PART 5. PRICE 1s.

RESEARCHES

ON

FOSSIL BONES,

IN WHICH ARE ESTABLISHED

THE CHARACTERS OF

VARIOUS ANIMALS

WHOSE SPECIES HAVE BEEN DESTROYED

BY THE REVOLUTIONS OF

The Globe;

BY

BARON CUVIER,

Great Officer of the Legion of Honour, Counsellor of State, and Member of the Royal Council of Public Instruction, One of the Forty of the French Academy, Perpetual Secretary to the Academy of Sciences, Member of the Academies and Royal Societies of London, Berlin, Petersburgh, Stockholm, Edinburgh, Copenhagen, Gottingen, Turin, Bavaria, Modena, The Netherlands, Calcutta, and of the Linnæan Society of London, &c. &c. &c. &c.

FOURTH EDITION,

Revised and Completed

BY ADDITIONAL NOTES,

AND A

SUPPLEMENT LEFT BY THE AUTHOR.

Triomphante des eaux, du trépas, et du temps,
La terre a cru revoir ses premiers habitans.

DELILLE.

IN FOUR VOLUMES.

LONDON:

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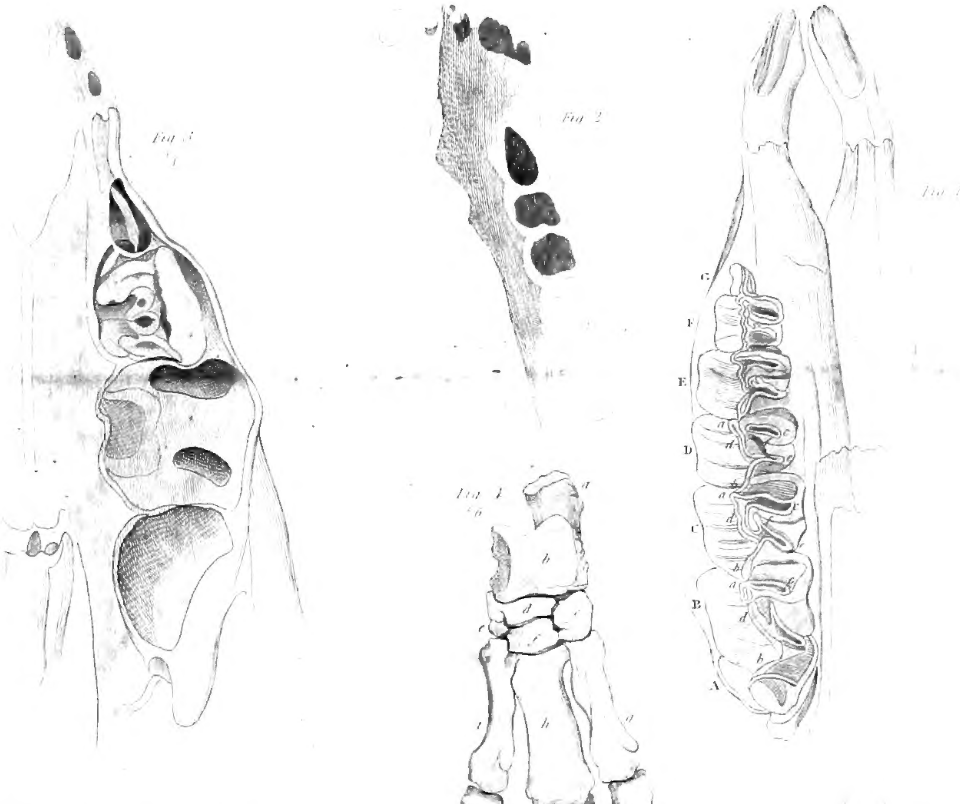

RHINOCEROS. PL. V.

