

ON THE
STRUCTURE,
PHYSIOLOGY, AND PATHOLOGY,
OF THE
PERSISTENT CAPSULAR INVESTMENTS AND PULP
OF THE
T O O T H.

BY ALEXANDER NASMYTH, M.R.C.S.

READ JANUARY 22ND, 1839.

THE teeth have been described as passing through three stages during their development and growth. These stages have been severally denominated the follicular, the saccular, and the eruptive. The nature of the follicular stage has been noticed and explained by Arnold, but has lately been more particularly investigated and described by my friend, Mr. Goodsir, in a very interesting paper published in the Edinburgh Medical and Surgical Journal for January 1839. The existence of this stage has however been disputed and denied by others. The saccular stage has long been well known, and its existence has never been called in question. In the present paper I shall confine myself more particularly to the nature of the third or eruptive stage.

The term, cutting of a tooth, has hitherto been employed to designate its protrusion through the capsule and the superimposed integuments. Respecting this process Cuvier thus expresses himself:—"Elle (la capsule) est percée à son sommet par l'évolution de la dent, mais ses bords s'attachent aux gencives, et en deviennent en quelque sorte la continuation."* This description of Cuvier has been, I believe, universally adopted; but my researches have led me to the conviction that it is erroneous, and that it is by a process of absorption, and not of disruption, that the tooth is emancipated.

The want of uniformity in the structure of the teeth, as described by anatomists generally, has long appeared to me to be inconsistent with the simplicity of the laws of nature. In the works of most authors on this subject we find it stated that, in the teeth of man, of the quadrumana, the carnivora, and indeed in simple teeth of all kinds, the enamel is protruded, and continues without any external covering whatever; whilst, in several other cases, there is described as existing on the same substance a dense coating of what is termed *crusta petrosa*. It struck me as remarkable that a texture so constituted as the enamel, should be in many cases exposed, divested of any tenacious covering, to the concussion of hard bodies, whilst in others it was provided with a dense, protecting investment; and the unaccountable nature of this diversity stimulated me to inquire into the subject.

* *Des Dents des Mammifères*, p. xxiv.

Some years ago, whilst engaged in some very minute anatomical investigations with my learned friend Mr. Bushell, I observed detached portions of membrane floating on the surface of the solution in which human teeth had been submitted to the action of acid. These were so delicate, and were separated with such facility, that it was some time before I could satisfy myself as to the part of the tooth to which they had appertained. After a minute and careful examination, however, I was able to demonstrate with the greatest certainty, that they were derived from the external surface of the enamel, and that they were continuous with the structure covering the fang, which latter is itself continued into the chamber of the tooth. I afterwards succeeded in tracing this covering on the whole surface of the enamel and fang of the tooth in one continuous envelope ; and eventually I was enabled to remove it from the crown of the tooth in the form of a distinct coat or capsule. This covering, which I proved to exist externally to the enamel, I have termed “ the persistent dental capsule.”

The method of demonstrating the existence of this capsule is very simple. It is of course most likely to be found in a perfect state on the crowns of teeth which have been recently extruded ; but on almost every tooth a remnant may be found which has not been destroyed by attrition. The teeth require merely to be macerated in muriatic acid, diluted to one-eighth of its ordinary strength, and, in the course of a few minutes generally, it will be

found to be loosened from the surface ; and, as soon as it is once partially separated, it may easily be altogether detached. In all cases where this covering has been removed by means of acid, it has, of course, the appearance of a simple membrane, in consequence of the earthy deposits having been dissolved, and of there being only present the animal tissue. The structure and appearance of the covering, detached in this manner from the enamel, are the same in every respect as those observed in the capsule of the unextruded tooth ; consisting, like it, of two layers, fibrous externally, and having on its internal surface, the peculiar reticulated appearance common to both, and shown at Plate V. fig. 6.

On first conducting these experiments I considered that the covering thus detached must necessarily be either a production of the capsule, or the entire capsule itself, or a part of it in a state of atrophy, ossified, and adhering to the enamel by means of the ossific matter deposited in it, or interposed between it and the enamel.

On examining carefully fine sections of several teeth under the microscope, I perceived here also that the structure in question was continuous with the crusta petrosa on the fang of the tooth. In the incisor of the ox, and in some other simple teeth, the characteristic ossific corpuscles of the crusta petrosa, as pointed out by Purkinje, are occasionally evident. (See Pl. V. figs. 4 and 5, at *a, a*, in each.)

