxide of iron. Occasionally there are found also, even in normal saliva, traces of urea and ammonium nitrite.

The average daily amount of saliva excreted ranges from 800 to 1500 grammes, or from a little less than a quart to three pints. Tomes places it at from 13 ounces to 3½ pounds.

According to Lehmann, the specific gravity of the saliva ranges in health from 1004 to 1006. He states, however, that it may rise to 1008 or 1009 or even sink to 1002 without the evidence of any existing disease.

According to Berzelius, normal mixed saliva gives the following analysis:

Water	992.9
Solids	7.1
Ptyalin	2.9
Mucin	1.4
Sulphocyanide	1.4
Salts	1.9

According to Frerichs,—

Water	994.10
Solids	5.90
Epithelium and mucus	2.13
Fat	0.07
Mucin and traces of alcoholic extract	1.41
Potassium sulphocyanide	0.10
Chlorides of sodium and potassium, phosphates of sodium and potassium, and oxide of iron	2.19

According to Jacobowitsch,—

Water	99.51
Solids	0.49
Soluble organic bodies, ptyalin, etc	0.130
Epithelium	0.160
Inorganic salts	0.182
Potassium sulphocyanide	0.006
Potassium and sodium chloride	0.084

The saliva as found in the mouth is a mixed fluid, being composed of the secretions of the various salivary glands—parotid, submaxillary, and sublingual—and of the oral mucous glands, its chemic and physic properties varying as the secretion from one or the other of these glands may predominate. In character it is generally a clear viscid or glairy fluid, containing epithelial cells, mucous corpuscles, and salivary corpuscles. The character, however, often varies considerably; at times it may be a thin, watery fluid, at other times thick and ropy.

The chemic reaction of mixed saliva is slightly alkaline, but when the secretions are scanty it may give a very slightly acid reaction. Saliva tested in the mouth with litmus paper often gives an acid reaction; but this is many times due, no doubt, to the formation of acids within the mouth from the fermentative action of the acid-producing bacteria upon alimentary débris.

The *excretion of the parotid gland* contains a trifle more water and is less viscid than the secretions of sublingual and submaxillary glands; it contains ptyalin, but no mucin; its calcic constituents are the carbonate and phosphate, the calcium phosphate being in minute amount. According to Hoppe-Seyler, the inorganic elements amount to 0.34 per cent.

The *secretions of the sublingual and submaxillary* glands are poor in ptyalin but are rich in mucin; the sublingual contains the highest per cent. Carbonate and phosphate of calcium are found in about equal proportions. These elements amount to about 0.43 per cent. in the submaxillary secretion, but the percentage is not so high in the secretion of the sublingual.

The *secretion of the mucous glands* contains a large amount of mucin. The organic and inorganic constituents average about 20 parts to 1000.

The calcic substances of the saliva are held in solution by the presence of a sufficient quantity of carbon dioxide (CO_2). This combination, however, is so unstable, that as soon as the saliva is exposed to the oxygen of the atmosphere or to the acids of fermentation produced in the mouth, or is at rest, the carbon dioxide escapes, and the calcic elements, being no longer able to maintain solubility, are precipitated and collect upon the teeth, thus forming what is known as salivary calculus, or tartar.

It is necessary, however, that the enamel be roughened or uneven, or that leptothrix threads have found attachment to Nasmyth's membrane or the enamel, in order that a nidus be presented for the formation of the concretion.

The viscid tenacious character of the saliva, however, is sufficient to form a nidus for the collection of tartar upon the teeth when for any reason —but particularly in the continued fevers and other wasting diseases—the mucin becomes dried upon the teeth, forming masses of sordes. These masses of dried mucin contain innumerable epithelial scales and salivary corpuscles. See Fig. 615. It is possible, also, that the particles of the calcic deposit are held together by the agglutinating effect of the coagulated mucin.

Kirk, however, believes there is a more intimate relation between the organic substances and the calcic elements of the tartar than their mere cementing properties. He thinks conditions exist which are somewhat similar to those under which calcoglobulin is formed, and suggests that salivary calculi bear a family resemblance to calcoglobulin.

Salivary calculus is composed, according to Berzelius, of:

Phosphates of calcium and magnesium	79.0
Salivary mucus	12.5
Ptyalin	1.0
Animal matter soluble in HCl	7.5

According to Charles, its average composition is as follows :

Calcium phosphate	55 to 64
Calcium carbonate	7 to 8
Ferric phosphate	1 to 3
Residue : organic matter, salts of alkalies, silica, etc.	24 to 28

There is a wide difference in these two analyses, but this may possibly be explained by the difference in the location from which the specimens were probably taken.

It is but natural to suppose that, inasmuch as the parotid secretion contains an abundance of calcium carbonate and only a minute amount of calcium phosphate, the concretions formed upon the teeth opposite Steno's duct would be composed largely of calcium carbonate ; while, upon the other hand, the concretions formed upon the lower incisors opposite the ducts of Wharton would be composed equally of calcium carbonate and calcium phosphate, as the secretions of the sublingual and submaxillary glands contain about equal portions of these salts.

Magitot claimed that the salivary calculus formed in the region of the parotid glands was almost wholly carbonate, while that formed upon the inferior central incisors was largely phosphate.

Alfred Vergne claimed that the calculus formed upon the superior molar teeth had less phosphate than that upon the inferior incisors, but that the carbonate was about equally distributed.

Salivary calculi, or the concretions found in the ducts of the salivary glands, are usually composed largely of calcium phosphate. They are generally of an elongated form, dirty yellow to brown in color, and are formed in concentric layers. They contain no leptothrix, and vary in size, form, appearance, and composition.

The following table, prepared by Charles, gives the average composition :

Calcium phosphate	30 to 80 per cent.
Calcium carbonate	11 to 15 " "
Organic matter	5 to 12 " "

Magnesium oxide, iron oxide, sodium chloride, sulphates, and potassium sulphocyanide have all been found as components of salivary calculi.

Calculi composed largely of *uric acid* have been found in the salivary ducts of individuals suffering from the uric-acid diathesis.

Varieties.—It has been customary among the earlier writers to classify the varieties of salivary calculus, or tartar, according to its color and density, as though the difference in these respects was a sufficient ground for designating it as a separate variety.

Salivary calculus varies in color from light yellow to black, and between these extremes it may present any shade of green or brown. In physical characteristics it may be soft or hard, brittle or coherent, but neither of these features or characteristics is of sufficient importance, either from a pathologic or a clinic stand-point, to form the foundation of a classification. All of the differences in color may be readily accounted for by the fact that the micro-organisms of the mouth are capable, through their chromogenic function, of imparting to the deposits any shade of these colors; while, upon the other hand, the ingestion of certain kinds of food and of medicines and the use of tobacco, either chewing or smoking, will also produce a change in the color of the concretions. Smoking produces a black color of the tartar, but time and the action of the micro-organisms will, as in caries, produce similar dark colors.

The physical characteristics are likewise governed by the element of time. Tartar that is freshly deposited is soft and yellowish-white in color, and so chalky in its nature that the slightest effort is sufficient to dislodge it in bulk; while that which has been deposited for a much longer time will be hard and brown or black in color, and require considerable force to dislodge it. The older the deposit becomes the darker will be its color. Its density, brittleness, and coherent qualities are also dependent upon the element of time for these characteristics.

Salivary calculus is formed most rapidly in a saliva which gives an alkaline reaction; while if the secretions are acid, salivary calculus not only does not form, but if the reaction is decidedly acid, the tartar already formed upon the teeth may be dissolved and removed.

Clinically there are three forms of salivary calculus:

1. That which is formed upon the surfaces of the crowns of the teeth, —*supergingival deposits*.

2. That which is formed in isolated islands, or as a narrow band at the cervices of the teeth, beneath the margin of the gums,—*cervical deposits*.

3. That which is formed in thin scales upon the sides of the root in open pockets more or less remote from the margins of the gums,—*subgingival deposits*.

The first variety, or *supergingival deposits*, of salivary calculus is found upon the crowns of the teeth. It may be soft and friable or hard and brittle, according to the length of time which has been consumed in forming the deposit. Its color is usually a dirty white or yellow, but it may be any shade of green, brown, or black, according to the length of time it has been forming, the especial chromogenic bacteria present in the mouth, and the habits of the individual. This variety of tartar is clinically the most common, as well as the least harmful. It frequently accumulates in great quantities, particularly upon those teeth which are directly opposite the salivary ducts. Sometimes the crowns of these teeth become completely covered with the deposits, so that the semblance of the tooth is lost. Figs. 616, 617, 618, and 619 show examples of such cases.

Teeth which stand out of the normal line, particularly when located inside of the arch and in the lower jaw, are most often covered with such deposits; such teeth may become so encrusted with the calcic material as to give them the appearance of necrosed and denuded bone. Such errors in diagnosis have been made, and serious surgical operations undertaken for the relief of a bone disease, which might have been prevented by counting the teeth upon that side of the jaw and searching for the missing ones which could not be accounted for by extraction or otherwise.

The writer well remembers such a case, in which he was acting as consultant. The tumor was situated upon the left side of the lower jaw, upon the floor of the mouth, in the region of the second bicuspid, which upon examination was found missing. All of the other teeth were in normal position. The tumor was about the size of a pecan-nut and had the appearance of necrosed bone, but the sensation conveyed by scratching it with a steel instrument was so different from that of dead bone that the writer was led to believe from this fact, and also from its location, which was directly beneath where the missing bicuspid should be, that the tumor was nothing more than the missing tooth, the crown of which was encased in salivary calculus. The diagnosis was proved by splitting the calculus with a chisel and mallet, when the halves fell apart, exposing the crown of the missing bicuspid tooth.

The rapid formation of salivary calculus is indicative of a disturbance in the equilibrium of the metabolic process of tissue waste and repair, or, in other words, constructive or synthetic metabolism is not keeping pace with that of the destructive process. The breath and the saliva under such circumstances have a foul and disgusting odor. The odor left upon the fingers of the operator when they have been in contact with such an offensive saliva is very disagreeable, indeed, and often requires repeated bathing in antiseptic and deodorant solutions before it is entirely removed.

The greatest care should be exercised in sterilizing the hands and the instruments used in the treatment of such cases, as the saliva is loaded with myriads of micro-organisms, often of the most virulent varieties.

Salivary calculus of the *first variety* often presents a distinct lamination which conforms to the outline of the surface upon which it was deposited.

The *pathologic effect* of salivary calculus deposited upon the crowns of the teeth will depend upon the *amount* and the *locality* of the deposit. When occurring in small quantity it seems to be entirely harmless,—in fact, it seems sometimes, when deposited upon a tooth with a carious defect, that it retards or entirely arrests the progress of the caries; many cases have been seen in which the carious cavity has been filled with salivary calculus and the disease completely arrested. It must be remembered, however, that the conditions which favor the formation of salivary calculus do not favor the progress of dental caries. An alkaline condition of the saliva promotes the deposition of calcic material and retards dental caries, while an acid condition of the salivary secretions favors the progress of caries and retards or altogether prevents the accumulation of salivary calculus.

When tartar of the first variety, or *supergingival deposit*, accumulates in large masses and impinges upon the gums, it acts as a mechanic irritant, and produces ulceration of this tissue, resorption of the alveolar plate, and recession of the gums. The accumulations may be so extensive in certain localities as entirely to cover the teeth and to unite them into a solid mass. Such accumulations have been known to involve the six anterior inferior teeth to such an extent as completely to destroy their attachment to the jaw and cause them to be exfoliated like a mass of necrosed bone.

The second variety, or *cervical deposit* of salivary calculus, is found

Fig. 616.—Salivary calculus.

Fig. 617.—Salivary calculus.

Fig. 618.—Salivary calculus.

Fig. 619.—Salivary calculus.

Fig. 620.—Glands of Serres. × 50.

upon the cervices of the teeth in the form of isolated islands, usually upon the lingual surface or in the form of a narrow band directly beneath the free margins of the gums. It is generally dark green or brown in color, very hard, brittle, and tenacious, requiring in some instances considerable force to dislodge it. This variety of calculus is most often found in the mouths of robust individuals, in those who live high, and those with rheumatic and gouty tendencies.

The *pathologic effect* of this variety of calculus is to establish a low grade of chronic inflammation of the gums, ulceration of the gingival margins, resorption or necrosis of the margins of the alveoli, and recession of the gums. These conditions are the result of the mechanic irritation produced by the impingement of the calculus upon the margins of the gums and the pericementum.

Acute inflammatory symptoms are rarely presented in this form of salivary calculus unless some traumatic injury has occurred to severely lacerate the gums, as by an unusual, vigorous use of the toothbrush or masticating hard substances. Such an inflammation may sometimes become degenerative and involve the gums of both jaws and extend to the hard palate, producing an obstinate ulcerative stomatitis.

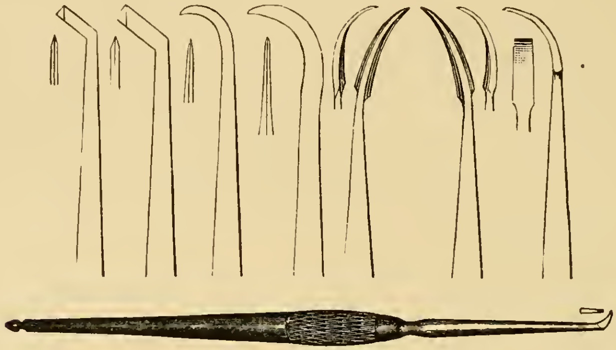
The presence of these concretions rarely produces a diffuse inflammation of the pericementum. The inflammation is usually confined to that location which is the direct seat of the irritation,—viz., the margins of the gum and the pericementum. These tissues are gradually destroyed by the encroachment of the deposit and the consequent inflammation and ulceration produced by their presence.

This variety of salivary deposit seems to accumulate most rapidly after a chronic inflammatory process has been established in the free margins of the gums. This led Serres and some other pathologists to the supposition that the glandular structures of the gums (glands of Serres, Fig. 620) were instrumental in causing the formation of the deposits. This question has, however, not been satisfactorily settled. The general opinion seems to be, however, that the deposits come directly from the salivary secretions, and that the inflammatory conditions of the gingivæ resulting from the mechanic irritation present in some way—perhaps through certain products of the decomposition of tissue, NH_3 and H_2S—more favorable conditions for the deposition of the calcic material found in the saliva than would be the case under other circumstances, hence its more rapid accumulation.

The third variety, or *subgingival* deposit, is that which is found in thin scales upon the sides of the roots of the teeth in open pockets more or less remote from the free margins of the gums. This form of deposit and its effect upon the pericementum and the surrounding tissues will be discussed in the chapter on pyorrhœa alveolaris.

Treatment.—The treatment of the *supergingival deposits*, or ordinary form of salivary calculus, and of the *cervical variety* consists in removing the concretions from the surfaces of the teeth by the aid of various instruments known as scalers. These instruments are made with suitable curves and angles adapted to reach every portion of the various surfaces of the tooth-crown, while the blades are of such form and temper that the edges can be kept sharp. Fig. 621 illustrates a few of the most useful shapes employed for this operation. Some of these instruments are intended to

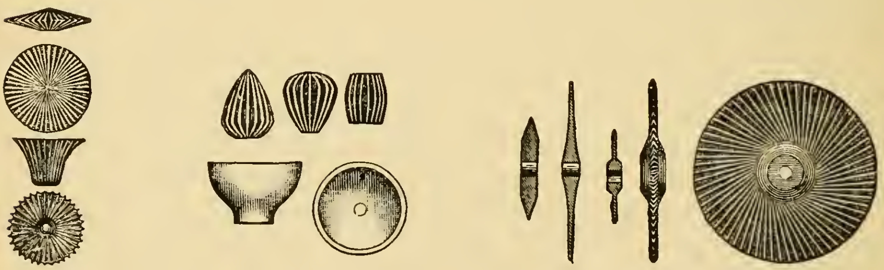
Fig. 621.



Small scalers.

be used as chisels, others as hoes or scrapers. The operation consists of first scaling or scraping away the accumulated mass of calculus, and afterwards thoroughly polishing the exposed surfaces of the teeth with pulverized pumice. This part of the operation may be done with any orange-

Fig. 622.



wood wedge-stick flattened at one end or by variously shaped rubber disks, wheels, and cups, or with small brushes, as shown in Figs. 622 and 623, used in the dental engine.

Fig. 623.

After the concretions have all been removed, the mouth should be thoroughly irrigated with a soothing antiseptic mouth-wash, like listerine, pasteurine, borolyptol, etc., followed by the spray from an atomizer charged with the same solution, which should be directed into the interdental spaces to make sure that all loose particles of calculus are removed from between the teeth and from beneath the margins of the gums. Finally, to relieve any inflammation that may be present and to promote the healing of the gums, they may be painted with a combination of the tinctures of iodine and aconite in equal parts.

The prevention of the further accumulation of salivary calculus will depend largely upon the time which the individual is willing to give to the cleansing of the teeth. Thorough brushing of the teeth after each meal with a suitable dentifrice and the judicious use of floss-silk and tooth-picks will usually prevent the further accumulation of deposits upon all accessible surfaces. The prevention, therefore, of the accumulation of salivary deposits sums itself up into the question of cleanliness. Many refined people who are extremely neat in every other respect often present mouths which are positively disgusting to behold, but whose sense of refinement would be greatly shocked if they were told that their mouths and teeth were in a very filthy condition, and that they carried about in their oral cavities conditions which were more fatal to good health than the presence of sewer gas in their dwellings.

CHAPTER XXXVIII.

PYORRHŒA ALVEOLARIS.

Definition.—Pyorrhœa (Greek πύον, *pus;* ῥοία, *a flow*). A purulent discharge. Alveolaris (Latin, a small hollow). Pertaining to the alveoli, or the sockets of the teeth. The term, therefore, means a flow of pus from the alveolus of a tooth. But as this is a symptom of several other diseases which involve the same tissues,—viz., alveolar abscess, traumatic pericementitis, scorbutic pericementitis, mercurial pericementitis, etc.,—the term does not seem to be well selected to express the characteristic pathologic features of the disease. The term pyorrhœa alveolaris has, however, been quite generally adopted by the profession, and for that reason it is perhaps better to retain it, although several others have been suggested which are more appropriate, as they convey a better idea of the true nature of the disease.

Synonymes.—Riggs's disease, suppuration conjointe, pyorrhœa inter-alveolar-dentaire, gingivitis expulsiva, osteo-periostiti-alveolo-dentaire, pyorrhœa alveolo, caries alveolaire specifica, cemento-periostitis, infectoso-alveolitis, periostitis dentalis, periostitis-alveolo-dentalis, calcic pericementitis, phagedenic pericementitis, gouty pericementitis, ptyalogenic calcic pericementitis, hæmatogenic calcic pericementitis, blennorrhœa alveolaris, interstitial gingivitis.

The various terms or synonymes which have been applied to this affection express in a certain sense the views held by the writers who have suggested them, as to the nature of the disease.

Pyorrhœa alveolaris is a disease which *primarily* affects the *pericementum*, manifesting itself in a suppurative inflammation, sometimes acute in form, but generally of a chronic type; and, *secondarily*, the inflammatory process involves the walls of the *alveolus* and the *gum*. This process is accompanied by loosening and turning or extrusion of the teeth, a discharge of pus from the alveolus, gradual disintegration of the alveolar process (caries), recession of the gums, and finally the tooth loses its alveolar and gingival connection and falls out.

Upon the loss of the tooth the inflammatory symptoms immediately subside, which proves conclusively that the local manifestations of the disease are primarily associated with the dental tissues, and not with the gingivæ or the alveolar processes.

Witzel and others have maintained, however, that the disease was primarily located in the alveolar border, and that the gum and pericementum were involved as a secondary feature of the disease.

Pyorrhœa alveolaris, next to the subject of dental caries, has attracted more attention from dental surgeons than any other affection of the human mouth. It has been thought to be a disease of modern origin and a result of the sins of our modern civilization; but a visit to the ethnologic departments of our large museums will convince any one that the disease is not confined to modern times nor to higher civilization, but that in all probability it is as old as the human race. Evidences of the disease are to be seen alike in ancient and modern skulls, in the skulls of aboriginal tribes, and also in those of barbarous, semi-civilized, and civilized nations. On the other hand, however, there seems to be some reason for believing the disease to be on the increase among civilized nations of the present day. Whether this is a fact or not remains yet to be proven. Statistics are necessary to establish such a fact, and these have not been gathered. This statement, however, seems quite true,—viz., the dental surgeon is called upon to treat more and more of these cases every year. Perhaps this is due to his better general knowledge of the disease, and to his ability to recognize its clinic aspects and manifestations not only in the fully developed disease but in its incipient stages; or it may be possible that the disease is sometimes confounded with other affections which present somewhat similar symptoms and pathologic features. It is no uncommon thing for a chronic alveolar abscess which is discharging through the alveolus to be mistaken in a hasty examination for a case of pyorrhœa alveolaris, and *vice versa*. It therefore becomes exceedingly important that every examination should be made with the utmost care and precision, that errors in diagnosis may be avoided.

Causes.—A wide difference of opinion exists among pathologists and dental practitioners in reference to the etiology of this disease. So much interest has been taken in the study of this subject in recent years that the literature upon the etiology of the disease has become quite voluminous, and nearly as confusing. The writer has found, however, that after a careful review of the literature these opinions can all be grouped under four heads:

1. That the disease originates in some *constitutional state* or *dyscrasia*.
2. That the disease is caused entirely by *local irritation and environment*.
3. That the disease is due to the *infection of the tissues with micro-organisms*.
4. That the disease is induced by *deficient exercise* of the teeth, gums, and alveolar process.

Constitutional Origin of the Disease.—Fauchard (1746)* was the first to call attention to the disease and record its essential clinical features, but offered no opinion as to the origin of the disease, neither did he designate it by any specific term.

Jourdain (1778)† published a communication describing the disease, and made the suggestion that it was of scorbutic origin, and termed it in its later stages "*conjoined suppuration*," because it is then complicated with a purulent discharge from between the margins of the gums and the cervices of the teeth and a gradual destruction of the alveolar processes.

Toirac (1822),‡ in his communication upon the disease, termed it "pyorrhœa-inter-alveolo-dentaire," but failed to offer an opinion upon the origin of the disease.

* Independent Dental Journal, 1875.

† Philadelphia Journal of Medical and Physical Sciences, 1821.

‡ Journal of the American Medical Association, 1879.

Bell (1829)* described the disease in all of its clinical features, and divided the affection into two distinct forms, one dependent upon the *formation of deposits* upon the teeth, the other caused by a *constitutional condition* which may be looked upon as a sort of premature old age. He says, "In forming a judgment upon cases of this description, however, and even upon those in which the loss of substance is associated with more or less of diseased action, it is necessary to recollect that the teeth are generally removed in old age by this identical mode,—namely, the destruction of their support by the absorption of the gums and the alveolar processes; and as this step towards general decay commences at very different periods in different constitutions, it may doubtless in many cases, even in persons not past the middle period of life, be considered as an indication of a sort of premature old age, or an anticipation, at least, of *senile decay*, as far as regards these parts of the body."

Harris (1853) † termed the disease a "*chronic inflammation of the gums*," dependent upon morbid constitutional conditions as predisposing causes, such as "bilious and inflammatory fevers, the excessive use of mercurial medicines, the venereal virus, intemperance, and debauchery; while any deterioration of the fluids of the body is peculiarly conducive to it. Persons of cachectic habit are far more subject to it, and generally in the worst forms, than those individuals in the enjoyment of good health." As immediate or exciting causes he mentions the "local irritation of salivary calculus, carious, dead, loose, or aching teeth or roots of teeth, or teeth which occupy a wrong position or that are crowded in their arrangement."

Marechal de Calvi (1860) ‡ looked upon the disease as an hereditary constitutional disorder, and termed it gingivitis expulsiva.

Magitot (1867),§ in his admirable paper upon the nature of the disease, describes it as a slow but progressive inflammation causing the destruction of the periosteal membrane and the cementum, which begins at the cervix and extends to the apex of the root, and involves the loss of the tooth. The term by which he designated the disease was "osteo-periostiti-alveolo-dentaire," as this was the exact seat of the disease. He believed the disease was primarily located in the pericementum, and that soon after the appearance of the inflammation in the membrane the gums and osseous walls of the alveolus became involved, but that the disease was never primarily located in those latter tissues.

He viewed the causes of this peculiar inflammation as very complex. In his opinion the origin of the disease lay in a faulty general nutrition. Persons of a gouty and rheumatic diathesis furnished the greatest number of cases, but it was also very common in individuals suffering from diabetes mellitus, albuminuria, and anæmia.

The formation of calcic deposits upon the teeth he regarded as purely accidental and playing no important part in the etiology of the disease. He

* Anatomy, Physiology, and Diseases of the Teeth.

† Dental Surgery.

‡ Journal of the American Medical Association, 1897.

§ Études et Expériences sur la Salive, Paris.

advised, however, as an indispensable preliminary to any form of treatment, the thorough removal of all concretions upon the roots of the teeth.

Wedl (1870),* in describing the disease, says, "That portion of the root-membrane which is in relation with the submucous connective tissue of the gums appears to be attacked secondarily in most cases, in consequence of the extension of the disease, either from the enclosed extremity of the root-membrane or from the inflamed gums. In these cases the gum becomes detached from the neck of the tooth, and pressure upon the alveolus forces out a puriform fluid. This condition results, without notable pain, in the loss of the affected tooth." In reference to the causation of the disease he says, "In these cases, then, we have to do, first of all, with a catarrhal inflammation of the gum, which afterwards extends to the root-membrane."

Brown (1870) † was the first to suggest that the disorder was due to the formation of certain deposits upon the roots of the teeth, which were derived from the serum of the blood, and which he denominated *serumal calculus*.

Salter (1875) ‡ denominates the disease "*false scurvy*," and believes it is more or less the manifestation of constitutional vice, being frequently associated with chronic dyspepsia and general ill-health, and as a result in females of frequent pregnancies. Certain drugs, like mercury and iodide of potassium, when given to excess have the power of producing the disease.

Sirlette (1876),§ in discussing the etiology and pathology of this disorder, stated that he regarded the disease as due to certain constitutional conditions, such as rheumatism, scrofula, syphilis, diabetes mellitus, albuminuria, etc., but that certain local conditions acted as exciting factors. He denominated the affection "periostitis-alveolo-dentalis."

Taft (1876) || regarded pyorrhœa alveolaris as arising from a general disorder of health, and unless the general state of the health was improved, local treatment would be of no avail.

Rehwinkle (1877),¶ in a paper upon the "Causes and Treatment of Pyorrhœa Alveolaris," says the origin of the disease can often be traced to the action of mercury, and in other cases to constitutional and inherited predisposition, while it often exists independently of foreign deposits and in the cleanest of mouths.

Davis (1879),** in a paper on "Gum and Alveolar Diseases," says he is unable to account for the phenomena of Riggs's disease, except upon the hypothesis of atrophy of the peridental membrane or of the external fibrous covering of the alveolus, while the deposits which are found upon the roots of the teeth are an accidental sequence, and not a cause of the disease.

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* Pathology of the Teeth.

† American Journal of Dental Science.

‡ Dental Pathology and Surgery.

§ Gazzetta Medica di Roma, 1876.

|| Operative Dentistry.

¶ Dental Cosmos vol. xix.

** Ibid.

Cowles (1879),* in a discussion upon the subject of "Riggs's Disease," said, "Wedging is a great producer of this difficulty, and therefore I am opposed to wedging, but a more general cause than all others is the lack of nutrition in the parts."

Essig (1879) † expressed the opinion that the primary cause was probably systemic; that it usually makes its appearance in mouths which were remarkable for an almost complete immunity from dental caries; and this fact has led to the assumption that such evident power of resisting the usual causes of decay until middle life implies extreme density and low degree of vitality in the structure of the teeth, resulting in a final severance between them and the more highly vitalized contiguous parts, thus constituting a predisposing cause of a disease liable to be developed by an accretion of calculus or other excitant. The disorder, he thinks, is a local manifestation of a constitutional cause, and the calcareous deposit merely an accident of opportunity.

Serran (1880) ‡ believed that the primary manifestation was a local congestion of the gums, followed by an inflammatory exudation in the peridental membrane, loss of vitality in the structure, the formation of pus, and all of the other symptoms and pathologic features which are characteristic of the disorder. He recognized the fact, however, that the disease was most common in the middle period of life, and that individuals suffering from gout, rheumatism, diabetes mellitus, and albuminuria furnished the principal number of cases. These statements were in certain respects in opposition to the views expressed by Magitot in 1867 relative to the tissues which were primarily involved in the disease.

A commission appointed by the Société de Chirurgie to consider the statements of Serran denied the gingival origin of the disease, and substantially upheld the views of Magitot.

Mills (1880) § claimed that the cause was systemic, and the deposit only a local manifestation. He believed, also, that age was not the only factor in the production of the disease, but that various influences, physical and mental, were often powerful abettors of the disease. Conditions of nervous exhaustion may exist at certain periods of life, permitting the local expression of a disease which altered circumstances in after-life may radically modify. In his opinion the disease not infrequently appeared in the mouths of youths, generally as a sequence of one of the eruptive fevers.

Atkinson (1881) ‖ was of the opinion that the disease was of constitutional origin, the result of nervous debility or original defective innervation, and the deposit a sequence of the disorder, but never the cause.

Coles (1881) ¶ was of the opinion that certain systemic conditions acted as predisposing causes, and micro-organisms as local exciting causes.

Ingersoll (1881),** in a paper upon "Sanguinary Calculus," maintained

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* Dental Cosmos, vol. xxi.

† Ibid., vols. xxii., xxiii.

‡ Bulletins et Mémoires de la Société de Chirurgie, tome vi. p. 411.

§ Dental Cosmos, vol. xxiii.

‖ Ibid.

¶ International Medical Congress, 1881.

** Ohio Dental Journal, 1881.

that certain concretions were formed upon the roots of teeth which could not be derived from the saliva, as they were formed near the apex of the root, and under circumstances which made it impossible that they could be of salivary origin. This form of calculus contained a dark coloring matter, and was always found in connection with ulceration and a discharge of pus. The liquor sanguinis contained the lime-salts in solution, and these were crystallized and deposited upon the roots of the teeth.

As this form of concretion could not have come from the saliva, he concluded that it must have come from the blood, and he therefore termed it *sanguinary calculus.*

This opinion is very similar to that expressed by Brown in 1870, which has already been quoted.

Rawls (1885) * believed the causes were primarily of systemic origin, as expressed in inherited and acquired tendencies, habits, and environment. Malarial fever, mercurial ptyalism, etc., and the excessive use of sodium chloride were all important factors in the production of the disease.

Reese (1886) † was of the opinion that the disease was due to the presence of the uric acid diathesis resulting from the abuse of alcoholic stimulants.

Patterson (1886) ‡ revived the theory of Wedl that the disease was due to a catarrhal condition of the oral mucous membrane and the gingivæ (oral catarrh). Patterson also believed that pyorrhœa alveolaris, like catarrh, was contagious, and sometimes even epidemic.

Farrar (1886) § looked upon the disease as being the result of a combination of systemic conditions and tendencies and local irritants, and held that there was a peculiar systemic condition associated with hypersecretion and an increased amount of earthy deposits.

Starr (1886) || regarded the disease as due to certain systemic conditions and tendencies, and associated with some undetermined local irritating factor. He was of the opinion that this local factor was the same as that which caused hypercementosis. He also stated that in his experience a majority of the teeth affected with pyorrhœa alveolaris were found in the upper jaw.

Sudduth (1887) ¶ expressed the opinion that pyorrhœa alveolaris was a sequel, or rather the secondary stage, of a disease which had its inception in a catarrhal stomatitis. In fact, he thinks he is justified in classing the disease as a localized catarrhal stomatitis which is dependent upon hereditary dyscrasia for its constitutional factor. The disease may be either acute or chronic.

Sutton (1887) ** regards the disease as undoubtedly of constitutional origin, as expressed in gout, rheumatism, mollities ossium, and other wasting diseases.

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* Dental Cosmos, vol. xxvii.
† Transactions of the Louisiana State Dental Society, 1886.
‡ Dental Cosmos, vol. xxvii.
§ Independent Practitioner, vol. vii. || Ibid.
¶ Sajous's Annual, 1888, vol. iii.
** Dental Record, 1887.

