fallacy. A dental pulp is a part of the general organic life with which it is related, and will be seen to have residing in it the impressions of the system at large. Thus, a first observation necessarily considers the state of health in the individual who may be the patient. As is found equilibrium in excitability, with normal nutritional functions, or otherwise degenerative tendencies, so will it prove the experience that attempts to save dental pulps are responded to or defied.

Founding the practice to be pursued in each particular case on an experience which shall come of observation, if indeed it be not already possessed by him whose judgment acts from the foundation of a knowledge of the principles governing all such matters, the practitioner determines either on destroying a pulp and removing it, or on attempt to preserve it. This latter conclusion is always to have the benefit of any doubt which may exist in the mind of the operator, as it is never to be overlooked that a destroyed pulp signifies necessarily a tooth with a diminished vitality, which diminution makes it a body more or less foreign to the parts with which it is in association.

The destruction of a pulp decided on, the operation is to be accomplished as follows: Should irritability and pain be present, these are, if convenient and possible, to be first subdued by means as suggested on a previous page. Quiet secured, and anæsthesia existing by reason of the presence of the morphia, the operator uses, of what is known as nerve paste, a portion corresponding with the requirements of his case; a piece larger than the ordinary pin-head being seldom needed. This paste is dropped gently into the deepest part of the cavity and overlaid with a pellet of cotton, which cotton is made protective against external influences by means of a solution of gum sandarac, which is dropped upon it from the point of an instrument, otherwise the pellet may be slightly touched to the solution previous to being put in place. A very little experience will demonstrate that it is undesirable to have the cotton too fully saturated,—an objection sure to exist if care be not taken to avoid it. Formulæ for nerve paste are variously given, but the author has found every reason to be satisfied with one here suggested:

℞.—Acidi arseniosi,
Morphiæ acetatis, āā gr. x;
Creasoti, q. s.
Sig.—A thick paste to be made; rubbing to be continued an hour.

The length of time that arsenic is to be allowed to remain in a tooth is found to depend on the structure of the organ and the amount of paste used. A proper measure would be just that quantity necessary to accomplish the destruction of the pulp, and which in such destruction would find itself antagonized. As such quantity might not, however, have accurate measurement, it is found desirable to consider rather the structure of a tooth. When this is very solid and close, there exists little objection to allowing the preparation to take care of itself. Where, however, the structure is loose, organic

matter being in excess,—a condition made satisfactorily evident by a few cuts with an excavator,—the effect of an application is to be watched with a judgment which, perhaps, comes only of observation. A period which approximates a rule as to the time arsenic is to be left in the adult tooth, is fifteen hours; although nothing is more common than to allow it to remain for twenty-four. The danger in excess of time lies in the passage of the agent through the foramen and tubuli, affecting thus the periodonteum.

That the action of an arsenical destructive on a pulp in a tooth of loose structure shall be as direct and speedy as possible, it is desirable practice—where the touch is sufficiently delicate to accomplish it painlessly—freely to expose the organ before making the application. Such exposure effected, the paste may be at once pricked, by means of a very sharp-pointed broach, into the part. By such an operation a pulp is to be destroyed almost without pain, particularly if morphia be previously used as an obtunder, and may be removed from its cavity within a period of time not exceeding fifteen minutes.

Recognition of the death of a pulp is found in the absence of a previously-existing sensibility, as made manifest by the touch of the exploring instrument.