Müller in his Physiology (one of the first textbooks of the present day) states that the crusta pe-

trosa is a secretion from the saliva. His words are, "This new substance is the cement or crusta petrosa. It seems to be merely a deposit from the salts of the saliva, and to be essentially the same as what is called tartar on the human teeth." To prove the fallacy of this opinion, I have shown in Plate V. fig. 1, the microscopic appearance of the crusta petrosa of the elephant's grinder, where its organic nature, and the analogy in structure to bone is quite evident from the existence of the characteristic corpuscles of Purkinje, and the numerous ramifying canals in a state of ossification, and having a definite direction. I believe Müller is the only exception, however, to its being acknowledged on all hands that the crusta petrosa emanates in some way from the capsule. According to some authorities it is a direct product of the latter; whilst others state that the capsule is converted into the crusta petrosa, which, in this case, would be neither more nor less than the capsule in an ossified state. According to my investigations, therefore, the enamel of human and of all other teeth, simple as well as compound, is covered by a distinct capsular investment. This capsule in the compound teeth of some animals, as, for instance, those of the ruminantia, &c., has been long noticed under the name of cementum or crusta petrosa. The cementum always contains corpuscles or cells, the peculiar character of which is shown in several of the Plates. These corpuscles exist in the persistent enamel-capsule of the incisor of the ox, and some others; but I have not hitherto been able

to discover them in that of the human subject, and therefore, in the present stage of the investigation, I think we are only entitled to designate it capsular, and not range it under the general head of *crusta petrosa*: although it is directly continuous with it, and in all other respects analogous. However, whether it is to be included under the collective appellation of *crusta petrosa* or not, we have in it a very interesting example of the uniformity of the laws of nature, inasmuch as it would then be general throughout the animal kingdom. The considerations connected with this covering in the positive state of *crusta petrosa* are very interesting in many animals, where it has not yet been generally recognized, such as the *Orycteropus*, *Bradypus*, *Rodentia*, &c.

In pursuing this branch of the inquiry, I detected in the composition of the teeth another structure which I believe has never yet been noticed, and of which, if I mistake not, the consideration will be found to be of no little importance and interest. I allude to a layer of substance distinct in its appearance, situated externally to the *crusta petrosa*, where that is considerable. Its existence in the elk, ox, bradypus, dasypus, kangaroo, hippopotamus, elephant, &c., is shown by specimens in my possession. The appearance of it on the tooth of the *Bradypus tridactylus* is seen at *d*, Plate V. fig. 3. It varies in colour from pale yellow to dark brown, and is of a laminated structure. Its thickness is very various, and seems to have a certain ratio to the

thickness of the crusta petrosa. It may be possible that this investment is the cartilage of the crusta petrosa, but the darkness of the material has hitherto prevented me from observing any other peculiarity in its structure than that of the laminated appearance. The persistence of such attenuated textures as we see developed on the incisors of man and most other animals, as well as this ultimate investment of the crusta petrosa which I have just alluded to, must generally be of short duration on that part of the tooth which is subjected to attrition ; and, as all will acknowledge also who have attempted to make microscopic sections of teeth, there is the greatest difficulty in preserving in their integrity the peripheral tissues of these organs ; and the accidental fracture and destruction of the substances of which I have just treated is, doubtless, the cause of their existence having escaped the extensive and vigilant researches of Retzius, Purkinje, Fraenkel, and others. Hence too I should not be justified in asserting that the latter of the two structures which I have pointed out exists only in the animals above enumerated : for, as we arrive at still greater perfection in making sections of teeth, we shall probably find that it exists in many other cases where we have not yet been able to demonstrate it. It would be interesting to inquire into the relation which this tissue bears to the capsule, but I should not at present be warranted in pronouncing an opinion on this point, as my own investigations with regard to it are at present incomplete.

The appearance and structure of the ultimate peripheral investments of the teeth of all animals are very interesting, and present diversities in the respective groups which extend even to characteristic peculiarities. A consideration of these, however, would necessarily be far too extensive a subject to enter upon in a paper like the present. With regard also to the observations above detailed, there still remain many interesting points to be further elucidated and carried out ; but I have been induced more from the advice of some friends, whose judgment I rely on, than by my own desire, to lay what I have done so far before the profession, without further delay. The views and observations which I here communicate have not, I believe, been, any of them, anticipated ; but there is a remark made by Fraenkel in his inaugural dissertation published in 1835, which, in justice to that acute observer, ought to be recorded here as the only approach to anticipation which I have been able to discover. The passage I allude to is at sect. ix., and is as follows :— Speaking of the cortical substance, he says, “ In the incisor of an old man of seventy-five we found the whole root surrounded with this substance, which at the extremity was very thick, and as it ascended thence, became thin by degrees, and extended onwards to that place, where the adamantine substance began ; moreover, on one side, ascending higher up, it coated a small portion of the adamantine substance itself, and like a single layer could easily be removed.”