Marshall (1891)* expressed the opinion that in many cases the origin of the disease could be traced to the rheumatic and gouty diathesis, and that the deposition of the concretions upon the roots of the teeth in those localities not easily reached by the saliva, or in which the presence of the saliva would be an impossibility, is due to the same cause which produces the chalky formations found in the joints and fibrous tissue of gouty and rheumatic individuals, and suggested that these deposits were formed of urates of lime and soda.

Pierce (1892, 1894, and 1895)† in a series of papers presented a number of clinic and pathologic facts which in their totality seemed to establish the kinship between pyorrhœa alveolaris, or hematogenic calcic pericementitis, and the systemic condition generally recognized as the gouty or uric acid diathesis.

Darby (1894)‡ strongly upheld the theory of the constitutional origin of the disorder, and ascribed it to the uric acid diathesis.

Burchard (1895)§ believed the disease to be due to constitutional and local predisposing causes and to local exciting causes. Among the constitutional predisposing causes he mentions hereditary influences, particularly arthritic diseases and the diseases of suboxidation and faulty elimination; among the local predisposing causes are overuse, disuse, and misuse of the teeth. These also often act as direct exciting causes. Subgingival deposits also act as exciting causes.

C. H. Tomes (1897)|| regards the causes and pathology of the disease as very obscure. There is much to support the idea that a constitutional cause is at the bottom of it,—for instance, it usually occurs with some near approach to bilateral symmetry, and the teeth first affected are often not those most liable to the deposit of tartar,—while he assigns to tartar a merely secondary influence in the progress of the disease which comes into operation only after the mischief has begun.

He does not, however, subscribe to the uric acid theory.

Harlan (1898)¶ regarded the disease as being largely influenced by heredity and acquired conditions, deposits acting as exciting causes.

Rhein (1899)** divides the disease into *pyorrhœa simplex* and *pyorrhœa complex*. The former he believes is caused entirely by local irritants, the latter by constitutional conditions, such as malnutrition, improper elimination, uric acid diathesis, etc.

Kirk (1899),†† recognizing the constitutional origin of the disease, says, "It is to the class of non-bacterial inflammatory tissue reactions that phagedenic pericementitis in its earlier stages belongs, and that the toxic irritant is the group of alloxuric bodies which, like their congener uric

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* Transactions of the American Medical Association, 1891.

† International Dental Journal, vols. xiii., xv., xvi.

‡ Ibid., vol. xv.

§ Dental Pathology, Therapeutics, etc.

|| Dental Surgery.

¶ Dental Cosmos, vol. xl.

** Dental Review, 1899.

†† International Dental Journal, vol. xx.

acid, are waste products of nitrogenous metabolism, and as a result of improper elimination find their way into the blood-stream and thence to the membranous investment of the tooth, that are the active causes of degeneration of the tissue in question, and, should the irritative influence be of sufficient intensity as related to the vital resistance of the elements of the membrane, may and do cause its molecular necrosis with attendant inflammatory reaction."

Fitzgerald (1899) * claimed that the production of pyorrhœa alveolaris depended upon a constitutional predisposing cause and an exciting cause in the form of a local irritation. The predisposing cause might be tuberculosis, syphilis, scurvy, the exhaustion following acute infectious diseases or any other source of malnurition. The exciting cause is usually a gingivitis induced by several forms of local irritation. He also recognized a gouty origin of the disease in which the local necrosis of the pericementum is caused by gouty disease of one of the blood-vessels in its substance.

Talbot (1899) † terms the disease *interstitial gingivitis*, and says the causes are divisible into predisposing and exciting, the predisposing causes being again subdivided into local and constitutional. As predisposing factors of the disease he mentions conditions of jaw evolution, the transitory nature of certain structures, degeneracy, and conditions of previous irritation and inflammation. The exciting causes are either constitutional or local, but, as a rule, are local or have a local action. He thinks calcic deposits are a result and not a cause of the disease.

Local Origin of the Disease.—Koecker (1821) ‡ regarded the disease, which he called *inflammation of the gums*, as one of local origin, and caused by the irritating effects of tartar. He said, "In all the various forms of the affection which he had observed he had never seen a case in which tartar was not present. . . . Persons of robust constitution are much more liable to this affection of the gums than those of delicate habit, and it shows itself in its worst form after the age of thirty oftener than at any earlier period."

Bromwill (1867) § was of the opinion that the cause of the disease was a local one, due to the thinness of the alveolar process between the teeth, which deprived the peridental membrane and the gum of proper support. Malocclusion of the teeth also exerted an influence by establishing inflammation.

Riggs (1875) || was very emphatic in his opinion that the disorder was due entirely to the local irritation of salivary calculus, which was deposited at the necks of the teeth just beneath the free margin of the gum, and extended from there towards the apex of the root, causing inflammation of the gum and peridental membrane, necrosis of the edge of the alveolus, a discharge of pus, and recession of the gums.

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* Clinical Journal, March, 1899.
† Interstitial Gingivitis, 1899.
‡ Principles of Dental Surgery.
§ Dental Cosmos, vol. xxiv.
|| Transactions of the American Academy, 1875.

Shieff (1875),* of Vienna, was of the opinion that the disease had its apparent origin in local irritants induced by mechanic, chemic, and thermic changes. The real origin of the disease, however, was often very obscure. The influence of the rheumatic diathesis was doubtful.

Niles (1880) † supported the theory that salivary calculus was the primary cause of the disease. But in certain cases there was a constitutional condition or diathesis in which there was an excess of phosphates and carbonates of lime in the circulation, and this condition exerted an influence in the production of the disease. This condition or diathesis was probably due to dyspepsia, excessive fatigue, mental or physical overwork, protracted illness, or any unusual strain on the system. He thought it safe to say that ninety-five per cent. of the cases seen in private practice are "*due to the deposit locally of lime-salts about rough surfaces on the teeth*, the nucleus being usually at the point where the enamel joins the cementum."

Walker (1881),‡ in a paper upon the disorder, expressed the opinion that its origin was local, and that the starting-point of the disease was to be found in a subacute inflammation of the gum which passed into the depths of the alveolar process.

Witzel (1882) § regarded the disease as a purely local affection, having no constitutional relations whatever. He asserted that the primary origin of the disease was an inflammatory condition of the alveolus, accompanied by caries of the border and followed by a deposit of calcic material just beneath the free margin of the gum, which caused the gingivæ to become retracted and reverted. The infection of the carious material with micro-organisms developed pus, which became infectious to a greater or less extent. He therefore termed the disease "infectious alveolitis," and described it as a molecular necrosis of the alveoli, or caries of the dental sockets, produced by septic irritation of the medulla of the bone.

Black (1886),|| in a most exhaustive article, gives it as his opinion that pyorrhœa alveolaris is a local disorder. He, however, describes two forms of the disease; one he terms *calcic inflammation*, the other *phagedenic pericementitis*. The former he believed to be due to calcic material deposited at the necks of the teeth, which gradually encroached upon the pericementum, establishing suppurative inflammation, while the latter form was characterized by a phagedenic state,—or destructive ulceration of the gingivæ,—and destruction of the peridental membrane and alveolar walls. He thinks this destructive inflammation of the peridental membrane is distinctive from other inflammations of this tissue, and that a serumal calculus may be associated with its origin. He looks upon the disease as having its primary origin in the peridental membrane rather than in the alveolus, although the destruction of these tissues apparently goes on together.

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* Wiener med. Presse, vol. xvi.

† Dental Cosmos, vol. xxiii.

‡ Transactions of the International Medical Congress, 1881.

§ British Journal of Dental Science, vol. xxv.

|| American System of Dentistry, vol. i.

Talbot (1886)* stated that it was his opinion that the disease was a local one, with both local and constitutional causes. He believed the disease began as a simple inflammation which later became chronic.

Sudduth (1894)† believed the principal exciting cause of pyorrhœa alveolaris was the lactic acid formed in the mouth by fermentation.

Arrington (1900)‡ claims there is but *one form*, although sundry features present as the disease progresses. That it is not dependent upon any particular state of the system for its origin, as all individuals alike, the robust and the feeble, are equally subject to it; nor is it a consequence of, or in any way complicated with, any other disease.

Grieves (1904) § maintains one of the principal causes of this disease is insufficient exercise of the teeth, gums, and alveolar processes, induced by the use of so much soft food, and says, "The young child in its efforts at mastication is supplied with so much soft food—meats made tender by cold storage and bread lacking body—that he never learns true mastication, and soon the lazy habit becomes so confirmed that his peridental membranes and periosteal tissues build neither stout fibers nor heavy alveolar walls. Nature, ever economical through marvelous arterial reflexes, not only lessens nourishment to parts little used, but actually resorbs deposited calcic salts to lay them up in the parts which work. Thus is permanently weakened a normally transitory structure—the alveolus—a structure subject to trophic changes, adapting itself to two dentitions and disappearing in the finally edentulous."

Bacterial Origin of the Disease.—Archovy and Izklai (1881),|| in discussing Dr. Walker's paper, read at the International Medical Congress, London, both ascribed the disorder to parasites or minute organisms.

Archovy (1884)¶ shared the opinion of Witzel, that the disease was a marginal necrosis of the alveolus, caused by a septic irritation, probably the result of minute organisms. He termed the disease *caries alveolaris specifica*. "The nature of the affection is that of a suppurative inflammation which spreads to all parts lying between the gum and the dentin."

Malassez and Galippe (1884) considered the disease as undoubtedly of parasitic origin, "which may be proved by an examination of stained sections; by cultivation and isolation of the parasites contained in the dental tubules; by the contagion spreading from tooth to tooth, as well as from individual to individual, as we observed more than once in persons of different sex who stand in intimate relations to each other."

Galippe (1888)** thought he had found the specific organism of the disease, which was designated by the Greek letters γ and β. Galippe's claims have not been substantiated by later observation and research.

Magitot,*** in reviewing the labors of Malassez and Galippe, does not

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* Dental Cosmos, vol. xxviii.

† Ibid., vol. xxxvi.

‡ International Dental Journal, July, 1900.

§ Dental Cosmos, 1904.

|| Transactions of the International Dental Congress, 1881.

¶ Diagnostik der Zahnkrankheiten, 1885, S. 232.

** Die infectiose arthro-dentare Gingivitis, 1888.

*** Miller's Micro-organisms of the Human Mouth, p. 324.

combat the theory of the parasitic nature of the disease, and concludes his remarks with three propositions:

1. The affection characterized by alveolar suppuration and by loosening and falling out of the teeth should be designated as a true symptomatic alveolar arthritis, septic and contagious.

2. It generally arises under the influence of certain unfavorable conditions of health and diathesis, also in exanthematic fevers, etc., where it manifests itself either as a complication or as a consequence.

3. The therapeutics should consist chiefly in the application of antiseptics, local alteratives, astringents, or caustics.

Miller (1890) * was unable to discover any specific micro-organism in the pus discharged from cases of pyorrhœa alveolaris. Out of twenty-six different cases examined, twenty-two different kinds of bacteria were found. In cases 8 and 13, and in 16 and 17, the bacteria were found to be identical. He therefore concludes that there is no specific bacterium yet found for this disease, as the four cases in which the bacteria were identical proved nothing. But if there is such an organism, it will not grow on gelatin, and he suggests that in further experiments media should be selected which can be kept at the temperature of the mouth. It may be possible, however, if such a bacterium exists, that, like many other mouth bacteria, it is not cultivable on any of the artificial nutrient media.

Whittles (1898) † says that in all genuine cases of pyorrhœa alveolaris which he has examined he has found in the pus a "particular bacterium which is probably of the anaërobic variety." The discovery of this organism, which, by the way, is not described, led him to search for an efficient antidote, which he found in the "green iodide of mercury," triturated in a mortar with a little glycerol to allow of greater readiness of application to the sulci or pus pockets of the affected teeth.

He looks upon the disease as another example of those affections which accompany a general lowered condition of the mesoblastic element as a predisposing cause, the real excitant being a bacterium.

Younger (1900) ‡ thinks Cook has discovered a specific organism for the disease, as a certain form was constant in his cultivations. No description is given of the organism, as it was still under cultivation.

From the foregoing *résumé* of the theories which have been advanced to account for the origin of pyorrhœa alveolaris, and the facts which have been deduced by observation and experiment, it is evident that such diverse etiologic factors cannot all be the real cause of the disease.

There is no doubt that a considerable number of cases of the affection are due primarily to certain acquired systemic conditions, like syphilis, mercurialism, iodism, anæmia, dyspepsia, scurvy, malaria, typhoid fever, diabetes mellitus, albuminuria, etc., or to inherited disease, like congenital syphilis, or to inherited tendencies to diseases like tuberculosis, gout, and rheumatism, which induce trophic changes in the tissues and establish a predisposition to early senile degenerations; while, upon the other hand, a considerable number of cases are due entirely to certain local irritative conditions *induced by the formation of salivary concretions* deposited at the

* Micro-Organisms of the Human Mouth.
† Dental Cosmos, vol. xl. ‡ Ibid., 1900.

cervices of the teeth and upon the sides of the roots, which by their encroachment upon the pericementum induce inflammation of a suppurative character, accompanied in its later stages by ulceration of this membrane, disintegration of the alveolar border, and recession of the gum.

It is a very doubtful supposition, however, that the disease is ever caused *primarily* by infection of the tissues with the pyogenic cocci, or by any specific bacterium. It would seem more probable that the infection was a secondary factor or exciting cause, while the primary cause was a lowered vitality of the tissues, due to some previous or exciting systemic condition, or to injury by local irritants, which had placed the parts in such a condition that they were unable to resist the action of the pyogenic micro-organisms which are always present in the mouth.

The disease may therefore be divided into three general forms,—one arising from purely *local causes*, the others from *constitutional or systemic conditions*, the first of which may be termed, as suggested by Peirce, "*ptyalogenic calcic pericementitis* ;" the second, "*hæmatogenic calcic pericementitis* ;" and the third, "*phagedenic pericementitis*," as suggested by Black.

PTYALOGENIC CALCIC PERICEMENTITIS.

Causes.—This form of the disease has its origin in those systemic and local conditions which produce inflammation of the gums. These causes are predisposing and exciting, general and local. Dental pathologists divide inflammation of the gums into two distinct forms, one general in its character and termed *gingivitis* or *ulitis*, and another confined to the borders or margins of the gums and termed *marginal gingivitis*.

Marginal gingivitis is often catarrhal in character, may be associated with catarrhal stomatitis, usually precedes ulcerative stomatitis, and is thought to give origin to ptyalogenic calcic pericementitis.

The predisposing causes of marginal gingivitis are general and local. The general predisposing causes are those conditions which are associated with a faulty metabolism,—conditions which lower the vital resistance of the tissues and predispose them to inflammation, suppuration, and various degenerative changes. The local *predisposing* causes are lack of exercise and the impaction and decomposition of food *débris*. The local *exciting* causes are various irritants of a mechanic, chemic, and septic nature, like harsh brushing, salivary calculus, irritating drugs, and micro-organisms.

The presence of a marginal gingivitis, either local or general in character, presents the most favorable conditions for the establishment of ptyalogenic calcic pericementitis that could possibly be arranged, for by the swelling and loosening of the gums at the cervices of the teeth pockets or sulci are formed for the lodgement of *débris*, while the tenacious product of the mucous glands—mucin—acts as a nidus for the formation of subgingival deposits, which "are produced by precipitation of the calcic material held in solution in the secretions through the action of the products of fermentation upon these fluids ;" * and thus the calcic material is deposited in the pockets, and by reason of the fact that it remains undisturbed in these locations it accumulates more or less rapidly and

* Dental Cosmos, vol. xxxvi.

becomes very dense. Its peculiar density is due to the fact that it contains less food *débris* and leptothrix than the common form of salivary calculus.

Pathology and Morbid Anatomy.—Ptyalogenic calcic pericementitis is characterized by the presence of *subgingival calcic* concretions, dark green in color, very hard, and deposited in the form of thin scales upon the sides of the roots in open pockets, beginning at the cervix and extending in a direction towards the apex.

The formation of this deposit is doubtless due to a catarrhal condition of the mucous membrane of the mouth, resulting in a marginal gingivitis. The calcic material is derived partly from the salivary secretions and partly from the exudations and abnormal secretions of the mucous membrane and the gums.

The effect of this deposit when once formed is to establish a continuous irritation of the margins of the gums, thus keeping up the inflammation and exciting degenerative changes not only in this tissue but also in the pericementum and alveolar border.

The existence of a persistent mechanic irritation causes in this case a chronic hyperæmia of the gum and pericementum, which lowers the vital resistance of these tissues and places them in a condition to be readily acted upon by the pyogenic micro-organisms which are always present in the food *débris* and mixed secretions of the mouth.

As a result of the inflamed condition of the margins of the gums they become swollen and everted, forming a space, sulcus, or pocket between the tooth and the gum, to which the altered secretions, food *débris*, and the saliva have free access. Precipitation of calcic material takes place, probably as a result of the products of fermentation coming in contact with the fluids of the mouth which hold the calcium salts in solution, and thus little by little the concretions are built up.

Burchard* says, "It is probable that these deposits have their origin in a reaction between the altered mucous secretion of the gingival glands and the products of lactic fermentation, their calcic salts being derived from the saliva."

The calcic deposits which are found upon the sides of the roots of the teeth at remote points from the margin of the gums, but which are in communication with the secretions of the mouth through open pockets, are productive of great damage to the integrity of the peridental tissues, sometimes causing acute diffuse suppurative inflammation and destruction of the pericementum, or of chronic inflammation and ulceration of the gum and pericementum, with a discharge of fetid pus, necrosis of the alveolar border (caries), and resorption of the gum.

In the first or *acute form* of this inflammation the process of destruction in the tissues is often very rapid, a few weeks or months only being required to cause complete exfoliation of the tooth, unless the concretions are removed ; and even then the inflammatory symptoms do not always subside nor the pockets close, but resist all treatment and remain in a

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* Pathology, Therapeutics, and Pharmacology.

state of subacute inflammation, the pericementum thickened, the tooth loosened in its alveolus, and gradually extruding or turning upon its axis, while it becomes more and more a source of irritation and annoyance to the patient until it is extracted or exfoliated.

In such cases, however, there is always associated with it some peculiar systemic condition or dyscrasia, like tuberculosis, syphilis, diabetes, albuminuria, or anæmia, which aggravates the local conditions and retards or prevents the healing process.

In the second or *chronic* form of the inflammation the process of destruction in the pericementum and the surrounding structures is much less rapid and the symptoms are all less aggravated, and whereas in the acute form of the inflammatory process the tooth may be exfoliated in a few weeks or months, in the chronic form of the disease this process may be extended over as many years. A large per cent. of the latter cases are amenable to surgical treatment, and these are the cases of pyorrhœa alveolaris which are so often advertised as cured. The cause of irritation is a purely local one,—a mechanic irritant; therefore when the cause is removed and the parts are assisted in the healing process a cure takes place.

In many of the remaining smaller per cent. of cases, which do not readily respond to treatment, there is often a history either of gout, rheumatism, malaria, anæmia, leukæmia, nephritic diseases, physical, nervous, or mental debility, reflex neurosis, or in married females of frequent pregnancies or prolonged lactations. Sometimes local conditions are present which produce over-stimulation or under-stimulation of the circulation of the pericementum, like malocclusions of the teeth, or loss of occlusion, which would in the one case predispose them to hyperæmia and inflammation of the pericementum, and in the other to atrophy, thus lowering the vital resistance of the tissues and preparing the way for the destructive action of the pyogenic micro-organisms.

The individuals who are the most liable to suffer from this form of pyorrhœa alveolaris usually possess teeth of finely organized structure, which are very resistant to cutting instruments and singularly free from dental caries. These facts were noticed by the earliest writers upon the disease, and were classed by them as predisposing etiologic factors, as it was thought that their density and consequent low vitality predisposed them to exfoliation when attacked by inflammatory disease of the root.

Harris* says, "It may also be produced by very hard teeth which, in consequence of their density, possess only a very low degree of vitality; for cases of recession of the gums, in which a very slight inflammatory action exists, are frequently met with in individuals having teeth of this description. This can only be explained by supposing a want of congeniality between these organs and the more sensitive and highly vitalized parts with which they are in immediate contact."

On making sections of these teeth, the enamel and dentin are found to be exceedingly hard and much more translucent than the average tooth. The pulp-chamber is usually considerably contracted, the pulp often show-

* Harris's Dental Surgery.

ing evidences of calcification, atrophy, and other senile changes. In the later stages of the disease the vitality of the pulp is often destroyed by the intense inflammation of the tissues of the apical space, the swelling producing pressure upon the pulp-vessels.

An examination of the root reveals the fact that the pericementum is greatly inflamed or undergoing degenerative changes (Fig. 624), or has been destroyed to a greater or less extent according to the character and stage of the disease when the tooth was removed. Wherever tophi (concretions) have formed upon the root the pericementum will be missing, not only upon that portion of the root covered by the deposit but for a considerable area beyond; this is a constant condition. It not infrequently happens that the pericementum will be destroyed upon one side of the root from the cervix to the apex while it will be intact over the remaining surfaces; or it may be destroyed upon all sides but one; and, again, the process of destruction may encircle the tooth for an equal distance upon all sides. The latter condition is most often associated with the anterior teeth, and especially when the tooth has no immediate neighbors.

As the disease progresses the teeth become more and more loosened in their alveoli, until finally they drop out or have to be extracted to relieve the intense soreness which is developed as a result of their mobility and frequent injuries due to their elongation and malocclusion.

In cases of long standing a secondary form of deposit is often observed upon the roots of these teeth. The *primary* deposit is formed in thin scales just beneath the gum margin; the *secondary* is formed beyond the primary deposit, upon the denuded cementum, in those locations which are constantly bathed in pus. The secondary deposits are so different in appearance that they cannot be mistaken for the primary deposit; for, instead of being formed in thin scales with an even surface, they are formed either in tiny bead-like islands or in larger masses with bead-like projections upon the surface, and very similar in appearance to the concretions formed upon bodies, either animal or mineral, that have been lodged in the tissues and bathed in pus for a considerable period of time. Such deposits are frequently seen upon the apical portion of the roots of teeth which have been the subject of long-continued chronic alveolar abscess. They are, therefore, not the primary cause of the disease, but the result of chronic inflammation and deposition of calcareous material from the inflammatory products.

Symptoms and Diagnosis.—The first symptom of the disease in its early stages is usually inflammation of the margins of the gum,—marginal gingivitis,—which are turgid and reddened, the tips of the festoons often being of a purplish color.

The extent of the swelling and discoloration will depend upon the severity of the inflammation and the diathesis of the individual. The gums bleed readily upon the least friction or rough usage. The margins of the gums are slightly everted, and the sulci or pockets formed between the margins of the gums and the cervices of the teeth are filled with food *débris* and thickened mucous secretions, or a thick, cheesy mass of material

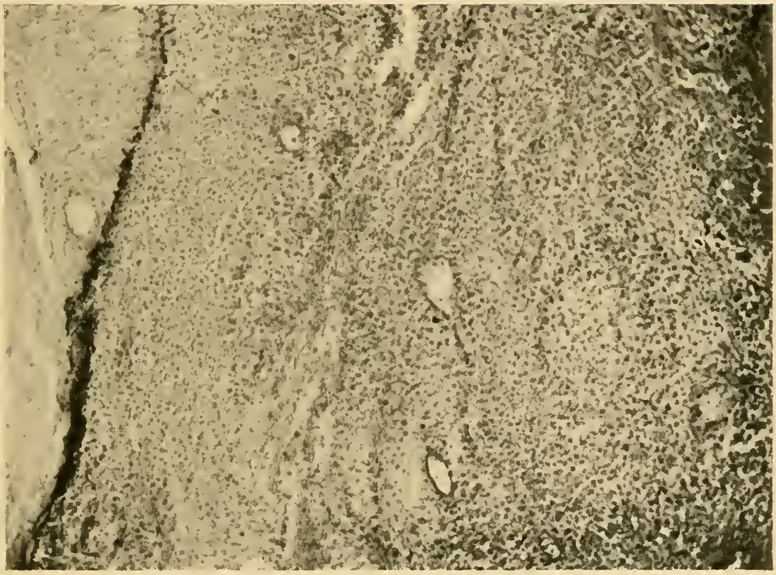


FIG. 624.—Inflamed peridental membrane from a case of pyorrhœa alveolaris. × 50.

made up of these substances and epithelial scales, numerous forms of bacteria, and calcic material.

Later in the history of the case, if an instrument is passed beneath the margins of the gum, a scaly deposit of dark-green calculus will be found adherent to the cervix of the tooth. This may be upon one surface only, or it may encircle a larger portion or the whole of the cervix.

Occasionally, however, cases will present in which the deposit seems to have occurred before the marginal gingivitis was developed, and that the deposit was the cause of the gingivitis. These cases may have their origin in *cervical deposits*, which later develop a chronic marginal gingivitis, as already described in the preceding chapter, or it may be that the inflammatory condition of the gum has subsided after the formation of a comparatively smooth calculus.

As the formation of the calculus progresses it encroaches upon the periosteum, causing inflammation and ulceration of this membrane. The constant presence of the pyogenic bacteria in the mouth affords the means of septic infection, which attacks the tissues as soon as they can gain an entrance to them through an abraded surface or other break in their continuity. As a result pus is formed, which may be pressed from beneath the margins of the gums. An examination of the margins of the alveolus with a fine probe will sometimes discover these edges eroded by caries, but more often they will not be found uncovered, the process of destruction seeming to be one of resorption rather than molecular disintegration by caries. In the former cases the odor of the pus is very offensive and disagreeably taints the breath.

As the disease advances the pericementum and the alveolar process are progressively destroyed, and the gum gradually recedes as this process continues, until the tooth becomes very loose in its alveolus. The increased mobility, elongation, and the malocclusion incident to these conditions excite inflammatory action in the tissues beyond the field of the original disease, thus increasing the soreness and discomfort of the tooth.

In some cases, at this stage of the disease, hyperæmia of the pulp may be developed, followed by embolism and death, or the inflammation and œdema of the apical tissues may be so great as to cause strangulation of the vessels of the pulp at the apical foramen. As a result of the devitalization of the pulp and septic infection, the case may now be complicated with a septic apical pericementitis.

The termination of the disease is in the exfoliation of the tooth. All inflammatory symptoms immediately subside upon the loss of the tooth, and the gums and alveolar border assume in a very short time a healthy appearance.

Prognosis.—The prognosis is favorable, even in the later stage of the disease, provided the exciting causes can be removed and the constitutional predisposing causes, when they exist, corrected.

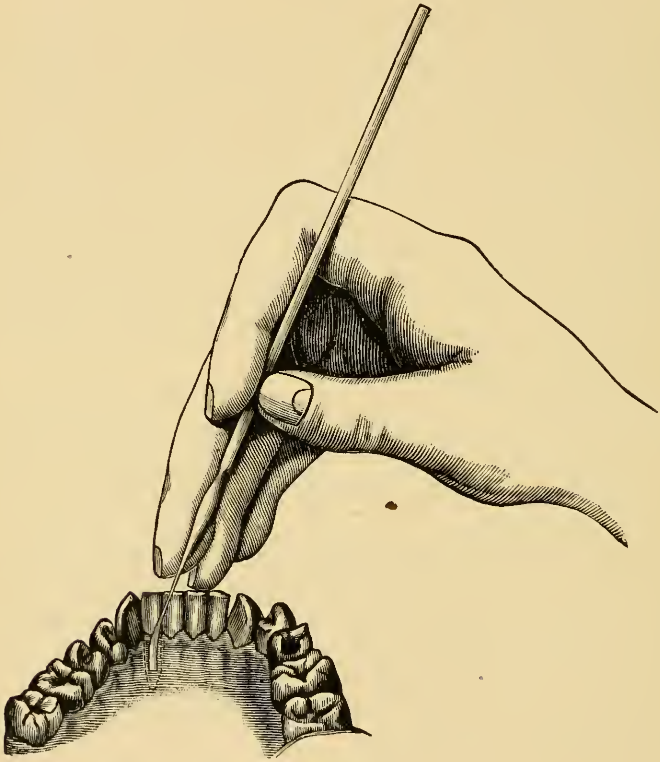
Treatment.—In the treatment of ptyalogenic calcic pericementitis there are two main objects to be considered. The *first* is the removal of all sources of irritation, and the *second* is supporting the diseased teeth so as to secure surgical rest during the healing process.

The removal of the sources of irritation comprehends all forms of local and constitutional irritants. The principal local irritants are the calcic deposits, food *débris*, and septic bacteria. The removal of the deposits is a surgical procedure, and requires special instruments for its success.

Instruments of an entirely different form are required in the removal of the subgingival salivary deposits from those employed in removing the ordinary forms of salivary calculus.

The most important *desiderata* in the instruments used for the purpose of removing the deposits from the sides of the roots beneath the gums are, first, that they shall be so thin that they will pass readily into the pockets formed in the alveolar wall between the root of the tooth and the gum;

Fig. 625.



After Burchard.

second, so flexible or springy that when the flat side of the instrument is laid against the side of the root a lateral and downward pressure will cause the instrument to glide over its surface, removing any concretions that may be thereon, but not cutting into the cementum.

These hard salivary concretions are most readily removed or scaled from the surface of the root by driving or pushing the instrument from the margin of the gum towards the apex of the tooth, keeping the flat side of the instrument always in contact with its surface. For this purpose chisel-shaped instruments only should be used. Fig. 625 shows the manner of holding the instrument, and Fig. 626 the application of the instrument to the root of the tooth.

Some operators, however, prefer instruments which can be used with a drawing motion, the cutting end of which is made like the hoe excavator, but with the blade much shorter. This of course makes the instrument bulky at its cutting end, and prevents it from being carried as near to the apex of the root as is possible with the thin chisel-shaped instrument; hence there is not the same certainty that the concretions are all removed in the farthest limits of the pockets as would be the case if the chisel-shaped instruments were employed. The instruments best suited to this purpose are the Allport and the Cushing scalers (Figs. 627 and 628).

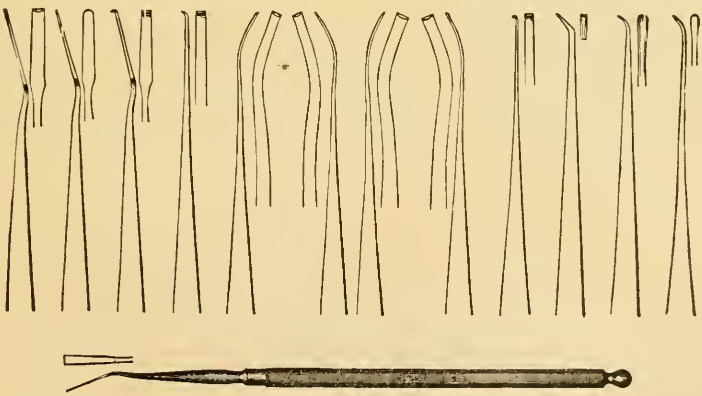
Fig. 626.

After Burchard.

The importance of the thorough removal of every particle of the deposit from beneath the gums cannot be over-estimated. Many failures to arrest the inflammatory symptoms in these cases can be traced to the fact that some small particle of adherent deposit has not been reached.

The operation even under the most favorable circumstances presents many obstacles and difficulties, which can only be overcome by those operators whose sense of touch has become so acute as to be almost the equal of vision. The six anterior teeth of both jaws present the most favorable conditions for the successful removal of such concretions. These difficulties, however, are greatly increased in the bicuspids and the molars by their

Fig. 627.



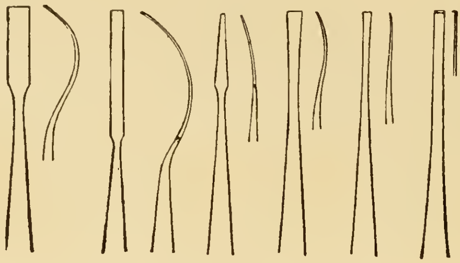
Allport's pyorrhœa alveolaris instruments.

more inaccessible location, by their shape, and the number of their roots. The most difficult problem is the removal of the deposits from the bifurcations of the roots and from the surfaces of the roots which look towards each other.

