XIV. *Some Observations on the Structure of the Teeth of graminivorous Quadrupeds; particularly those of the Elephant and* Sus Æthiopicus. *By* Everard Home, *Esq. F. R. S.*

Read May 30, 1799.

WHEN Mr. CORSE did me the honour of putting into my hands his Observations on the Elephant's Teeth, and shewed me the teeth themselves in their different stages of growth, in illustration of what he had advanced upon the subject, I very readily engaged in the prosecution of so curious an investigation. I examined several specimens of elephants' teeth, preserved in spirit, while in a growing state, which are deposited in Mr. HUNTER's collection of comparative anatomy, and compared them with the teeth in Mr. CORSE's possession. From these two sources, I was enabled to procure every information that was required, to explain the structure of the elephant's teeth, and to point out the general principle upon which all teeth are formed, that have the enamel intermixed with the substance of the teeth; a subject, as far as I am acquainted, not hitherto investigated.

The success that has attended this inquiry may be ascribed to my opportunities of consulting Mr. HUNTER's collection:—this tribute I pay with much satisfaction, and mention it here, in proof of the value of that collection, which is not confined to the discoveries and investigations of Mr. HUNTER, but extends much further; since the collection contains materials relating to many subjects at present but little understood, and which, if they are hereafter rendered accessible to those engaged in such researches, will lead to the advancement of knowledge, and to many useful discoveries.

As Mr. CORSE'S labours in India have enabled him to give so correct and satisfactory an account of the mode of growth of the elephant's teeth, I was desirous that the facts which I had discovered respecting their structure, should be introduced into his Paper, to render the account more complete:—this offer, Mr. CORSE however declined, not choosing to bring forward any thing that was not wholly his own; I have therefore added them in this place, as a proper supplement to Mr. CORSE'S Paper.

To make my observations on the structure of the complex tooth of the elephant intelligible to this learned Society, it appears necessary to mention, generally, the mode in which the more simple teeth of the human species, and of carnivorous animals, are formed: this knowledge will render the account of such additional parts as are met with in those of the elephant, more easily understood.

The teeth of carnivorous animals are formed from a vascular pulp, of the same shape with the future tooth, upon the external surface of which the substance of the tooth begins to grow, and increases till it is completely formed. This pulp is inclosed by a capsule, the cavity of which, while the tooth is growing, is filled with a viscid fluid, similar to the synovia of joints; and this fluid, by the absorption of the thinner parts, becomes inspissated to a proper state for crystallization, so as to form the enamel, which adheres to the surface of the tooth.

Teeth formed in this way, are composed of two parts, of dissimilar texture: one, the enamel, which is striated; the other, the substance of the tooth, which is laminated, like ivory, being more compact than common bone, and less so than the enamel; but differing from both in the mode of its formation.

Bones are formed in two different ways: those that are cylindrical, have cartilage for their basis; those that are flat, either cartilage or membrane; but, in no instance in the body are they formed upon a pulp. The substance of the tooth must therefore be considered as distinct from bone, and may be ranked, both from its structure and mode of formation, as a species of ivory.*

The teeth of the elephant differ from those just described, in being composed of a great many flattened oval processes; these, while growing, are detached; but, when completely formed, their bases unite together, and make the body of the tooth, to which the fangs are afterwards added; and, as the fangs are lengthened, the tooth rises in the jaw. This is what may be considered as the tooth itself, being composed of the same materials as the teeth of carnivorous animals; but, in addition, there is another substance, which unites all the processes together, laterally, into one mass; this is softer than the substance of the tooth, and, upon examination, proves to be similar, in its texture and formation, to common bone.

* The tusks of the elephant are formed upon a pulp, similar to teeth.

Tumors are sometimes met with in the frontal sinuses of the human body, having a perfect resemblance to ivory; they have their origin in the bony cavity of the sinus, and extend themselves into the orbit of the eye. Of these, I have seen two instances, and was unable, at the time, to account for them; but am now induced to believe they were formed upon vascular excrescences, growing from the lining of the sinuses, similar in their organization to the pulps above mentioned.

As teeth have been hitherto considered of the same texture with common bone; it is probable that nothing but the two substances being united in the same mass, could have led me to the discovery of their differing materially from each other. It will therefore be proper to explain, in this place, the circumstances which first gave me the present view of the subject.

To obtain an accurate knowledge of the different parts of the elephant's tooth, a longitudinal section was made, of one that was full grown. This section exposed the lateral connection between the different processes, and the intermediate substance which unites them into one mass; it also showed the mode in which the processes are continued into the body of the tooth and fangs.

That the internal structure might be made more distinct, the surface of this section was polished very highly, which led to the discovery of the processes of the tooth having a more compact texture than the intermediate substance; for, although both had the same appearance after being sawn, the processes bore a polish, (which the other did not,)* and were laminated, like ivory; while the other parts were porous, like the internal structure of common bone.

This led me to examine preparations of the elephant's teeth, in a growing state, preserved in spirit, which explained the mode of growth of these two substances to be different. In these prepa-

* A portion of the jaw itself bore the same degree of polish as the intermediate substance of the tooth.

The cells in the elephant's skull are no part of its common structure; they communicate freely with the cavity of the tympanum, and are therefore appendages to the organ of hearing, which I shall explain more fully on some future occasion.

rations it was found, that the processes of the tooth, which may be called ivory, were all formed upon so many portions of one common pulp, which had its origin in the jaw; and that the intermediate substance, which may be called bone, was formed upon a species of ligament situated immediately under the gum, from which, membranous elongations extended into the spaces between the processes of the tooth.

As this is a subject not favourable for minute description, the annexed drawings will give a more satisfactory idea of what is meant to be described, than can readily be done in words.

In these drawings is represented the ligamentous substance, with its projecting membranes; and the vascular pulps; also the mode in which the ossification takes place in the one, and the formation of the substance of the tooth in the other.

This structure of tooth is not peculiar to the elephant, but common to the teeth of all animals whose food requires to be ground, or much bruised, before it is swallowed.

In the elephant's tooth, from the largeness of its size, the parts are more distinct, and more readily contrasted with each other; but, in other animals, even those of a small size, as the sheep, the different structures are readily detected.

It is singular that this structure should have escaped the accurate investigation of the late Mr. HUNTER; particularly as the formation of the teeth was one of the first objects he employed himself upon; and he continued to pursue it to the end of his life, marking the varieties which occur in different animals.

The cause of his overlooking it was the following: in making preparations of horses' teeth, to show the figured appearance on the grinding surface, he rendered them black by means of fire, which did not affect the enamel, so that the white lines of the enamel were beautifully distinct on the black ground; but the bony part and the substance of the tooth were equally coloured, and had an uniform appearance.