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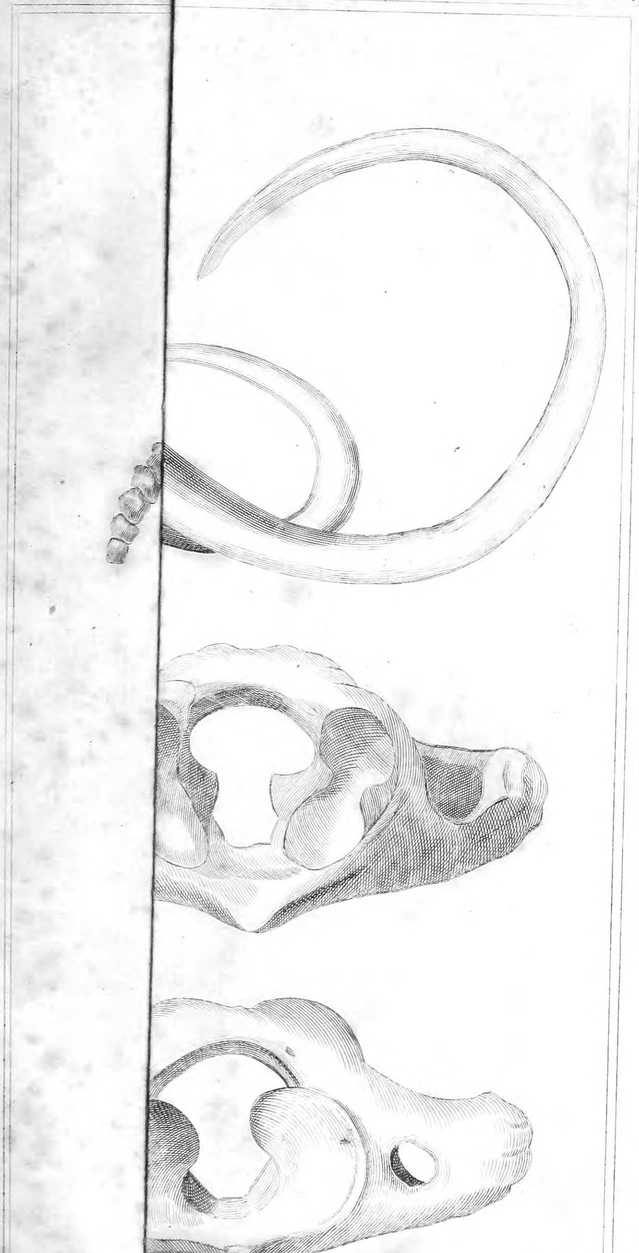