After the concretions have all been dislodged from their attachment to the root, the pockets should be injected with a drop or two of hydrogen dioxide (H_2O_2) by the use of the Dunn medicinal drop syringe (Fig. 629), in order to free the pockets from all calcareous *débris*, after which they may be treated by the application of aromatic sulphuric acid, lactic acid, trichloracetic acid, a saturated solution of iodine crystals in beechwood creosote, or the pockets may be packed with quinine after the method of Dr. James Truman. Various other remedies are employed for the treatment of the pockets, but the mention of these is sufficient to indicate their character.

The after-treatment consists in the free use of antiseptic mouth-washes

Fig. 628.

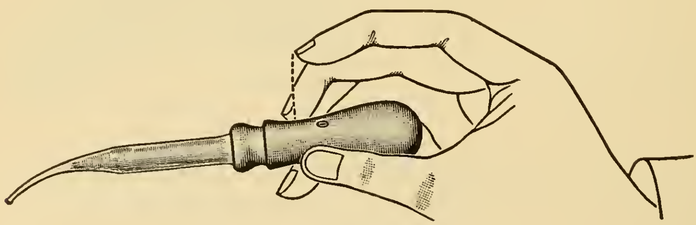


Cushing's pyorrhœa alveolaris instruments.

and painting the gums with equal parts of tincture of iodine and tincture of aconite every other day for a week or ten days.

The writer has for many years been in the habit of employing an atomizer for applying the antiseptic lotions or mouth-washes in the treatment of these oral conditions. The patient is instructed to thoroughly brush the teeth after each meal, then to pass floss-silk between all of the teeth, and follow this cleansing process with the atomizer, using sufficient force to drive the antiseptic fluid through the interdental spaces. If by the end of a week the gums have not assumed their normal color, or there is still a discharge of pus from any pocket, the chances are that a small adherent scale of calculus still remains. This should be searched for and removed and the case treated as before. In all of those cases that are

Fig. 629.



Dunn medicinal drop syringe.

complicated with systemic disorders which predispose to pericemental degenerative changes, attempts should be made through the family medical adviser to correct these conditions.

Local treatment under such circumstances, although it may prove helpful in relieving immediate suffering and placing the mouth and teeth in a more hygienic condition, will not prove curative until the constitutional dyscrasia is improved.

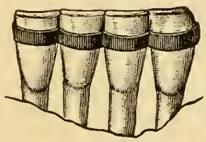
Surgical Rest.—Teeth which have become much loosened by reason of the resorption of the alveoli must be given surgical rest if the healing process is to be successfully completed. This rest may be secured by supporting the teeth, either by ligatures of silk or linen attached to contiguous teeth, or by wire, either of gold or silver, or by splints made of gold or platinum and cemented to the teeth.

These splints (Fig. 630) are most readily made by fitting thirty-four to thirty-six gauge bands to the individual teeth, taking an impression of them *in situ*, investing, and soldering the whole together.

Fig. 630.

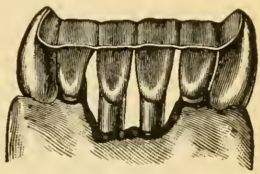
Splint prepared. (After Burchard.)

Fig. 631.



Labial view of splint in position. (After Burchard.)

Fig. 632.



Lingual view of swaged splint in position. (After Burchard.)

Fig. 631 shows this splint after it has been cemented in position. Or an impression may be taken of the teeth after they are supported with silk ligatures, and a splint swaged from gold or platinum and cemented in place, as shown in Fig. 632.

CHAPTER XXXIX.

HÆMATOGENIC CALCIC PERICEMENTITIS.

THIS form of pyorrhœa alveolaris is found most frequently in persons suffering from certain peculiar inherited or acquired constitutional conditions,—viz., rheumatic and gouty affections, or, in other words, the arthritic diathesis, and for this reason it has been termed by some writers *gouty pericementitis.*

Magitot (1867), as stated in the preceding chapter, called attention to the fact that in his opinion persons of the gouty and rheumatic diathesis furnished the greatest number of cases of pyorrhœa alveolaris. Reese (1886) pointed out most clearly the association of this disease with the gouty diathesis. The writer (1891) demonstrated the analogy between the gouty deposits and the degenerations of the fibrous tissues of the joints and certain pericemental degenerations, and suggested that certain deposits were found upon the roots of the teeth in locations which had no communication with the salivary secretions, and that these concretions were deposited from the elements of the blood, and were composed of the urates of lime and soda. Peirce (1892–94–95) has proved by careful experiments the truth of the above suggestions of the writer in relation to the location of these deposits and their composition.

The demonstration of the fact by Dr. Peirce that the deposits found upon the roots of the teeth in these locations gave the murexid reaction proved conclusively that they contained biurates, the same as found in the gouty concretions in other portions of the body. The establishment of this fact gave a great impetus to the study of the association of this disease with the gouty diathesis. The result of this study, however, in certain directions, through a misunderstanding of the premises laid down by the advocates of the theory, has been to throw doubt upon the correctness of their conclusions. The teeth that have been used in these studies by the opponents of this theory have admittedly been taken in great quantity, hap-hazard, from the scrap-box of the *professional extractors,* which made it impossible to obtain the history of a single case; neither could there be any means of knowing whether the concretions used for the chemical analyses were deposited from the saliva in open pockets or from the elements of the blood in locations where the secretions of the mouth could not have come in contact with them.

These are important distinctions, and if they are observed in future researches upon this subject they will give the same results as those obtained by Peirce and the other advocates of this theory.

Predisposing Causes.—The predisposing causes of this form of pyorrhœa alveolaris (gouty pericementitis) are those conditions of the system which are designated as the gouty and rheumatic affections. Gouty pericementitis, however, is only a local manifestation of this general morbid state of the system, which is due either to imperfect metabolism (sub-oxidation and faulty elimination) or to an excessive formation of uric acid, resulting in the accumulation within the system of an abnormal amount of certain waste products termed the *urates*. Individuals who are thus affected are said to possess the *uric acid* or *gouty diathesis*. It must be remembered, however, that lead-poisoning resembles gout in giving rise to an excess of uric acid in the blood.

Urates are always found in excess in the serum in instances of deficient oxidation, arthritis, and valvular diseases of the heart. They are also found in the urine, as, for instance, in a case of phthisis where an insufficient amount of oxygen is absorbed, oxyhæmoglobin is deficient, and consequently many of the normal transformations of the body are completely or partially arrested. In such cases quantities of oxalate of lime will be found in the urine, the carbon of the food and of the waste material from the tissues is only partially oxidized, and that which should have been exhaled from the lungs as carbonic acid is excreted by the kidneys as oxalic acid. Again, in the condition of venous stasis arising from feeble action of the heart the blood stagnates in the veins, becomes loaded with poisons, is not carried to the lungs with due rapidity, and those nitrogenous parts of food and tissue which normally are converted into, and excreted as, urea appear in the urine as uric acid, free or combined. (Vaughn.)

A persistent excess of uric acid in the urine is, therefore, always considered as a significant symptom of an important systemic condition, due to an increase in tissue metabolism in some particular organ or group of organs.

Heredity.—The gouty diathesis is usually inherited, and the active manifestations may be induced in such individuals by high living or by the deprivations of extreme poverty.

Gairdner and Garrod state that in about ninety per cent. of all persons suffering from gout, the disease also existed in their forefathers. Peirce is of the opinion that in gouty pericementitis fully ninety per cent. manifest an hereditary tendency to the disorder.

Gout diminishes the powers of resistance against disease and injuries, especially when the kidneys and the liver are affected. Many gouty individuals, however, live to an advanced age.

Diet.—The excessive use of foods containing large quantities of nuclein or saccharine substances, and the use of alcoholic beverages, particularly fermented liquors, are predisposing causes of gout, and also of this form of pyorrhœa alveolaris.

Sex.—Sex does not seem to play a very important part in the predisposition to pyorrhœa alveolaris in general. Men, however, are much more subject to gout than women, and as a natural consequence to gouty pericementitis.

Age.—Gouty manifestations may appear at any period of life from infancy to old age. It is most common, however, after middle life. This is true also of gouty pericementitis, although cases have been recorded as occurring before the age of puberty.

Magitot and Peirce both agree that this form of pyorrhœa is most frequent between the ages of thirty and fifty years, and that it rarely appears after the age of sixty.

Occupation.—Sedentary occupations are important predisposing causes of gouty pericementitis, as they favor imperfect oxidation of the food, faulty metabolism, and retard the elimination of the waste products. Systematic exercise in the open air tends largely to counteract these faults in the functions of the body.

This morbid state of the system, known also as *uricacidæmia* or uricæmia, finds expression in a multitude of ailments and abnormal conditions of various tissues and organs, some of which are acute, others chronic, in their manifestations.

Blood-Vessels.—Various functional and organic changes are found in the blood-vessels of gouty subjects, such as dilatation of the aorta, thickening of the walls of the arteries, loss of elasticity, atheroma, and even calcification. Phlebitis is a well-recognized gouty ailment, which may produce thrombosis, and by dislodgement of the clot cause sudden death by impaction in the heart, pulmonary artery, or lungs.

Circulation.—The effects of uricacidæmia upon the circulation, as pointed out by Haig, are to produce "contraction of the arterioles, and thus increase arterial tension." When these conditions affect the cerebral circulation they result in headaches, mental depression, fatigue, irritability of temper, hysteria, vertigo, epilepsy, and convulsions.

Asthma and chronic bronchitis are often the result of the effect of uric acid upon the pulmonary and bronchial circulation, and seem to explain the association so often noticed between these affections on the one hand, and gout and chronic Bright's disease upon the other.

Dyspepsia may undoubtedly be produced by the contraction of the arterioles of the stomach and intestines, thus inhibiting gastro-intestinal digestion and permitting putrefactive processes to take their place, which would explain the association between dyspepsia and such affections as sick-headache, mental depression, fatigue, epilepsy, etc., or the relationship between dyspepsia and Raynaud's disease or paroxysmal hæmoglobinuria.

The liver is subject, also, to more or less congestion as a direct or indirect result of circulatory changes produced by uric acid.

Blood.—The blood itself is changed in a greater or less degree by the action of uric acid, both in its structure and its nutritive power. The presence of uric acid in the blood reduces the percentage of hæmoglobin and the number of red corpuscles, thus producing anæmia. Haig was able to increase or diminish the amount of hæmoglobin and the number of red corpuscles in his own blood from day to day by the administration of iron and uric acid respectively. The amount of uric acid in healthy blood is so small that it is with extreme difficulty that it can be detected. Garrod has demonstrated the fact, however, that in gout the blood is especially rich in uric acid, and has found as high as 0.175 parts in 10,000, and that the blood is especially charged with it just prior to and during acute attacks, but that it is always present in chronic gout.

Roberts claims, however, that uric acid as such is never found in the blood or deposited in the tissues, but that as normally found in the blood it is in the form of a quadrurate, a compound of four equivalents of uric acid with one of soda or potash. This quadrurate is an exceedingly unstable compound, and under especial conditions is liable to be decomposed into biurate and uric acid. The tophi of gout consist of the biurate, but this salt is almost insoluble in serum; even at body temperature it is dissolved only in the proportion of 1 in 10,000. (Levison.)

The tophi are formed by the transformation of the quadrurates found in the blood into biurate and uric acid, which gives rise to the deposition of the former compound in various tissues of the body, while the uric acid is eliminated by the kidneys. The tophus formed from this crystalline deposit of sodium biurate "acts passively and physically as a foreign body in the affected tissue or organ." (Luff.)

Tunnecliffe and Rosenheim* combat the claim of Roberts of the existence in the blood of uric acid in the form of quadrurates. They concede, however, the existence of two classes of uric acid salts, the neutral $(C_5H_2N_4O_3)M$ and the acid or biurate $(C_5H_2N_4O_3)HM$. They conclude that there is no evidence of the existence of quadrurates, that the term should be abandoned, and that any theory concerning the pathology or treatment of gout built upon this assumption requires revision. They think the existence of two forms of uric acid (the tantomeric lactam and lactim forms) may explain the variation in the physic and physiologic behavior of this acid and its salts.

Molliere has demonstrated the fact that uric acid and the urates are antagonistic to the development of the pyogenic micro-organisms. *This explains the reason why suppuration so seldom occurs about tophi, other than those located upon the roots of teeth.*

Duckworth found the red corpuscles diminished and the leucocytes somewhat increased in those cases already affected with chronic nephritis.

The amount of urea found in the blood in all cases associated with granular kidney disease doubtless depends upon the degree of renal inadequacy.

Garrod frequently found oxalic acid in the blood of gouty subjects; he believed its formation occurred principally in the paroxysmal stages, and that it was derived by oxidation from the uric acid.

Ebstein discovered that xanthin and hypoxanthin were formed in the blood drawn from gouty subjects upon exposing it in a warm chamber, while minute quantities of uric acid disappeared.

Secretions.—During attacks of uric acid headaches the urine and the salivary secretions are diminished, the mouth and tongue often being dry and parched; in chronic gout this dry parched condition may last for months, but in acute gout, as soon as the excess of uric acid has been eliminated from the blood by the administration of appropriate remedies and the blood has assumed a normal alkalinity, the secretion of urine and of the oral fluids becomes for a time relatively excessive. The saliva often

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* London Lancet, June 16, 1900.

shows a decided acid reaction during attacks of acute gout, and usually gives a slight acid reaction in chronic gout.

The amount of *urea* excreted in the urine, according to Garrod, is about three hundred and twenty grains per diem. Few analyses have been made of the excretion of urea in acute gout, but such as have been recorded show no material variation from the normal amount. The variation, however, such as exists, bears no relation to the amount of *uric acid* excreted at the same time. (Garrod.) The excretion of urea is diminished just before an acute attack of gout.

Haig gives the relation of urea to uric acid in the healthy adult as one to thirty-three, and says that in uric acid headache the excretion of urea was practically unchanged, while that of uric acid fluctuated greatly, particularly in relation to the headaches. Granville's examinations of the urine of gouty subjects corroborate the records of Haig.

The non-elimination of uric acid has been demonstrated by Garrod to be a constant and marked feature of paroxysmal gout. He found in several cases examined in reference to this point that the average amount was about five grains less than the normal,—3.62 grains as against 8.569 grains. As a consequence of its non-elimination by the kidneys there is an increasing amount stored up in the blood or the tissues of the body. Haig is of the opinion that much of this may be stored in the liver and the spleen.

The greatest amount of excretion in health occurs during the alkaline tide of digestion. (Roberts.) It is probable that the excretion of uric acid in gout, could it be watched from hour to hour, would be found to vary considerably. (Duckworth.)

Sansone,* in analyzing one thousand grains of morning urine in a case of acute gout, found 0.830 grain of uric acid; in one of chronic gout, 0.120 grain; and in a healthy person, 0.250 grain.

Gouty individuals often suffer from gravel and calculosis; oxaluria is not uncommon, while chronic cystitis and urethritis are occasionally observed in elderly persons suffering from gout.

Kidneys.—The morbid changes which are found in the kidneys of gouty subjects present the ordinary signs of granular atrophy, and cannot be distinguished from it either by the symptoms or by an examination of its anatomical structure. The relationship between chronic Bright's disease and certain features of uricacidæmia is so constant that many observers have been led to believe that the disease was caused by imperfect metabolism of the albumins, and possibly as the result of the presence of an excess of uric acid in the system.

Duckworth † is of the opinion that the gouty habit is alone the potent factor in a considerable proportion of all cases of interstitial nephritis.

Ord and Greenfield,‡ in a large series of cases examined with the object of determining the presence or absence of renal disease in gouty subjects

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* Beale, Urine and Urinary Deposits, 2d edition, p. 162.

† Treatise on Gout, p. 101.

‡ Transactions of the International Medical Congress, 1881.

with uratic deposits, found that in 66.66 per cent. of the hospital cases of gouty affection of the metatarso-phalangeal articulation of the great toe there was a definite coexistence of contracted granular kidney, and that in the remaining 33.33 per cent. there were affections of the kidneys closely allied thereto. Out of ninety-six cases of renal disease, there were eight and possibly nine in which no uratic deposits were found in the joints. Of these, two were examples of extreme granular contraction, two of marked contracted granular, two of slightly granular, and one of mixed granular and tubular nephritis.

Moore * examined forty-nine cases of chronic interstitial nephritis in males, and found uratic deposits in twenty-two. In another series of sixteen females, uratic deposits were present in five cases.

Continental European physicians generally hold the opinion that uratic deposits are constantly found in the contracted kidneys of gouty subjects, and that this condition is somewhat dependent upon the presence of such deposits. Duckworth's studies do not corroborate this opinion, as he rarely found such deposits in the kidneys of the gouty.

Liver.—Haig † is of the opinion that the hyperæmia or congestion of the liver always present in diabetes is due to the same cause that produces this condition of the liver in gouty dyspepsia,—viz., the presence of an excess of uric acid in the blood.

Ord ‡ has pointed out the fact that general high arterial tension may cause an excess of blood in the liver, and thus produce diabetes; while Haig § has shown that the contracted arterioles and arterial tension are in a direct ratio to the amount of uric acid circulating in the blood, and the so-called "liver attacks" he looks upon as uric acid storms, almost if not quite identical with attacks of uric acid headaches.

Diabetes seemingly holds a close relationship to gouty conditions, and must be dependent upon some error of metabolism for its existence. Both of these conditions present many similar symptoms. Latham || observed "that diabetic individuals often have an excess of uric acid in their urine and suffer from neuralgic pains in the joints and limbs."

Anderson ¶ observed "many clinical facts which seem to prove that gouty arthritis and diabetes mellitus are in certain cases merely transformed symptoms of the same diathesis; not present at the same time, but one taking the place of the other."

Garrod ** noticed this relationship, and says, "In the course of practice I have seen several cases in which gouty patients have become affected with saccharine diabetes or glycosuria. In one case of gout of twelve years' standing, in a gentleman sixty years of age, diabetes suddenly developed, and for a period of over four years there were no more attacks

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* Loc. cit.

† Uric Acid the Causation of Disease, p. 287.

‡ British Medical Journal, 1889.

§ Uric Acid the Causation of Disease, p. 272.

|| Ibid.

¶ British Medical Journal, 1886.

** Ophthalmic Review, 1889.

of the gout. But when the diabetes was checked the gout very soon returned."

Muscles.—Although no morbid changes have been observed in the muscular system in uricacidæmia, uric acid has often been found in these structures.

Uricacidæmia produces, probably through depression of the nerve-centres, a disinclination to muscular exercise during gouty attacks; this results in a deficient circulation in the muscles, and consequently in imperfect elimination of the waste products. The tendons become involved in association with the joints and uratic deposits are formed in them. The muscles often become the seat of neuralgic pains, which come and go with other gouty symptoms.

Nervous System.—So far no morbid changes have been discovered in the anatomical structure of the nerves of gouty subjects except those due to cachexia in cases of long standing. Uratic deposits are rarely found in the nerve-tissues or their investments. Cornil discovered sodium urate in cerebro-spinal fluid, and uratic deposits have been detected in a few instances in the cerebral meninges.

Albert and Ollivier also found such deposits on the spinal meninges. There are strong clinical reasons for believing that uricacidæmia may induce neuritis in almost any nerve-trunk, with motor, sensory, and vasomotor symptoms. (Duckworth.) Neuralgia is a common affection in gouty individuals. Sciatica and general myalgia are not infrequently associated with other gouty symptoms, and the writer has seen several cases of trifacial neuralgia which were undoubtedly due to gout.

Skin.—The circulation and the nutrition of the skin are often markedly affected by the presence of an excess of uric acid in the system, which are manifested during uric acid headaches in a pale, cold condition of the surface of the skin, and in certain eruptive diseases, particularly those of an ulcerative character. Among the diseases allied to gout may be mentioned erythema, eczema, urticaria, psoriasis, prurigo, and acne. (Sarjou.) Golding-Bird discovered uric acid in the contents of the vesicles of gouty eczema, and Begbie found it in the bullæ of pemphigus.

Ulceration of the skin and suppuration often accompany the exfoliation of the tophi located about the joints.

Periosteum and Bone.—Uratic deposits frequently occur in the periosteum, resulting in inflammation and sometimes in exfoliation or extrusion of the deposit. On the other hand, inflammatory symptoms are often present in and about the epiphyses of the long bones, particularly of the legs, feet, and hands, which result in the formation of nodes or of a true exostosis. The thickening of the edges of the alveolar processes so often seen associated with gingivitis is usually the result of chronic irritation or inflammation of the periosteum of these parts due to the gouty diathesis.

Nails.—These tissues are dermal appendages, and are therefore more or less profoundly affected by all diseases which have a predilection for dermal structures. In gouty individuals the nails are observed to be coarse, fibrous, and brittle, striated, fluted, and lined vertically.

After an acute attack of gout depressions or white spots or lines are observed, forming crescent-like curves, which points to faulty nutrition, and, inasmuch as the nail requires six months in which to complete its development, these defects, by their position, would indicate the date at which the illness occurred, just as faults of nutrition are recorded upon the enamel of the permanent teeth, and indicate by their location the age of the individual when the illness occurred.

Hair.—Senile changes occur earlier in certain tissues than in others. These tendencies may be acquired as the result of disease or of debauchery, or they may be inherited as a family peculiarity, or an evidence of degeneracy.

This tendency to early senile change is particularly noticed in reference to the hair. In some individuals the hair turns gray at or before the thirtieth year, while in others distinct baldness may occur at an equally early age. These conditions are often noticed to be associated with the gouty diathesis, and in some instances are no doubt dependent upon uricacidæmia as a primary factor in its causation. "The hardened tophaceous matter sometimes found in the sebaceous glands of gouty subjects is composed largely of urates. About fifty per cent. of it is sodium and calcium salts of uric acid, about ten per cent. sodium chloride, and the remainder calcium phosphate and animal matter." (Duckworth.)

Teeth.—The character of the teeth in gouty subjects is remarkable in that, as a rule, they are well formed, finely developed, having strong, hard enamel, which is inclined to a yellowish color; they have strong roots which are firmly set in their alveoli, and are comparativeiy immune to caries. After middle life they are inclined to show considerable wear upon the morsal surfaces. This has been thought to be due to the habit of grinding the teeth which is so common with rheumatic and gouty individuals. This habit is doubtless formed as a result of irritation and hyperæmia of the pericementum so constantly present in chronic gout. Neuralgic pains are also frequently present, and come and go with other gouty symptoms. The teeth, like the hair, often show evidences of early senile changes. The pericementum and the alveolar processes atrophy and are resorbed, while the gums gradually recede as the former conditions progress until the teeth become loose and fall out. These changes often begin before middle life is reached, and when these tendencies are associated with a gouty diathesis the destructive process becomes most marked and rapid in its progress.

Exciting Causes.—The immediate exciting cause of gouty pericementitis is undoubtedly the presence of uratic deposits in the pericemental membrane. This morbific material plays the part of a foreign body, and causes mechanical irritation and death of the surrounding cellular elements,—necrobiosis,—which favors the further deposition of the urates. The inflammatory process does not always progress to the suppurative stage, as infection with the pyogenic cocci is necessary for the establishment of a septic inflammation.

Impaired nutrition of the pericementum with its consequent lowered vitality is also an important factor in the establishment of the disease. These conditions are to be found as a result of severe mechanical strain from over-exercise of the teeth,—*misuse*,—as in malocclusion and the loss of the teeth, which places the strain of mastication upon a few remaining teeth; in insufficient exercise of the teeth—*disuse*—from various causes, as, for instance, loss of occlusion, the constant use of soft, pulpy foods which require little mastication to comminute their substance; *overcrowding of the dental arch; traumatic injuries* consequent upon wedging, malleting, changing the position of certain teeth in the process of regulating, and other similar procedures. The unskilful or immoderate use of the tooth-pick, floss-silk, and the toothbrush may occasionally induce conditions of irritation which impair the nutrition of the pericemental membrane.

Varieties.—In gouty pericementitis two forms of inflammation may be observed,—one which produces a new growth of cementum, or hypercementosis, and another which results in a deposition of calcic material combined with sodium biurates from the elements of the blood. The former variety has already been described in the preceding chapter on "Pericementitis." The latter variety is that condition which has been classed by Peirce, Darby, Burchard, Jack, the author, and others as *gouty pericementitis*, and which he has described as a local manifestation of the gouty diathesis, in which tophi are formed within the pericementum, and upon the surface of the cementum in closed pockets, in various locations more or less remote from the cervix and at the apex. "These tophi are composed of sodium and calcium biurates, free uric acid, and calcium phosphate, as has been demonstrated by careful analysis." (Peirce.)

The manner in which these tophi are formed within the pericementum is as yet an unsolved proposition, although various theories have been advanced in explanation of the process.

Pathology and Morbid Anatomy.—Gouty deposits are met with only in tissues which have a scanty vascular supply, or in which the circulation is more or less sluggish. Tophi are most frequently found in the tissues which surround the joints, like the cartilages, aponeuroses, and periosteum. The small joints are most often affected. The relation of the teeth with the alveolar process is that of gomphosis, a species of joint termed the dento-alveolar articulation, and the tissue which intervenes between the cementum and the bone is the pericementum, a dense fibrous structure having a *scanty vascular supply* as compared with the somewhat analogous structure, the periosteum. Under certain conditions exostosis and nodular formations occur upon the surfaces of the bones as a result of the irritation of the periosteum from the presence of the gouty poison in the blood and its deposition within the tissues. The same condition has already been referred to as occurring upon the roots of the teeth from the same cause. There would seem to be, therefore, no good reason for objecting to the conclusion which has been reached by so many able observers,—viz., that the deposits formed upon the roots of the teeth primarily in the pericementum and in closed pockets which could not have been at any time in communication with the oral cavity, must have been deposited from the blood; and, inasmuch as tophi are also found in the periosteum surrounding a joint, the inference is fair that similar tophi may be formed in the pericementum surrounding the root of the tooth and forming the "joint" with the alveolar process.

Formation of Deposits.—In relation to the manner or *modus operandi* of the formation of these tophi, Mordhorst* says, "The granular urate is always the precursor of the crystalline form, and in the body-fluids the uric acid circulates in the form of invisible granules of sodium urate. Gouty deposits are only met with in non-vascular tissues, and as acids and acid salts diffuse more rapidly and readily than alkalies and alkaline salts, we must suppose that the alkalinity of the non-vascular tissues is less than that of the blood. Hence if a transudate almost saturated with urate enters such a less alkaline tissue the solution becomes supersaturated and granular urate is precipitated in the tissue, the precipitation being favored by such additional factors as lowered temperature or increased concentration of the fluids of the tissue. The precipitation of the granular urate in the spaces of the interstitial tissue and in the lymph-channels is the cause of the various phenomena of gout. In the course of time the urate deposited becomes converted into acicular crystals of sodium biurate, or under favorable conditions may be redissolved and disappear, and with them disappear the lesions to which they gave rise." If this theory is correct it explains why constitutional treatment, which aims to redissolve and eliminate the biurates, often mitigates the severity and sometimes cures certain cases of gouty pericementitis.

Ebstein † believed that in gout uric acid is formed in excess in the body, and that hyper-production also takes place in regions which ordinarily do not produce uric acid, as, for example, the bone-marrow, the cartilages, etc.

When the blood and the lymph are overcharged with uric acid it may act as a chemic poison, causing morbid processes in the tissues and giving rise even to necrobiotic changes; when these have reached a certain degree the biurate is deposited in the necrotic parts of the structures, whereas such deposition is never found elsewhere.

Klemperer ‡ is of the opinion that "the phenomena of gout cannot be explained by a mere crystallization of urates from the blood, or by the production of necrotic changes due to its presence in the circulation, seeing that in other conditions in which uric acid is present in excess in the blood, such as leucocythæmia and chronic nephritis, neither uratic deposits nor necrosis of cartilage are met with. Some unknown substances produce in gouty persons inflammation and necrotic changes in various tissues, and the necrosed tissues possess the power of attracting to themselves the excess of uric acid in the blood, while the chemic affinity of the necrosed parts for uric acid prevents the deposits from being redissolved by the blood.

The writer has called attention to the fact § that rheumatic and gouty

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* Zeits. f. klin. Med., p. 65, 1897, from Sarjou.

† Nature u. Behandlung d. Greht., from Sarjou.

‡ Deutsche med. Woch., xxi. p. 655, 1895, from Sarjou.

§ The Rheumatic and Gouty Diathesis, as manifested in the Peridental Membrane, Journal of the American Medical Association, 1891.

conditions are often observed in the form of inflammation of the peridental membrane as a primary symptom of an approaching acute attack of articular rheumatism or of gout, and that many times this condition is the only local expression of the diathesis. This fact has been overlooked by the general practitioner, and consequently no mention is made of this symptom of gout and rheumatism in works upon these diseases.

The fact of the acute susceptibility of the peridental membrane to the presence of the *materies morbi* of these diseases is a clinical fact which has only been recognized by dental specialists during the last few years. Inflammation of the pericementum as a manifestation of the gouty diathesis is proved by the relief obtained from the exhibition of therapeutic remedies which eliminate the uric acid from the system.

In the preceding pages it has been shown upon the best authority that gout, which is primarily a joint affection, may also exist in certain disorders of the blood-vessels, the circulation, the blood, the secretions, the muscles, the kidneys, the liver, the stomach, the nervous system, the skin, the periosteum, the bones, the hair, the nails, etc. The effects upon these tissues and organs of the presence in the system of an excess of uric acid are peculiar to each particular kind of tissue and to the function of the organ, the variety of the manifestations being as numerous as the tissues and organs affected.

In the periosteum, the character of whose tissue most nearly approaches that of the pericementum, these manifestations are, as already noticed, of two forms, one chronic in character, which results in the formation of nodes and exostoses, and the other acute, in which uratic deposits are present.

These deposits may be in the form of defined concretions, when they are readily detected; but, as pointed out by Mordhorst, they may be deposited in the form of invisible granules and later converted into acicular crystals of sodium urate, which still might be so small as to escape detection.

The deposits which are formed upon the roots of the teeth in gouty pericementitis are thin, greenish-colored, hard scales composed of urates of sodium, calcium, etc., which are very adherent and often require considerable force to dislodge them. These concretions may be located upon any aspect of the root, but most frequently upon the lingual and approximal surfaces towards the apex.

Uratic deposits upon the roots of the teeth are, however, not so common as might be supposed from the literature upon the subject. All calcic deposits of dark color found upon the roots of the teeth are by no means evidence of a gouty condition of the system. Such deposits which have been exposed to the fluids of the mouth and constantly bathed with pus will always be dark colored and have the appearance of being formed from tiny globular masses, a condition usually observed in the concretions which have accumulated upon the surfaces of foreign bodies, bullets, fragments of metal, etc., which have been buried in the tissues and bathed in pus for a considerable period. This same form of deposit is found upon the roots of devitalized teeth which penetrate the floor of the antrum of Highmore, and which, by inducing septic infection of this sinus through the agency of a putrefying pulp, has caused empyema.

Roots of teeth which have been forced into the antrum in an effort to extract them, teeth which have erupted into this sinus, and foreign bodies which have been introduced by traumatism invariably induce suppuration. These bodies after a time become covered with concretions which have a dark-green color and a roughened surface like that just described.

The variety of deposit found upon foreign bodies and the roots of teeth seems to be peculiarly and almost invariably the result of the suppurative process, the concretion being calcic material, and rarely responding to the murexide test for uric acid.

Concretions which are identically the same are frequently found upon the "roots of the teeth in pyorrhœa alveolaris in its later stages, when the roots of the teeth have been bathed in pus and the oral secretions for months, and the deposit constantly accumulating until the tooth is exfoliated. Cases of this character when tested for uric acid usually give negative results, and yet it is largely this class of cases which have been selected for chemical analysis with the view of discrediting the theory that uric acid plays an important part in producing that peculiar form of pericementitis accompanied with suppuration which has been designated "gouty pericementitis."

The deposits in true gouty pericementitis are formed in tiny islands of irregular outline, and in the form of thin scales with smooth surface, dark-green in color, and very firmly adherent to the surface of the cementum. These deposits are doubtless formed in the pericementum through the agency of some unknown substances, as suggested by Klemperer, which in gouty persons produce inflammation and necrobiotic changes, while the necrosed tissues possess the power of attracting to themselves the excess of uric acid in the blood. The chemic affinity of the necrosed tissues for uric acid also prevents them from being redissolved by the blood when it has assumed its normal alkalinity.