The examination of these preparations led him to believe, that the horse's tooth consisted of only two substances, the tooth itself and the enamel. Under this impression, Mr. HUNTER examined the growing teeth of the horse, and found the pulp rising from the jaw, and the vascular membranes passing down from the gum, into the spaces between the portions of pulp; he was therefore led to conclude, that the pulp was for the formation of the tooth, and that the membranes which came from the gum were for the formation of the enamel.

Having so fully explained, in the elephant's tooth, the real uses of these two parts, it is not necessary to say more in refutation of this opinion, which is published in Mr. HUNTER's work on the teeth; but, in justice to the correctness of his other observations, I shall subjoin his account of the circumstances under which the enamel of the human teeth is formed, taken from the same work. He says, " the pulps are surrounded " by a membrane, which is not connected with them, except at " their root, or surface of adhesion. This membrane adheres, " by its outer surface, all round the bony cavity in the jaw, " and also to the gum, where it covers the alveoli.

" When the pulp is very young, as in the fœtus of six or " seven months, this membrane is pretty thick and gelatinous. " We can examine it best in a new-born child, and we find it " made up of two lamellæ, an external and an internal: the " external is soft and spongy, without any vessels; the other " is much firmer, and extremely vascular, its vessels coming " from those that are going to the pulp and body of the tooth.

"While the teeth are within the gum, there is always a muci-
"laginous fluid, like the synovia in joints, between this mem-
"brane and the pulp of the tooth."*

This mucilaginous fluid, I have already asserted, deposits the enamel; which is further confirmed by the following experiments and observations.

The complex tooth of the elephant, being composed of three different structures, each of which has a peculiar process for its formation, led to an inquiry whether the materials themselves were different, or only differently arranged.

To investigate this, Mr. CHARLES HATCHETT, from a zeal to promote the pursuits of science by which he is distinguished, obligingly gave his assistance, and made some experiments, the results of which are as follows.

It is to be understood, that a complete analysis was never intended to be made; as neither Mr. HATCHETT's time admitted of it, nor did it appear necessary for the object of the present inquiry.

Experiment I. Some enamel, rasped into a fine powder, was put into a matrass, and, pure muriatic acid being added, the whole was suffered to remain without the application of heat during one hour; in the course of this time, the enamel was completely dissolved, with a gentle effervescence.

To this solution, some sulphuric acid was gradually added, till all precipitation had ceased: the precipitate was separated by a filter, and was found to be selenite. The filtrated liquor, by evaporation, afforded a small additional quantity of selenite, which was also separated; after which, the liquor, being evapo-porated, became thick and viscid. This, when diluted with water, precipitated lime from lime water, in the state of phosphate.

To another portion, solution of acetite of lead was added, and caused an immediate precipitation of a white matter, which, when dried and sprinkled on burning charcoal, produced a light and smell like phosphorus; it, moreover, was soluble in nitrous acid, and was thus to be distinguished from muriate or sulphate of lead.

Experiment II. Some of the raspings of enamel were dissolved by digestion in nitric acid, and, when the solution had been diluted and filtrated, it was saturated with carbonate of ammoniac. The precipitate thus produced was collected, and edulcorated in a filter. The small excess of carbonate of ammoniac, in the filtrated liquor, was saturated with acetous acid; after which, the phosphoric acid was precipitated, by solution of acetite of lead. Upon examining the first precipitate, or that produced by the carbonate of ammoniac, it was found (contrary to expectation) that it was still composed of lime, combined with a portion of phosphoric acid, instead of carbonic acid, which might have been supposed.

To effect, therefore, a complete separation of the two ingredients, (lime and phosphoric acid,) acetous acid was poured on the precipitate, by which it was immediately dissolved. The whole of the phosphoric acid was then separated from this solution, by acetite of lead; after which, lest any lead should be present, the liquor was saturated with pure or caustic ammoniac, and the lead was separated by a filter: lastly, the lime which remained dissolved, was precipitated (in the state of carbonate) by carbonate of ammoniac.

The enamel has been supposed, not a phosphate but a carbonate of lime. This error may have arisen from its solubility in acetous acid or distilled vinegar; but the effects of the acetous acid are, in every respect, the same on powdered bone as on the enamel. Consequently, when enamel, or bone, is put into a glass matrass containing acetous acid, placed in a sand bath, the portion which is dissolved, is not (as has been supposed) carbonate but phosphate of lime; for, if to the filtrated solution nitrate or acetite of lead is added, a precipitate is produced, of phosphate of lead, in the same manner as when nitrate or acetite of lead is added to urine.

This mode of treating substances supposed to contain phosphoric acid, as bone, &c. Mr. HATCHETT has found of great utility; because, by this means, he can detect phosphoric acid, when the substance is in too small a quantity to be examined in any other manner.

Similar experiments, on the substance of teeth formed on pulps, and on common bone, afforded similar results.

Mr. HATCHETT considers lime and phosphoric acid to be the essentially constituent principles of these three different structures; and, any difference that is met with, only seems to be that which would constitute species of the same genus, similar to what is found in the mineral kingdom, under lime-stone, marble, and calcareous spar: these differ only by a small change in the proportions of their constituent principles, and by a different arrangement of their integrant particles.

The head of a human thigh bone was found, some years ago, with a thin crust of highly-polished enamel, similar in some respects to that of the teeth, upon a portion of its surface, an inch and half in length, and an inch in breadth; the cartilage having been previously removed by disease. This uncommon appearance, at the time, could not be accounted for; but the forementioned observations, on the formation of the enamel of the teeth, appeared to throw some light upon it; and Mr. Hatchett, at my request, made the following experiment, to determine whether the synovia, in a healthy state, contains phosphate of lime.

960 Grains of synovia, by a gradual evaporation, afforded 21 grains of a substance which resembled dried glue. This, being collected, was put into a small porcelain crucible, which (placed in a larger crucible) was exposed to a red heat, during nearly an hour.

The matter in the porcelain crucible was much reduced in bulk, and appeared like a glazing, thinly spread on those parts of the crucible which had been in contact with it in its former state.

Boiling distilled water was digested on the matter in the crucible, for some time. This water afterwards afforded, with acetite of lead, a copious precipitate of phosphate of lead; but no appearance of lime could be obtained.

On the residuum in the crucible, acetous acid was digested, which was afterwards divided into two portions.

To one of these, solution of acetite of lead was added, and, as before, afforded a plentiful precipitation of phosphate of lead.

To the other portion was added oxalic acid, by which, a small quantity of a precipitate was obtained, which was an oxalate of lime. Phosphate of lime is therefore present in synovia, although but in a small quantity; and as, from these experiments, there is reason to believe, that more phosphoric acid was obtained than was requisite to saturate the lime, it seems probable, that part of it was combined, in the synovia, either with soda or ammoniac; and this accounts for the part dissolved by the distilled water.