3. *A Diseased State of the Periodonteum.* (See *Periodontitis* and *Alveolar Abscess.*)

4. *Confinement of Pus and Gas in the Pulp-Cavity.*—When the dental pulp dies, decomposition is likely to follow. As the result of such lesion we have two sequences: either the decomposed matter is gradually absorbed into the dentinal tubuli, and thus disposed of, as made evident in the marked opacity of the tooth, or it becomes a source of great irritation and offence to the surrounding healthy structures, periodontitis being provoked, the evolution of gas forcing the matter unduly into, and in many cases entirely through, the foramen. If inflammation of the alveolo-dental membrane do not result, then the trouble induced becomes of the ordinary neuralgic character, the living nerve-filament at the foramen, still more or less associated with its continuation ramifying in the dead pulp, taking on inflammation, and thus irritability not only of these special filaments results, but the whole tri-facial tract is apt to sympathize. Some of the most severe and unbearable neuralgias situated about the various parts of the head, have been quickly cured by discovering and treating the cause in a confined dead pulp. A case just now recalled furnishes an example. The patient, a professional man, had been completely lost to self-control, or reason, for a period of three days, from the effect of neuralgic pain running between the orbit and dura mater of the anterior portion of the cranial cavity. In this case not the slightest complaint was made of any of the teeth. Examining the mouth in search for a cause, discovery was made of a half-carious and evidently

dead lower bicuspid tooth, but with no connection between the cavity of decay and that of the pulp. With a spear-shaped drill communication was effected, and in a single instant the patient expressed himself as cured. Relieved of the pain, he fell into a sound sleep, which continued some fifteen hours; the next morning he went about his duties as usual.

Any portion of the head, throat, or associate parts supplied by the fifth nerve, or, indeed, by its related nerves, may be the seat of reflex trouble from a dead pulp. Thus we have odonto-gastralgia, odonto-cephalalgia, odonto-cardialgia, etc.; even sciatica has been cured by the extraction of a diseased tooth.

A common practice in all such cases is to remove the tooth, or otherwise, if it be desirable to save the organ, drill an opening into the pulp-cavity. The relief experienced is generally instantaneous.

A tooth containing a dead pulp is distinguished by a loss of translucency when compared with its fellows, or in an opacity, exhibited by reflecting upon it, by means of a hand-mirror, the rays of the sun.

A case illustrative of practice in this direction finds example in a patient under the care of the author at the moment of writing this paragraph. Mrs. H., a lady of delicate organization, suffered for a whole week with severe pain situated in the alveolar region overlying the superior incisor teeth,—the teeth, however, seeming not at all implicated. In the beginning of the second week of the attack the lady first presented herself, directing attention to an elongation of the right central tooth, but which elongation according to the statement of the mother, had always existed. Examination of the mouth exhibited not the slightest discoloration or inflammation about the gums. The lateral incisor, however, was recognized to be slightly loose,—this and the continuous pain being the only expressions of a pathological condition. Diagnosing the existence of a dead pulp in this tooth, the chamber was entered by a means of a spear drill applied to the palatal face. On opening the cavity at least a teaspoonful of pus escaped into the mouth. A treatment pursued, which has so nearly eventuated in a cure that the patient will be dismissed on her next visit, is as follows: The quantity of pus demonstrating the existence of a reservoir outside the tooth, an incision was made through the gum at the apex of the root, thus exposing the bone; to this bone was next applied the point of a strong bistoury, which being pressed forward was felt to pass through a shell and enter a cavity; out of this cavity issued a second volume of pus. Examination of the cyst exhibited it as capable of accommodating all the fluid that had escaped, while, furthermore, absorption was seen to be progressing towards the right naris, into which, without doubt, sooner or later, the abscess would have discharged itself. The cavity, after being washed out, was injected with the ordinary officinal tincture of iodine, a tent of cotton being inserted to keep the opening in the soft parts patulous. On the third day the pulp-canal of the tooth was filled with gold to its apex, great care being taken that no portion of the metal should be thrust through

the foramen, which foramen, without doubt, was enlarged. Up to the present hour—two weeks having passed—the cyst has been daily injected with the iodine solution, and has been daily growing smaller, until now it is about obliterated.

The inflammation in this particular case was decidedly of a cold, or chronic character. Had it been acute, the tooth would have been found too painful to fill with so short a period intervening between the time of attack and operation. One sinus, however, is always enough in an alveolar abscess; if this exist in the gum there can be no objection to filling the tooth as soon as the sensibility of the organ admits of the operation being performed.