The presence of these deposits upon the root of the tooth produces symptoms of irritation of the pericemental membrane. Sooner or later this develops inflammation and the formation of an abscess at the location occupied by the deposit, which may point directly through the gum or burrow along the side of the root and discharge at the cervix. These abscess pockets, as the writer pointed out some years ago, have no communication with the oral secretions until pointing takes place, and this fact has been demonstrated over and over again by the most thorough and painstaking examinations. The infection, therefore, which induced the suppurative process could not have occurred from the mouth,—unless the suggestion of Black* is correct, that "infection may possibly take place through the glandular structures which he has discovered in the pericementum,"—but most likely it has come through the avenue of the circulation. For this reason the writer is of the opinion that the gouty deposits in the pericemental membrane do not immediately cause suppuration, and that the presence of the pyogenic cocci in the blood-current are necessary to establish this process.

* Dental Review, vol. xi. p. 258.

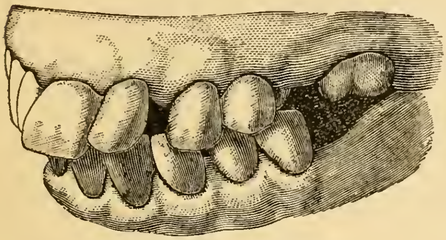
The character of the inflammation which is primarily established in these cases is always acute, the abscess usually pointing in from twenty-four to forty-eight hours. The presence of the concretion is readily demonstrated by laying the abscess open, excavating the pus, and packing the cavity with a tiny strip of gauze or a pledget of cotton for a few hours or overnight. On removing the dressing and irrigating the cavity the deposit is brought to view. This would seem to settle the question of the *deposit being the cause of the irritation*, and that it was not formed as a result of the suppurative process, as this is acute and of such brief duration that a concretion of this character could not be formed in so short a time. Neither is it possible for the concretion to have been deposited from the oral secretions, for no communication existed between them until the abscess pointed.

Symptoms and Diagnosis.—The first symptom of gouty pericementitis is soreness and elongation of the tooth, followed in a few hours in the suppurative variety by swelling of the gum either upon the buccal or lingual aspect at locations varying from midway of the length of the root to the apical region. The swelling is accompanied by considerable pain of a throbbing character. At the end of twenty-four to forty-eight hours fluctuation may be felt, and upon opening the swelling pus escapes. The early stages of the disease so closely simulate septic apical pericementitis and dento-alveolar abscess that it may readily be mistaken for these affections. It may, however, be differentiated from them (1) by the fact that the teeth affected are usually vital; (2) that the swelling is generally confined to the gum over the affected tooth, and rarely extends to the overlying soft tissues; (3) the character of the pain is not so severe nor the duration of the attack so prolonged; (4) the abscess is limited to a comparatively small area, and there is usually no communication between the abscess-cavity and the apical space. The peculiarity of this variety of abscess is that it is formed about a tophus located upon the surface of the cementum, and that until the abscess ruptures there is no communication between it and the cavity of the mouth.

Prognosis.—The prognosis will depend largely upon the success of the constitutional treatment in eliminating the uric acid from the system and preventing its excessive formation afterwards, and also in the thoroughness with which the irritating concretions are removed from the roots of the teeth. Marked and almost immediate relief is frequently obtained by vigorous general therapeutic measures addressed to the elimination of the quadrurates. A favorable prognosis cannot be hoped for, however, by constitutional treatment alone. Local treatment must be instituted for the removal of the concretions, and this must be effectually done if the suppurative process is to be controlled.

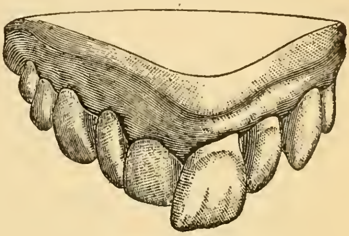
Because one or more teeth have been attacked by this disease it does not follow that all of the teeth, or even any others, will be so affected. The disease usually manifests itself in those teeth which have suffered injury of some form to the pericementum whereby its resistive power has been weakened. Constitutional measures which have for their object the control of the disease by restricted diet and proper exercise must be rigidly carried out if the desired object is to be gained. Half-way measures are worse than useless. The prognosis will be unfavorable if the irritating concretions are not removed or the constitutional dyscrasia combated. Such cases are marked by chronic inflammation and suppuration, loosening and extrusion of the tooth, which may also turn upon its axis

FIG. 633.



After Dr. George S. Allan.

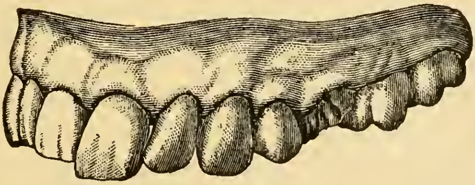
FIG. 634.



After Dr. George S. Allan.

and form a wide separation from its neighbor on one side. Dr. George S. Allan presented to the New Jersey State Dental Society casts taken from the mouth of a gentlemen which represent these features of the disease. Fig. 633 represents the denture before the disease appeared;

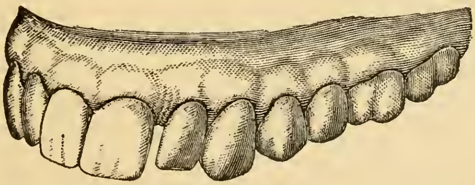
FIG. 635.



After Dr. George S. Allan.

Fig. 634 shows the condition one year later; Fig. 635 exhibits the case with the tooth permanently elongated after treatment, while Fig. 636 shows the appearance of the denture after the tooth had been shortened by grinding to match its fellow.

FIG. 636.



After Dr. George S. Allan.

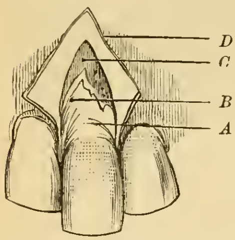
Treatment.—The treatment of gouty pericementitis to be effective must be applied to both the local and the constitutional conditions.

Local Treatment.—The treatment of the local conditions comprehends the removal of the deposits, the control and suppression of the inflammatory symptoms, the stimulation of the healing process, the institution of thorough and vigilant oral hygienic measures, and the support of the teeth to obtain surgical rest, as already described under the head of ptyalogenic calcic pericementitis.

The tophus may be readily discovered by opening the abscess by means of a curved incision, lifting the flap, and packing the cavity for a few hours with gauze or cotton.

After removing the concretion the cavity should be irrigated with an antiseptic solution, the flap brought into apposition and retained until healed by a couple of sterilized horse-hair sutures. (Fig. 637). When pockets have formed, these should be treated as described in the preceding chapter on ptyalogenic calcic pericementitis.

Fig. 637.



Gum turned aside, showing underlying condition in a case of pyorrhœa alveolaris. *A*, cervix of tooth; *B*, thickened and degenerated pericementum; *C*, alveolar process thinned and irregularly absorbed; *D*, flaps of gum.

Constitutional Treatment.—The constitutional treatment of gouty pericementitis is that which should be prescribed for gout. Any *régime* which will prevent the accumulation of an excess of uric acid in the blood or effect its elimination when formed will produce beneficial results in gouty pericementitis.

Preventive Treatment.—Prophylactic treatment in gouty conditions of the system should be instituted early enough in those individuals who have inherited the predisposition to ward off a first attack; or after the development of the disease to prevent or, at least, to retard the recurrence of any future attack.

Gouty individuals and those with the inherited tendency to the affection should eschew all food which contains much *nuclein*, as this substance tends to increase the percentage of uric acid in the blood. Sweetbreads, liver, brains, kidneys, and meat extracts all contain large quantities of nuclein, hence are contraindicated in gouty subjects. Eggs are admissible, as they contain no nuclein, but instead *paranuclein*, which during the metabolism of digestion and assimilation is not converted into uric acid. Meat and fish contain *proteids*, but as this substance is not decomposed to form uric acid, a moderate amount of these foods may be taken. Sarjou places the daily allowance at two hundred grammes, a trifle over seven ounces. A larger quantity he thinks would overtax digestion and the eliminative powers of the kidneys.

Haig * says, "The uric acid taken in the food constitutes the bulk of the uric acid eliminated. The avoidance of animal food containing xanthin compounds or uric acid, and also tea, coffee, and cocoa, whose alkaloids are similar xanthin compounds, will gradually eliminate any excess of uric acid in the system."

Kolisch † would eliminate every influence which might tend to irritate or injure the kidneys, and he regards alcohol and foods which might increase the amount of the irritating alloxins as especially harmful in this direction. Among the latter he classes flesh rich in cellular elements, while muscle, particularly if it has been boiled, he regards as permissible.

* British Medical Journal, March, 1897.
† Wiener klin. Woch., No. 45, 1895.

Milk and eggs he thinks are free from objection, as the nucleins (paranuclein) which they contain do not form alloxins. The carbohydrates and fats he thinks are allowable, and vegetables,—salads and greens,—excepting asparagus, are useful.

Nothnagel* recommends as a diet for gouty patients plenty of fresh vegetables, fruits, and starchy food, small quantities of meat, and the exclusion of sugars.

Laquer† recommends fatty milk, according to Gärtner's formula, as a suitable diet for all cases of gout. He thinks the administration of milk increases the excretion of xanthin bases and reduces that of uric acid. An increased quantity of water in the diet increases the alloxin bodies (uric acid and xanthin bases) in healthy persons.

Wood‡ thinks that milk probably suits the largest number of gouty patients, but believes there is no diet for gout. The diet must be adapted to the individual case. Nevertheless, in a large majority of cases, sugar and starches must be cut off. But in spare gouty subjects a farinaceous diet may be essential.

The ingestion of large quantities, three to four pints or more, of fluids, such as milk and pure water, especially skim-milk and buttermilk, and distilled water or lithia water, is to be recommended, to favor the free action of the kidneys and to stimulate the elimination of the waste products.

Alkaline waters were at one time very widely recommended in gout and rheumatism, but experience has shown that when the waters contain soda in any appreciable amount their ingestion is liable to accelerate the deposition of the biurate and thus provoke an attack of gout. (Sarjou.)

Alcohol as a beverage in whatever form should be eschewed by gouty subjects, as numerous observations have proved its pernicious effects. Alcohol increases the formation of uric acid and favors the deposition of the urates. The pernicious effect of alcoholic beverages in these cases is thought to be due to the incomplete process of fermentation by which they are produced.

The light wines are the least injurious, and Bordeaux, Mosel, and Rhein wines may be taken in small quantities; but the stronger wines, like sherry, port, and champagne, and ale, porter, and stout, should never form a part of the diet of a gouty individual. In certain persons a glass of any of these beverages would be sufficient to provoke an attack of acute gout of the great toe, a gouty sick headache, or an attack of pyorrhœa alveolaris.

Exercise.—Exercise to be beneficial as a prophylactic measure in gouty conditions should be regular, and of such a vigorous nature as to bring a healthy glow to the surface of the body and stimulate the emunctory organs. Such exercise should be taken out of doors, and may consist of walking, riding, cycling, or playing tennis, golf, cricket, base-ball, etc. "Over-exercise is harmful on account of the tendency to increase the alloxin productions." (Kloisch.)

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* Internat. klin. Rundschau, February 14, 1892.

† Berliner klin. Woch., September 7, 1896.

‡ New York Medical Record, July 10, 1897.

Treatment of Acute Attacks.—In the systemic treatment of acute attacks of gout, it is obvious that the treatment should be directed towards the elimination of the excess of uric acid and its compounds which are present in the blood and tissues of the body.

Until quite recently alkalies and alkaline combinations have been the most generally favored remedies in the treatment of gouty conditions. Of these combinations the most generally employed were the carbonates and phosphates of sodium and potassium and the carbonate of lithium. The use of these remedies was based upon the supposition of an acid condition, or rather a lessened alkalinity of the blood, and that by the ingestion of alkaline remedies the alkalinity of the blood would be increased and its power to dissolve uric acid and prevent the deposition of the biurate greatly augmented. The experiments of Roberts have proved these suppositions to have been based upon false premises. In the first place, there is no such thing as an abnormal acidity of the blood in gout, and, second, "the addition of the carbonates and phosphates of alkalines to blood-serum impregnated with uric acid did not retard the precipitation of biurate; the alkalines are consequently without power to prevent the formation of uratic deposits, and the salts of soda may even prove directly pernicious when taken in large doses." (Levison.)

The alkaline lithiu mcompounds—the citrate and carbonate—have been quite extensively employed in the milder cases of gout, the subacute and chronic forms, and with seeming good results. Tartarlithine, lithium bitartrate, and alkalithia, prepared in five-grain tablets, are very convenient for use. They may be prescribed, one tablet dissolved in a glass of hot water three or four times per diem.

Of the mineral springs the Saratoga, Vichy, Buffalo lithia, Carlsbad, and Apollinaris are probably the best. Among the prepared waters the ozonated lithia is the best. Waters of this character to be of real benefit should be drunk in large quantities, so as to increase the excretion of urine to from three to five pints daily.

Among the other remedies which are employed to eliminate the waste products and check the excessive formation of uric acid are colchicum, guaiacum, calomel, and the salicylate of sodium.

In order to check the excessive production of uric acid it is necessary to promote liver-metabolism and relieve the congested state of the portal system. These results may be secured by regulating the diet and daily regimen and the administration of colchicum. This drug is usually administered as wine of colchicum, in doses of twenty-five minims three times per diem. Or it may be combined with three to five minims of the tincture of aconite. Colchicum must be used with circumspection, as it is liable, if administered in large doses, or its use long continued, to produce nausea and diarrhœa. For these reasons the use of the drug should not be continued in any case for more than four to six days. Colchicum not only relieves the torpid condition of the liver and the portal system, but it relieves the severe pain of gout better than any other drug. Its mode of action, however, is obscure.

Guaiacum also stimulates hepatic metabolism and checks excessive uric acid formation. It also stimulates the kidneys, and assists them to eliminate the uric acid formed in them, and prevents its absorption by the blood. This drug is usually prescribed in the form of the tincture guaiaci; dose, one to two fluidrachms three times per diem, administered preferably in milk.

Calomel is administered for the same purpose, but the best results are obtained by giving it in divided doses until it freely moves the bowels.

"To promote the elimination of the quadrurates formed in the kidneys and so to prevent their absorption into the blood is to strike at the primary evil in the causation of gout. To promote this, diuresis should be increased and the acidity of the urine diminished. Citrate of potassium is a good diuretic, which not only increases the solubility of the quadrurates, but also diminishes the acidity of the urine, and should be continued until moderate alkalinity of the urine is produced." (Luff.)

Salicylate of sodium and the salicylate of lithium have been more or less extensively employed in the treatment of acute gout, but they are greatly inferior to colchicum.

These remedies find their most useful field in those cases in which colchicum is not well borne by the stomach. They have the power of clearing the system of uric acid, but they do not reach the primary cause of the disease, which lies in a faulty metabolism.

Various basic organic compounds, such as piperazin, lycetol, and lysidin, have been recently introduced as specifics for gout and uric acid gravel. But the opinions as to their value are so conflicting that they cannot at present be recommended.

In this study of gouty pericementitis the writer has endeavored to present the subject in such a manner that the student may get a somewhat broad view of that condition of the general system known as "uricacidæmia," and its manifestations in the various tissues of the body other than those which surround the root of the tooth, with the hope that the presentation will assist in clearing up some of the misconceptions of those who oppose the theory and of some of its over-zealous advocates who have claimed too much for it.

CHAPTER XL.

PHAGEDENIC PERICEMENTITIS.

Definition.—Phagedena (from the Greek φαγεῖν, to eat) is a spreading and destructive ulceration, often of an obstinate character, which rapidly destroys or disintegrates the soft parts.

Dr. Black first introduced the use of the term "phagedenic pericementitis" to describe a peculiar form of pyorrhœa alveolaris whose most characteristic symptom was a progressive ulceration and destruction of the pericementum and alveolar process.

Phagedenic pericementitis may be described as an inflammation of the peridental membrane accompanied with a progressive ulceration of a phagedenic or spreading type, showing a marked inclination to extend or progress most rapidly in a direction corresponding to the long axis of the tooth, and beginning apparently at the gingival border of the gum in a slight gingivitis, but really in the marginal attachment of the membrane. The disease causes destruction of the pericemental membrane and of the alveolar process immediately overlying the inflamed area, but in the early stages leaves the gum intact. This process of disintegration is accompanied with a slight reddening and congestion of the overlying gum, the formation of deep narrow pockets, the deposition in some cases of calcic material, and the discharge of a variable quantity of pus which makes its appearance on pressure being applied over the inflamed area.

The disease may be either acute or chronic in its manifestations.

Phagedenic pericementitis is entirely distinct from hæmatogenic calcic pericementitis, in that the inflammation is not dependent upon the formation of uratic deposits, and that the destructive process always begins at the marginal attachment of the membrane and progresses towards the apex of the root, spreading less rapidly in lateral directions, and destroying the pericementum and alveolar tissue simultaneously by a process of molecular necrosis, while it presents clinic features which indicate it to be an infectious disease. In hæmatogenic calcic pericementitis the inflammatory process is dependent upon the formation of uratic deposits within the peridental membrane; these concretions are deposited in locations remote from the marginal border of the membrane; they form distinct abscesses, which are confined at first to these locations, and have no connection with the oral cavity until the abscess ruptures; neither does the affection show any characteristics of an infectious disease. In other respects they have many features in common.

Causes.—In regard to the nature and etiology of phagedenic pericementitis very little is positively known. Certain general and local conditions seem, however, to have a bearing upon the disease, either as causative or resultant factors. It is true that some of these conditions seem to act as predisposing and others as exciting causes of the affection. They may therefore be divided into *predisposing* and *exciting causes*, the former being largely of constitutional origin, the latter principally local.

Predisposing Causes.—Certain systemic conditions, by a seeming predilection, find expression in various inflammatory manifestations in the peridental membrane, some of which are constructive in their character, others destructive; as, for instance, certain gouty conditions cause through irritation of the pericementum and stimulation of the cementoblasts the formation of new cement-tissue (hypercementosis), or in scurvy, which causes through intense inflammation of the pericementum destruction of this membrane and exfoliation of the teeth.

Phagedenic pericementitis generally arises under the influence of certain diseases or unfavorable conditions of health,—conditions which are productive of general debility and degenerations of special tissues like the pericementum,—and it is manifested either as a complication or as a sequel of these conditions and diseases. Among the more common general conditions and diseases which are sometimes complicated with phagedenic pericementitis or are followed by it are hereditary tendencies, anæmia, locomotor ataxia, diabetes mellitus, albuminuria, osteitis deformans, scurvy, certain nervous diseases, typhoid fever, tropical fever, certain infectious diseases, particularly the exanthematic fevers, influenza, smallpox, syphilis, gonorrhœa, and tuberculosis, pyæmia, nephritis, pregnancy, sterility, and the selective action of those drugs which produce mercurialism, plumbism, iodism, and alcoholism.

The pericementitis of scurvy, mercurialism, plumbism, and iodism in their aggravated forms are always of the phagedenic type.

It should be remembered, however, that the teeth are dermal appendages, and are therefore more liable on this account to be affected by such diseases and drug impressions as are peculiarly manifested in or have a predilection for epiblastic and hypoblastic tissues. The teeth are also in a certain sense transitory organs, and are therefore prone to take on senile and other degenerative changes, resulting in atrophy of the pericementum and alveolar structures and loss of the teeth. For this reason some authorities have looked upon phagedenic pericementitis as a "premature senile degeneration" or alveolar atrophy. The disease is most common between thirty and fifty years of age.

It is interesting to notice the great similarity in the clinic features of phagedenic pericementitis and of the oral manifestations of osteitis deformans as described by Sir James Paget. He says, "The surrounding gum becomes spongy, deep red, and sometimes tender; it separates from the neck of the tooth, while at the same time the periosteum (pericementum) suppurates and discharges pus, which is continually oozing out around the necks of the teeth, and can be generally pressed out in great quantity. It is extremely chronic, beginning generally in early middle age and may continue for an indefinite time without influencing the general health. The early stages of the disease are sometimes attended with pain varying widely in severity. The breath is usually foul, the roots of the teeth covered with irregular masses of greenish or blackish tartar, the discharges offensive, and the whole mouth tender."

Certain local conditions, like traumatisms, malocclusions, loss of antagonizing teeth, unhygienic conditions of the mouth, disease of the teeth, marginal gingivitis, etc., act as local predisposing causes of the disease.

There is no doubt in the mind of the writer that *disuse* or lack of proper exercise of the teeth, gums, and alveolar processes is an important factor in many instances in establishing a predisposition to the phagedenic form of this disease.

Deficient exercise of a muscle or group of muscles induces a degenerative change or involution, termed atrophy. Similar conditions, from similar causes, may take place in the dental organs and those tissues which form a part of the dental apparatus, thus establishing the beginning of a degenerative change which may be termed a premature senile decay or a retrograde involution.

The transitory nature of the dental organs and the alveolar processes markedly predisposes them to this class of influences, and consequently, when once these influences are established, it becomes very difficult to arrest the process of degeneration and re-establish the normal tone and functions of the parts.

Exciting Causes.—According to Black, the disease may have "its beginning in a gingivitis that in its inception cannot be distinguished from the simple form, or its character may be marked by deposits of either salivary or serumal calculus."

The active or exciting causes of the disease, in the opinion of the writer, are local traumatisms and pyogenic infections which induce a marginal gingivitis; this, through the continuity of structure, is transmitted to the already debilitated pericementum, when the conditions are favorable, through a lowered vital resistance, for the development of the pus-producing micro-organisms.

Traumatic injuries of the margins of the gums, caused by the sharp particles of very hard foods or the lodgement of such particles beneath the free margins of the gums, the too vigorous use of the toothbrush, toothpicks, and floss-silk, or the accumulation of cervical deposits, are frequent; such wounds and abrasions, though slight, may nevertheless readily establish infection by giving entrance to the tissues of the pyogenic organisms of the mouth. And as debilitated tissues are prone to degenerative changes, inflammation and ulceration are readily produced. Or a marginal gingivitis may be established through a catarrhal condition of the oral mucous membrane following a general catarrhal state of the upper air-passages, induced by coryza or influenza, or it may be produced by unhygienic conditions of the mouth, the result of improper care, or by thermic irritation of the mucous membrane, induced by the ingestion of excessively hot liquids and foods.

Pathology.—An examination of the teeth which have been lost by phagedenic pericementitis may not discover any abnormal appearances, except that the roots are denuded of every vestige of the peridental membrane. They may have deposits upon their roots or they may be entirely free from them. The teeth are usually of fine organization and dense structure, and singularly free from caries. The pulp-chamber is usually small, and the pulp shows evidences of atrophy.

An examination of the teeth *in situ* reveals the fact that upon one side the root is denuded of its pericementum to a considerable depth, while perhaps upon all other sides it is intact. This denudation of the pericementum is most often upon the lingual or buccal aspects of the root in the order named, while it is less rarely found upon the mesial and distal surfaces. The alveolar process is usually destroyed to nearly the same depth as the pericementum, while the edge is denuded and rough and apparently the seat of caries, if one may judge from the peculiar odor of the pus (characteristic of bone caries) which exudes from about the margins of the gums. This degenerative process sometimes destroys the pericementum and the alveolar septum between two approximating teeth, while the remaining parts are unharmed for a considerable period thereafter. The pockets not infrequently extend to the apex and involve the apical space, even permitting an instrument to pass over the apex, while the attachment of the membrane to the balance of the alveolus will remain in a comparatively normal condition for an indefinite period. The formation of a pocket upon one side of the root usually causes the tooth to move out of position, the displacement occurring in a direction from the diseased surface. (Black.) Occasionally the entire gingival margin of the pericementum is attacked and the whole membrane rapidly destroyed, causing extrusion of the tooth and finally exfoliation.

The examination develops the further fact that some of these cases have subgingival deposits upon their roots, while others do not. The formation of the deposits in these cases is evidently the result of the disease, and the calcic material is in all probability derived from the salivary secretions and the pus. Gingivitis is the rule wherever calcic deposits are found upon the roots of the teeth. Black thinks in these cases the phagedenic pericementitis is complicated with "calcic inflammation," and that "this dual condition has long delayed the recognition of phagedenic pericementitis as an independent disease."

In those cases which do not present calcic deposits there is often an absence of gingival inflammation, and instead there is an atrophic condition of that portion of the gum-tissue which has lost the support of the alveolar process, which often exposes the root to the extent of the lost alveolar plate.

The gums, as a rule, give little or no evidence by their appearance of the condition of the pericementum and alveolar plate lying beneath. Occasionally, however, the ulcerative process which has attacked the pericementum will be communicated to the gum and the tissue overlying the pocket rapidly destroyed. The edges of the notch thus formed in the gum-tissue will be covered with very red, coarse granulations, which bleed upon the least provocation, and are covered in the morning with an ichorous discharge. After the ulcerative process reaches the limit of the destroyed alveolar plate the edges of the gum heal and form a close union with the exposed surface of the root, thus obliterating the pocket, and in many instances controlling, and in a few others completely arresting, the further progress of the affection. This, the writer believes, is nature's method of curing the disease.

Another peculiar feature of this disease, which was first pointed out by Black, is a thickening and eversion of the alveolar margins. The phenomenon is peculiar in that as the alveolar plate is thinned upon the surface lying next to the root of the tooth new bony material is laid down upon its gingival surface, so that upon examination the alveolar edge is found to be not only thickened but has the appearance of being everted.

The disease is irregular in its attacks; sometimes it will be confined for a considerable period to the side of the root of a single tooth, or of two or more teeth upon the same side of the mouth; at others it may attack one or more teeth upon opposite sides of the mouth,—and this is the more common condition,—and then *spread to adjoining teeth* until one by one the entire denture may be lost. This latter peculiarity of the disease has given rise to the opinion among some authorities that it was infectious in its nature. Neither individual teeth nor groups of teeth seem to possess any especial liability to be attacked by the disease, but all are equally susceptible.

Witzel, Black, Arkovy, Izlai, Miller, and others are of the opinion that the disease is essentially infectious, and that it has its origin in some specific micro-organism; but none of these investigators has as yet been able to isolate the specific germ. On the other hand, the fact that the disease shows a marked tendency to bilateral symmetry, and the teeth first attacked are often not those which are most liable to ptyalogenic deposits, strengthens the theory of its constitutional origin.

Symptoms and Diagnosis.—The most marked and characteristic symptoms of phagedenic pericementitis are a thickened and turgid condition of the margins of the gums, the ulceration and destruction of the peridental membrane upon one or more sides of the root, forming deep pockets, which may reach to the apex, or the destruction of the pericementum may progress until it encircles the entire root. The process of ulceration always begins at the cervical margin, and progresses most rapidly in a direction towards the apex. Accompanying the ulcerative process there is a discharge of pus and a molecular disintegration (caries) of the alveolar process. The odor of the pus is characteristic of caries of bone. The edges of the alveolar process are denuded and rough, and the disintegration of this tissue keeps pace with the destruction of the pericementum.

Loosening of the teeth is an early symptom, the degree depending upon the character of the inflammation and the extent of pericemental and alveolar destruction.

The gum in the early stages of the disease, as a rule, maintains its integrity over those portions of the root which have lost the pericementum and alveolar plate, but in the more advanced stages recession takes place, sometimes by atrophy, at others by ulceration.

When the gum is being destroyed by ulceration the margins are covered with coarse granulations of an indolent character, and are covered during the intervals between meals, and in the morning, with an ichorous discharge. The discharge of pus is most abundant in those cases in which the pockets are deep and the gum intact.

An atrophy or ulceration of the gum which progresses to the limit of the loss of the pericementum and alveolar plate obliterates the pocket and tends to an abatement of the symptoms of the disease.

As a rule, little or no pain attends the progress of this form of pyorrhœa alveolaris.

A marked symptom of the disease is the movement or displacement of the teeth, which begins as soon as a pocket is formed at the side of the root. This movement takes place in a direction opposite to the surface

FIG. 638.—Fibroid degeneration of the pulp from a case of pyorrhœa alveolaris. (V. A. Latham.) × 110.

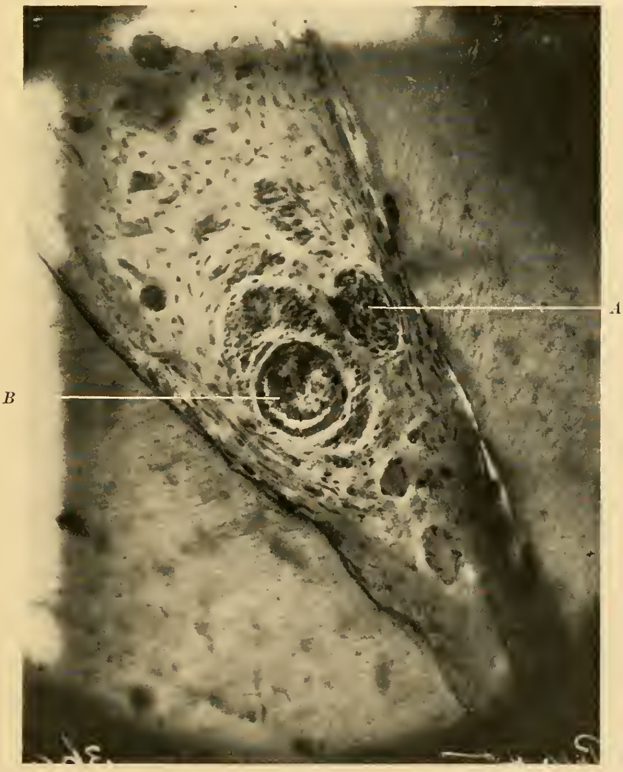

FIG. 639.—Human pulp *in situ* showing calcic degeneration. (V. A. Latham.) × 65. Thrombus in vessels at *A* and calcific areas at *B*.

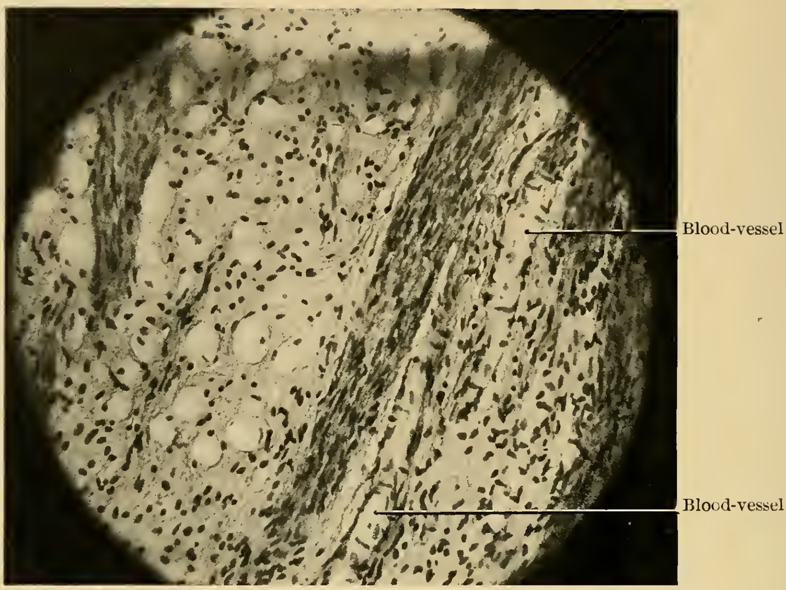

Fig. 640.—Hyaline degeneration of the pulp. (V. A. Latham.) × 100.

Fig. 641.—Colloid degeneration of the pulp. (V. A. Latham.) × 21.25.

upon which the pocket is formed, as, for instance, in a superior central incisor, if the pocket is upon the lingual surface, the tooth moves outward, if upon the mesial surface, it moves distally, etc. In other cases the tooth will turn upon its axis, usually in an outward direction, causing the mesio-labial angle to become most prominent when the pocket is upon the mesial surface, etc.

Deposits are rarely found upon the roots of the teeth in the early stages of the disease, except at the cervices, but in the later stages of the chronic form the presence of dark-green deposits is the rule. In fact, the presence of deposits marks the chronic form of the disease. In the acute form deposits are rarely or never formed upon the roots.

These facts seem to prove very conclusively that calcic deposits are not the cause of this form of the disease, but are rather a consequence of it, being formed from the salivary secretions and the pus.