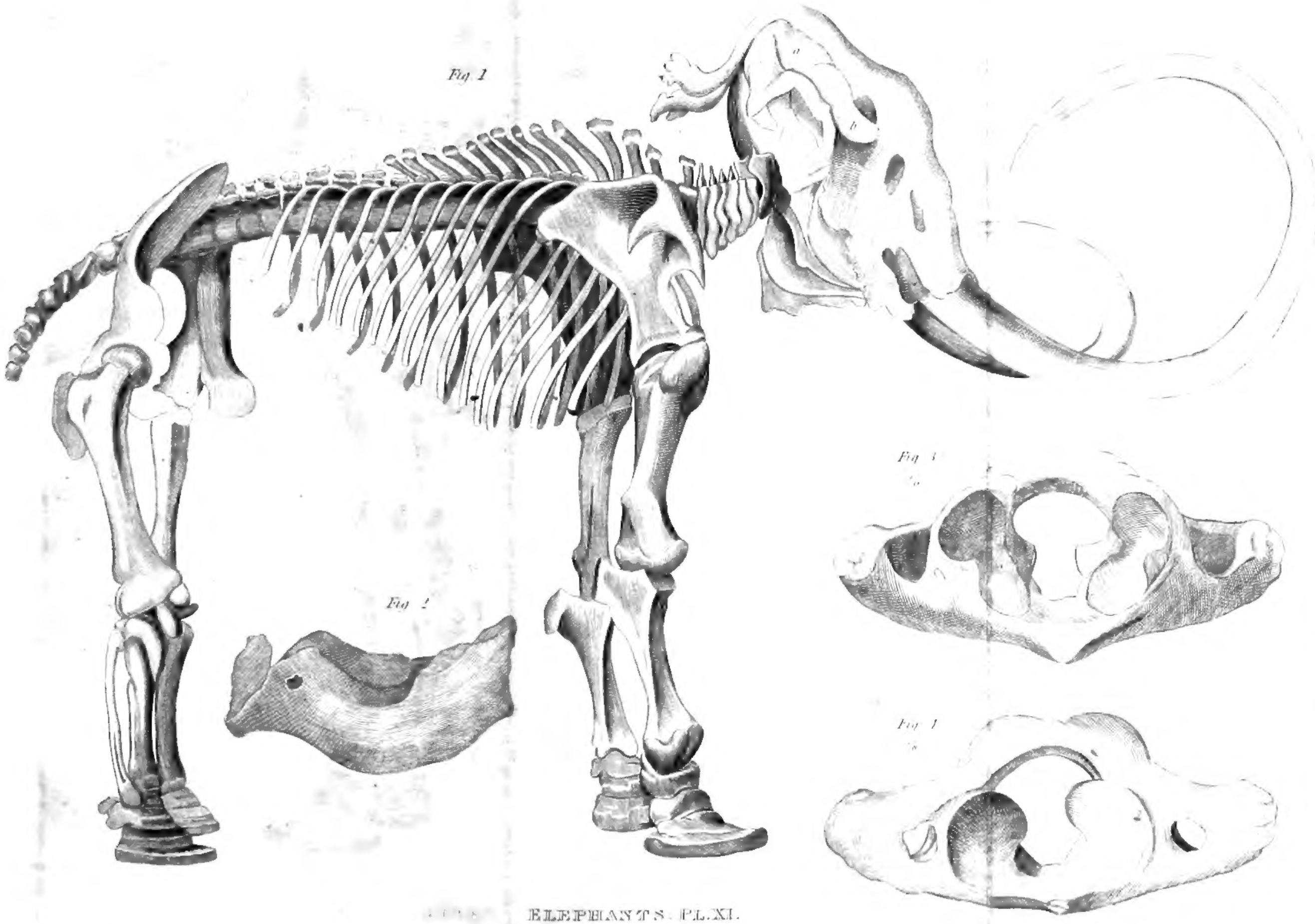

ELEPHANTS. PL. XI.

London, G. Henderson, 2 Old Bailey.

On Human Fossil Bones.

(Additions to pages 74—77, &c.)

I HAVE already said that human bones, regarded as fossils, have only been found in recent or newly deposited formations, in clefts, ancient galleries of mines, or, in short, among stalactites; but that none exist in regular beds, not even in those which contain bones of the elephant, rhinoceros, and hippopotamus.

M. D'Hombre Firmas, Mayor of Alais, has presented to the Academy of Sciences a very interesting memoir relating to a cavern in the environs of Durfort, near Alais, known in the country by the name of *Baume* (or grotto) *des morts*, and where many human skeletons are incrusted with stalagmite. The Abbé Dicquemare had previously written a similar one, of the environs of Havre, in the Journal de Physiques of 1779, tom. ii, p. 302. These are depositories into which has been thrown, under urgent circumstances, such as a day of battle, a great number of bodies.

Mr. Buckland, who saw in the Grotto of Pavyland a skeleton of a female, and many works of art, has well described, in his excellent work, *Reliquiæ Diluvianæ*, how these modern objects have become intermingled with the ancient deposites.