M. MARGUERON, in the *Annales de Chimie*, (Vol. XIV. page 123.) estimates the proportion of water in 288 grains of the synovia of an ox at 232 grains. The other ingredients therefore amount to 56 grains: but, by evaporation, Mr. HATCHETT obtained, from 960 grains of synovia, only 21 grains of residuum; which proves that the proportion of water is much greater; for, 56 to 288, is as 1 to 5,14; but, 21 to 960, is as 1 to 45,71.

It is possible, that the proportion of water to the other ingredients may not always be the same. M. MARGUERON also, probably, estimated the albuminous matter, &c. in a moist state; for, without one of these suppositions, it is impossible to reconcile such a very great difference.

By these experiments of Mr. HATCHETT, phosphate of lime was ascertained to be present in the synovia; which, although in a very small quantity in the natural state of that fluid, explains the mode by which the crust of enamel on the head of the thigh bone could be produced, when, by a morbid action of the parts, the quantity of phosphate was preternaturally increased.

A mixture of bony matter with the enamel and the substance of the tooth, is a structure, as has been mentioned, not confined to the elephant: it is common to all truly graminivorous quadrupeds. But the whole number of grinding teeth belonging to each side of the jaw being confined in a case of bone, so as to form one large grinding surface, and the teeth being pushed forward from behind, instead of a second set being formed immediately under the fangs of the first, as in other animals, are peculiarities not met with in any teeth hitherto described, except those of the elephant.

These peculiarities have, however, been ascertained, in the course of the present inquiry, to belong to the *Sus Æthiopicus*; a skull of which, with the teeth, is preserved in Mr. HUNTER's collection. The particular species to which it belonged was determined, by its exact similarity to a skull, without the grinding teeth, in the British Museum, marked, in Dr. SOLANDER's hand-writing, *Sus Æthiopicus*, from Guinea.

As the grinding teeth of this animal have not been before noticed, figures of the head and teeth are annexed, (Tab. XVIII. and XIX.) and, as it has been ascertained by Dr. SOLANDER to come from Guinea, there is reason to hope so curious a species of the hog will attract the notice of naturalists, and be the means of perfect specimens being introduced into this country.

From the appearance of the teeth in the perfect skull, the animal had probably arrived at its full growth, and only one grinder remained on each side of the jaw, consisting of seven different processes, cased with bone, similar to those of the elephant. The grinding surface of those processes which had their points worn down sufficiently to show a transverse section, exposed three oval portions of tooth, surrounded by enamel, inclosed in bone; which is more like the tooth of the African elephant than the Asiatic, and makes another variety of form of these processes.

The tusks of the *Sus Æthiopicus* are uncommonly large, and in their structure resemble those of the elephant.

The skull was shown to Sir JOSEPH BANKS, whose readiness to forward the labours of those who engage in the pursuits of science, by liberally communicating to them his own knowledge of the subjects connected with their inquiries, is sufficiently known to the members of this learned Society. He identified the species of the genus to which the skull belonged, in the manner above mentioned; and, by an accurate search among the skulls of animals deposited in the British Museum, discovered a small head in a dried state, which, when properly macerated and cleaned, proved to be that of a young *Sus Æthiopicus*, whose teeth were in a growing state, and enable me to explain all the necessary circumstances respecting this curious mode of dentition.

The grinding teeth, in this young head, are distinct from each other, and four in number, on each side of the jaw.

That which is most anterior is the smallest, and has a grinding surface only equal in extent to that of one of the processes contained in the large tooth of the full grown animal: the second has a grinding surface equal to that of two such processes: the third is still larger, its surface being equal to that of three processes.

These three teeth, in their general appearances, resemble those of the common hog; they have also the same kind of fangs; their only peculiarity is, the enamel being intermixed with the substance of the tooth, but without any bony matter surrounding it.

The fourth or last tooth is very different from the others, and exactly resembles that found in the large head, only that this is in a growing state. It is composed of seven processes, united together; these are in different stages of growth, fitting them to come forward in succession, similar to those of the elephant. The two first have their grinding surface worn smooth: the points of the two next have recently cut the gum; and the other three are still concealed in the jaw, not being completely formed; of the last of these, the first rudiments only are to be seen.

This large tooth, (which may be considered to be a second set of teeth,) as the concealed processes enlarge, advances forwards, pushing the other teeth before it: the most anterior of these, as soon as its body is worn away, has its fangs removed by absorption, and drops out: the same thing takes place with the second and third; and, in this way, room is made for the large one to supply the place of all the others.

The mode in which they succeed one another, is illustrated by the annexed drawing of a side view of the jaw, Tab. XIX. in which the fangs of the different teeth are exposed; and the body of the third tooth, having been moved forward, as the last increased in size, is distinctly seen.

These peculiarities in the teeth of the *Sus Æthiopicus*, led to the examination of the teeth of the other species of the same genus; all of which appear to resemble the human grinders, only that the last in the jaw has a broader grinding surface than the rest, which is common to most quadrupeds. It is worthy of remark, that the number in each side of the jaw in the common hog is seven; in the Pecary, six; in the Babyroussa, five; and in the *Sus Æthiopicus*, till a certain age, four.

It is curious, that one species of a genus should differ so widely from all the others, in respect to its teeth; and should be allied to the elephant in the structure of its tusks, the mode of formation of the grinding teeth, and the manner in which they succeed one another. From these circumstances it appears,

state, is supplied with a

different kind of food from that of other hogs, and is an animal of greater longevity.

Upon comparing the internal structure of the elephant's tooth with that of the horse, cow, and sheep, it was found, that they were similar in having an intermixture of bone with the substance of the tooth, but that they differed materially from one another in the proportions and situations of the bony portions. Each of these animals having the grinding surface of their teeth adapted for particular kinds of food, the parts composing that surface are variously combined, so as to answer the purpose for which the teeth are intended. In all of them, the mode of growth is the same; the substance of the tooth is first formed, and the bony part is afterwards adapted to the irregularities of that surface.

In the horse's grinding teeth, the processes are two in number; and, in an early stage of their growth, they appear, as well as those of the elephant, to be separate teeth: they differ, however, extremely in their shape, forming irregular cylindrical tubes, the central part of which is filled up by the projecting membranes from the gums, that are to be changed for bone. This division of the tooth into two parts, is very distinct in the shedding teeth, but not in the second set or permanent teeth.

These two portions of bone in the middle of the tooth, have frequently a hole in them, (probably the passage of a blood-vessel, never completely filled up,) and the food getting into it, as the tooth is worn down, considerably increases its size. Besides which, there is a portion of bony substance surrounding a great part of the outside of the tooth.