Death of the pulp sometimes occurs as a result of the involvement of the apical tissues in the process of pericemental ulceration, or it may occur as a result of degenerative changes. These degenerations may be fibroid in character, as shown in Fig. 638, or calcic, as seen in Fig. 639, or hyaline, as represented in Fig. 640, or colloid, as shown in Fig. 641. Under such circumstances the disease may be complicated with an alveolar abscess. In multiple-rooted teeth one root may be so affected while the pulp in the others may still be vital.

As the disease progresses the teeth become more and more loose, until finally they are picked out with the fingers or they drop out.

Differential Diagnosis.—There are two disorders affecting the pericementum and the alveolus which under certain circumstances might be mistaken for this disease,—viz., gouty pericementitis and alveolar abscess discharging at the cervical margin of the gum. The former may be differentiated by the absence usually of cervical deposits except in the later stages of the disease, nearly normal attachment of the gingival margins, hæmatogenic deposits found high up in the pockets towards the apex of the root, the history of a painful swelling (abscess) upon the gum, and periodic soreness of the tooth. This may be supplemented by the family and personal history which give evidences of other gouty conditions.

The latter may be differentiated by applying those tests to determine the vitality of the teeth which have been mentioned in the chapter on "Pulpless Teeth."

Prognosis.—Very little encouragement can be given as to the permanent conservation of those teeth which have been once attacked by this disease; and yet by a judicious system of general and local treatment, which shall build up the debilitated condition of the body, and if possible reestablish normal function in the various excretory organs and place the teeth and the mouth in the best possible hygienic condition, much may be hoped for in the way of controlling the progress of the disease.

But the common history of such cases reveals the fact that sooner or later the teeth are lost. When the disease assumes an acute type the affected teeth may be lost in a few months; when the chronic form prevails the ultimate loss of the teeth may compass many years.

Treatment.—Treatment will prove of little benefit if it is applied to the correction of the local symptoms only; for inasmuch as the disease is influenced by or is largely due to certain abnormal states of the general system, it stands to reason that these abnormal conditions must be corrected if local treatment is to be of any real value.

It is best, therefore, at the beginning to call for a consultation with the family medical adviser and go over the case together, and then decide upon the line of general treatment which the particular case requires, leaving the conduct of this part of the case in the hands of the physician, while the dentist addresses himself to the local treatment of the oral manifestations. By such co-operation between the general practitioner and the oral specialist a much better service can be rendered the patient than if each wrought upon the case independently and with no harmony of action.

The local conditions which demand correction are malocclusion, extrusion or rotation of teeth, loss of antagonizing teeth, undue mobility, suppurative discharges, carious alveolar structure, foreign deposits, inflammation of the gums, and general unhygienic conditions of the mouth.

Malocclusions are responsible for the establishment of the disease in many instances by exciting congestion and other inflammatory symptoms in the peridental membrane. The correction of the malocclusion by simply grinding off the opposing tooth or dressing down a filling will often give relief and check the further progress of the disease.

Extrusion and *rotation* of the teeth is often arrested in the same manner, for many such cases have their origin in a malocclusion. Certain cases are dependent upon the inflammatory disturbances of the peridental membrane, the malposition increasing with the destruction of the pericementum.

Drs. M. L. Rhein and D. D. Smith have both recommended as a remedy for the correction of the abnormal conditions which produce this shifting of the teeth the devitalization of the pulp. It is argued that by devitalizing the pulp the supply of blood which was originally intended for the pulp is directed to the pericementum, and the threatened degeneration of this structure is averted. The argument seems good, and clinic experience tends to substantiate the argument, although there have not been, to the knowledge of the writer, any corroborated histologic data presented in proof.

Loss of antagonizing teeth is a most prolific source of extrusion of the bicuspids and molars. The loss of a tooth from any cause throws its antagonist into disuse, and thereby predisposes it to certain diseases of the pericementum like atrophy and degeneration. The substitution of the lost teeth by a bridge or a plate corrects these tendencies if taken in time.

Undue mobility should be corrected by ligaturing, wiring, or splinting, as mobility of the tooth increases the irritation of the peridental membrane, and by that much aggravates the already existing morbid condition.

Local treatment directed to the removal of deposits and necrotic tissue, and the sterilization of the pockets, will be of greater benefit if the teeth can be held firmly in place—put at rest—during the healing process.

The *treatment of the pockets* is an important feature in these cases. Various opinions are held upon this part of the subject. Black* is cautious

* American System of Dentistry, vol. i. p. 981.

not to injure the gum margin in the removal of the deposits, but when once beyond the gum margin to use vigorous means to remove the concretions, not fearing to injure the tissues which line the pocket. Burchard* also offers the same suggestion. The writer has found an opposite course of treatment in reference to the gum margins to give the best results. This plan of treatment was suggested more than twenty years ago by studying certain cases in which, by atrophy or ulceration of the gum overlying the root of a tooth, the pocket had been obliterated and a spontaneous cure established. This evidently was nature's method of arresting the progress of the disease, and therefore it seemed safe to follow her leadings. From that time to this the writer has employed it many times, often with the very best results, and has to-day cases under observation which were treated by this method fifteen to eighteen years ago, and are still doing good service. Not all cases, not even a majority so treated, however, prove successful; but where the general condition of the system can be built up to normal tone, and the patient will keep the mouth in a hygienic condition, the best results follow.

The method is to excise the gum down to the bottom of the pocket by removing a V-shaped flap, the apex of the flap pointing towards the apex of the root. This exposes the denuded surface of the root and the carious edge of the alveolus, and makes it possible after the hemorrhage has ceased to find all of the concretions, remove the ulcerating pericementum, and curette the carious alveolar margins. It also secures perfect drainage and makes sterilization easy.

Objection has been raised to its employment upon the labial aspect of the anterior teeth, and for cosmetic reasons the objection is valid. An exposed root, with a healthy pericementum, alveolus, and gum surrounding it, is, however, a thousand times better than leaving the gum intact and with it all the disgusting features of the disease.

The first cases treated by this method were superior incisors having pockets upon the lingual aspect of the root. Some of these did so well that it was tried upon the palatal roots of molars, and, as courage was gained, to all of the teeth in any location of the mouth. The method succeeds best if done in the early stage of the disease, but it proves beneficial in all stages. The only serious objection to the operation being performed upon the labial surfaces of the roots of the anterior teeth is the one already mentioned, and for that reason, if the patient has a short lip and shows the gums in talking and laughing, it would prove an ugly disfigurement; aside from this the operation may be commended. In such cases as last described the gum may be slit open from the margin towards the apex, the flaps laid back to expose the carious margin of the alveolus, as suggested by Garretson, and the gum afterwards brought together and closed by sutures.

The instruments which are best adapted for curetting the alveolar border in this operation are hoe or spoon-bladed excavators with an angle of about forty-five degrees, or sharp chisels. During the operation the side of the blade should be kept close to the root in order that the gum-

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* Dental Pathology, Therapeutics, and Pharmacology, p. 475.

tissue may not be unnecessarily injured. The same instruments are valuable for curetting the alveolus in any form of operation that may be adopted.

The late Dr. Allport designed a bur (Fig. 642) for the especial purpose of curetting the alveolar border by passing the instrument into the pocket from the margin of the gum. This instrument permits the removal of the diseased border without unnecessarily injuring either the cementum or the overlying gum. The tapering enlargement of the instrument between the bur and the shank allows the head of the instrument to be kept close to the cementum without cutting its surface, and insures the certainty of a complete removal of all the carious portions of the alveolus.

FIG. 642.

Dr. Allport's bur.

Effort should be made also to freshen the margin of the pericementum by passing a delicate hoe-shaped instrument of the pattern just described to the bottom of the pocket and sweeping around the denuded edge of the alveolar plate. The pus, blood, and the *débris* of the operation can be cleared out of the pocket by irrigating it with hydrogen dioxide, and then sterilizing with a 1 to 500 solution of mercuric chloride in water, or the same strength solution may be made in hydrogen dioxide. The Dunn medicinal syringe is a most convenient instrument for the purpose of irrigating such pockets and of applying other liquid remedies.

Caustic and escharotic remedies should be avoided after such an operation, as in a majority of cases the application of such powerful agents would prevent the process of granulation by paving the way for the production of more necrotic tissue in the very location in which a moment before so much pains had been taken to remove it. Such kind of treatment in general surgery would only be considered permissible in cases of malignant disease where the surgeon felt that there was quite strong presumptive evidence that all of the malignant tissue had not been removed. But if applied under any other circumstances he would expect to find his efforts to produce healing of the wound defeated by the presence of necrotic tissue, which must be again removed before regeneration could take place.

Black recommended making a semicircular incision in the gum over the carious alveolar border, raising the flap and operating through this opening with sharp chisels, and, after irrigation with hydrogen dioxide, stitching the flap in position. The main object of this operation is to remove the carious material without injuring the gum margin.

The after-treatment should consist of thorough hygienic care of the mouth and the use of antiseptic stimulating and astringent mouth lotions. Tincture of capsicum and myrrh, one part capsicum to four parts of myrrh (one teaspoonful to a goblet of water), is one of the best stimulating and astringent lotions for this purpose.

Replanting.—Treatment of this disease by extraction and replanting has been recommended from time to time, but the operation has met with such indifferent success that it has never become a popular method of treatment. The writer some ten years ago made several of these operations in dispensary and private practice, and although at first they gave great promise of a successful issue, all of them were lost inside of two years as the result of the recurrence of the disease in an acute form following slight injuries. The methods adopted were the same as those described in the chapter on dento-alveolar abscess.

Sponge-Grafting.—Dr. E. C. Briggs * and the late Dr. W. H. Atkinson † first called attention to the use of sponge-grafts to reproduce tissue lost by this disease, and while successes were undoubtedly obtained under favorable conditions of oral hygiene, the great majority of such operations in the mouth were failures, because of the difficulty in obtaining and maintaining aseptic conditions.

Electricity.—The employment of electricity in its various forms is sometimes beneficial in the treatment of those cases of the disease which

Fig. 643.

Improved dento-electric cautery.

are free from deposits. The writer has found the best results to follow the application of the galvanic cautery to the diseased tissues of the pockets, and afterwards applying a mild faradic current to stimulate the circulation of the pericemental membrane.

Before applying the cautery a ten per cent. solution of cocaine should be applied to the pocket. Eucaine or chloretone in proper strength will answer an equally useful purpose, and be less liable to produce unfavorable constitutional impressions. After the gum has become anæsthetized the cautery-point (Fig. 643) may be applied and the current turned on for a sufficient space of time to permit the cauterizing of the margin of the pericementum, the whole surface of the pocket, and the carious border of the alveolus. The parts should next be irrigated, and instruction given to the patient to keep the mouth thoroughly clean by the use of antiseptic lotions, etc. The cauterized tissue sloughs away in a day or two and healthy granulations appear upon its surface. The faradic current may now be employed to stimulate the sluggish circulation of the pericemental membrane by applying the anode to the gum over the affected root and the cathode to the external surface beneath the jaw.

The current employed should never be strong enough to be unpleasant. The duration of the treatment may be from ten to twenty minutes. Cataphoresis may also be employed with cocaine to produce local anæsthesia, and also to obtain diffusion of such drugs as are employed to stimulate the diseased tissues to a more healthy functional activity.

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* Transactions American Medical Association, 1884.

† Transactions American Dental Association, 1885, pp. 152–154.

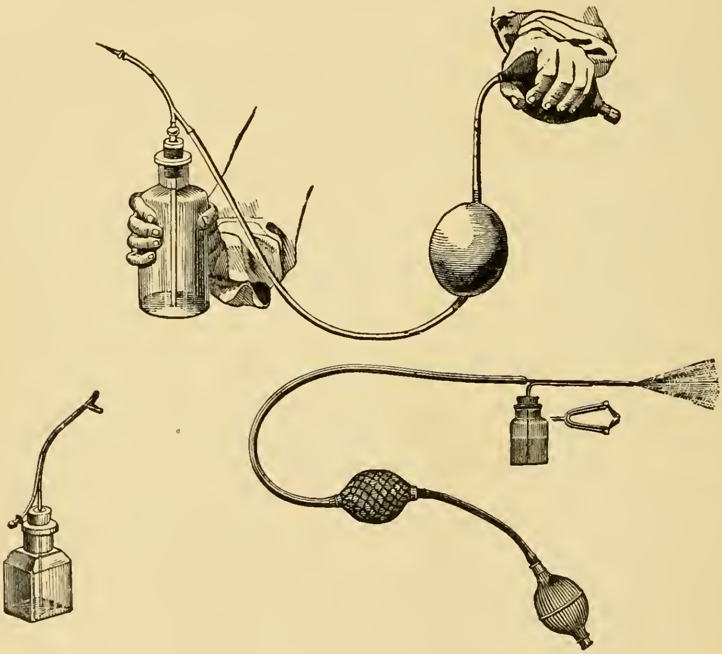
CHAPTER XLI.

ANÆSTHETICS, LOCAL AND GENERAL.

Definition.—Anæsthetic (Greek, ἀν, priv., and αἰσθάνεσθαι, to feel), a substance that produces insensibility to feeling or to acute pain, diminished muscular action, and other phenomena.

Anæsthesia is a state or condition of insensibility or loss of feeling due to pathologic conditions of the nerve-centres, of the nerve-trunks, or of their peripheral terminations, or to the artificial production of insensibility by means of the toxic effect of certain substances which temporarily inhibit the sensory functions of the nerve-centres, of the conducting paths

Fig. 644.



Spray apparatus—hand-instrument.

of the nerves, or of their peripheral terminations. The former is termed *pathologic anæsthesia*, the latter *surgical anæsthesia*. Surgical anæsthetics are of two general classes,—viz., those which act locally at the point of application and are termed *local anæsthetics*, and those which act through the general system, termed *general anæsthetics*.

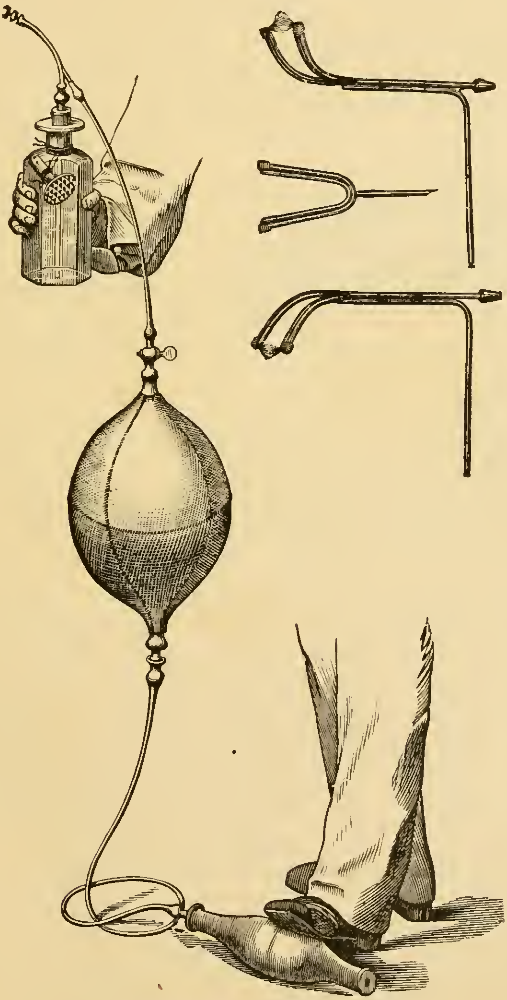
Local Anæsthetics.—Various remedies have been introduced from time to time for the purpose of producing local insensibility to pain, especially for the extraction of teeth and other minor surgical operations. Most of these, however, have been discarded for various reasons, such as the unreliability of their anæsthetic power, their danger of producing general toxic effects upon the central nervous system, or their tendency to cause local gangrene and sloughing of the soft tissues.

These remedies may be divided into two groups,—first, *those which produce anæsthesia by the local abstraction of heat;* and second, *those which produce anæsthesia through their local narcotic effect upon the tissues to which they are applied.*

ANÆSTHESIA BY THE LOCAL ABSTRACTION OF HEAT.

Richardson Method.—Dr. B. W. Richardson (1866) suggested the use of ether in a finely divided spray thrown upon the parts to be oper-

FIG. 645.



Spray apparatus—foot-instrument.

ated upon. This was accomplished by means of a hand or foot bellows-atomizer. Fig. 644 shows the hand-instrument; Fig. 645 shows the foot-instrument. The strongest ether is used, freed from alcohol and water, and mixed more or less with atmospheric air. The apparatus consists of a bottle to contain the ether, in the mouth of which a cork is fitted and perforated with two holes, through which a double glass tube is passed, one extremity of the inner part going to the bottom of the bottle; above the cork a tube connected with the bellows pierces the outer part of the double tube and communicates by a small opening with the interior of the bottle at the inner side of the cork. The inner tube, reaching to the bottom of the bottle, delivers the ether at the extremity of the outer tube. Compression of the bellows produces two currents of air, one of which descends and presses upon the surface of the ether contained in the bottle, causing it to rise in the inner tube; the other ascends through the outer tube and plays upon the column of ether as it ascends through the inner tube, converting the ether into a finely divided spray.

The effect of the spray is to increase the rapidity of the evaporation, which produces intense cold, abstracting the heat of the tissues to such an extent as nearly to freeze them, and thus rendering them, for the time being, insensible to pain.

Rhigolene, which is a distillation product of petroleum, is used for the same purpose and by the same means. This substance is the lightest of all known liquids; its specific gravity is 0.625, and it boils at 70° F. It volatilizes more rapidly than ether, and consequently reduces the temperature of the tissues much more rapidly than does the ether.

Special points for the atomizer have been devised for the use of the dentist, as shown in Fig. 645, which permit a spray to be thrown upon each side of the gum.

Letamendi's Method.—Dr. Letamendi (1875) suggested an improvement upon Richardson's method as follows: After applying a perfectly neutral sulphuric ether spray for about two minutes, he found the surface of the skin becomes red or hyperæmic and is the seat of a disagreeable sensation of cold, but no sensation of burning in the part. At this stage of the process he made a slight incision in the centre of the hyperæmic area with a convex-edged bistoury, eight to ten millimetres in length, but not going deeper than the capillary layer of the cutis. Almost immediately there is produced an anæmic zone around the incision which enlarges outwardly. If the spray is again made to play for a few seconds over the surface which has become anæmic, the region becomes perfectly bloodless and completely anæsthetic. The advantage of this method is that the tissues become anæsthetic much sooner than by the Richardson method, and there is not the danger of so reducing the temperature as to freeze the part and thus cause death of the tissue and sloughing.

Dr. Letamendi offers the following theory to account for the effect of the slight incision made in the superficial structures of the skin.* "The abstraction of heat caused by the application of the ether spray causes relaxation and consequently dilatation of the vessels. The incision produces a sudden reaction, or stimulus, which converts the extreme dilatation

* Archives de Physiologie, 1875.

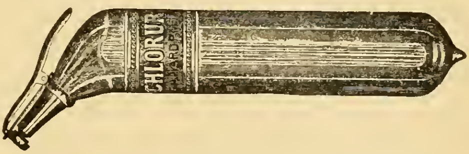
into an extreme contraction, which makes the anæmia and consequently the anæsthesia complete."

Arnott suggested as a substitute for ether and rhigolene a freezing mixture composed of ice or snow and common table salt in the proportion of two parts of ice or snow to one of salt. To be most effective it should be enclosed in a bag, one side of which should be made of rubber sheeting and the other of a coarse meshed linen or cotton cloth, to permit the water formed by the melting of the ice to drain away.

In applying the bag to produce anæsthesia of the gums preparatory to extracting a tooth, the cloth side should be placed in contact with the gums and tooth, the rubber side being against the cheek, thus protecting it from injury which might result from a reduction of the temperature. The briny fluid which accumulates in the mouth from the melting of the ice may be removed by the use of the saliva ejector.

These agents have given place during the last few years to the use of *ethyl chloride*, or mixed *ethyl* and *methyl chloride*. Ethyl chloride is contained in glass tubes with capillary points and is exceedingly volatile. (Fig. 646.) The spray is directed upon the gum over the tooth to be extracted until intense anæmia or ischæmia is produced, which is announced by the whiteness of the tissue, when it will be found to be in a state of analgesia or anæsthesia.

Fig. 646.



Ethyl chloride is inflammable and explosive, and must therefore be kept in a cool place and far from a flame.

The danger from these methods lies in the fact that if great care is not exercised in applying the spray, the vitality of the tissues may be destroyed by reducing the temperature to a lower degree than living tissues can endure.

It is interesting to note in this connection the high and low degrees of temperature that are safely tolerated by vital tissues. If the temperature be raised above 130° F. or 140° F., and maintained for any *considerable* period, death of the tissue is the inevitable result. Higher temperatures act still more rapidly. If the temperature be lowered to 60° F. or 65° F., and maintained for any *considerable* time, the vitality of the tissue will be destroyed. (Ziegler.) Much higher and lower degrees of temperature can be safely borne by the tissues if they remain at these temperatures but for a short time. The prolonged application of the hot-water bag or of the ice-bag frequently causes death of limited areas of soft tissue, which slough and are sometimes slow to heal.

ANÆSTHESIA BY THE LOCAL NARCOTIC EFFECT OF DRUGS.

Cocaine.—"Cocaine is the chief alkaloid extract of *erythroxylon coca*, and when applied locally it is a powerful anæsthetic in a limited area. It resembles *caffeine* in its action on the nerve-centres, and atropine in its effects upon the respiratory and circulating organs. Its action is most rapid upon mucous tissues. Applied to the conjunctiva, it dilates the pupil and paralyzes the function of accommodation."

The introduction of *cocaine hydrochlorate* as a local anæsthetic has to a very large extent superseded all substances previously employed for this purpose.

When cocaine was first used for the purpose of producing anæsthesia for tooth extraction, it was applied to the surface of the gum, but its anæsthetic effect did not extend beyond the mucous membrane, consequently it proved of little value, as it did not render the operation painless. Later it was employed hypodermatically in solution, when the tissues so infiltrated were found to be rendered completely anæsthetic.

Immediately following its employment by hypodermatic injection, many cases were reported of the development of unpleasant and serious constitutional symptoms, and not a few fatal cases have been recorded as the result of paralysis of the respiratory and cardiac functions.

These serious symptoms and fatal results demonstrated the fact that cocaine was one of the actively poisonous vegetable alkaloids, and that its use must be restricted to such persons as were free from pulmonary and cardiac diseases, and that the dosage needed to be greatly reduced when applied hypodermatically.

It had been customary at this time to prescribe cocaine per stomach in doses of from half a grain to one grain, and hypodermatically from one-fourth to one-half a grain. The doses now administered by the stomach are from one-fourth to three-fourths of a grain, and hypodermatically from one-twelfth to one-eighth of a grain. The larger-sized dose cannot be exceeded with safety to the patient.

The poisonous effects of cocaine are manifested upon the respiratory and cardiac centres, and when long continued, as in the "cocaine habit," it produces insomnia, moral and intellectual decay, emaciation, and death.

Its action is at first stimulating, and afterwards narcotic and depressing. When administered in a fatal dose it acts by paralyzing the respiratory and cardiac functions. The physiologic antidote is *morphine.* To neutralize the toxic effect of cocaine upon the respiratory centres, it is not necessary to administer a full dose of morphine; one-twelfth of a grain is sufficient for the purpose.

To neutralize the toxic effect upon the heart and arteries, which is manifest in the form of tonic spasms of the muscles of these organs, one drop of a one per cent. solution of *trinitrin* may be added to each dose administered hypodermatically.

Curtis* *regards volasem*—an extract of violets—as the "natural antidote" of cocaine. He claims for the drug that it neutralizes the general toxic effect of the cocaine while it does not interfere with its local effect. It acts by stimulating the heart action and the respiratory movements, contracts the arterioles, and raises the blood pressure. Administered in five-drop doses immediately before the cocaine injection, it is claimed to effectually prevent the general toxic effects of this drug, and in cocaine poisoning is an efficient antidote.

* International Dental Journal, 1900, p. 613.

Experience in the use of cocaine administered hypodermatically for the extraction of teeth and other minor surgical operations has proved that the smaller dose—one-twelfth of a grain and even less—is just as effective in producing a local anæsthesia as is the larger dose; while by the employment of the smaller dose the dangers of developing constitutional symptoms are entirely overcome, except in those cases in which there exists an idiosyncrasy against this drug.

The writer has found from a large experience with cocaine, both in the extraction of teeth and in surgical operations, sometimes of considerable magnitude, like the extirpation of cancerous growths of the lips and jaws, that a one or two per cent. solution of cocaine is just as efficient as a four or even a ten per cent. solution. When the area to be anæsthetized is large and there is a possibility of exceeding a medium dose, a one per cent. solution may be employed. In extracting teeth, two to three minims of a two per cent. solution should be injected upon each side of the jaw, care being taken to keep the needle close to the alveolar process, as by this method better results are obtained than when the injection is made nearer the external surface. In operations for the removal of tumors, a one per cent. solution can be used, but double the quantity employed, and the injections made at several different points. The one-twelfth of a grain dissolved in a drachm of sterilized water is more efficient than the same dose in one-half the quantity of the menstruum.

By using a standard solution the dose may always be accurately gauged, and the possibility of an overdose being administered entirely obviated.

The galvanic current as applied in cataphoresis hastens the anæsthetic action of the drug and makes it more profound. For the methods of its application the reader is referred to the chapter on Hypersensitive Dentin.

Cocaine solutions are liable to spoil, if kept for any length of time, by the development of fungi. It therefore becomes necessary to add an efficient antiseptic to solutions that are intended to be permanent, as sterilization by heat cannot be employed without producing chemic changes in the cocaine which destroy its character. Boiling causes it to split up into methyl, benzoic acid, and ecgonine. By using a one-half per cent. solution of carbolic acid as the vehicle for making the cocaine solution the development of fungi is entirely prevented, and such solutions will keep for weeks without change.

Burchard recommends the following prescription:

℞ Cocainæ hydrochlorid., gr. $\frac{1}{8}$;
Morphinæ sulph., gr. $\frac{1}{12}$;
Or atropinæ sulph., gr. $\frac{1}{150}$;
Trinitrin (one per cent. solution), gtt. i;
Acidi carbolici, gtt. i;
Aquæ, ad q. s.

Sig.—The above represents a half-syringeful, and is a full dose.

Tropacocaine is derived from the small-leaved coca of Java. It possesses a decided advantage over cocaine as a local anæsthetic in that it is considerably less toxic in its effects, has but a slightly depressant action upon the cardiac functions, and is free from any paralyzing effect upon the function of respiration. As an anæsthetic it is more rapid in its action than cocaine, but it is not so persistent in its effects. The dose is from one-third to two-thirds of a grain. It is made in solution with sterilized water, and the drug is of itself slightly antiseptic.

Eucaine.—Eucaine hydrochlorate "A" is a synthetic body of similar chemical constitution as cocaine, and the observed similarity in this respect was the means of causing experimentation with it as to its value as an anæsthetic and mydriatic. It is a white, neutral, crystalline powder, soluble in ten parts of cold water, about nine per cent. It is preferred by many ophthalmologists to cocaine for all purposes in which this drug is used, as its toxic effects are less powerful, while its anæsthetic and mydriatic powers are more persistent than those of cocaine.

Its physiologic effect upon the central nervous system is primarily one of exaltation, as shown in a quickened heart-beat, and secondarily of depression and paralysis. Locally it produces hyperæmia of the capillaries, while cocaine produces ischæmia.

Solutions of eucaine are made in distilled water, and are much more stable than those of cocaine. Sterilization by boiling does not decompose the eucaine. The maximum dose hypodermatically is from one-fourth to one-half a grain. It is employed in dental surgery in from four to nine per cent. solutions. Solutions stronger than nine per cent. are not stable, and will separate crystals of eucaine.

Beta Eucaine.—Eucaine hydrochlorate "B" is a similar synthetic body to eucaine "A." It is a white, neutral crystalline powder, soluble in from twenty-seven to twenty-eight parts of cold water—three to four per cent.—at ordinary room-temperature. The toxicity of eucaine "B," according to the experiments of Drs. Dumont and Legrand, is 3.75 less than that of cocaine, and about three times less than eucaine "A," while its anæsthetic effect is equally rapid, but of shorter duration. It is complete in from three to five minutes, and disappears in from ten to twenty minutes. Later experiments place the toxic effect of eucaine "B" at five times less than that of cocaine. It is employed hypodermatically in dental surgery in solutions of one-tenth to one per cent. The dose usually employed is one to two centigrammes (one-sixth to one-third of a grain) of a one per cent. aqueous solution.

Chloretone (acetonchloroform, or trichlor tertiary butyl alcohol) is another synthetic compound, prepared by Parke, Davis & Co., and "is formed when caustic potash is slowly added to equal weights of chloroform and acetone, and may be isolated from this mixture, after the removal of any excess of acetone and chloroform, by distilling with steam. Obtained in this manner, it is a white, crystalline compound, having the odor of camphor. When freed from water by melting and allowed to cool, the camphoraceous odor is more pronounced, and its general appearance resembles camphor more closely. It is very soluble in chloroform, acetone, strong alcohol, ether, benzine, and glacial acetic acid, sparingly soluble in cold water (one per cent.), more soluble in boiling water. Dilute acids and alkalies are apparently without effect; concentrated sulphuric acid decomposes it." (Houghton and Aldrich.)

Chloretone possesses hypnotic and general and local anæsthetic properties. Its general effects are mainly confined to the central nervous system, differing only from most of the other hypnotics and anæsthetics of the fatty acid series in that it has little or no depressing effect upon the circulatory system. Experimentation has shown that chloretone has a selective action for the central nervous system, as more of this drug was found in the brain in several instances than in any other organ of the body. Its local anæsthetic properties are of a high order and in many respects resemble those of cocaine. It also possesses marked antiseptic properties, and for this reason is free from the objection sometimes raised against solutions of cocaine used for hypodermatic injection,—viz., that abscess and sloughing sometimes follow its employment.

Chloretone may be used hypodermatically in all cases where cocaine can be employed, while it is free from the serious objection to cocaine in that it has little or no depressing effect upon the action of the heart.

In dental surgery it may be employed locally for obtunding hypersensitive dentin and producing anæsthesia of the dental pulp preparatory to its surgical extirpation and for the extraction of teeth. For obtunding hypersensitive dentin and anæsthetizing the pulp, a solution is prepared by mixing equal parts by weight of sulphuric ether and chloretone crystals. This is applied upon a pledget of cotton after the rubber dam has been adjusted. It may also be applied cataphorically after the manner of cocaine.

For extracting teeth, a solution may be prepared by mixing fifteen per cent. of alcohol with eighty-five per cent. of distilled water, and adding enough chloretone to form a saturated solution. (Leo.) The dose of this solution (one per cent.) hypodermatically is from fifteen to twenty-five minims, and the full local anæsthetic effect is obtained in from one to three minutes. The dose of the crystals per stomach for its anodyne and hypnotic effect is from five to fifteen grains, administered in capsules or tablets.

In the employment of anæsthetic drugs which are applied by hypodermatic injection, the operation must be performed under the strictest antiseptic precautions, in order to preclude the possibility of septic infection.

The surface to be punctured should be cleansed and rendered aseptic by repeated washing with one of the common antiseptic solutions. The syringe should be of metal throughout—cylinder and piston—so that it may be sterilized by boiling; any other form of syringe cannot be subjected in all of its parts to such a process without spoiling it, and unless so treated it is unsafe to use. The solutions employed should also be sterile, otherwise abscesses may follow their injection into the tissues.

The immediate dangers from the hypodermatic injection of any of these drugs are their toxic effects, and these may develop at any time and when least expected. The operator should therefore be prepared at all times with such remedies as may be useful in combating these effects.

The *symptoms of cocaine poisoning* are dizziness and sense of faintness, great pallor, rapid and feeble pulse, bluish-white lips, cold perspiration, spasmodic respirations, and syncope. To combat these symptoms, diffusible stimulants are called for, such as aromatic spirit of ammonia and whiskey or brandy.

The aromatic spirit of ammonia may be administered in doses of from one-half to one fluidounce in water, or whiskey or brandy in doses of from one to two fluidounces. If the patient cannot swallow, one-half of this amount of whiskey or brandy may be administered hypodermatically. When the heart action is very weak, sulphate of strychnine, one-hundredth of a grain in a drachm of whiskey, or digitalin in doses of from one-hundredth to one-fiftieth of a grain, may be administered hypodermatically. The tendency to fatal syncope may be combated by the inhalation of amyl nitrite in doses of from two to three minims dropped upon a napkin and held under the nose. This remedy is also put up in tiny glass flasks or *pearls* containing three minims each, which may be crushed upon a napkin.