We have already described, after M. Kœnig, the human skeleton that is in the British Museum, which was detached from a rock on the coast of Guadeloupe, at a place called The Mole, near Point-a-Pître. Since then, by the orders of the Marquis of Clermont-Tonnerre, and by the exertions of M. Lherminier, a learned naturalist of Basse Terre, Guadeloupe, there has been sent to the cabinet of the king of France a skeleton from the same place, and incrusted in the like manner. This skeleton is more perfect; it has a part of the two jaw-bones, all the spine viewed posteriorly, a great portion of the basin, the ribs of the left side, all the left superior member, with the fingers only a little disordered, and the thigh and the leg of the same side. The spine has the appearance of an arc, and the thigh is bent up as if the individual was in a squatting position. Unfortunately, the upper part of the head is wanting; and so much so, that it is difficult to determine the race from whence it came, but no doubt exists as to the nature of the incrustation in which it is embedded. It was found in a spot where it seems there are several others, but inaccessible on account of the sea, which perpetually covers it, and probably from the waters of the island, which have a determination here, from the steepness of the shore. It is believed that these waters deposit stalactites, like those of Tivoli; for the stone is a Travertine, resembling much that of Rome. The skeleton was not entirely enveloped in it; but it was only from some parts jutting from the back that we were assured of its presence. When it arrived, only some portions of the spine, arm, and femur, were perceptible. Our chisel has brought all to view; and we have, at the same time, detached some small shells, similarly incrusted as the skeleton. Some are univalved, belonging to the fresh-water species, and other kinds known on the island; the others are small bivalved marine shells common on the coast. It is evident that the first have been drifted by the streams, the others by the waves, and that the stone which envelops them is of recent formation. Its upper portion was more soft than the rest, and in proportion as it was penetrated it possessed more solidity. The block, says M. Lherminier, rested on arenaceous chalk, which afforded facilities for its extraction. This sort of gravel stone is likewise modern, because there have been found in several masses of it in the same environs, teeth of the caïman, several fragments of Caralean pottery, hatchets made of stone, and particularly a small piece of wood, very hard and black, representing on one side a mask very rudely sculptured, and on the other an enormous frog, extended and plainly engraved. It was gaïac wood, but had become hard and black as jet.

M. Lherminier sent with the block a great number of incrustations formed on shells and madrepores, which strongly prove that the waters which pour over these parts of the bank are disposed to form gravel, stone, or stalactites.

A human head of monstrous thickness, engraved in the Oryctology of Argenville, Plate xvii, and described since in a special dissertation, by M. Jadelot, has also been presented as a fossil, and as belonging to a different race of the human species; but one equally resembling it has been found in the Archbishopric of Munster, the particulars of which M. de Sœmmering has made known, and a model of which has been communicated by M. Schleyermacher. I have read to the Academy of Sciences a memoir on these heads, in which I have not only adopted and confirmed the opinion of M. de Sœmmering and other medical men, that they have been deformed by some species of disease of the bone, called *maladie eburnée;* but also from the state of dentition, I have established that they were the heads of children of that age when they begin to change their teeth.

RESEARCHES

ON

THE FOSSIL BONES

OF

QUADRUPEDS.

PART I.

ON THE FOSSIL BONES OF PACHYDERMATOUS QUADRUPEDS, DISCOVERED IN ALLUVIAL FORMATIONS.

Preliminary Remarks on these Formations, and on the Family of the Pachydermata in general.

SEVERAL reasons have decided us in selecting the bones of pachydermatous animals of alluvial formations, as the objects of our first researches.

In the first place, Fossil Bones in general are much more common in alluvial formations than in any of the other strata. Those of quadrupeds are even so rare in the regular rocky strata, that some distinguished geologists have doubted of their existence therein.

In the next place, the nature of these strata enables us to obtain the bones in a more perfect state, and one in which they can be more easily known.

Thirdly, as these formations constitute the most superficial strata of the globe, they are the most frequently dug into; and finally, as the superficial layers are necessarily also the most recent, the bones they contain bear more resemblance to those of the animals now existing, and consequently admit of being more readily determined with respect to their genera and species.

There are however considerable differences in point of antiquity between the alluvial strata; some which constitute the ground of spacious valleys, or the surface of spacious plains, are extended to considerable distances, and to considerable depths: these form the principal object of our present researches; most of the bones they contain belong evidently to animals foreign at least to our climates, such as elephants, rhinoceroses, buffaloes, &c.