The splitting of teeth from expansion of gas confined in a pulp-cavity seems a matter of record too authentic to be doubted. A case having peculiar interest in such direction, published by Dr. J. H. McQuillen, is to be found on the pages of the *Dental Cosmos*, vol. xiii.

5. *Granules of Osteo-dentine in the Pulp.*—In rare cases there is found to exist an irritability of the dental pulp which exhausts itself in the formation of isolated granules of semi-bonelike character, which granules obtain lodgment in some portion of the organ, and become, in turn, a source of great offence to the parts, resulting indeed frequently in an odontalgia than which there are few severer forms. To diagnose this condition is an exceedingly difficult matter. The manner of doing it is by exclusion. The teeth in these cases present every appearance of the highest health: no discoloration, no soreness on pressure, commonly no local pain; this last manifestation being situated in some distant part, as the ear, the eye, the scalp, etc. Whether, however, the pain be localized or diffused, it is always expressed by the patient as being of a nature entirely unbearable; it is generally more or less paroxysmal in character, thus being mistaken for idiopathic neuralgia, and frequently so treated. A case illustrative just comes to mind. During a late session of the University of Pennsylvania, a student in the medical department suffered from neuralgia so severely as to have entirely incapacitated him for study for a period of some three weeks. During that time he had tried all the ordinary remedies which had suggested themselves, without finding the slightest relief. The pain varied between the tuberosity of the superior maxilla and the ear. The teeth, about the part, were entirely sound and healthy-looking; there was apparently no local lesion; while, on the other hand, the physique of the gentleman was not at all of the neuralgic type. The writer was at sea with the case, until, after a day or two, there came to his mind an instance of innodular calcification of the dental pulp once seen, where the patient had suffered in about a like manner. Now, while not prepared positively to affirm that here was a second case of calcification, permission was requested and obtained to pass an exploratory drill into the pulp-cavity of the wisdom-tooth. The result was the finding of the pulp filled with granules,—granules of secondary dentine, as they are techni-

cally termed. The extraction of the tooth was followed by immediate cessation of all pain, and the patient was able to go direct from the operation to lectures.

A marked case, where the lesion gives direct local manifestation, the pain being seated directly in the affected tooth, exists in the person of a professional friend. The gentleman may be said to be affected with a diathesis in this direction. More beautiful teeth than he possesses, or, rather, did possess, are seldom seen; and yet, one by one, they take on this condition, exciting such maddening pain that, regardless of everything, he flies to extraction for relief. In this way, within the past few years, he has lost all those of the upper jaw.

The treatment for this form of odontalgia consists in drilling into the body of the affected tooth, and securing thus a cavity of retention, applying the arsenious paste as has been directed. There are, however, cases in which, under these circumstances, it seems impossible to effect the destruction of the pulp. Here nothing is to be done but extract the tooth or teeth.

The subject of the changes which may take place in the dental pulp, being the result either of age or other circumstances, commands, necessarily, the attention of the surgeon. Much as physiologists differ with regard to the precise method of dentinification, says Mr. R. T. Hulme, M.R.C.S., in an admirable paper on the Calcification of the Dental Pulp, yet all are agreed that it takes place through the agency of the pulp, and that, commencing on the apex and external surface of the formative organ, it then proceeds inward until the tooth acquires its prescribed form and size, and the dentine has attained its normal thickness.* When this is accomplished, the formation of the tooth is completed, and the same arrest of growth takes place as occurs in every part of the body at the adult period of life. If the person enjoy good health, and the tooth remain free from injury or disease, the organ may continue for some time without any appreciable alteration, in either the hard tissues which enter into its formation, or in the pulp itself. Sooner or later, however, as years go on, a change takes place in the character of the nutritive process throughout the body. The proportion which the fluids bore to the solids in early or middle life is diminished, nutrition is accomplished more slowly, and the composition of the various tissues undergoes a marked alteration. There is a general induration of the parts, and a tendency to the deposition of ossific matter; ligament is converted into cartilage, cartilage into bone, the coats of the blood-vessels are often impregnated with calcareous matter, and the cartilage of the ribs becomes ossified. If we turn our attention to the teeth, or, more correctly speaking, to the dental pulps, we shall find that they also are liable to a similar alteration of structure. When a section is made through an old tooth, apart from the changes which are to be