In the cow's grinding teeth, there are two portions of bony substance in the middle of the tooth, as in the horse, in shape of crescents, and a very small portion in the hollows on the outside of the circumference of the tooth; but none on the projecting parts.

In the grinding teeth of the sheep, the middle portions of bone are similar to those of the cow, but on a much smaller scale; there is no portion of bone on the outside of the tooth.

It is not to be wondered at, that there is so great a variety in the grinding surfaces of the teeth of different genera of graminivorous quadrupeds, each, no doubt, adapted to the kind of food they are in a state of nature destined to live upon, since there is even a variation between the teeth of the African and Asiatic elephants. In the African elephant, the processes of which the tooth is composed are not flattened ovals, as they have been described in the Asiatic, but are in the form of an oblong square or parallelopipedon, so that, in the middle line of the tooth, the processes are in contact with each other, although at no other part; by this means, the middle line of the tooth is the hardest; the whole surface therefore does not wear regularly, as in the Asiatic elephant, but with a ridge in the middle.

As a description of the grinding surface of the teeth of the African elephant, the horse, cow, and sheep, would be very tedious, to make it at all intelligible, and as the surfaces of the teeth can be very distinctly represented in a drawing, I have preferred that mode of showing their comparative structure. See Tab. XVI. and XX.

Having, by the foregoing observations, established a well marked characteristic distinction between the teeth of truly carnivorous and truly graminivorous quadrupeds, I was desirous of knowing how far this general rule applied to quadrupeds at large, and, if it did not, in what animals the teeth were differently formed.

The teeth of the hippopotamus and rhinoceros are found to differ in their structure from those above described, partaking in some measure of the properties of both, and forming two very curious links in the chain of regular gradation between the one and the other.

The grinding teeth of the hippopotamus are made up of the substance of the tooth and enamel only, having no portion of bone mixed with the other parts; but, what is I believe peculiar to them, the enamel pervades the substance of the tooth to a considerable depth, so as to be intermixed with it. This will be better understood by referring to the figures, (Tab. XX.) which represent the appearance of the enamel in different sections of the tooth.

The grinding teeth of the rhinoceros have a peculiarity of a very different kind: they also are only composed of the substance of the tooth and enamel; but the tooth is so formed as nearly to surround a middle space, which, were it filled up with bone, would make a truly graminivorous tooth, not unlike those above described. This middle space is left open, and becomes filled up with the masticated food, which falls into it, and cannot afterwards be readily removed; so that the grinding surface will be always kept irregular, and in a still greater degree than in any of the other teeth which have been described. The particular form of this tooth is represented in Tab. XXI.

It is highly probable that there are many other varieties in the structure of the grinding teeth of quadrupeds, but these will be sufficient to illustrate the general principles upon which such varieties depend.

EXPLANATION OF THE PLATES.

Tab. XIII.

A longitudinal section of a grinding tooth of the Asiatic elephant, in a growing state. The tooth had been previously steeped in the muriatic acid, to render it soft, that it might be divided with less injury to the tender parts.

The different processes which compose the tooth are distinctly seen, but the enamel which surrounded them was dissolved in the acid; so that there is a vacant space, between them and the bony substance in which they appear to be imbedded. The bony substance, which is completely formed along the upper surface of the tooth, is hard and compact; but the projecting portions, near their termination, are not yet ossified, but are in the state of a membrane.

The cavity of the body of the tooth is filled with a vascular pulp, portions of which pass up into the processes, for their formation: these are conical in their shape; so that the processes of the tooth formed upon them, as they become longer, have their sides separated more and more, till at last the lower edge comes in contact with, and unites to, that of the neighbouring processes, connecting them together, and forming the cavity of the tooth, to which the fangs are afterwards added.

aaaa. The pulp on which the tooth is formed.

bbbb. The processes of the tooth, formed upon the pulp.

cccc. The intermediate bony substance between the processes.

Tab. XIV.

The rudiments of the bony substance which makes a portion of the elephant's tooth, preserved in spirit, before ossification had begun to take place.

It is represented here, to show that it has an entirely different texture from the pulp on which the tooth itself is formed, and resembles the membranes in which ossifications have their origin, for the formation of the flat bones of animal bodies.

In the more solid parts it resembles ligament; but, where it is thin, as towards the terminations of the projecting portions, it is exactly similar to membrane.

Tab. XV.

A longitudinal section of the elephant's tooth, highly polished, to show more perfectly the different textures of which it is made up. These, being of different degrees of hardness, bear a very different polish, which renders them distinct from one another: they are also distinguishable, by having different arrangements of the parts which form them. In the enamel, the texture is fibrous, and the direction of the fibres is transverse. In the processes, the texture is laminated, and the direction of the laminæ is longitudinal. In the bony part, there are no distinct fibres, nor laminæ.

In this tooth, a small portion only is completely formed, the rest being still in a growing state. The fangs are not yet added: there is, however, the origin of one of them, at that end of the tooth which is most perfect, and which has had a small portion of its grinding surface in use.

Tab. XVI.

The grinding surface of the African elephant's tooth, to show that the processes of which it is made up, are of a different shape from those which compose the tooth of the Asiatic elephant.

To see the true shape of each process, it is necessary that the points should be worn down to some depth, which, in the present specimen, is only the case with the four largest; the other three, which are less worn, show the different thicknesses of the processes, nearer their termination on the upper surface of the tooth.

Tab. XVII.

A longitudinal section of a portion of the African elephant's tooth, highly polished, to show the relative situation of the substance of the tooth, the enamel, and the bone, of which it is composed. The cavity of the tooth, and the fang, are also exposed.

A thin narrow slip of the bony part only is seen between the processes, in consequence of the processes, in the central line of the tooth, coming nearly in contact with each other.

Tab. XVIII.

A side view of the skull of the *Sus Æthiopicus*, (half the natural size,) to show the situation and appearance of the large grinder, and the remains of the alveoli belonging to the fangs of the preceding one.

Tab. XIX.

Fig. 1. A side view of the skull of the young *Sus Æthiopicus*, to show the mode in which the grinders come forward, as the large one increases in size.

Fig. 2. A side view of the full grown grinder tooth.

Fig. 3. A transverse section, polished, to show the mixture of bone with the enamel and substance of the tooth, and the particular appearance of the processes.

Tab. XX.

Fig. 1. A transverse section of the horse's grinding tooth, polished, to show the relative situation of the bony part, with respect to the enamel and substance of the tooth. Two portions of it are inclosed by enamel, and a third portion is on the outside of the tooth altogether.

The two holes were probably to give passage to arteries, and were enlarged by the food falling into them, and wearing away their sides.

Fig. 2. A similar section of a grinding tooth of the cow. The shape of the bony portions inclosed by the enamel is different, and there is a smaller portion of bone on the outside of the tooth.