The other alluvial strata, less extended, and especially more recent, are deposited daily by rivers, either at the time of their inundations, or in places where their banks are most concave. They form what are strictly called *alluvia*. Composed almost entirely of red sand, they contain only bones of animals belonging to the country.

But among all the bones contained in these strata, we had still particular motives for commencing with those of the Pachydermata.

They are those which are most generally collected, because most of the species belonging to this family are very large; and they being all foreign to our climates, their exuviæ must strike the curious more by their singularity. Thus, we had materials in greater abundance for them than for the others.

Their osteological examination was also more easy, because the order of the Pachydermata comprises but a small number of genera; because these genera are very distinct from each other, and because it is therefore more easy to ascertain their several parts. There is not one of their teeth, nor of their bones either of the head or extremities, which are not of themselves sufficient to furnish distinct characters; which cannot be said of the ruminantia for example, inasmuch as they bear too strong a resemblance to each other.

In fine, the state of the science will furnish me with another order of motives. I had occasion for all the series of my demonstrations, and particularly for determining the extraordinary animals of our plaster-stones, which form the object of my second part, and which I consider as my principal discoveries in this genus; I had occasion, I say, for the osteology of several animals of this family, whose skeletons have not been yet described. Neither the skeletons of the *rhinoceros*, of the *hippopotamus*, nor of the *tapir* were known; that of the *elephant* itself was imperfectly known. I had then to describe them; and the most natural place for doing so was where I was to speak of the Fossil Bones of the same genera.

Accordingly it was with these Fossils I must commence my work. When I shall have concluded their history, I shall proceed, in my second part, to that of the animals of our plaster-stones, which also are nearly all of the family of the *pachydermata*, but of genera wholly unknown; then coming back to the Fossils of the alluvial strata, I shall treat succesively, in my third part, of the *carnivora*, and of the other unguiculated Fossils, as also of the ruminantia, that is to say, of animals with hoofs not *pachydermatous*.

Lastly, I shall speak of the cetacea and of reptiles. The order then which I shall follow will be neither strictly geological nor strictly zoological; but it will be that best calculated to conduct the reader through so many difficult researches, and to enable him to seize the thread, and feel the force of the proofs, by disclosing to him the true course followed in the discoveries.

This family of the pachydermata, so natural, and one entirely mistaken by Linnæus, and still more by his predecessors, was rightly understood only by Storr*.

He had defined it mammiferous animals *with hoofs, with more than two toes*.

But as I discovered in the course of my researches on Fossils, a

* Prodromus Methodi Mammalium, Tubing. 1780.

genus with only two toes, which is however not the less a true pachydermatous animal (the *ano-plotherium* of our gypsum quarries), as I even found on consulting the entire structure, that it would be necessary to associate the solipedes with the ordinary pachy-dermata, it is manifest that the number of toes cannot be taken into consideration in this family more than in any other. For the purpose of characterising it, then, it becomes necessary to confine ourselves to the terms *non-ruminant animals with hoofs.*

This order of pachydermata formerly contained but five genera, *elephants, rhinoceroses, hippopotami, tapirs,* and *hogs:* I transferred two to this order.: *horses* and *damans:* I severed one from that of the elephants (the *mastodontes*), and two others from that of the hogs (the *phacochæri* and *peccaries*): lastly, I discovered four, which I shall make known in this work, two of which, the *anoplotheria* and *palæotheria,* are already made known to naturalists: which raises the total number of the genera of pachydermatous animals to fourteen.

The hippopotami, the hogs, phacochæri and peccaries form among them a small group, which bears marked resemblances to the ruminantia, more particularly by the osteology of the feet, and which in this respect is connected to the camel, through the medium of my new genus of anoplotheria.

We know that the camel differs considerably from the generality of ruminantia by its upper incisors, its numerous canine teeth, one bone more at the tarsus, a different kind of hoof, and even by some differences in the form of the stomach.

Another small group is that which includes the *rhinoceros, tapir,* and *daman.*

The *daman* by means of his teeth connects the rhinoceros to my two new genera of *palæotherium,* and *anoplotherium;* for these four genera have almost entirely the same grinders.