If these measures fail, artificial respiration and electricity should be employed, and further stimulation of the nerve-centres attempted by the hypodermatic injection of nitroglycerin in doses of one-half minim to one minim of a one per cent. solution, increased to two minims if necessary.

GENERAL ANÆSTHETICS.

The substances which are commonly used for the purpose of producing general anæsthesia are *chloroform*, *ether*, and *nitrous oxide gas;* various other substances have been introduced and tried for the same purpose, but none of them has ever enjoyed popular favor. Among these substances may be mentioned *amylene* (*pental*), *carbon tetrachloride*, *chloral hydrate*, *ethene chloride*, *hydrobromic ether* (bromide of ethyl), and various mixtures of alcohol and chloroform, and alcohol, chloroform, and ether.

The substances which are most commonly used in the practice of dental surgery are nitrous oxide gas (N_2O) and sulphuric ether $(C_2H_5)_2O$. Chloroform ($CHCl_3$) is rarely used in the extraction of teeth or other operations which require for their performance a sitting position, on account of the depressing effect of the drug upon the functions of the heart. These dangers are, however, greatly lessened if the patient can be kept in a recumbent position during the entire period of anæsthesia. Infants and little children bear chloroform better than adults, and in many ways it acts more kindly upon little children than any other anæsthetic. Chloroform has proved itself to be so unsafe for dental operations upon adults that it is rarely used at the present time for these purposes. Nitrous oxide gas and ether are so much safer, and so completely fill the requirements of anæsthetics in both brief and prolonged operations, that there is no need of running the risk of a fatal accident by employing chloroform when comparatively safe remedies may be used in its stead.

Nitrous Oxide Gas.—This substance is the safest of all of the anæsthetics employed for dental purposes that have so far been discovered. It suffers no chemical change at the temperature of the body or during its inhalation. Its only drawback is the fact that the anæsthesia produced by it is of such short duration—usually from thirty to sixty seconds—that it can be employed only in momentary operations, like the extraction of teeth, the lancing of an abscess, or the extirpation of a vital pulp. For this reason it has but little place in general surgery. It has been used in operations for strabismus, the removal of small tumors, for painful examinations, the setting of a recent luxation, or the performance of a tenotomy; but in all operations requiring more than a very few minutes ether is to be preferred, as with this substance anæsthesia may be maintained for an hour or two if required.

Nitrous oxide gas is made by the fusion of granulated ammonium nitrate in a glass retort, the gas being passed through three wash-bottles containing water and collected in a small gasometer.

The manufacture of the gas requires very close attention to obtain it in a pure state. The most common impurities likely to be found in the gas are chlorine and nitric oxide, and for this reason every sample of ammonium nitrate used should be tested for chlorine before using it, and the greatest care exercised not to allow the heat to rise above 482° F., as nitric

Fig. 647.

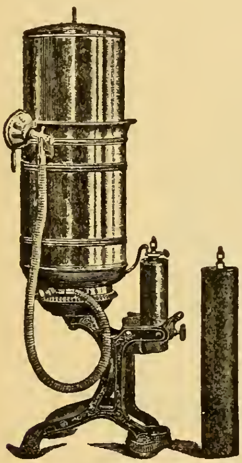
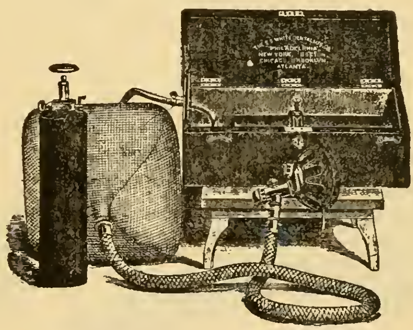


Fig. 648.



oxide is given off above this degree of heat. For the complete process of its manufacture the reader is referred to works on chemistry.

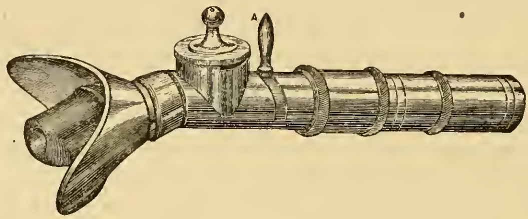
Since the introduction of liquefied nitrous oxide gas few dentists manufacture the gas for themselves. The liquefied gas is so universally pure, that the dentist feels he can obtain a better article than he can manufacture for himself; while it is in such a convenient form to handle, and the apparatus takes up so little space in the operating-room, that there is no longer any need of his consuming his time in its manufacture or filling his office with a cumbersome apparatus.

Nitrous oxide gas, when properly employed, is almost, if not entirely, free from danger, and is rarely productive of those disagreeable symptoms of nausea and depression which so commonly follow the administration of ether and chloroform.

There are several forms of apparatus used for administering nitrous oxide, both for that made in the usual manner and for the liquefied gas. Fig. 647 represents one of the most commonly used office apparatuses, while

Fig. 648 represents a portable apparatus which may be carried in the hand. In the former the condensed gas is discharged from the cylinder into a gasometer, and the gas drawn from the gasometer through a flexible rubber tube and the inhaler. In the latter the gas is discharged into a rubber bag to which are attached a flexible rubber tube and an inhaler. The inhaler is the most important part of the apparatus, and should be so constructed as

Fig. 649.



to admit or exclude air at the will of the operator. It should also be armed with a stop-cock by which the gas may be turned off, and an automatic valve whereby the expired air may be expelled and prevented from entering and mixing with the gas as it passes through the inhaler.

Fig. 649 represents an inhaler with a removable lip-shield, while Fig. 650 represents an inhaler having a face-piece or hood which covers not only

Fig. 650.

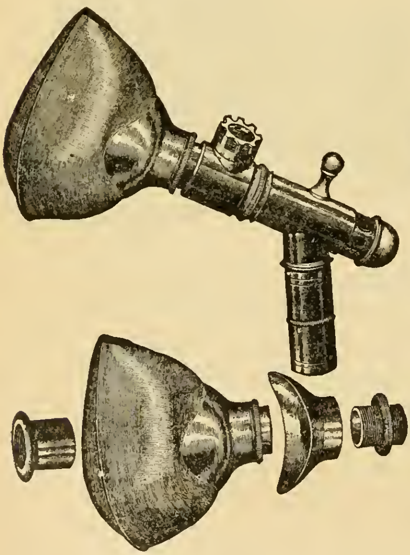
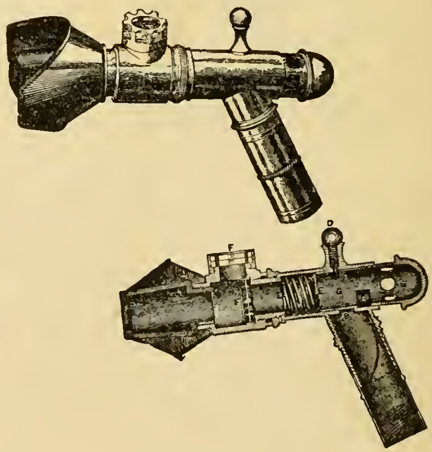


Fig. 651.

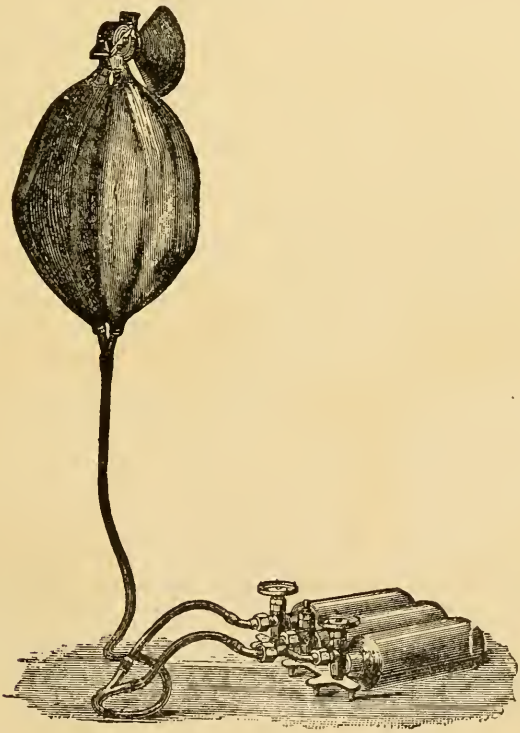


the mouth, but the nose as well. The advantage of the former lies in the fact that when the lip-shield is removed the lips can be lightly compressed around the mouth-piece by the fingers of the operator, and it also gives a full view of these parts, so that the changes in their color, as shown in the mucous membrane, can be carefully watched and those symptoms noted which indicate the lack of oxygen and the accumulation of carbonic acid in the blood. Cyanosis of the lips, stertorous breathing, and jactitation, etc., are the danger signals. In the latter instrument the face-piece or hood is a serious disadvantage, in that it covers the mouth and nose, making it impossible to watch the effects of the gas upon the blood, while in those patients who wear a beard it is impossible to exclude the admission of air. Occasionally, as in cases of harelip, or when the *orbicularis oris* muscles are so much swollen that it is impossible to close the lips about the mouth-piece, the hood becomes of great service. Fig. 651 shows the mechanism of the inhaler.

Hewitt's Method.—Dr. Hewitt, of London, England, believing that the symptoms of asphyxia which so often accompany the administration of nitrous oxide gas might be overcome by the admixture of a proper amount of oxygen with the gas, devised an apparatus by which oxygen can be mixed with the gas in various proportions.

The apparatus (Fig. 652) consists of three cylinders of compressed gas, two filled with nitrous oxide and one with oxygen, the valves of which are

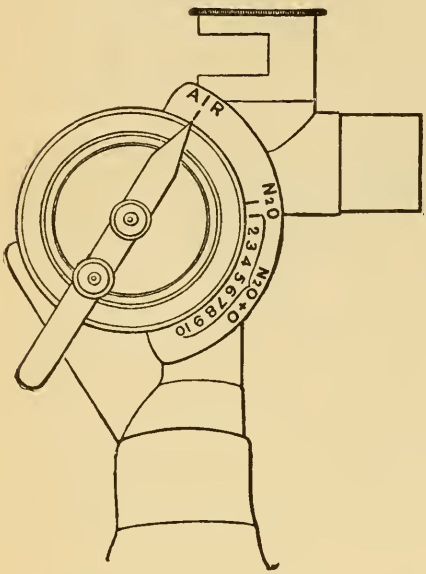
Fig. 652.



under the control of the foot of the operator. Connecting the cylinder with the rubber inhaling-bag, which is divided into two compartments by a rubber septum, is a double tube for conveying the gases to the bag. To the upper end of the inhaling-bag is attached a mixing-chamber, and to this is attached the mouth-piece or inhaling-tube.

When about to administer the gas, the valves of the mixing-chamber are closed. Oxygen is then let into one compartment of the inhaling-bag until it is nearly full and nitrous oxide into the other. The inhaling-tube is then placed in the mouth of the patient, who is instructed to make long, full, deep, and steady inspirations and expirations, the nose being closed with the thumb and finger of the operator, and the valve of the mixing-chamber (Fig. 653) so changed that only air is breathed for a few inhalations. The indicator is then pressed downward to the notch, which cuts off the air, and the patient now breathes only the pure nitrous oxide. After a few inhalations the indicator is carried still further downward to the second notch, which permits the passage of one part of oxygen to mix with the nitrous oxide. If the indicator is carried downward to the third notch, two parts of oxygen are mixed with the nitrous oxide, and so on until the patient receives the amount of oxygen necessary to prevent the appearance of the symptoms of asphyxia. The amount of oxygen required to prevent these symptoms varies considerably with each individual; some require more, others less, and the amount varies also with the stage of the anæsthesia. The first symptom and the best guide to the condition of asphyxia is the cyanotic appearance of the lips and face.

Fig. 653.



Similar advantages may be gained by the admission of atmospheric air in proper quantity and at the right time during the production of anæsthesia, but it is not possible to prolong the anæsthesia for so long a period as by the Hewitt method.

EXAMINATION OF THE PHYSICAL CONDITION OF THE PATIENT.

Before administering a general anæsthetic the condition of the patient should be ascertained by a critical physical examination, and if there is found to be present any serious functional or organic affection of the heart, of the lungs, or of the kidneys, ether and chloroform are contraindicated. Nitrous oxide may, however, in some of these cases be used with success, but there can be no positive assurance that a successful issue will follow its administration. It is better, therefore, in all such cases as would naturally come under the care of the dental surgeon for operation in which serious diseases of the heart, lungs, or kidneys exist, to use a stimulant to brace the patient for the ordeal of the operation, rather than to take the chances of administering an anæsthetic.

The shock incident to the extraction of a tooth or the lancing of an alveolar abscess may be prevented in great measure, if not completely, by the administration of stimulants or anodynes to such patients as cannot with safety take an anæsthetic.

Ether is positively contraindicated in bronchial and pulmonary diseases and in diseases of the kidneys, and chloroform in diseases of the heart. For surgical operations which must be performed to save life, ether is the safest anæsthetic for patients suffering from functional or organic disease of the heart, while chloroform is safest for those suffering from bronchial and pulmonary diseases and affections of the kidneys. If the dentist does not feel that he is competent to decide the question of the physical condition of the patient, he should consult with the family physician in relation to the matter, and if the patient has no family physician, it is best to divide the responsibility of the case by calling in some other physician to make the examination and administer the anæsthetic.

PRECAUTIONS AGAINST ACCIDENTS.

Anæsthetics should never be administered just after eating, as vomiting may be induced, and as a result particles of food may be drawn into the larynx on taking a deep inspiration and asphyxia be the result.

If nitrous oxide is used, the dentist should never assume the double responsibility of administering the anæsthetic and performing the operation alone. An intelligent and capable assistant should always be present. If ether or chloroform is used, the patient requires the undivided attention of the person who administers the anæsthetic, while the operator should not have his mind distracted by the care of the patient while under the anæsthetic. There is also another reason why in operating upon females under the influence of an anæsthetic the operator should not be alone, but should have another person present, preferably a nurse or a friend of the patient. Not infrequently hallucinations and erotic desires are stimulated by the effects of the anæsthetic, and the patient clings to the delusion that an indecent assault has been made upon her while she was in a helpless condition from the anæsthesia. The operator, therefore, if he would guard himself against unjust reproach and a serious criminal charge, should see to it that some friend of the patient is present during the operation.

Before beginning the administration of any general anæsthetic, the mouth should be examined for the presence of artificial teeth, especially partial plates, as failure to take this precaution has in several instances resulted in a fatality from the plate becoming dislodged and falling into the larynx or becoming lodged in the œsophagus.

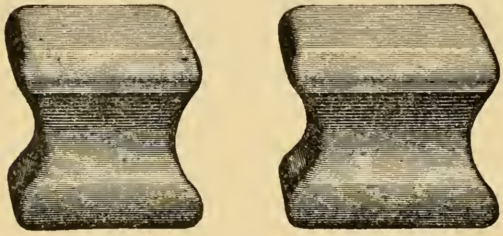
In the administration of nitrous oxide a mouth-prop (Fig. 654 or Fig. 655) is necessary to keep the mouth open during the operation. This should be applied before the mouth-piece is placed in position, so that when anæsthesia is complete no time will be lost in efforts to pry the mouth open to insert the prop.

Props made of wood or vulcanite are the best; they should have a long string securely fastened around the centre by which they may be withdrawn if by accident they should be dislodged and fall into the fauces.

Clothing which is tight at the throat or the waist should be loosened, that there may be no obstruction to the most perfect movements of breathing.

In the extraction of teeth, and particularly of roots, the operator should use the utmost care to prevent the tooth or root from slipping from the forceps and falling into the larynx, and when the elevator is used to dis-

Fig. 654.



Mouth-prop (Dr. S. H. Guilford pattern).

Fig. 655.

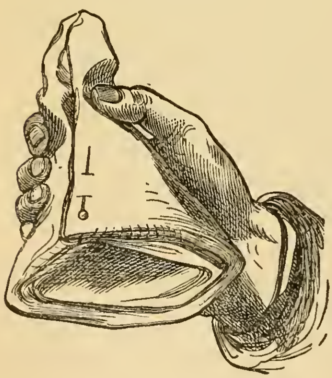
Dr. Daintree pattern.

lodge a root, it should be removed from the mouth before another is extracted, for if left in the mouth it might fall into the larynx or be drawn in by a quick inspiration, and the patient die from asphyxia before it could be removed or relief obtained by tracheotomy.

ADMINISTRATION OF ETHER.

In favorable cases which require operations that consume more time than would be allowed by nitrous oxide anæsthesia, sulphuric ether is the safest and best anæsthetic that can be employed. This substance may be administered by means of a cone (Fig. 656) formed of a towel or a folded newspaper, in which a napkin has been folded or a sponge has been placed and secured with an ordinary pin or a safety-pin. The napkin or sponge is saturated with ether, care being taken not to put on so much as to cause it to drip upon the face of the patient. It is then slowly advanced to the face of the patient, allowing plenty of air to be inspired with the ether vapor until the air-passages become accustomed to the irritation and the tendency to cough has passed away. It may then be brought close to the face and all air excluded except that which passes through the open end of the cone and through the sponge or over the surface of the napkin. In this way the patient receives a sufficient amount of oxygen to support the functions of life, while at the same time the air is thoroughly im-

Fig. 656.



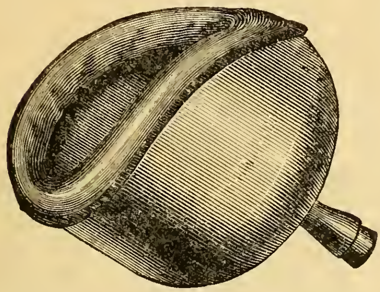
Towel done up as a cone.

pregnated with the ether vapor, and the patient is rapidly brought under its influence.

Various forms of inhalers have been introduced from time to time for the administration of ether, the best of which are the Lente (Fig. 657) and the Allis (Fig. 658).

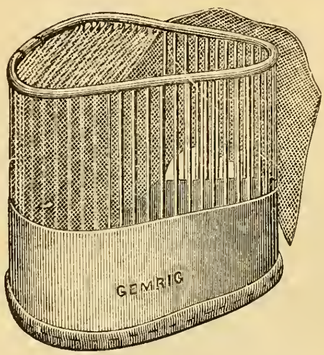
The Lente inhaler is a cone made of sheet brass, fitted with a rubber air-cushion around the edge to exclude the air from entering between the cone and the face, while the upper end has an opening fitted with a cork-stoppered tube large enough to admit sufficient air. When in use the cone is lined with a piece of sheet lint or cotton, held in place by a piece of wire or whalebone slipped in, and long enough to curve upward, so as to keep the cotton from touching the face. The cotton lining is saturated

Fig. 657.



Lente's inhaler.

Fig. 658.



Allis's inhaler.

with ether, and the apparatus is ready for use. Additional ether may be supplied through the open tube without removing the apparatus from the face, but great care must be exercised not to pour on more ether than the cotton will absorb, as there is danger of its running into the throat and causing asphyxia.

The Allis inhaler "consists of a wire framework sufficiently large to cover the lower part of the face; these wires are parallel, and about one-quarter of an inch apart. Between the wires and from side to side a strip of muslin bandage, two and one-half inches wide and three yards long, is passed. The wire frame is five inches long by three inches at its greatest width. Outside of the wire frame there is a covering of sheet brass, and over this another metal cover with a cushioned edge to fit over the face, covering both the nose and mouth, as shown in Fig. 659. When ready for use, the top is left open for the free entrance of air and for supplying the ether from without."

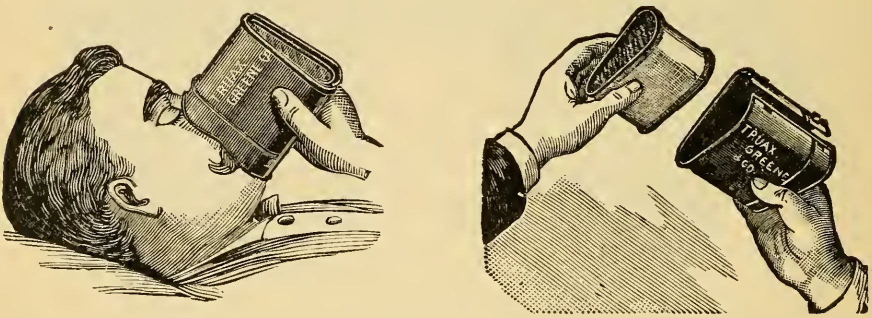
Many times, if the confidence of the patient can be secured beforehand, a tooth may be extracted, an abscess opened, or a pulp extirpated before the patient loses consciousness, as sensation to pain is lost long before this stage of complete anæsthesia is reached. In serious operations, however, profound anæsthesia is necessary in order to prevent shock and to obtain perfect control of the patient during the operation, as struggling or the spasmodic contractions of the diaphragm and abdominal muscles incident to efforts to vomit caused by nausea are great hinderances to a delicate operation.

During the stage of excitement or when the contractions of the abdominal muscles indicate the existence of a tendency to vomiting, the anæsthesia should be hastened, in order to allay these symptoms and secure complete anæsthesia as quickly as possible.

Complete anæsthesia may be recognized by placing the surface of a finger upon the conjunctiva of the eye, when, if sensation is not present, no contraction of the muscles of the lids will be observed. Complete relaxation of the muscles is another indication of complete anæsthesia. This may be demonstrated by raising an arm, which will immediately fall if complete relaxation of the muscles has taken place.

When the stage of muscular relaxation is reached there is a tendency for the lower jaw to drop and the tongue to fall into the fauces, which

Fig. 659.



Allis's aseptible ether inhaler, all metal.

by its pressure upon the larynx and the glottis causes obstruction to breathing. This tendency of the jaw to drop may usually be overcome by placing the fingers upon its under side midway between the angle and the mental foramen, and bringing the teeth of the lower jaw in contact with those of the upper, and supporting it in that position. If the tongue falls into the fauces, it should be grasped with the tongue-forceps and withdrawn, and so held until muscular relaxation has passed.

Dilatation of the pupil and stertorous breathing are danger signals, indicating that the limit of safety has been reached. The ether should therefore be withdrawn, and the free administration of atmospheric air allowed. If the respirations cease and cyanosis of the lips and face is present, the tongue should be quickly grasped with a tenaculum or tongue-forceps, and the organ drawn well forward; this opens the *rima glottidis* and allows free entrance of air. If, however, breathing does not immediately begin again, artificial respiration must be instituted and maintained until nature re-establishes the normal physiologic process. Other methods which may be employed to resuscitate the patient have already been described in an earlier part of this chapter under the head of cocaine anæsthesia.

CHAPTER XLII.

EXTRACTION OF TEETH.

THE operation of extracting teeth is one which requires experience, skill, good judgment, and an accurate knowledge of the anatomy of the teeth and of the contiguous parts. An operator who attempts to extract teeth without this exact knowledge will prove himself a bungler, and be the means of causing great suffering and irretrievable injury to the integrity of the remaining teeth and to the jaws. For these reasons it is very important that the operator thoroughly understand:

1. The anatomy of the teeth and their most common anomalies.
2. The relations of the roots of the teeth to the jaws.
3. The indications which call for the extraction of teeth.
4. The selection of the proper instruments with which to extract individual teeth or roots.
5. The proper adjustment of the instrument to the tooth or root.
6. The proper kind and direction of the force to be applied, and the lines of least and greatest resistance of the alveoli.
7. The difficulties, complications, and accidents which are liable to occur in the operation.

The anatomy of the teeth and their anomalies, and the relations of the roots of the teeth to the jaws, have already been discussed in Chapter I., to which the reader is referred.

INDICATIONS WHICH CALL FOR THE EXTRACTION OF TEETH.

The indications for tooth extraction are dependent upon such varied conditions, both local and general, that no arbitrary rules can be laid down by which to decide the many questions involved. All that can be done in this direction to assist the practitioner and the student is to suggest those conditions which most imperatively demand the operation.

Deciduous Teeth.—There are certain conditions which demand the extraction of the permanent teeth which do not appear in relation with the temporary teeth by reason of their deciduous nature and function.

The most important conditions which call for the extraction of the deciduous teeth are:

1. When the teeth are the seat of alveolar abscesses which do not respond to appropriate treatment.
2. When from other causes they are a source of continued irritation, affecting the comfort or the general health of the patient.
3. When the retention of the deciduous teeth is causing the permanent teeth to erupt out of their normal position.
4. When a deciduous tooth is retained long past the normal period for its exuviation by reason of the non-eruption of its permanent successor,

and it is becoming wedged between its immediate neighbors as a result of the approximal inclination of these teeth.

Permanent Teeth.—The most important conditions which call for the extraction of the permanent teeth are :

1. When a tooth or roots of a tooth are the subject of a *chronic alveolar abscess* which does not respond to treatment, or when there is in the upper jaw an abscess which discharges into the *antrum* or the *nasal fossa.*

2. When a tooth is the subject of an *acute alveolar abscess of malignant type,* which threatens to cause *acute septicæmia.*

3. When a tooth is rendered useless from *extrusion* caused by the loss of its antagonist and a proper occlusion cannot be restored by artificial means, or it has become very loose from resorption of the alveolar process or from pyorrhœa alveolaris.

4. When a tooth or the roots of a tooth have become useless for the purpose of crowning, bridging, or supporting a plate, by reason of the presence of fungoid growths of the pulp or the gum or of their gradual destruction by resorption.

5. When a tooth is the subject of hypercementosis which causes a persistent neuralgia.

6. When a tooth is the subject of a persistent odontalgia dependent upon pulp-nodules or a pulpitis which does not respond to treatment and is causing serious reflex or constitutional irritation.

7. When an erupting tooth is retarded by reason of insufficient room in the alveolar arch or the impingement of another tooth, and it is causing irritation and pain or acute deep-seated abscess of the jaw. This applies most often to the third molars, particularly those of the lower jaw.

8. When it becomes necessary to sacrifice certain teeth to perfect the alignment of the dental arch.

9. When the first permanent molars in children under eleven or twelve years of age—before the second molars are erupted—present with exposed pulps or alveolar abscesses. Under such circumstances all of the first permanent molars had better be extracted, as such a procedure will result in a more perfectly formed arch and a better occlusion than if only the offending tooth is removed. The writer is aware that there has been considerable discussion upon the advisability of such a course of treatment ; but he believes, after many years of experience and close observation of the results of both of these lines of treatment, that the best results are obtained by the extraction of all of the first permanent molars.

After the second molars have erupted the extraction of the first molars is unadvisable, except when the teeth are causing serious local or constitutional irritation, for after their removal there is a tendency for the second molar to tilt forward, forming an inverted V-shaped space between itself and the second bicuspid, and preventing a normal occlusion of the mesial cusps.

10. When it is necessary to remove certain sound teeth preparatory to inserting an artificial denture.

Under such circumstances the teeth that should be removed are : (1) all roots which would be covered by the denture, except those which might be utilized to carry a crown or form an abutment for a bridge; (2) all teeth which have been rendered unsightly or loose by reason of the resorption of the gums and the alveolar processes; (3) all teeth that have become so far extruded from their alveoli as to render it impossible to place occluding artificial teeth in the opposing jaw; (4) a single tooth or two teeth standing together, when they are the only teeth remaining in the upper jaw. This applies particularly to the incisors, cuspids, and bicuspids. Molars may often be left with advantage if they have occluding natural teeth; (5) when one tooth remains upon either side of the upper jaw—if they are in good position and of proper shape to receive a clasp or give support to the plate—they should not be extracted; (6) when a single tooth remains in the lower jaw, or a single tooth upon either side, it is advisable to retain them, especially if the patient is about to have inserted the first lower plate, as such teeth are valuable for supporting the denture by means of clasps, until such time as the patient becomes accustomed to it.

GENERAL CONDITIONS UNFAVORABLE TO EXTRACTION.

Certain systemic conditions are generally regarded as unfavorable to the extraction of teeth, for the reason that the operation may under these circumstances aggravate an existing morbid condition, set in operation a train of unfavorable symptoms, or establish a dangerous and perhaps fatal complication.

The systemic conditions which are most liable to cause unfavorable results from the extraction of teeth are:

I. General debility.

II. Nervous irritability.

III. Organic disease of the heart.

IV. Epilepsy.

V. Hemorrhagic diathesis.

VI. Pregnancy.

I. General Debility.—This is a condition which greatly predisposes the individual suffering from it to *nervous depression* and *shock.* In a large majority of these cases the vital forces are depressed, the nervous system is in an irritable condition, and the heart action weak. It therefore becomes necessary in these cases to prescribe tonic treatment in the form of iron, quinine, and strychnine, to prepare the patient for the ordeal of the operation. If, however, an immediate operation is imperatively demanded, stimulants should be administered and the operation performed under an anæsthetic.

II. Nervous Irritability.—General nervous irritability may be an inherited condition or diathesis, or one which is the result of morbid conditions of the system induced by disease, great nervous strain, overwork, and such like circumstances. In either case the affection is a manifestation of a debilitated condition of the nerve-centres calling for general tonic treatment, such as that just indicated, to build up the system; and sedatives, such as potassium bromide, asafetida, and valerianate of ammonium, to control the more irritable nervous manifestations. Operations upon such individuals not infrequently result in severe shock to the nervous system, resulting in chorea, hysteria, or more serious nervous affections.

III. Organic Disease of the Heart.—In organic disease of the heart in any of its many forms,—hypertrophy, fatty degeneration, valvular insufficiency, etc.,—there is great danger of shock in even trivial operations. It therefore becomes necessary, whenever the operation of tooth-extraction is imperatively demanded, that every precaution be taken to guard against shock and its possible fatal termination. The nervous excitement and fright incident to the contemplation of the operation in individuals suffering from a weak heart are sometimes sufficient to produce fatal shock. For these reasons the dental practitioner should never permit himself to operate upon such individuals without the knowledge and co-operation of the patient's family physician. Such an association is a safeguard, in case of a serious or fatal termination of the operation, against unjust criticism or a suit for supposed malpractice.

Whenever a tooth has to be extracted for a person suffering from any organic heart affection, it becomes necessary to administer cardiac stimulants, such as whiskey or brandy, aromatic spirit of ammonia, digitalis, strychnine, or a one per cent. solution of nitroglycerin. To obtain the best results, some one of these agents should be prescribed an hour or two before the contemplated operation.

The operator who is thoroughly prepared for all emergencies will have a hypodermic syringe charged with a tablet containing one-fiftieth of a grain of digitalis or one-fiftieth of a grain of strychnine sulphate dissolved in one drachm of whiskey or brandy, or with the following combination (also put up in tablet form by Nelson, Baker & Co., of Detroit, Mich.).

℞ Digitoxin, gr. $\frac{1}{240}$;
Nitroglycerin, gr. $\frac{1}{200}$;
Strychnine sulph., gr. $\frac{1}{100}$.
Dissolve in one drachm of distilled water.

This combination is an exceedingly efficient remedy in cases of threatened heart failure, shock, or collapse, and should find a place in all emergency outfits.

IV. Epilepsy.—Individuals who are so unfortunate as to be the subjects of epilepsy may be prepared for the operation by the administration of large doses of potassium bromide, which will in many cases, for the immediate time at least, prevent or mitigate the severity of an attack. Nitrite of amyl, if applied during the convulsion, will sometimes cut the attack short. The nervous condition of these poor unfortunates is such that anxiety, fear, or the shock of an operation is prone to bring on an attack; it is therefore unwise for the dentist to undertake the extraction of a tooth without the presence of the family physician or some other medical adviser. In case an attack comes on, all that can be done is to place the patient in the recumbent position, protect him against injury during the paroxysm, and prevent the laceration of the tongue and other soft tissues of the mouth from the spasmodic closing of the jaws. This may be accomplished by placing a piece of soft rubber between the teeth, or a roll of bandage or other such material.

V. Hemorrhagic Diathesis.—The hemorrhagic diathesis is due to deficient muscular tone in the coats of the blood-vessels, and to a lack of a normal coagulability of the blood. This diathesis may be hereditary or acquired, and it usually first shows itself at about the period of second dentition. It is a condition which often causes great anxiety and alarm to the operator, the patient, and the friends, as many cases of fatal hemorrhage following tooth-extraction in these individuals have been recorded. When the operator is aware of the diathesis he can usually, by appropriate treatment instituted a few days before the contemplated operation, control the tendency to hemorrhage by improving the tone or contractility of the blood-vessels and restoring the normal coagulability of the blood.