* Dentinification is not, as deemed by Mr. Hulme, calcification of the pulp itself, the process occurs in a secretion by the pulp. (See *Dentition*.)

noticed in the color and transparency of certain portions of the original dentine, the pulp-cavity will be seen to have been greatly encroached upon, and the entire mass of the tooth increased in thickness. The extent to which this filling-up of the pulp-cavity can take place is shown in the accompanying drawings. Fig. 81 represents a section of a fully-developed molar in early life, when the tooth has attained its normal amount of growth; while Fig. 82 represents a similar section of a molar tooth taken from an elderly person, and in which the pulp-cavity has become diminished to the extent of fully one-half its original dimensions. This change in the cavity of the tooth can only have taken place through the agency of the pulp, which, after a period of repose, must have returned to its original function of calcification, and have added fresh layers of dentine to the inner surface of the tooth.

Fig. 81. Fig. 82.

The teeth, as suggested by Wedl, are distinguished at different ages by a diminution of the pulp-cavity, an increase of thickness in the *cementum*, and a lessening of that of the enamel, and of the transparency of the three dental substances; by the edges and angles becoming blunted, and the surface assuming a yellow tinge, etc. These distinctions are most striking in the teeth of old men. In the *pulps* of teeth in this condition will be noticed a considerable diminution in the quantity of blood, the color of that tissue often passing into a brownish yellow, from the quantity of pigment deposited in it. Earthy salts, assuming the outward form of the botryoidal corpuscles met with in the pineal gland, occur on the inner surface of the pulp-cavity and of the dental canal, and also deposited in groups in the substance of the pulp. An increased number of layers of *cementum* will be observed, though these are often concealed by the opaque, brownish-yellow color of the inter-corpuscular substance. In thin sections, the *dentine*, sometimes throughout, sometimes only in isolated spots, appears less transparent than natural, and the dentinal tubes become less distinct, and occasionally disappear in the dark-gray or brownish-yellow substance. These partial opacities of the dentine are manifested, even to the naked eye, by a speckled appearance. The enamel presents dark, reddish-brown spots, and, as well as the dentine, appears to have lost some of its elasticity, and to have become more brittle.

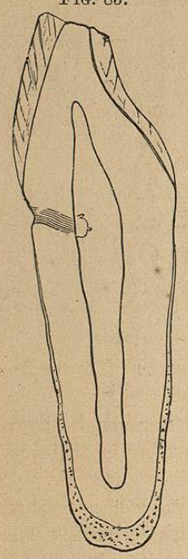
Teeth subjected to sources of local irritation are frequently—indeed, it is rather to be said, are commonly—found responsive in the way of self-attempting deposits. This subject is discussed in connection with filling and filing teeth (which see). In Fig. 83, after Mr. Hulme, is exhibited a tooth which, as may be seen, has been worn into a groove at the neck; in the pulp-cavity, antagonizing the groove, is seen a deposit of secondary dentine.

The re-formative efforts of the dental pulp differ from conditions as shown in the diagrams to the complete conversion of its substance into a species of dentine, so that it is often found, on cutting open a tooth long subjected

to irritating influences, that the cavity commonly existing is occupied by solid matter.

A form of secondary dentine occasionally met with is shown in Fig. 84. This diagram represents a specimen described by Mr. S. J. Salter, and by him presented to the attention of the Pathological Society of London. In this case, as is seen, the mass is attached to the chamber-wall of the tooth.