On the other hand, the *palæotherium* connects the *tapir* to the *rhinoceros,* by the form of the feet; as the tapir connects the palæotherium to the *peccaries,* and so on to the *hogs,* but particularly to the *horse,* by means of the incisors and canine teeth.

The *anoplotherium* alone remains isolated in this last respect, not resembling any known animal, by reason of the uninterrupted series formed by its three sorts of teeth.

The front teeth are not the sole point of resemblance of the horse to the *tapir,* the *palæotherium,* and the *rhinoceros.* The bones of the extremities of these animals are very similar. Though the *horse* has the appearance of having but one toe, he has in reality three, the lateral toes beneath the skin being almost reduced to nothing: and we shall see a species of *palæotherium,* where the middle toe posteriorly is considerably greater than the two others.

The nose of the tapir, which that of the palæotherium must very much resemble, is also but a prolongation of the horse's nostrils. Several very singular muscles are also common to these two genera, as may be seen in my *Comparative Anatomy,* whilst the elephant's proboscis is constructed on a plan entirely peculiar to it.

The elephant will find no analogies, except in the *mastodons,* or the animals of the Ohio, Simorr, &c. &c.

CHAPTER I.

ON THE BONES OF ELEPHANTS.

THE fossil bones of elephants are those which first awakened, and most generally engaged the attention of observers, and even of the public. Their enormous size caused them to be remarked and collected every where: their very great abundance in all climates, even in those where the species could not subsist at present, has struck men with astonishment, and given rise to an infinity of hypotheses to account for it; but men have expended much less of care in determining the conditions and nature of the problem, than they have of labour and assiduity in attempting to solve it; and probably this negligence in establishing with precision the basis and even the terms of the question, has been one of the causes which have rendered most of its solutions so unsuccessful.

What I mean to say is, that not till a very late period was attention directed to several partial questions, which a person should have been able to answer before he essayed his strength on this grand problem.

Are the elephants now amongst us all of the same species? Supposing that there may be several species of them, are the fossil elephants of the different countries indistinctly of one or other? or else, are they also distributed in different countries according to their species? or might they not be of species altogether different and now lost, &c.?

It is evident that we can say nothing demonstrable on the problem, until we have solved these preliminary questions; and still antecedently to us, men scarcely had the elements necessary to the solution of some.

The osteologies of elephants previously published were so deficient in detail, that even to this day one could not say of several, whether they belong to one or other of our living species; and considering this immense quantity of fossil bones, of which so many writers have spoken, we had scarcely obtained tolerable figures of two or three. Daubenton, who had but one skeleton of an African elephant before his eyes, perceived not the enormous differences between its molars and the fossil molars, and he confounded a fossil femur of the animal from Ohio with that of the elephant. The comparisons made by Tenzel, by Pallas, and so many others, of fossil bones with fresh bones, were never expressed but in general terms, and were accompanied neither by those exact figures, nor those rigorous measures, nor those copious details, which researches of such importance necessarily called for.

I could not even dispense with giving a new plate of the entire skeleton of the *Elephant of India.*

In fact, the figure published by Allen Moulin*, copied in the *Elephantographie* of Hartenfels, in the *Amphitheatrum Zootomicum* of Va-

* Anatomical Account of the Elephant accidentally burnt in Dublin, &c., Lond., 1682, pp. 72, in 4to. cum. 2 tab.

lentin and elsewhere, is such, that one cannot distinguish any thing precise in it, not even the species to which it belongs.

That of Patrick Blair* belongs, it is true, to the *Indian species;* but besides having been done after a young animal whose epiphyses were not soldered (soudées), it is very badly designed. The scapulas are reversed in it; six toes have been given to the left fore foot, and only four to the hind feet, &c.

Those of Perrault†, and of Daubenton‡, both taken from a skeleton still preserved, belong to the *African species.* The first is well enough, but the head is represented in it too small; the second is at most passable.