A pill containing from ten to twenty grains of gallic acid and one grain of opium may be administered after each meal for three days, or the fluid extract of ergot may be given in doses of from twenty drops to one fluidrachm every two to four hours on the day previous to the operation. Ergot, however, *must not be administered to pregnant females*, on account of the danger of producing an abortion.

VI. Pregnancy.—Women who are performing the functions of menstruation, gestation, or lactation should as far as possible be shielded from all operations.

During the period of menstruation most women are in a peculiarly nervous condition, and much more susceptible to irritation and shock than at other periods. Vicarious menstruation from the alveolus of a recently extracted tooth has also been recorded.

Many cases of premature labor have been placed on record as the result of shock from the extraction of a tooth, while congenital deformities and monstrosities have been charged to the same cause. A very slight nervous or mental shock is sufficient in some women to produce premature labor, while in others even a severe shock makes no impression. It is safer, however, under all circumstances requiring operation upon pregnant women to administer a general anæsthetic, and thus prevent the shock which would be likely to occur from the operation.

During lactation mental anxiety, nervous irritation, and shock are liable, through some peculiar action of the nervous system, so to change the character of the lacteal fluid as to make it unfit for the nourishment of the infant, and in some cases to render it absolutely poisonous. Carpenter * records a case of this character in which immediate death of the child followed the taking of the breast of a nursing mother who had suffered great mental agitation. These occurrences have been explained in part by the discovery of Dr. Victor C. Vaughn, of Michigan University, who found that under certain fermentative changes a poisonous ptomaine, which he has termed *tyrotoxicon*, is formed in milk and cheese, and also in ice-cream.

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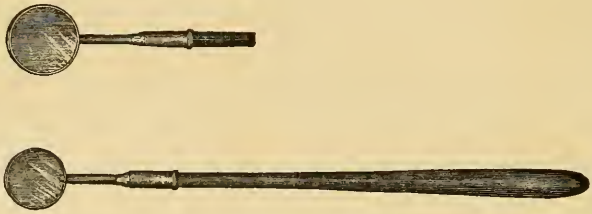
* Physiology, 1862, p. 742.

INSTRUMENTS USED IN THE OPERATION OF EXTRACTING.

An examination of the mouth and of the tooth to be removed should always be made before any steps are taken in the operation. For this purpose a *mouth-mirror* (Fig. 660) and a curved probe or explorer are necessary.

Fig. 660.



Mouth-mirror.

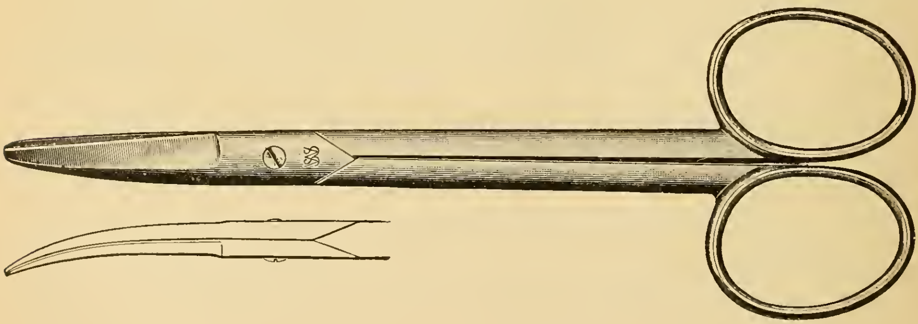
Gum-lancets (Fig. 661) are employed in some cases to dissect the gum from around the cervix of the tooth prior to the adjustment of the extracting instrument. These cases are represented by the third molars, teeth which stand alone, and roots which are buried more or less completely

Fig. 661.

Gum-lancet.

by overlying gum-tissue. In all other cases the use of the gum-lancet is rarely indicated, provided the beaks of the forceps are made sharp, so that they will cut their way through the margin of the gum as the instrument is pushed towards the alveolar border.

Fig. 662.



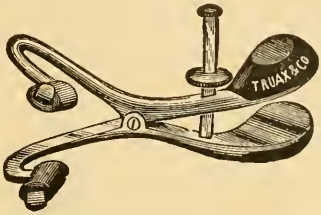
Curved scissors (Fig. 662) are also necessary to a complete extracting outfit, and should be at hand for severing any portion of gum-tissue that might be found adherent to the cervix of the tooth.

Mouth-props and gags (Figs. 663 and 664) should be employed when a general anæsthetic is administered, the object being to obviate the necessity of having to open the mouth forcibly before the tooth can be reached, and to conserve valuable time, which is an exceedingly important consideration when nitrous oxide gas is used. (See also those on page 592.)

FIG. 663.

Mouth-prop.

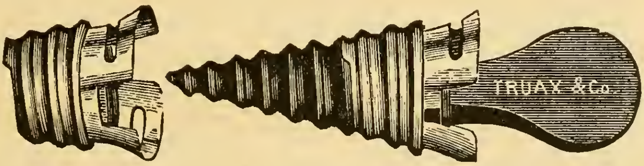
FIG. 664.



Mason's gag.

The jaws of the Mason gag should be covered with rubber tubing, to prevent them from slipping or causing injury to the teeth. The jaws of the gag are separated by turning the milled nut downward. The curve of the jaws of the instrument is such that the handles extend backward

FIG. 665.



Warren's screw-gag.

under the lobe of the ear, and are therefore entirely out of the way of the operator.

In adjusting the gag, its jaws should be placed between the molar teeth upon the side of the mouth opposite to that where the operation is to be performed.

The *screw-gag* (Fig. 665) is an exceedingly useful instrument for opening

FIG. 666.

Tobolt's laryngeal forceps.

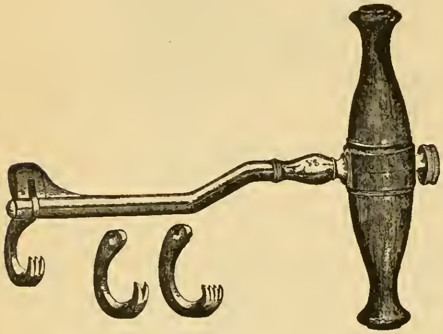
or extending the jaws in cases of trismus caused by inflammation and swelling. Its application needs no explanation.

A laryngeal forceps (Fig. 666) is also a necessary part of a complete extraction outfit. In case a tooth or a fragment of one should fall into the fauces beyond the reach of the finger, this instrument would be most valuable for its removal.

The instruments which are employed for the extraction of teeth are the turnkey, forceps, and elevators.

Turnkey.—The turnkey, which for many years was the only instrument employed in the extraction of teeth, has at the present time been almost entirely discarded. It is, however, a very serviceable instrument in certain cases where the crown of a molar has been broken away by caries or accident to a point beneath the gum, upon the buccal or lingual side only, while the remaining portion is strong. Such cases offer great difficulties to their extraction with the forceps, which either slip off or carry away the remaining portion of the crown, while it is often impossible to remove them with an elevator. The application of the turnkey (Fig. 667) to such teeth converts a difficult operation into a simple one. This is accomplished by placing the fulcrum upon the gum upon the side of the tooth which has been broken away, and the claw upon the opposite side of the tooth at the margin of the gum. This permits a proper direction of the force applied, and admits of an easy and natural removal of the tooth.

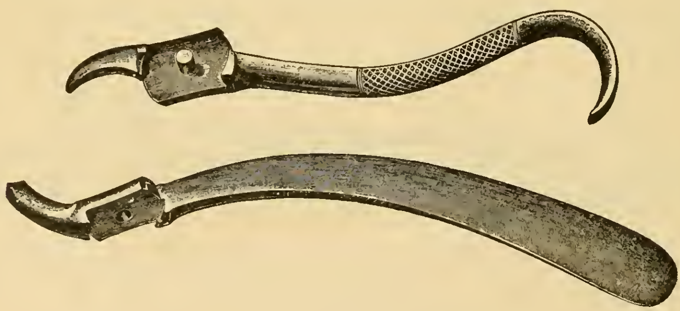
Fig. 667.



Turnkey.

Forceps.—In these days of aseptic surgery all forceps should be made in such a manner that they may be taken apart, as this gives a better opportunity for thorough sterilization. Fig. 668 shows an instrument of this character, the joint of which is very simple in construction, strong, and easily cleansed.

Fig. 668.



Aseptic forceps.

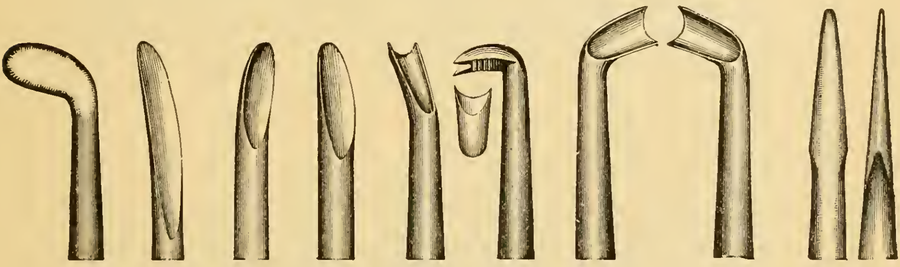
The *beaks* of the forceps should be of such shape as to fit as large a surface as possible of the cervix of the tooth for which they are constructed, without pressing too hard upon the cervix or the crown. If the pressure comes too hard upon the crown, it is liable to be crushed; while if the curve of the beaks is so great that the terminal edges grip the cervix only, there is danger of fracturing the tooth at this point. This quite often happens with the use of lower molar forceps that are improperly constructed. The terminal edges of the beaks should be made sharp, so that when they are crowded against the cervical border of the gum they will cut their way, and thus avoid the necessity of using the gum-lancet.

The *handles* of all forceps should be serrated in such a manner that when gripped by the hand they will not slip. This is very important, for if any considerable pressure is placed upon the handles to keep them from slipping, there is danger of crushing the crown or cutting it off.

The *curves* of the beaks and the handles must be of such form as to permit a proper adjustment of the beaks to the teeth to be extracted, while the handles should not impinge upon the anterior teeth of the opposite jaw, and should allow the force which is applied to be made in a direct line with the long axis of the tooth, or, in other words, in a line with the general direction of the roots.

Elevators.—These instruments are devised for the extraction of roots which are too frail to withstand the grip of the forceps or the pressure of

Fig. 669.



Elevators.

the turnkey. In applying these instruments the grooved face is adjusted to the surface of the root, and the blade carried downward to the alveolar process. Force is then exerted in a direction to lift the root from the alveolus. Fig. 669 shows several forms of elevators, all of which are useful, and should be found in every complete extracting outfit.

Fig. 670.

Dental screw.

The dental screw (Fig. 670) is also a valuable instrument for the removal of very frail roots in which caries has followed the pulp-canal and converted the root into a mere shell. This instrument is applied by screwing it into the cavity in the root until the thread takes a firm hold upon the dentin, when the root is easily lifted from its alveolus.

THE SELECTION OF THE PROPER INSTRUMENTS FOR THE EXTRACTION OF THE VARIOUS CLASSES OF TEETH, THEIR PROPER ADJUSTMENT, AND THE KIND AND DIRECTION OF THE FORCE APPLIED.

The teeth, from the stand-point of their proper extraction, may be divided into *seven classes*, according to the number and the anatomic form of their roots.

The first class includes the superior central and lateral incisors, which have single, cone-shaped roots.

The second class embraces the inferior central and lateral incisors, which have single, considerably flattened, cone-shaped roots.

The third class comprises the superior and inferior cuspids, which have single, very long, slightly flattened, cone-shaped roots.

The fourth class includes the superior and inferior bicuspids, which have single, sometimes bifurcated, flattened, cone-shaped roots.

The fifth class comprises the superior first and second molars, which have three cone-shaped roots,—two buccal and one lingual.

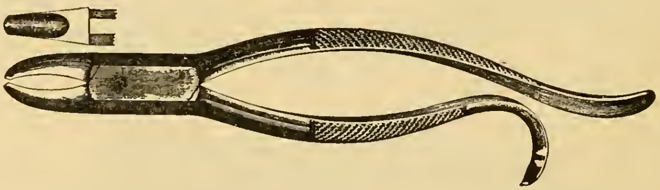
The sixth class embraces the inferior first and second molars, with two flattened, cone-shaped roots,—one mesial and one distal.

The seventh class includes the superior and inferior third molars, which may have either a single cone-shaped root that curves backward or multiple roots.

Fig. 671 shows the relation of the teeth to the alveolar process, and Fig. 672 shows the form and number of the roots of the teeth and their deeper relations to the alveolar processes.

First Class.—In the extraction of teeth of the *first class*, the operator should stand upon the right side of the patient, who is seated in the operating-chair with the head thrown well back and supported between the chest and the left arm of the operator, and the lips shielded from injury by the fingers of his left hand. The forceps selected for the operation should be straight, as shown in Figs. 673 and 674. The instrument shown in Fig. 673 is intended for the extraction of the superior central

Fig. 673.



Superior central incisor forceps.

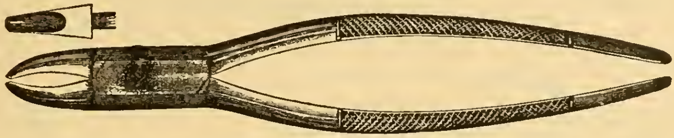
incisors, but it is equally adapted for the extraction of the superior cuspids. The forceps is adjusted to the tooth by grasping the handles loosely with the right hand, with the *little finger* between the handles. This gives control of the opening and closing of the jaws of the instrument, and permits the regulation of the force applied in grasping the tooth, which is of considerable importance in extracting a tooth much weakened by caries. The beaks of the forceps are then crowded well beyond the cervix of the

FIG. 671.

FIG. 672.

tooth, and in so doing cut their way to the alveolar border, loosening the attachment of the gum. In applying the force, the tooth should be gripped with sufficient firmness to prevent the forceps from slipping, and then *rotated* in a mesial or distal direction, when the attachments of the root with its alveolus will be broken up and the tooth removed. Should rotation fail to dislodge the tooth, a *forward* and *backward* movement may be given to the forceps, combined with rotation.

Fig. 674.

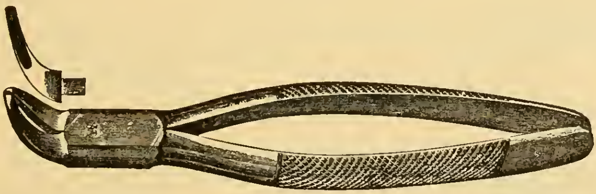


Superior lateral incisor forceps.

Fig. 674 shows the usual form of the forceps employed for the extraction of the superior lateral incisors. The adjustment of the instrument and the application of force are the same as for the extraction of the superior central incisors.

Second Class.—In extracting teeth of the *second class*, the operator should stand upon the right side of and a little behind the patient, whose

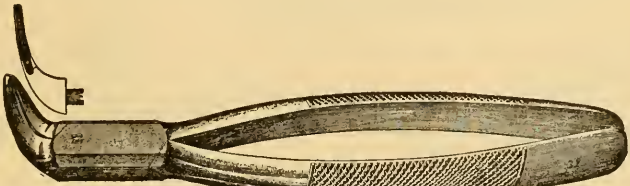
Fig. 675.



Inferior incisor forceps, full curve.

lower jaw is supported with his left hand, and the lips shielded with the fingers of the same hand. The forceps shown in Figs. 675 and 676 are most admirably adapted for the removal of the inferior central and lateral

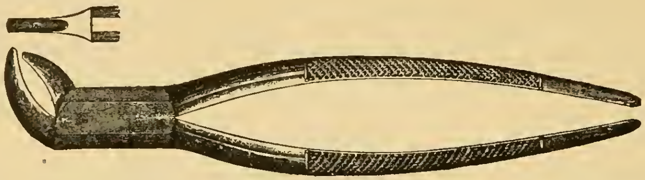
Fig. 676.



Inferior incisor forceps, narrow beaks, full curve.

incisors, while the hawk-bill forceps shown in Fig. 677, and the half-curved, narrow-beak forceps shown in Fig. 678, are useful in removing very narrow inferior central incisors and other inferior teeth with single roots which, by reason of an irregularity in their position, prevent the application of the broader-beaked instruments ordinarily used for their extraction. The direction of the force which should be applied in the removal of these

Fig. 677.



Inferior incisor forceps, hawk-bill.

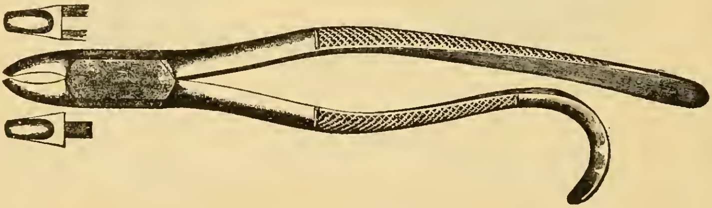
Fig. 678.

Inferior incisor forceps, half curve.

teeth is *forward* and *backward*, to break up their attachments to the alveolus, and in an *upward* direction to lift them out.

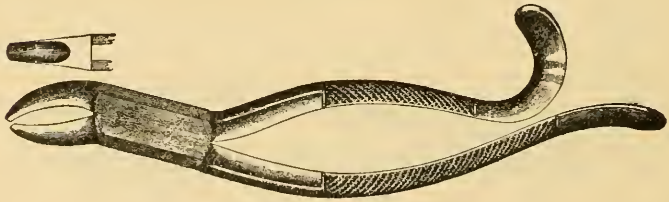
Third Class.—The positions of the patient and the operator and the means of supporting the head and protecting the lips are the same as described for the *first class*. The forceps best adapted to the extraction of

Fig. 679.



Superior cuspid forceps.

Fig. 680.

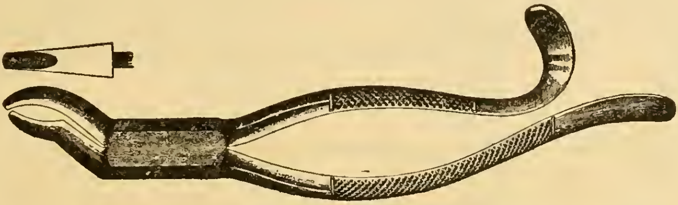


Superior cuspid and bicuspid forceps.

the *superior cuspids* are those shown in Figs. 679, 680, and 681. Inasmuch as these teeth have the longest roots and are the most firmly fixed in their alveoli of all the teeth, it requires more skill and strength to extract them than any other teeth in the mouth, and consequently the instruments used for this purpose must be very strong. In adjusting the forceps, the beaks should be forced upward and beyond the cervix as far as the border of the alveolus, the tooth firmly gripped, and force applied by a combined *rotary*, *forward*, and *backward* movement. The attachments of the tooth are thus broken up, and it is removed from its alveolus.

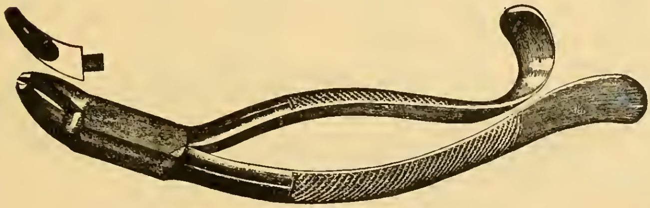
The position of the patient for the extraction of the *inferior cuspids* should be as nearly upright as possible, with the chin well down upon the chest, while the position of the operator should be upon the right side and

Fig. 681.



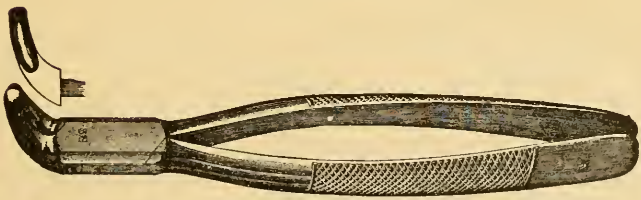
Superior cuspid and bicuspid forceps.

Fig. 682.



Inferior cuspid and bicuspid forceps.

Fig. 683.



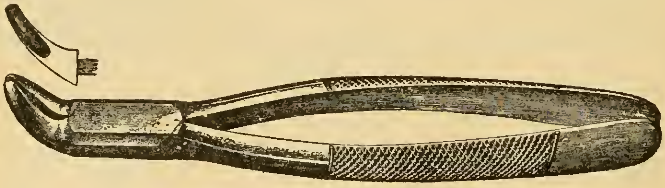
Inferior cuspid and bicuspid forceps, full curve.

slightly behind the patient. The chair should be low enough to give him full opportunity to apply force in an *upward* direction, while at the same time it is applied in a *forward* and *backward* direction. The roots of these teeth are so much flattened laterally that *rotation* cannot be successfully employed. The forceps best adapted for the extraction of these teeth are shown in Figs. 682 and 683.

Fourth Class.—The forceps which are best adapted for the extraction of the superior bicuspids are the same as those used for the removal of the superior cuspids.

The positions of the patient and the operator, the support of the head, and the protection of the lips are the same as described for the removal of teeth of the *first class.* The instrument is adjusted by grasping the tooth at the cervix and crowding the beaks upward to the border of the alveolus, then firmly gripping the handles of the forceps and applying force for extraction in a combined *forward, backward,* and *downward* direction.

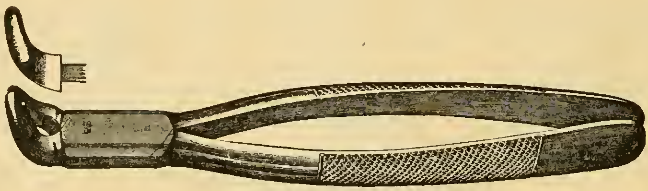
Fig. 684.



Inferior bicuspid forceps, half curve.

In extracting the *inferior bicuspids* the positions of the patient and operator, the position of the chair, and the protection of the lips are the same as described for the extraction of the inferior cuspids. The instru-

Fig. 685.



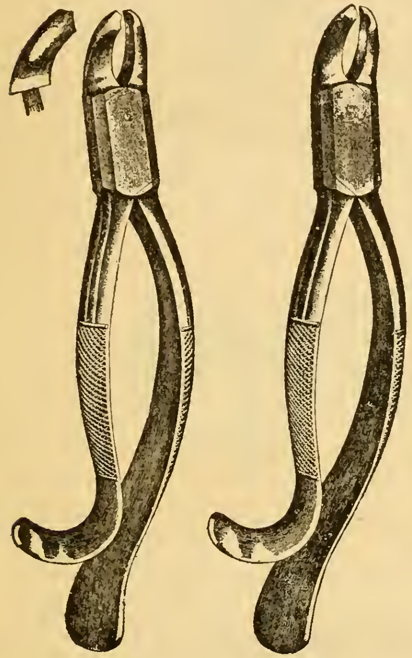
Inferior bicuspid forceps, full curve.

ments best adapted for the extraction of these teeth are shown in Figs. 684 and 685. The application of force should be in a combined *forward, backward,* and *upward* direction.

Fifth Class.—The *superior first* and *second molars,* by reason of the number and form of their roots, often require considerable strength to dislodge them from their alveoli. The beaks of the forceps which are used for the extraction of these teeth require to be especially made to conform to the shape of the teeth at the cervix. The outer or buccal beak of the forceps is constructed with a projecting point in the centre, which fits into the sulcus formed by the bifurcation of the buccal roots, while the inner beak is made plain, to fit the convexity of the lingual surface of the lingual (palatal) root. These instruments are usually made in pairs, right and left, to suit the form of the teeth upon opposite sides of the mouth. The jaws and handles should be so curved as to make it possible to grasp these teeth and not have the handles come in contact with the corner of the mouth or the lips. Fig. 686 shows the form of these forceps. Another form of forceps is that shown in Fig. 687. These instruments are bayonet-shaped, and have the beaks like those just described, one adapted for the teeth of the right side, the other for the left. The bayonet form given to these instruments makes them very valuable for the extraction of these teeth when the oral commissure is very small.

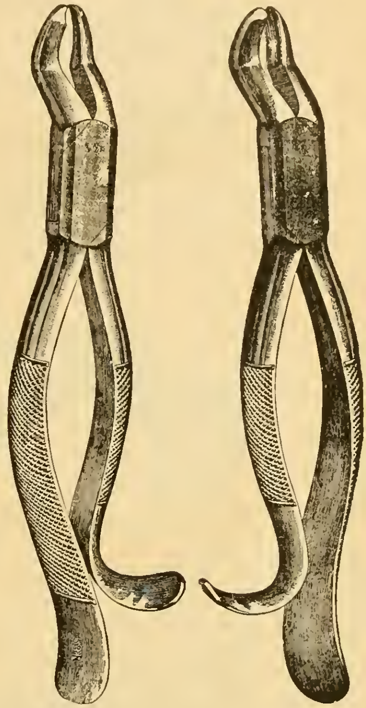
In adjusting either of these instruments to the tooth the beaks are made to grasp the tooth at the cervix, the pointed beak being inserted between the buccal roots, and the instrument forced upward to the border of the alveolus. The handles are then firmly gripped, and the

Fig. 686.



Right. Left.
Superior first and second molar forceps. (Dr. Harris.)

Fig. 687.

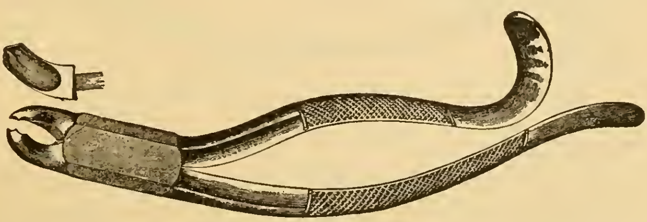


Right. Left.
Superior first and second molar forceps (bayonet shape).

tooth rocked by a *backward* and *forward* movement until it is loosened in its alveoli, when force may be applied in a *downward* direction, and the tooth dislodged.

Sixth Class.—The *inferior first* and *second molars* have but two roots, and do not, therefore, as a rule, require so much force to extract them as do

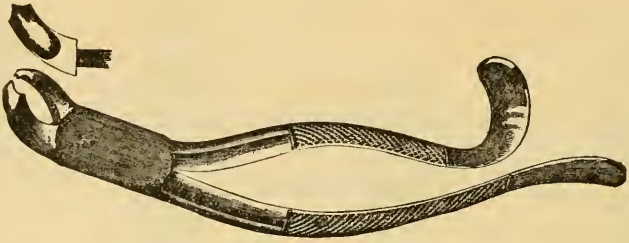
Fig. 688.



Inferior first and second molar forceps (universal), either side. (Dr. Harris.)

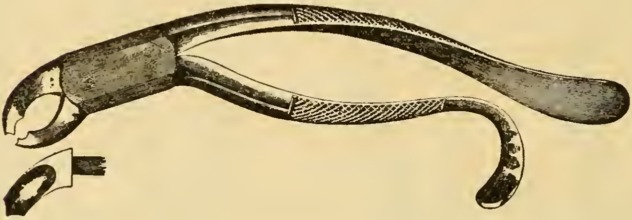
the superior molars. The beaks of the forceps which are used for the extraction of these teeth are each made with a projecting point which fits into the buccal and lingual sulci formed by the bifurcation of the root. The jaws and handles of the forceps are also curved in such a manner as to permit the tooth to be grasped while the handles remain clear of the lips and of the corner of the mouth. Fig. 688 shows an instrument

Fig. 689.



Inferior right first and second molar forceps.

Fig. 690.

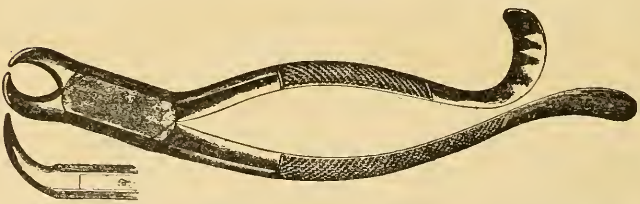


Inferior left first and second molar forceps.

Fig. 691.

Inferior universal first and second molar forceps. (Dr. Hutchinson.)

Fig. 692.



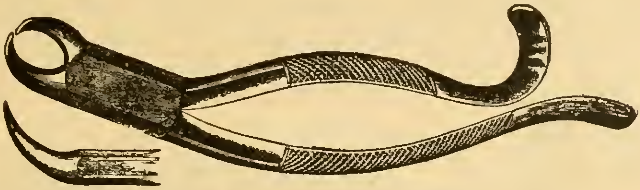
Inferior universal cow-horn forceps, first and second molars.

which is adapted for use upon either side of the mouth, while in Figs. 689 and 690 are seen forceps made in right and left forms.

Fig. 691 shows another form of universal lower molar forceps, the invention of Dr. Hutchinson, while Fig. 692 illustrates a universal cow-horn lower molar forceps. These are also made for the right and left sides (Figs. 693 and 694).

The position of the patient, that of the operator, and the method of protecting the lips are the same as in the extraction of the inferior cuspids and bicuspids.

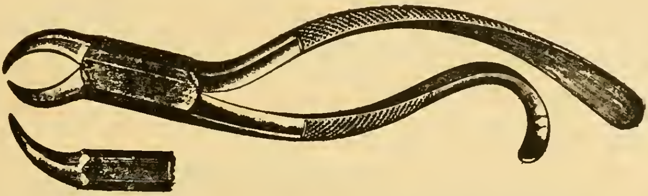
Fig. 693.



Inferior left first and second molar, cow-horn forceps.

In adjusting the forceps care must be taken to see that the points of the beaks are inserted into the buccal and lingual sulci formed by the bifurcation of the roots. The application of force should be a *forward* and *backward*

Fig. 694.

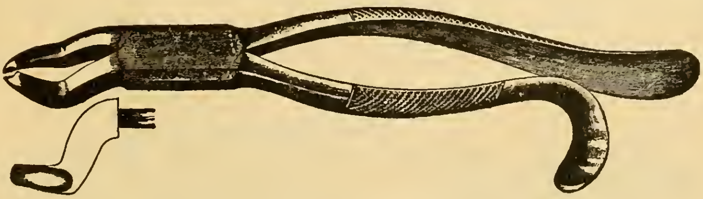


Inferior right first and second molar, cow-horn forceps.

rocking movement until the tooth is loosened in its alveolus, when the tooth should be removed by traction *upward.*

Seventh Class.—The *superior third molars,* by reason of their position and the usual backward curvature of their roots, are often very difficult to extract. When the root, however, is straight, their extraction is a very simple matter by the use of bayonet-shaped forceps having simple beaks made to fit the convexity of the root upon the buccal and lingual surfaces. Fig. 695 shows such an instrument designed for use upon either the right

Fig. 695.

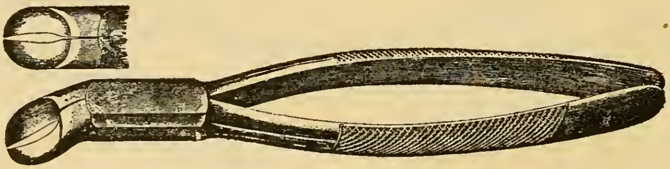


Bayonet-shaped superior third molar forceps (universal).

or the left side of the mouth. The positions of the patient and the operator and the application of force are the same as for the extraction of the other superior molar teeth. Sometimes these teeth are large and have bifurcated roots. Under such circumstances the ordinary superior molar forceps should be employed for their extraction.

When the roots of these teeth curve backward the ordinary forceps used for the extraction of the third molars will not dislodge them. Special forceps are then called into use. To meet these requirements the late Dr Physick invented the forceps shown in Fig. 696. The jaws of this instrument represent two inclined planes looking towards each other. The instrument is designed to act as a double wedge when placed between two

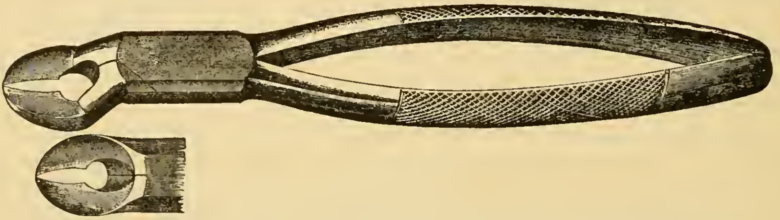
FIG. 696.