Fig. 3. A similar section of a grinding tooth of the sheep. The portions of bone inclosed by the enamel are very small, and there is none on the outer side of the tooth.

Fig. 4, 5, and 6. Are three sections of a grinding tooth of the hippopotamus, to show that there are portions of enamel intermixed with the substance of the tooth, but no bone whatever.

Fig. 4. A transverse section, polished, similar to those of the other teeth.

Fig. 5. A view of the grinding surface of a shedding tooth, to show the uncommon appearance of its surface, before it is worn by use. The fangs have been absorbed.

Fig. 6. A longitudinal section of a full grown tooth, to show the plate of enamel passing down the centre: on one side, the enamel passes lower down than on the other.

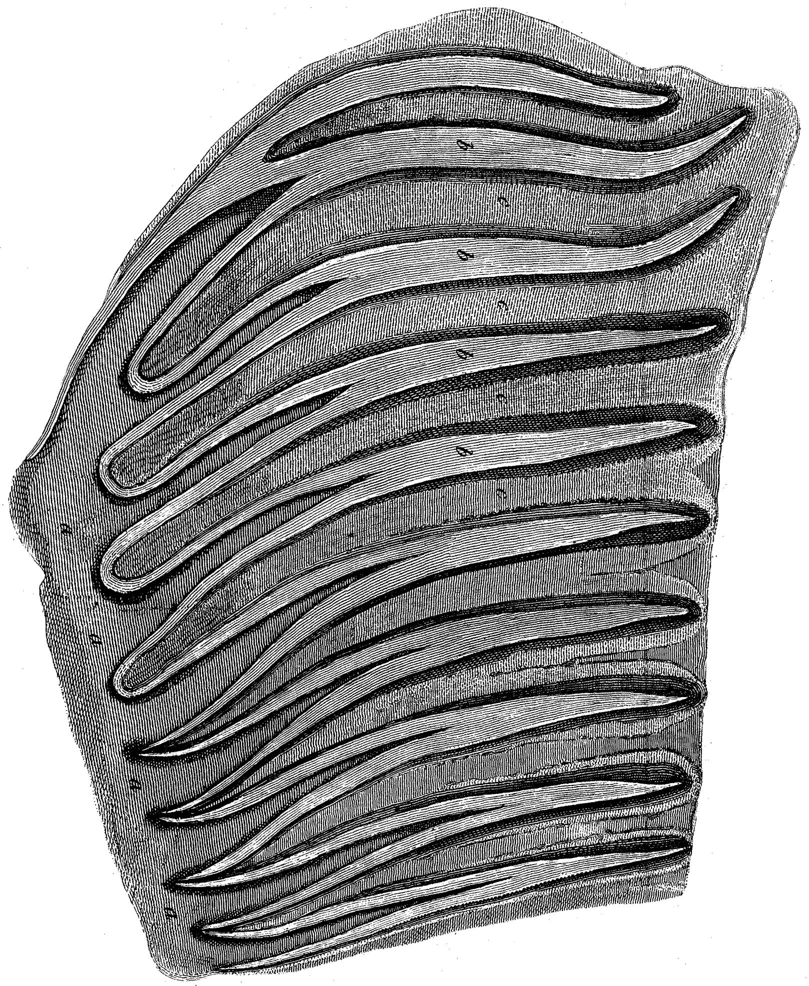
Tab. XXI.

This plate contains three views of a grinding tooth of the rhinoceros, to show its shape and internal structure.

Fig. 1. A view of the grinding surface, taken obliquely, seen from the side of the tooth next the mouth, to show the middle space, which is hollow, between the two projecting walls of the tooth.

Fig. 2. A front or external view of the tooth, showing its shape and size, alsot h e number of its fangs.

Fig. 3. A transverse section of the tooth, polished, to show the peculiar shape of the middle space, and the irregular projecting portions of the tooth, in that direction; also the mode in which the enamel surrounds every where the substance of the tooth.



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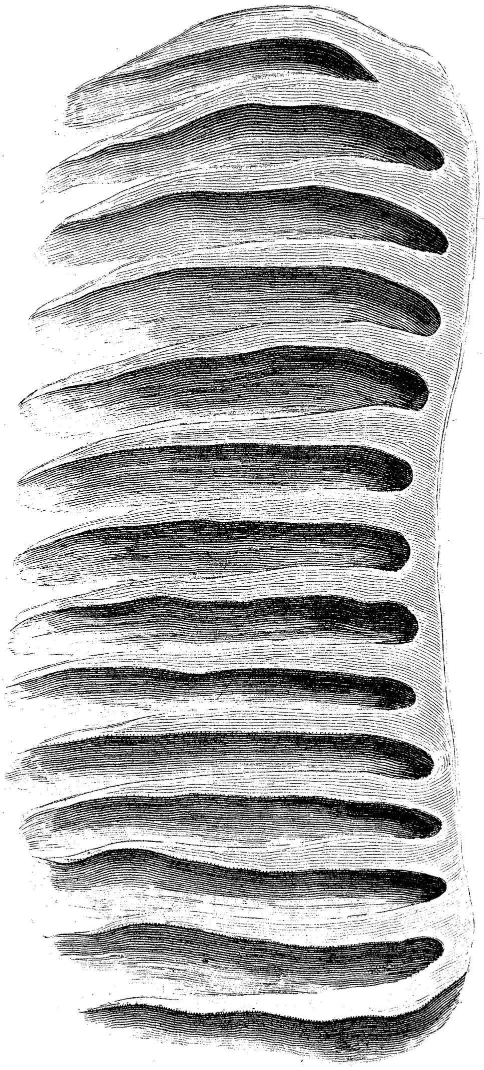