I now proceed to the second section of my subject, viz., the consideration of that part of the capsule and capsular investment which is extended over the fang. The persistence of this portion of the capsule itself is manifest throughout the whole of the life of the tooth, from the circumstance that the *crusta petrosa* is produced during all periods of the existence of its vitality. There the capsular investment is generally limited to a thin crust, even in those animals where the crown is densely coated with *cementum*, so that in many cases an abrupt line marks the point where the enamel joins the fang. In the human tooth, however, the osseo-membranous covering is much thicker round the fang than round the enamel, and the portion which invests the former increases in size, in a ratio somewhat in proportion to the age of the individual.

The functions of the capsular membrane are of great importance at the period when the temporary teeth are removed to make room for the permanent series, inasmuch as it is the agent by which this removal is effected.

Where the temporary tooth has continued in a healthy state, and in vigorous vitality, its absorption proceeds with perfect regularity, and without causing any inconvenience, provided the new tooth is so situated as to exercise in its progress a regular pressure on the root of its predecessor. This pressure would seem to be necessary to the process of absorption, for we almost constantly find that the milk-teeth persist, where from irregularity in the arrange-

ment or growth of their permanent successors, it is not directly applied. In such cases, should the temporary tooth continue healthy, there seems to be no limit to its persistence ; and I have seen instances in which it has remained in the perfect exercise of its functions till a very late period of life ; the permanent tooth being then either altogether deficient, or remaining encased in the jaw ; or forcing its way up laterally in the same row, as is shown in a model in my possession, where the under centre-incisor is seen retaining its position, and producing the apparent anomaly of the existence of five incisors in the human jaw.

Where the tooth is diseased, the capsule investing the fang is also affected, and is disabled from performing the function of absorption. In this case, the fangs of the temporary tooth only partially disappear, and generally maintain their position, notwithstanding the pressure which the growing tooth exerts upon them. Sometimes they remain so firmly wedged between their permanent successors, that it becomes a difficult matter to disengage them. The portion of the capsular membrane under consideration, seems to be the only agent capable of effecting the process of absorption ; and we may have ocular demonstration of its performing this, by withdrawing carefully a deciduous tooth when it is near falling off. The fangs will then be found to have almost disappeared, and only a small portion of the membrane to remain ; the latter is observed on the spot from which the tooth has been removed ; it is in

connexion with the pulp, and the whole is highly vascular, and retains an exact impression of the surface of the tooth which was opposed to it. As absorption can only be carried on by the surface in immediate contact with the part absorbed, it follows, that this membrane must be so organized as to be able to effect that process. The fangs of the permanent teeth are subject to a similar action, being often absorbed, but in a very imperfect manner.

The normal exercise of the function of absorption by the capsular membrane may with facility be observed on the fangs of the temporary teeth of the lower animals ; and also, to cite a curious instance, in the gradual loosening and separation of the anterior molars of the elephant, which are removed by its means. I have in my possession a tooth of the cachelot whale, furnishing an example of abnormal absorption. I have dwelt thus long on this process, because Retzius, and some of his followers, deny that it ever takes place, either normally or abnormally. The former thus expresses himself on the subject : “ The crown of the advancing tooth appears to have pressed itself into the extremity of the deciduous one. I have carefully examined how this appearance is produced, and have come to the decided conclusion, that neither tabescence, absorption, or erosion takes place!” This opinion having been circulated and sanctioned by Müller and others, who advocate the tubular system of the teeth, I have thought it necessary to communicate the above details, which I think completely refute it. I am at issue, also,

on this point, with Cuvier and Rousseau, the latter of whom thus expresses himself on the removal of the milk-teeth: "Elles (les dents de la seconde dentition,) exercent sur ces alveoles une pression si forte qu'elles privent les dents de lait, en comprimant les nerfs et les vaisseaux qui s'y rendent, de la faculté de recevoir les fluides qui jusque-lá les avaient vivifiés." (Rousseau, p. 71.)