FIG. 83.



The tooth, as mentioned in Mr. Hulme's paper, was a central incisor which had been extracted from a woman on account of severe neuralgic pains, obviously connected with one of the central incisors of the upper jaw. The pain was described as of a gnawing character, abiding, but not constantly severe; frequently amounting to a mere consciousness of the presence of the tooth, and at other times sharp and darting. In the former condition it was confined to the region of the tooth; in the latter, it flashed up the side of the face, and through all the branches of the superior maxillary division of the fifth nerve of that side. Sudden pressure or a tap upon the tooth, or a marked change of temperature, produced a considerable augmentation of pain. The tooth itself was sound, to all external appearance; it was somewhat elongated beyond its fellow, and was very slightly loose. The gum surrounding it was red at the edge, and a little swollen. When the tooth was removed, no exostosis was discovered on it; and, with the exception of some small patches of half-organized lymph, it appeared quite healthy.

Upon making a vertical section of the organ from side to side, a small pear-like excrescence of dentine was found growing from the side of the pulp-cavity, so as to encroach much upon it, and occupying for a short space more than half its diameter. It was of an oval form, its long axis corresponding to that of the tooth; in color less opaque, and yellower than the neighboring tissue.

The structure was of that irregular character which has been previously described as occurring in secondary dentine, which has arisen from the wearing away of some part of the tooth's surface. The removal of the tooth was accompanied with a violent paroxysm of neuralgic agony, but was followed by a total cessation of pain, and the cure was permanent.

Masses of dentine—nodular dentine, as it has been named by Mr. Salter—occupying positions in the substance of the pulp, are to be met with as among the causes of odonto-neuralgia, as alluded to on a former page. These nodules may be single or multiple; the author has in his possession specimens in which at least a dozen are to be found in the same pulp. These

nodules differ markedly in form. Dr. J. F. Flagg, whose curiosity has prompted him to the preservation of a large number of specimens, makes an

FIG. 84.

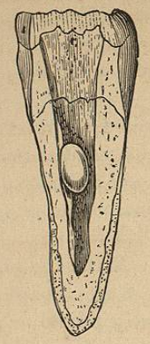
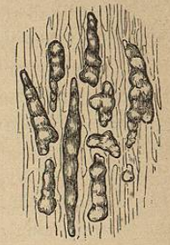


FIG. 85.



interesting classification. The author has to add a suggestion as to the frequency of their deposit where the syphilitic vice is present.

Taking advantage of a cut at command (Fig. 85), a specimen is shown from the collection of Mr. Hulme, and which is thus described by that gentleman:

Examination of the Tooth.—The decay extended to the pulp-cavity, and the median third of the crown was more or less affected by caries. The tooth was then broken open and the pulp examined. It was of a pinkish color, and somewhat more vascular than usual. On endeavoring to withdraw the pulp from the cavity, at the part which was directly under the carious portion there was found a solid lump of osseous matter as large as a canary-seed, and something less than a grain in weight; it was not adherent to any part of the inner wall of the tooth. On examining the remainder of the pulp beneath the microscope after the addition of a solution of caustic soda, it was seen to be thickly crowded with rounded masses of dentine, but more opaque and of a different character to the dentine globules of Czermac. The drawing represents the appearance presented by this portion of the pulp.

No form of odonto-neuralgia is more severe and persistent than this arising out of pulp calcification. In this direction it has happened the author to see among his clinic patients quite a number of cases. The diagnosis is perhaps always, as has been suggested, difficult, and at times only satisfactorily to be settled by the extraction of teeth presenting more or less evidence of complication. The condition is more frequent than generally supposed, and is to have consideration in all cases of obscure neuralgia. A multitude of illustrative cases could be quoted. (See *Neuralgia.*)

6. *Sympathy.*—Sympathetic toothache is most frequently found associated