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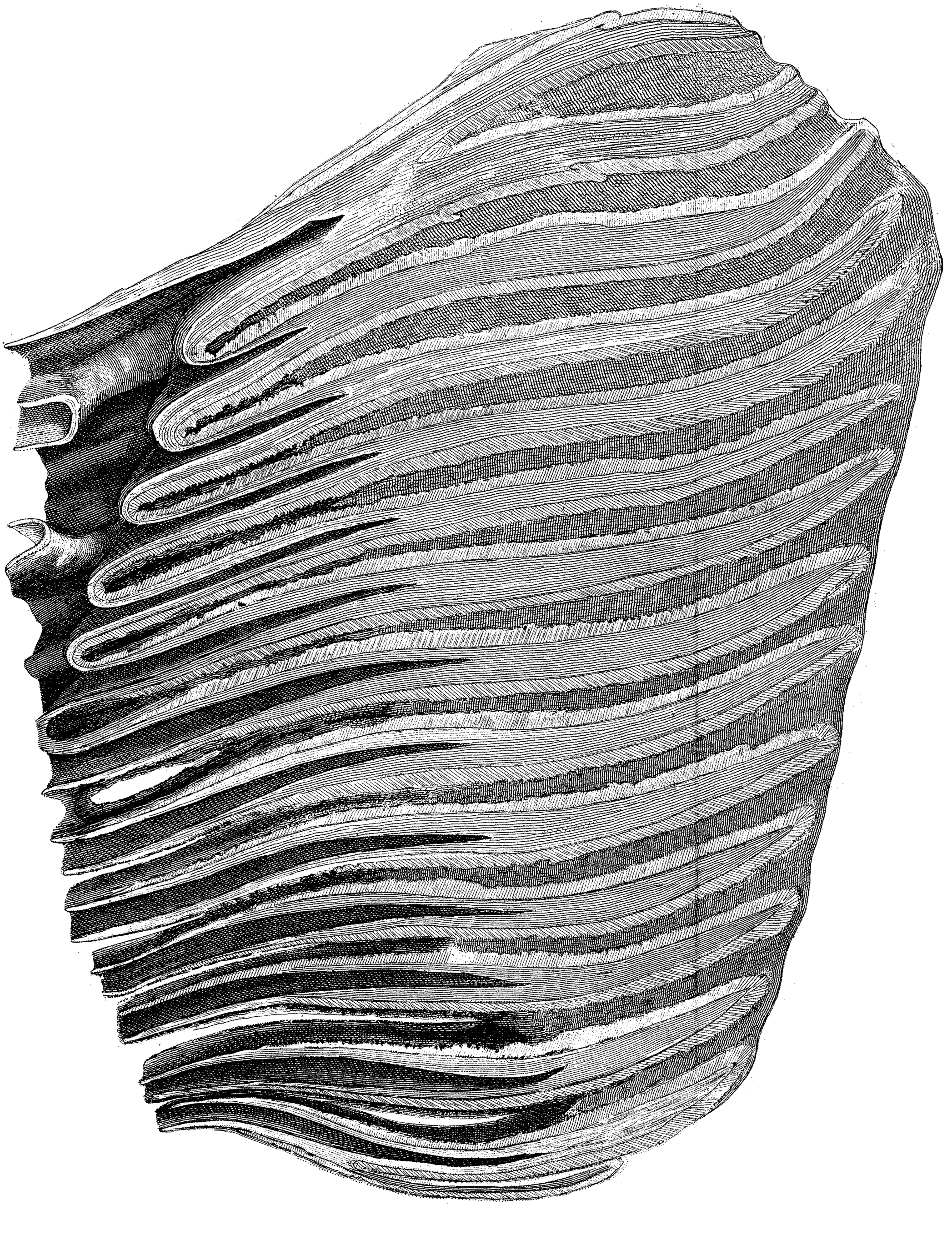

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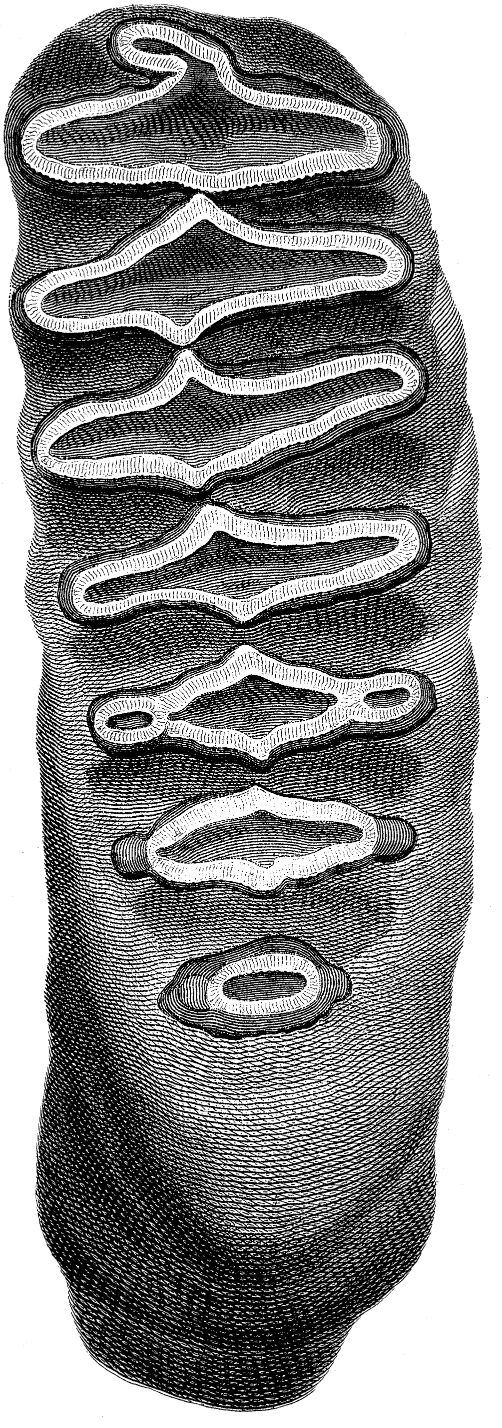