Where the milk-tooth is withdrawn, as above described, before the process of absorption is completed, the membrane remains behind; but the contrary takes place when it has invested the fang with a peculiar bony structure; in this case, it is generally found adhering to the adventitious matter, with which it comes away. This leads me to notice a formation which throws great light on the analogy between the functions of the different portions of the capsular membrane. I allude to the increment on the fang which is generally termed an exostosis, and which assumes all kinds of shapes, as may be seen from Plate VI. figs. 1, 3, and 6, at *a, a*, in each. The general texture of its internal structure, however, is uniform, as may be seen by the appearances shown in the longitudinal and transverse sections given in the above figures, and resembles true bone, though it has characteristic peculiarities, as may be seen from the highly magnified portion shown in fig. 5. The appellation, exostosis, as applied to a product of the ivory of the tooth, always seemed to me to imply a higher order of vitality in that substance than it actually possesses.

The morbid action producing this enlarged growth of cementum, or peculiar enlargement, generally called exostosis, may have a variety of causes, but it is generally induced by exposure to the atmosphere, or by the presence of some foreign body in contact with the internal membrane, when it has been denuded of its natural covering by ordinary decay. In this latter case, there is generally great pain referred to the tooth itself; but the jaw and surrounding parts often suffer to such an extent, that cerebral congestion, rheumatism, ear-ache, tic-douloureux, &c., are often supposed to exist, and the patient is submitted to the routine-treatment for these affections, without, of course, any permanent alleviation. Individuals of a sanguine, scrofulous diathesis, seem to be peculiarly liable to this form of disease, and females, I think, are more so than men.

Teeth which have lost their antagonists, frequently protrude from their sockets, and then the capsular membrane of the fang often throws out a considerable earthy growth, which, though it produces but little local pain, is attended with morbid symptoms, manifesting themselves in other parts. A similar growth often takes place when the teeth of adults have been forced out of their natural position, by oblique pressure from an antagonist tooth. I have known several instances where all the teeth, as far as I could ascertain, were thus affected. This growth occasionally renders them very difficult of extraction, for by enlarging the fangs, it, of course, causes them to be wedged more tightly in the socket. I am

not acquainted with any mode of arresting this malady, and have never known an instance where any other treatment except extirpation has been of the slightest avail. The existence of these bony growths may sometimes be detected, though never very easily, by a slight alteration in the colour of the tooth, and by its yielding a little more than natural in one direction, when steadily and forcibly pressed ; in some cases the enlargement takes place in one fang more particularly, and then the tooth protrudes from the socket in an oblique direction.

On the necks of teeth notches are frequently seen, into which the nail or the point of a small instrument may be inserted, but not without causing a very acute sensation, derived, as it appears to me, from the vessels of the capsule covering the fang. Whether the absorption of the alveolar process, following the exhibition of mercury and other mineral medicines, be the work of the membrane under consideration, I have not been able to determine.

The absorption of the fang, and the deposition of osseous matter on its surface, are comparatively slow processes, from the gradual operation of their causes, but in cases of what is called alveolar abscess, disease is much more rapid, and its effects violent and sudden ; here the fang is found dead and denuded of its membrane, which in a thickened state, at some distance from its surface, forms part of the suppurating sac.

When disease has once invaded this membrane to any extent, we may palliate it by other remedies,

but the only effectual cure is extirpation of the tooth, the true exciting cause. Where the teeth of the patient have suffered either from neglect or bad treatment, and present various stages of decay, the bone surrounding them is affected; a quantity of decomposed osseous matter is constantly being swallowed; the breath becomes horribly foetid, and in an emaciated countenance, an enfeebled frame, and an irritable habit, we mark the effects of suffering the mouth to be converted into a charnel-house of diseased bone. The maladies which I have hitherto glanced at, may truly be considered as benign, when compared with others which must be regarded as their sequelæ, but which do not fall within the scope of the present paper.

There now remains to be considered the third section of our subject,—the pulp, which is a continuation of the capsular membrane.

The pulp seems to be a necessary agent in the construction of the teeth of the higher animals, and produces, as is well known, the substance called ivory, which is analogous in its general structure to the enamel. When the growth of the tooth is completed, the primary function of the pulp ceases; but in teeth of which the period of growth is unlimited, its action of course only terminates with their vitality. It occupies a small cavity in the interior of adult teeth of limited growth, and a conical cavity at the root of those of which the growth is unlimited. In the former case, one or more additional fangs may be formed by its subdivision into pro-

cesses, whilst in the latter the arrangement of the structures at the base of the tooth is the same as in its entire length. In some of the lower animals, being surrounded by the ivory which itself has secreted, it is normally converted into an earthy structure, the appearance of which is intermediate between ivory and bony substance. Examples of these appearances are given in Plate V. figs. 2 and 3, at *a, a*, in each; fig. 2 being a section of the tooth of the two-toed sloth, and fig. 3, that of the three-toed sloth. In man and other animals where the ossification of the pulp is the sequela of disease, the appearances presented possess many of the characteristics of true bone; but still is not generally so similar to it as is the ossific growth produced by the capsule of the fang, as will be seen on examination of Plate VI. figs. 1 *b*, 3 *b*, 7 *b*, and 4; fig. 4 being a more highly magnified view of a portion of fig. 3.