Superior third molar forceps. (Dr. Physick.)

resisting bodies and force is applied by closing the handles. In the extraction of a superior third molar the jaws of the forceps are opened and the edges placed between the approximating surfaces of the second and third molars. The handles of the forceps are then closed and depressed, or rather carried towards the morsal surfaces of the superior teeth : the

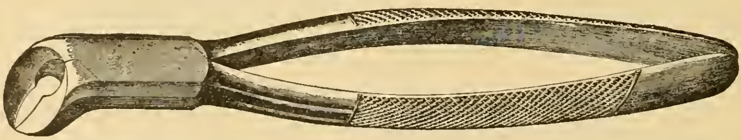
FIG. 697.



Superior third molar, extracting, separating, and excising forceps. (Dr. Stellwagen.)

double wedge of the jaws thus starts the tooth from its alveolus and the depression of the handles carries the crown backward, dislodging it from its alveolus. Figs. 697 and 698 represent instruments designed by Dr. Stellwagen for the combined purpose of extracting superior and inferior third molars and excising and separating roots. The principle involved in their application is the same as in the Physick forceps.

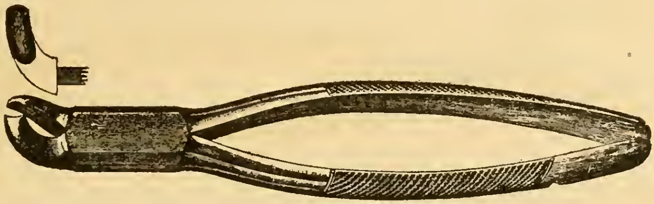
FIG. 698.



Inferior third molar, extracting, separating, and excising forceps. (Dr. Stellwagen.)

The *inferior third molars* have usually single roots which curve backward, but occasionally the roots are multiple. Under these circumstances they can usually be extracted with the forceps shown in Fig. 699, but when the root is curved it becomes necessary to employ the Physick or Stellwagen forceps. The instrument is applied as for the removal of the superior third molars, and the handles are closed and *depressed.* This starts the tooth from its alveolus, tips it backward, and dislodges it. Care must always be exercised in the use of these forceps not to injure the tooth in front which acts as the fulcrum. If these instruments are carelessly

Fig. 699.

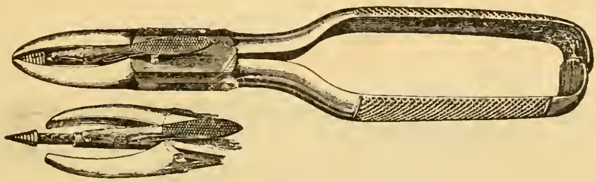


Inferior third molar forceps.

handled there is danger of fracturing the enamel, thus preparing the way for the establishment of caries in the injured tooth.

Extraction of the Roots of Teeth.—For the extraction of the roots of teeth specially devised forceps are generally employed: these have usually thin, narrow beaks that can be insinuated between the gum and the root.

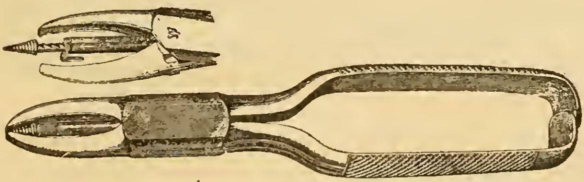
Fig. 700.



Screw-forceps. (Dr. C. H. Dubs.)

For the extraction of the roots of the six superior anterior teeth which are so decayed as to present thin, frail walls the Dubs screw-forceps (Fig. 700) and the Hullihen screw-forceps (Fig. 701) are the best. These instruments combine the dental screw with the narrow-beaked forceps.

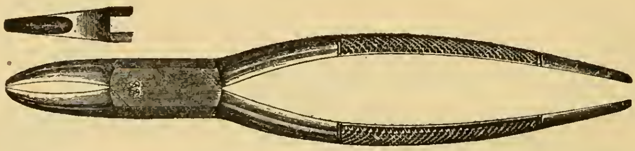
Fig. 701.



Screw-forceps. (Dr. S. P. Hullihen.)

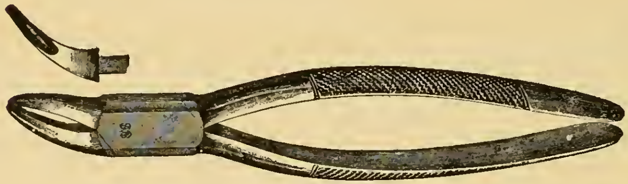
To adjust the instrument to the root the conical screw is first set into the pulp cavity. If much softened dentin is present this should first be removed and the screw so set that it takes hold upon the sound dentin. The socket between the jaws of the forceps is then placed over the shaft of the screw, and the beaks of the instrument are insinuated between the gum and the root and carried down to the alveolus. The handles are then gripped with just sufficient force to prevent the instrument from slipping, and the root is rotated to the right,—the direction in which the screw is set,—and the tooth is dislodged from its alveolus.

Fig. 702.



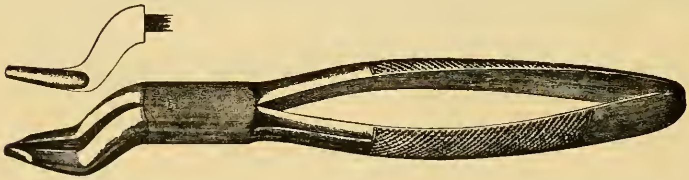
Superior anterior root forceps.

Fig. 703.



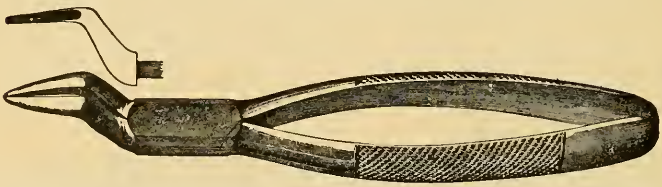
Superior bicuspid and molar root forceps, half-curve.

Fig. 704.



Superior bicuspid and molar root forceps, bayonet shape. (Dr. B. F. Arrington.)

Fig. 705.



Superior root forceps, bayonet shape. (Dr. Ambler Tees.)

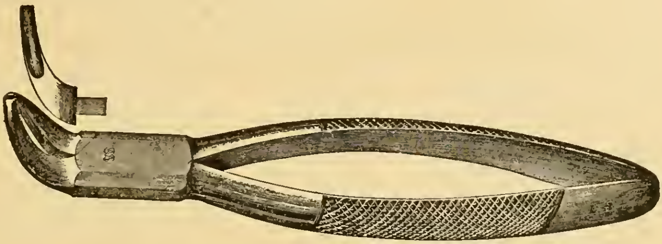
Fig. 702 represents a straight root forceps designed for the extraction of the roots of the six superior anterior teeth, which can be used in all cases where the root is not so badly decayed as to be liable to crush under the pressure necessary to keep the instrument from slipping during the extraction.

For the extraction of the superior bicuspids, the half-curved forceps represented in Fig. 703 will be found most admirable instruments.

For the extraction of the roots of the superior molars there is no better instrument than the bayonet-shaped root forceps shown in Figs. 704 and 705.

Great care should be exercised in the extraction of the roots of the superior bicuspids and molars not to force them upward into the antrum of Highmore, as under such circumstances an extended surgical operation becomes necessary for their removal, involving the exsection of a considerable portion of the floor of the sinus.

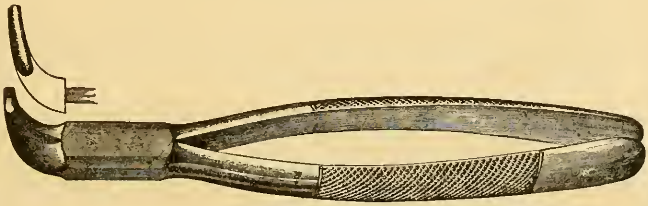
FIG. 706.



Inferior incisor, cuspid, and bicuspid root forceps, full curve.

For the extraction of the roots of the six inferior anterior teeth and the bicuspids, the full-curved lower-root forceps shown in Figs. 706 and

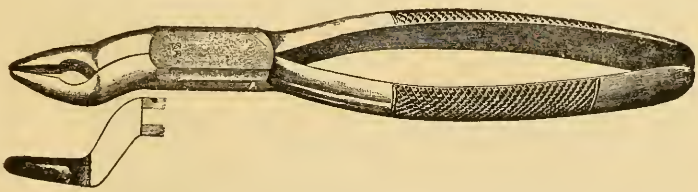
FIG. 707.



Inferior root forceps, full curve. (Dr. Ambler Tees.)

707 will be found most useful. The points of the beaks in the "Tees" forceps are made thin so that it is possible to insinuate them between the root and the gum.

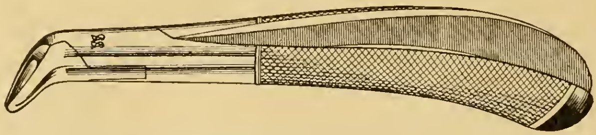
FIG. 708.



Superior alveolar root forceps, bayonet shape, with beaks of Dr. Kell's pattern.

In the extraction of roots in the superior jaw that are buried in the tissues, the "alveolar" forceps shown in Fig. 708 is most admirably adapted. When using this instrument the gum should be incised upon the labial and lingual surfaces in a line corresponding to the long axis of the root, and the edges of the gum lifted from the alveolar process upon both sides of the incisions. The beaks of the forceps may now be insinuated between the gum and the alveolar process, and by a quick, firm pressure upon the handles, the alveolar process is cut through and the root removed.

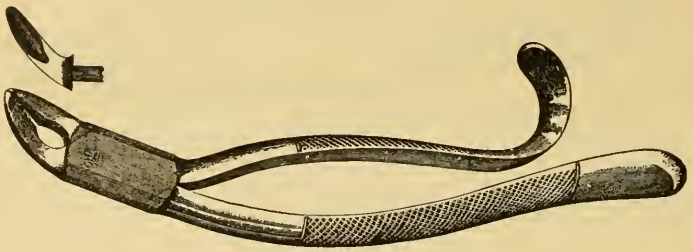
Fig. 709.



Deciduous inferior universal forceps. (Dr. M. H. Cryer.)

In the extraction of the roots of lower molars the forceps shown in Fig. 709 is most admirably adapted, the beaks being long, thin, and narrow.

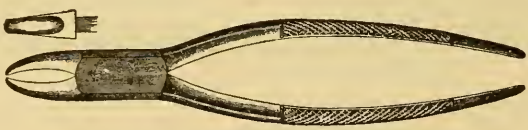
Fig. 710.



Inferior alveolar root forceps. (Dr. J. D. Thomas.)

The "alveolar" forceps of Dr. Thomas shown in Fig. 710 is a very valuable instrument for removing such roots as are broken off below the gum.

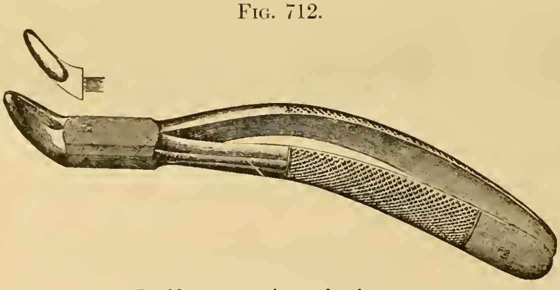
Fig. 711.



Deciduous superior anterior and root forceps.

The forceps which are used for the extraction of the deciduous teeth should be much smaller and lighter than those employed for the extraction

Fig. 712.



Deciduous superior molar forceps.

of the permanent teeth. Three pairs are sufficient for all purposes. Fig. 711 is for the extraction of the six superior anterior teeth and roots, and

FIG. 715.

FIG. 716.

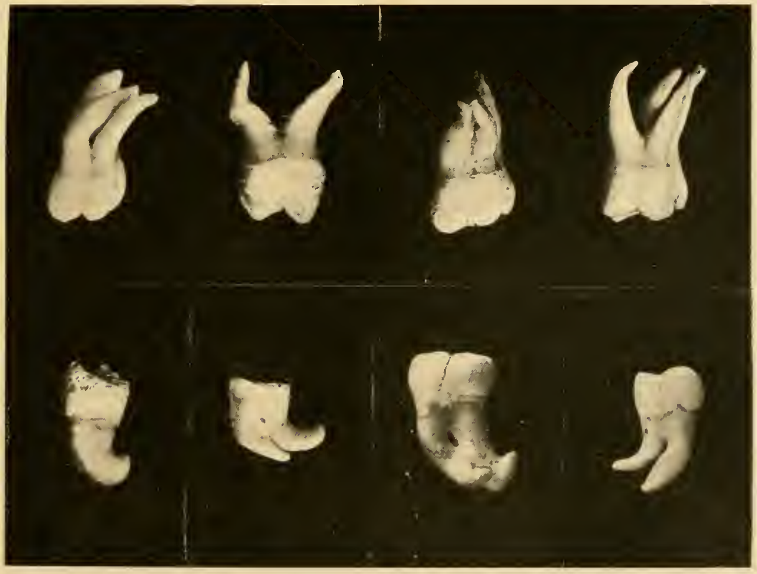


FIG. 717.—After Dr. M. H. Cryer.

FIG. 718.—After Dr. M. H. Cryer.

FIG. 719.—After Dr. M. H. Cryer.

FIG. 720.—After Dr. M. H. Cryer.

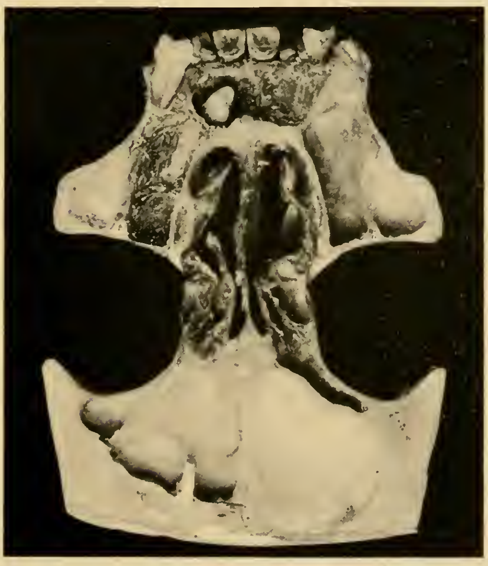


FIG. 721.—After Dr. M. H. Cryer.

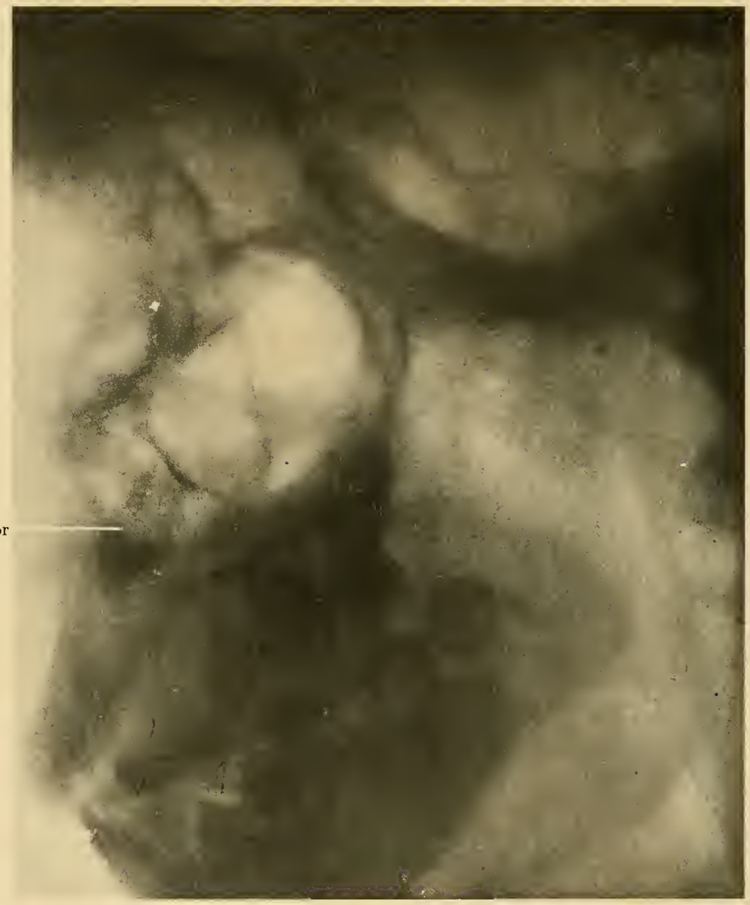


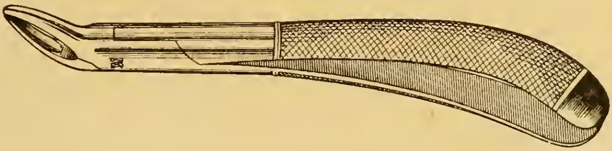
FIG. 722.—Skiagraph showing misplaced superior cuspid tooth.

Fig. 712 for the superior molars. Fig. 713 is used for the extraction of the six inferior anterior teeth and for the inferior molars. The "universal" root forceps of Dr. M. H. Cryer (Fig. 714) are also admirable instruments for the extraction of children's teeth.

FIG. 713.

Deciduous inferior anterior and molar forceps.

FIG. 714.



Deciduous and superior universal root forceps. (Dr. M. H. Cryer.)

DIFFICULTIES, COMPLICATIONS, AND ACCIDENTS.

Anomalous Teeth.—The accompanying illustrations (Figs. 715 and 716) represent some of the more common deformities of the teeth. Figs. 717, 718, 719, 720, and 721, which are kindly loaned to the writer by Dr. M. H. Cryer, show some of the more common malpositions of the teeth which complicate the operation of extraction, and often render it extremely difficult and sometimes hazardous.

Skiagraphy as a Means of Diagnosis.—The introduction of the skiagraph or Roentgen-ray picture as a means of diagnosis in various pathologic conditions of the teeth and jaws, and in obscure and undetermined aberrations in the process of eruption of the teeth, has greatly simplified the labors of the diagnostician, and cleared the path of the operator, by removing all doubts as to the nature and extent of these pathologic conditions, and positively demonstrating the absence or presence of certain unerupted teeth, their shape and exact position in the jaws.

This means of diagnosis is particularly valuable in determining the presence of abscesses in the alveolar processes, the presence of hypercementosis or malformations of the roots of teeth, and the position of unerupted teeth, especially the lower third molars which are so prone to malformation and malposition and are so often the cause of inflammatory processes which not infrequently produce most serious results.

The old methods of diagnosis by exploration are now largely superseded by the more modern Roentgen ray, and the operator who fails to avail himself of so great an adjunct to his other means of diagnosis, is not utilizing his opportunities nor rendering the best service to his patient. (Fig. 722 is a skiagraph showing a misplaced superior cuspid.)

The cases which present the greatest difficulties are the teeth having sharply curved roots, hypercementosed roots, and teeth which are misplaced and impacted in the jaws, particularly impacted third molars.

Teeth having curved or hypercementosed roots offer great resistance to the force applied for their extraction. In the former the curved end of the root is often fractured and left in its alveolus, while in the latter the alveolar process is usually fractured, the external plate giving way on a line with the alveoli, in the endeavor to remove the tooth.

The former accident is, however, of small moment, and the fractured portion of the root may be allowed to remain, as it very rarely causes any serious after-trouble.

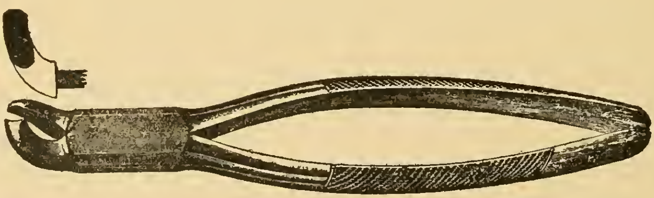
The fracture of the alveolar plate is more serious, and if neglected or improperly treated may result in necrosis. If, however, the fractured parts are brought into close apposition by squeezing them together with the thumb and index finger, and the alveolus frequently irrigated with antiseptic solutions, union will take place and little or no inflammation or soreness will result; but if, on the other hand, the fractured parts are allowed to remain separated, and no attention is paid to antiseptic treatment, osteitis and necrosis are liable to occur.

The most difficult teeth to extract are the impacted third molars, which lie more or less horizontally in the jaw and impinge upon the distal surface of the crown or the root of the second molar, as shown in Fig. 723. This condition of impaction occurs most often in the lower jaw. When the crown of the inferior third molar is tilted forward so that it impinges upon the distal surface of the second molar near the cervix or lower down upon the root, further progress in the eruption of the third molar is arrested, and irritation and inflammation are liable to supervene, making it necessary to extract the tooth. In order to accomplish the removal of the impacted tooth, it becomes necessary to cut away with corundum disks a considerable portion of the mesial cusps of the third molar. After this has been done the tooth may be grasped with the forceps shown in Fig. 724 and the tooth dislodged from its alveolus. Or it may be dislodged with the Physick or Stellwagen "wisdom-tooth" forceps (Fig. 725).

Fig. 723.

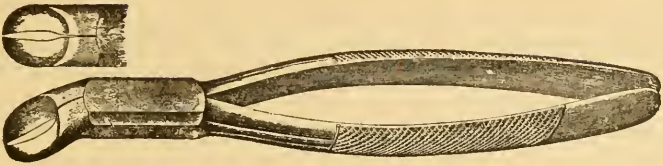
Inferior left second and third molars as they were located in the jaw.

Fig. 724.



If, however, the third molar has not erupted or only shows a very small portion of the crown through the gum, and the tooth occupies a horizontal position in the jaw, two courses only can be suggested for its removal.

FIG. 725.



Physick forceps.

The *first* is to remove the second molar, as this makes it possible to reach the third molar and extract it.

The *second* is to dissect the gum from over the impacted tooth, chisel or bur away the bone overlying it, and then lift it from its bed with an elevator or Physick forceps.

Operations of this magnitude should, of course, be made under a general anæsthetic, preferably ether, as nitrous oxide anæsthesia would not last long enough to permit the operation to be performed painlessly.

Other teeth than the third molars are sometimes impacted in the jaws, and require surgical operations for their removal. Those which are most commonly misplaced are the superior cuspids (Fig. 721), laterals, and bicuspids, and the inferior bicuspids and cuspids, their relative frequency, according to the experience of the writer, being in the order named. A good general rule to be followed in operations for the removal of impacted teeth is never to sacrifice any other tooth if it can possibly be avoided.

Fractures of the Teeth.—In the extraction of teeth that are badly decayed, and in those which by reason of abnormalities in form or position present great difficulties in their removal, fractures of the crown are very liable to occur. Under such circumstances the roots should be immediately removed with instruments suited to the individual case. Sometimes, however, the fracture occurs at the alveolar margin or even lower down, making the removal of the root an exceedingly difficult task, except by the subalveolar method previously described. For this reason the alveolar forceps shown in Figs. 708 and 710 should be found in every complete extracting-case. If the tooth which has been fractured has double or multiple roots, it often becomes necessary to divide them with Stellwagen excising forceps, and extract each root separately.

When a tooth is extracted, fractured or crushed, great care should be taken to prevent the tooth or the fragments slipping from the jaws of the forceps and falling into the fauces, and becoming arrested at the entrance of the larynx by engaging in the *rima glottidis*, or, passing downward, becoming lodged in the trachea or one of the bronchi (more often the right), thus preventing or impeding the admission of air to the lungs and causing spasmodic coughing, dyspnœa, and the more serious symptoms of asphyxia.

Whenever a foreign substance falls into the fauces the body of the patient should immediately be thrown forward, and the index-finger passed into the mouth and swept around the fauces, in the hope of removing it.

Failing in this, the patient's body should be inverted, and while in this position the back vigorously slapped with the flat of the hand. If, however, the foreign body has passed beyond the reach of the fingers, the laryngeal forceps may be employed to reach it, and this may often be done if it has not passed beyond the *rima glottidis*. If the foreign body has entered the trachea or become lodged in a bronchus, an immediate tracheotomy is the only means of relief. Cases of this character may prove immediately fatal; while, upon the other hand, if the fragment of tooth is small, and has passed into a bronchus, it may give rise to no immediate symptoms, but later the patient may be seized with violent fits of coughing, dyspnœa, bloody expectoration, and finally collapse of the lung. Miller records a case of suppuration and gangrene of the lung due to the presence of a fragment of a decayed tooth.

Impaction of a tooth or a fragment of a tooth or other foreign body in the œsophagus or the pyloric orifice of the stomach sometimes occurs, and may give rise in the former to symptoms of dysphagia, and in the latter to gastric dilatation and ulceration. The treatment of these cases belongs to the domain of general surgery.

Fractures of the Alveolar Process.—Fractures of the alveolar process are frequently the result of the extraction of the teeth. This accident most often occurs in connection with the superior and inferior cuspids and the superior molars.

Teeth which stand alone are the most liable to this accident, although it may occur in connection with the extraction of any tooth if the process is thin, or the operation is roughly or unskilfully performed, or the roots are malformed, abnormally large, or, as in the molars, widely spread.

Sometimes the attachment of the alveolar process is so firm that the fractured part comes away with the tooth. This makes an ugly wound in the gum, which may require two or three stitches to bring it together.

In the treatment of the other forms of fracture of the alveolar process the simple adjustment of the fractured parts to their normal position and the use of antiseptic solutions is usually all that is required.

Osteitis.—Inflammation of the alveolar process is a frequent sequel of the extraction of a tooth in which the gums and process have been bruised and lacerated. This most frequently occurs in those cases where the tooth has been fractured some distance beneath the margin of the gum, and repeated unsuccessful attempts have been made to remove it.

The disease is attended with great pain, tenderness, and swelling of the surrounding tissues, suppuration, and sometimes sloughing of the soft tissues and death of the bone.

The treatment consists in the free use of antiseptic and stimulating lotions, and anodynes to control the pain.

Gangrene and Necrosis.—These conditions frequently follow the unskilful extraction of the teeth, and are the result of crushing the soft tissues in the one case, and of fractures, injuries which cut off the circulation, or inflammation in the other. The treatment consists in removing all dead or gangrenous soft tissue with scissors or knife, washing the parts with hydrogen dioxide to remove the pus, and following this with suitable antiseptic lotions.

Necrosed bone should not be disturbed until separation has taken place between the dead and the living portions. *Meddlesome treatment* only aggravates the inflammatory process, and often causes an extension of the disease far beyond the limits which were previously involved. The only treatment to be recommended is that comprehended under the term antiseptic until the sequestrum has formed, when it should be immediately removed, and the parts assisted in the healing process by thorough cleanliness and the use of stimulating and antiseptic solutions.

Hemorrhage.—Hemorrhage of a severe and continuous type often seriously complicates the operation of tooth extraction in those individuals who are subjects of the hemorrhagic diathesis, and quite a number of cases are on record in which the hemorrhage has proved fatal after every effort had been made to arrest it.

Hemorrhage may be *primary*, *recurrent*, or *secondary*.

Primary hemorrhage is that which occurs from the alveolus immediately after the tooth has been extracted, and usually does not continue for more than half an hour. Sometimes, however, the primary hemorrhage is profuse, and calls for treatment for its control. The use of cold water or ice-water, or water as hot as can be borne in the mouth, to which a few drops of tincture of myrrh or aromatic sulphuric acid have been added, will generally be sufficient to arrest it.

Recurrent or secondary hemorrhage is that which follows a few hours after the primary hemorrhage has ceased.

This form of hemorrhage usually comes on in the night following the day upon which the tooth was extracted, or following the sloughing of soft tissue whose vitality had been destroyed by the traumatism or by the application of escharotic styptics.

Sometimes the hemorrhage seems to be confined to the artery which supplied the tooth, the blood welling up from the apex of the alveolus ; in other cases the whole inner surface of the alveolus seems to take part in the hemorrhage ; while in others it may be confined to the gum. In the more severe cases in which there is a marked history of the hemorrhagic diathesis, the blood is found to flow not only from the dental artery, but from the inner walls of the alveolus and the gums as well, the bleeding in some cases being so profuse that the patient may lose from a pint to a quart or more of blood in a few hours, causing great weakness and considerable alarm and anxiety upon the part of the patient and the friends.

In examining the mouth in a case of secondary hemorrhage, care should be taken to locate the exact source of the bleeding, whether it is from the gum, the inner wall of the alveolus, or the dental artery.

If the hemorrhage comes from the gum, the bleeding point may be compressed with the hæmostatic forceps, or any little vessel picked up and torsion applied. If this does not arrest the bleeding, a compress may be made of warmed gutta-percha or modelling compound, pressed over the part, and when cooled removed, lined with lint or cotton, saturated with a solution of tannic acid in glycerol, and returned to the mouth, and compression made by closing the jaws upon the compress, and binding them together with a four-tailed bandage. When the hemorrhage is from the socket or the dental artery, the case should be treated by plugging the alveolus. This may be done by forming a plug to fit the alveolus from warmed wax or modelling compound, made in the form of a cone, a little longer and larger than the tooth which had been removed, and pressing it firmly into the alveolus. The large end of the plug should rise a little above the crowns of the adjacent teeth, so that when the jaws are closed pressure will be brought to bear upon the plug. When cooled it can be removed, the alveolus cleared of blood-clots and washed with ice-water charged with a suitable antiseptic, and the plug returned to the alveolus after it has been rolled in tannic acid or dipped in the tannic acid and glycerol solution. The jaws should then be closed upon the plug and maintained in that position by the adjustment of the four-tailed bandage.

The writer considers this method very much better from the aseptic stand-point than the old method of packing the alveolus with cotton, lint, or strips of bandage, as the liability to septic infection and suppurative inflammation is greatly reduced.

When the hemorrhage comes from the alveoli of several contiguous teeth, each alveolus should be treated by the method described, and then all may be bound together, while they are in place, by another piece of warmed modelling compound pressed down over the exposed ends of the plugs and moulded to the gums upon the buccal and lingual surfaces, and when nearly cooled the jaws may be closed upon it sufficiently to take an impression of the opposing teeth.

After the mass has thoroughly cooled it may be removed altogether, the plugs treated as just described, and the whole returned to its place and retained in position by the closed jaws and the four-tailed bandage.

If there is time to do so, and the facilities are at hand, a metal or vulcanite splint may be constructed from an impression taken of the parts. When this method is pursued, the alveoli should be plugged with modelling compound and the splint used to force the plugs into place and produce compression upon the gums.

A few cases are on record in which, after arresting the hemorrhage from the alveolus, oozing of blood from the mucous surface of the gums occurred, as is sometimes seen in scorbutus and *purpura hæmorrhagica.*

In these cases it becomes necessary to secure compression over a considerable area of the gums, and this can best be accomplished by the metal splint just described.

Before applying the splint it should be lined with cotton or lint, and saturated with a non-irritating styptic. Adrenalin chloride solution (1 : 1000) has proved very efficient for this purpose in several cases during the last year, that have occurred in the writer's military practice at the Presidio of San Francisco. The use of escharotic styptics, like the perchloride of iron, nitric acid, and chromic acid, should never be permitted, as they cause sloughing of the soft tissues and secondary hemorrhage, which is more difficult to control than the former condition, by reason of the greater surface involved as a result of the escharotic action of the remedy.

After the compresses have been applied, the patient should be instructed to keep as quiet as possible, maintain the sitting posture, and avoid all hot fluids and stimulants. Liquid diet should be ordered,—milk, beef extracts, broths, and soups.

In those cases in which there has been great loss of blood, stimulants may be administered and the body kept warm. The hot foot-bath is sometimes serviceable in diverting the blood to the lower extremities and relieving arterial tension in the upper part of the body.

To the constitutional remedies which have been mentioned as useful in controlling the tendency to hemorrhage in those persons having the hemorrhagic diathesis,—viz., gallic acid combined with opium, and the fluid extract of ergot,—the perchloride of iron may be added,—

℞ Liq. ferri perchlor., m. x;
Aq. destill., f ℥j. M.
To be taken every two hours.

Fatal syncope has been known to follow the extraction of a tooth in cases in which there was no functional or organic disease of the heart.

Tomes calls attention to two such cases that have been placed on record. A similar case came under the knowledge of the writer, as occurring in the practice of a friend. In this case, however, there was fatty degeneration of the heart, as shown by the *post-mortem* examination. The patient was a lady about sixty years of age, and was apparently in good health. The dentist seated her in the chair preparatory to the operation, and turned to his case to select the instrument, when she fainted and could not be resuscitated, death occurring almost instantaneously.

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