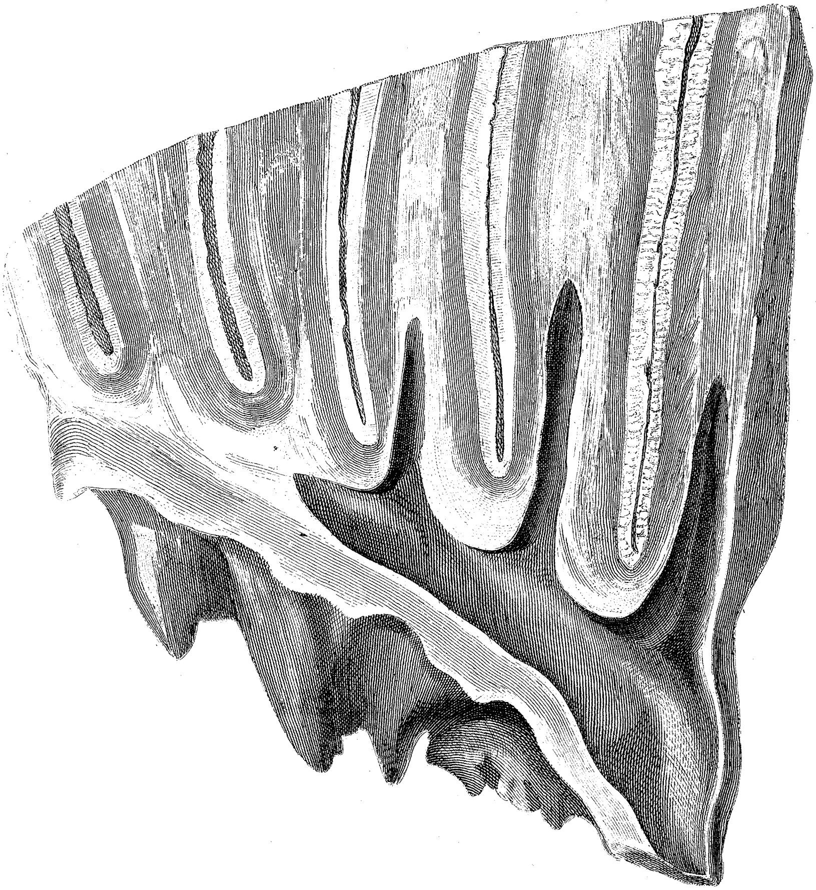

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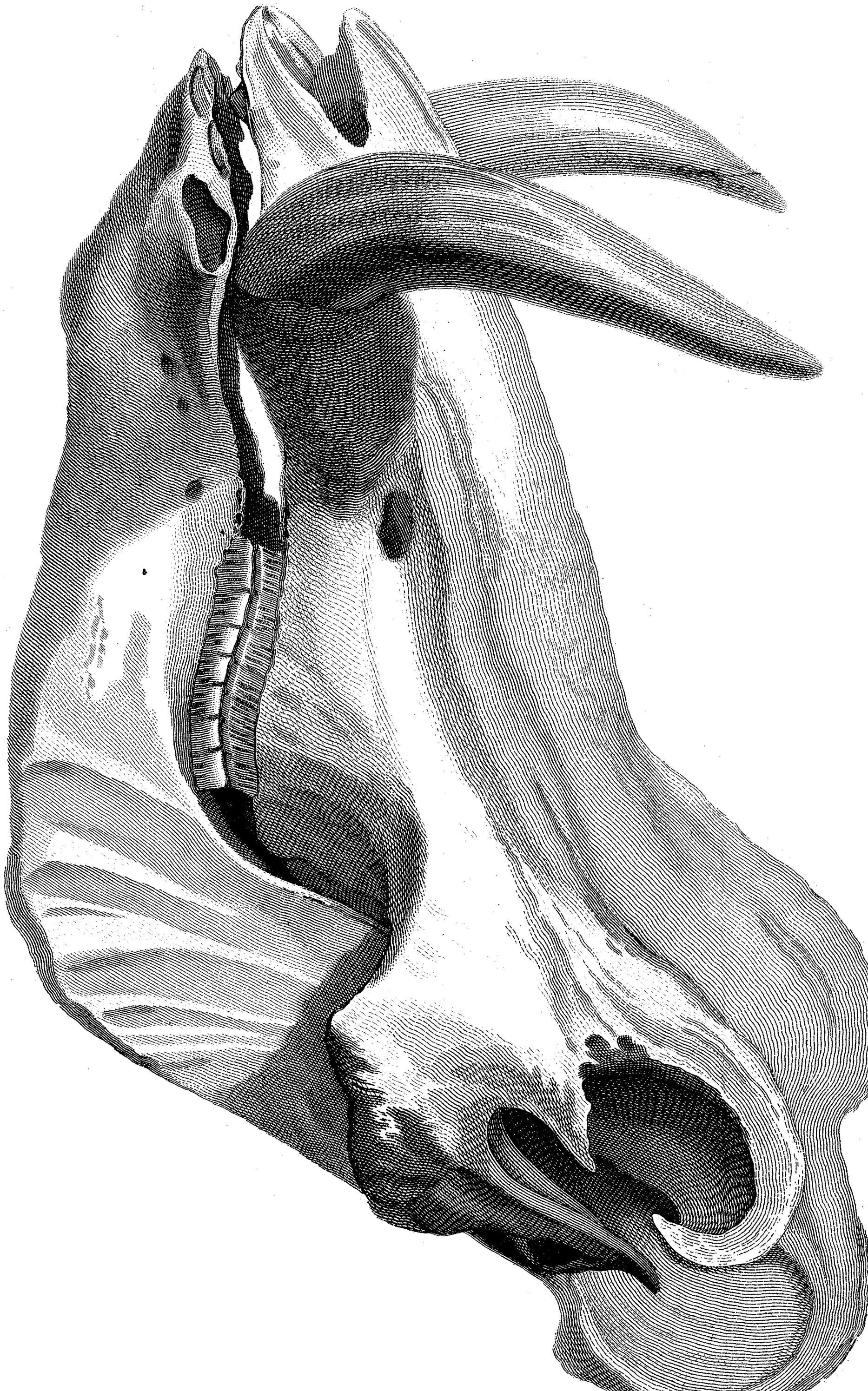

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Fig. 1.

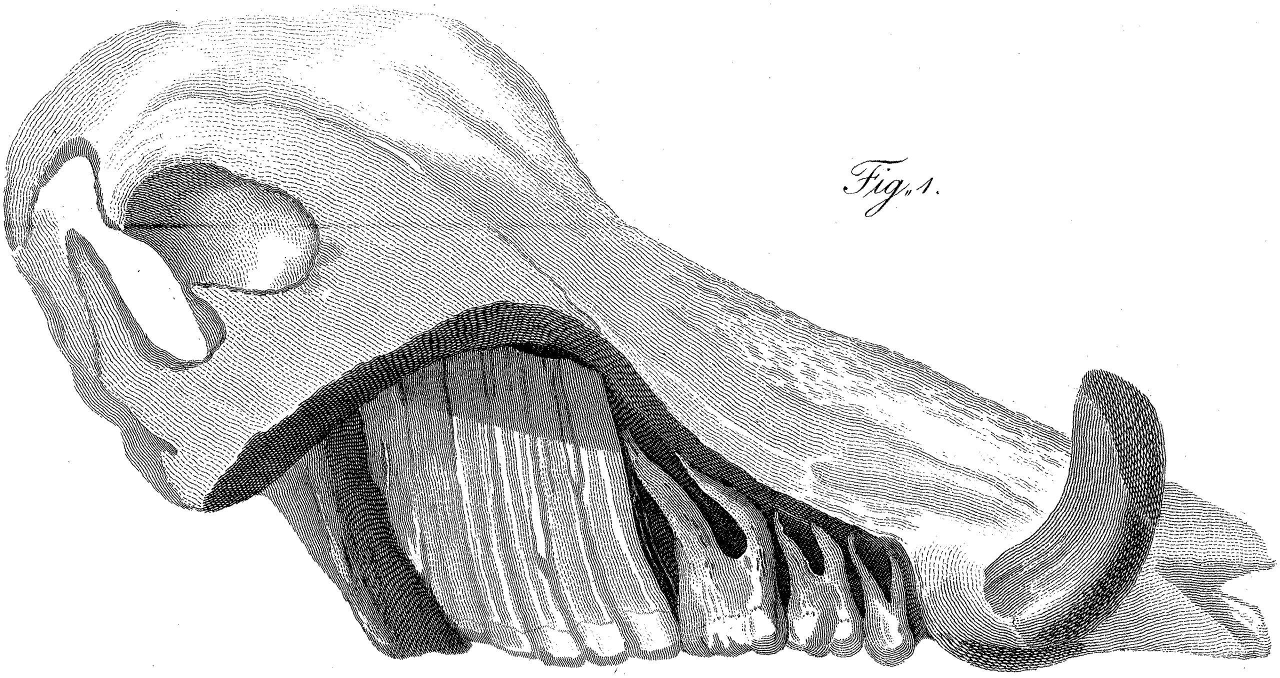
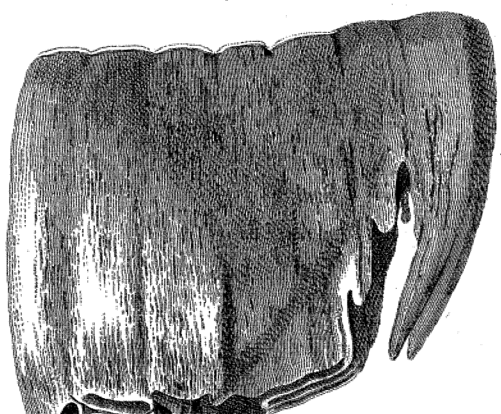