The substance under consideration, the nature of which has not hitherto been dwelt upon, partakes much of the fibrous character of the ivory, being composed of irregularly radiating filaments, blended with small calcigerous cells, in which ossified vessels are seen to ramify. The conversion into osseous matter is sometimes partial, and sometimes general throughout the membrane. In the longitudinal section, Plate VI. fig. 3, at *b*, the bony pulp completely fills up the cavity of the crown, and that in the fang. In the transverse section, fig. 7 at *b*, the cavity of the crown is only partially occupied; and in the longitudinal section, fig. 1 at *b*, the ossification seems to

have commenced in the centre of that portion of the membrane which is contained in the fang; and in this case a cavity has been formed round the ossified portion.

In the lower animals a similar ossification takes place when the functions of the part are interfered with; examples of which are often met with in the tusk of the elephant, hippopotamus, *cystophera probosciana*, and in the teeth of many other animals. The ossified pulp in the human subject is of frequent occurrence, and is generally, and indeed in every case wherè I have met with it, the sequela of long-continued disease, either of the tooth itself, or of some part of the mouth; though there is no direct evidence to prove that ossification of this structure may not take place without previous morbid symptoms. The predisposing cause, however, of the process is often at a considerable distance, and frequently shows itself when the actual or other cautery has been used to allay the sensibility without actual destruction of the internal membrane. Very frequently it supervenes on resistance to complaint, or on the determination on the part of the patient to retain a tooth which has given pain in stopping.

The process is always accompanied by pain, and by a peculiar uneasiness of the tooth itself, which is shared also by the surrounding parts. As it frequently takes place without any co-incident external decay, the only possible relief is often withheld, as there are no infallible diagnostic symptoms warrant-

ing a decided opinion ; and the patient is left to suffer, till the malady having crept on to the external capsular membrane, affords to the careful observer a decided demonstration of its existence.

Disease manifests itself in various other forms in this membrane, which is endowed with no powers of repair. When completely denuded, it sometimes forms an acutely sensible fungus, and occasionally small white tumours are found in its substance, though the tooth is sound externally ; but I have never met with these cases except in strumous habits, and in connection with considerable disease of the neighbouring parts.

With regard to the general subject of Dental Physiology, I hope that the sketch which I have given will serve to reconcile many conflicting opinions concerning the vitality of the teeth. The researches hitherto made allow us, I think, to attribute only a very low degree of vitality to the enamel and ivory of the teeth ; for the phenomena which have generally been adduced in opposition to this doctrine, are, in fact, referrible not to the tooth itself, strictly speaking, but to different portions of the periosteal capsule.

I have shown above, that ivory, enamel, and cement, are not the sole constituent formations of the tooth ; and I may here remark, that I am inclined to add another, which, though it has never been described, is, in my opinion, so frequently present, and so perfectly different from the other structures, in the mode of its formation, the nature of its func-

tion, and the appearance which it presents, as to merit the appellation of the fourth, distinct, constituent substance of the teeth,—I allude here to the osseous substance with which the pulp, in many animals, is normally converted, by interstitial deposition. Examples of these normal structures, as has been already mentioned, being given in Plate V. figs. 2 and 3, at *a, a*, in each. The simplest forms of teeth are almost exclusively composed of this substance, and in many of those which consist of cement and ivory, without enamel, it fills up the internal cavity. A clear definition and classification of the different substances which enter into the structure of the teeth, furnish, in my opinion, the only valid foundation for a scientific arrangement of the different modifications of these organs throughout the animal kingdom. This important subject, however, I hope to find an early opportunity of discussing, and shall, for the present, conclude, by expressing my belief that very much still remains to be accomplished before we can consider ourselves fully conversant with the structure of the teeth.

The points to which I wish at present particularly to call the attention of anatomists, are, first, the capsular investment on the surface of the enamel; secondly, the layer external to the crusta petrosa, already indicated in some animals; and, thirdly, the structure and development of the “fourth constituent substance,” or ossified pulp.