Fig. 2.



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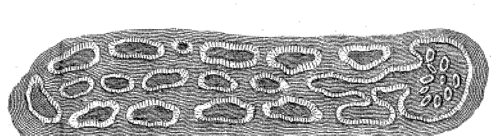

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Fig. 1.

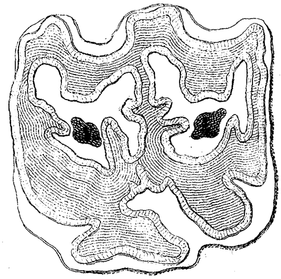


Fig. 2.

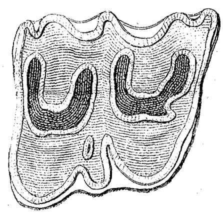
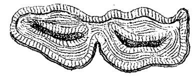


Fig. 3.



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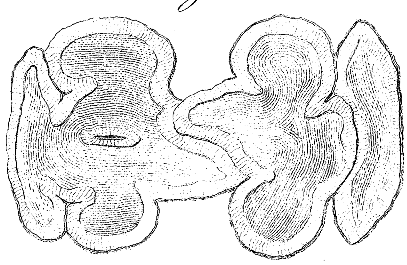

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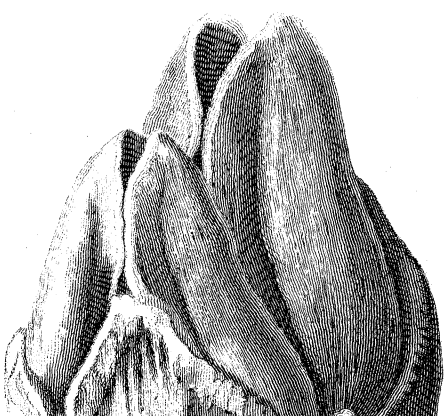

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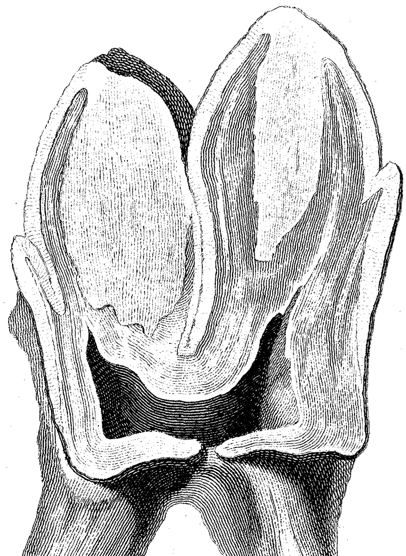

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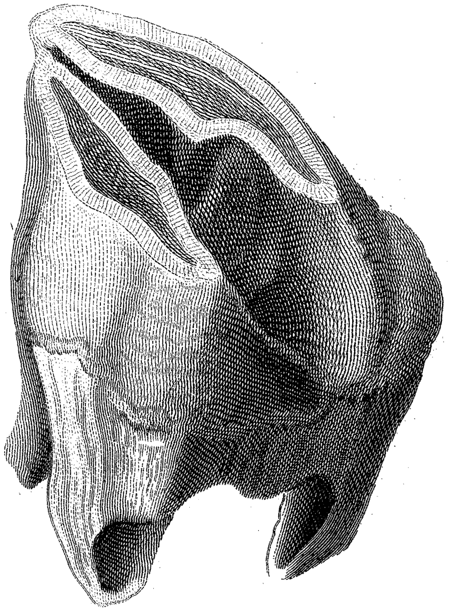
Fig. 1.



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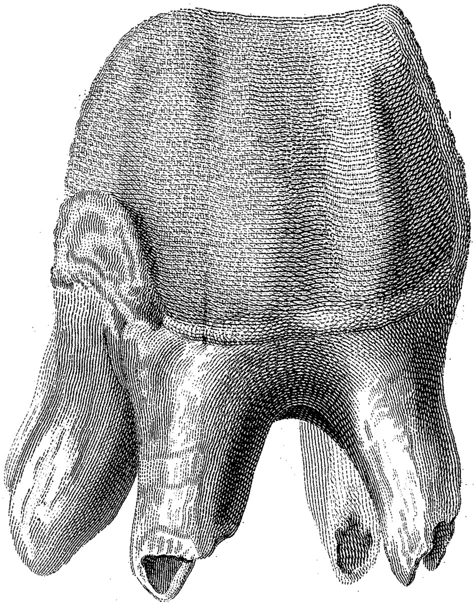
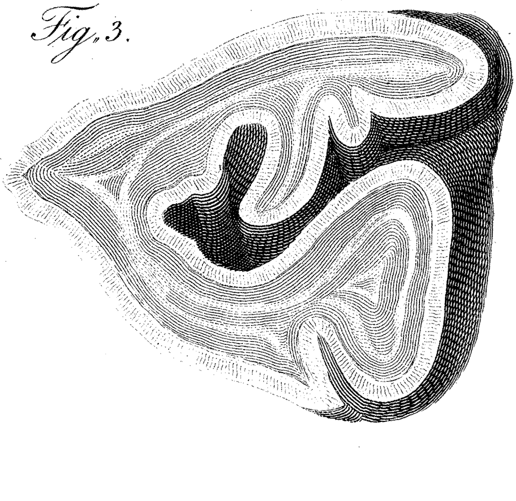


Fig. 3.



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