That of Camper§, as that of Blair, is of the *Indian species;* but though better designed than the others, it is done from a very young animal, which had not acquired all its form, and from which the ligaments had not been removed. It therefore became necessary for me to take up this subject entirely, and to describe first of all the osteology of living elephants.

The opportunities which I have had of dissecting three of these animals, and of seeing several of their skeletons, have supplied me with valuable data for this purpose: the figure from a large design, which I got made under my own inspection, with great care, by M. Huet, will be seen, I trust, with considerable pleasure (*pl.* 7, *fig.* 1); the figure of a young head, where all the sutures are still marked, which I got drawn in London in M. Brookes' splendid cabinet of comparative anatomy (*pl.* 18, *fig.* 1 and 2), and that of an adult head, which I had observed in the same city in the cabinet of the India Company, and of which M. Clift, conservator of the Museum of the College of Surgeons, had the kindness to make me a drawing (*pl.* 18, *fig.* 4). The extracts from my observations regarding the growth of teeth, and their structure, will be received with equal interest; and I must here observe, that necessary as this is in the history of fossils, it possesses still more general importance in another point of view: and it is capable of illustrating the history of the teeth in man and animals, inasmuch as the size of the elephants' teeth renders quite visible things which are rather difficult to be distinguished in the other species.

It is after these preliminary researches on the osteology of living elephants, and when we shall have compared their different species together, that we shall be enabled to devote ourselves with certainty to the examination of the fossil bones of the same genus.

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* Transact. Phil. t. xxvii., No. 326, June 1710, pl. 11.

† Mem. pour servir a l'Hist. des An., 111e partie. pl. xxiii. Elle a paru en 1734.

‡ Hist. Nat., in 4to. tom. xi, pl. iv.

§ Descript. Anat. d'un Elephant, pl. xvii, fig. 1, et dans ses Œuvres, trad. fr. atlas pl. xxiv, fig. 1.

SECTION I.

OF LIVING ELEPHANTS.

THE genus of the elephant is one of the most extraordinary in the entire animal kingdom; its structure is such, that it does not completely approach any other; and though naturalists may have classed it among the pachydermata, with the rhinoceros, hippopotamus, and the hog, it differs much more from all these quadrupeds than they differ from each other; we may even say that in several respects this gigantic animal presents striking traits of resemblance with the order of the glires, which of all the orders of mammifera is most restricted in size.

Let us, in fact, compare successively all the parts of the head of the elephant with that of the other animals, it is almost always among the glires that we shall find their analogies.

The enormous alveoli of the incisors are the first and most striking of the characters which are common to them.

The size of the sub-orbital foramen is a second. It is only in some glires, particularly of the tribe which are without clavicles, and whose nails are nearly as developed as hoofs, in the cabiais, pacas, and porcupines, that we see suborbital foramina equalling or surpassing that of the elephant: and the reason of it is that these animals require, for their enormous muzzle, considerable nerves; which is necessary also for the trunk of the elephant.

The zygomatic arch is strait, and again formed in the elephant as in these glires; the os jugale is, in each, suspended in the centre of the arch.

The length of the upper incisors, that is to say of the tusks, which correspond to the incisors of other quadrupeds, by their insertion into what is called the incisive, or intermaxillary bone, is a characteristic owing in a manner to that of the size of their alveoli. In fact, the name of incisors is not applicable to the tusks of the elephant, which grow indefinitely, and are not at all trenchant; but their growth arises from this circumstance, that they are not arrested by encountering the lower teeth, and their want of cutting power is to be attributed to their enamel enveloping them equally on every side. These two circumstances, which assign to tusks a different use from that of ordinary incisors, take nothing from the analogy in nature and position of these two sorts of teeth; we even know that in the true glires, when an incisor falls by accident, the opposite incisor is prolonged nearly as much in proportion as the tusks of the elephant, but in an irregular direction, which sometimes even causes the death of the animal, by preventing it from taking its food. The tusks, which were not destined, as the incisors of glires, for the division of aliments, either of wood or bark, have not received on their anterior surface that layer of a thick and hard enamel, which, by means as simple as efficacious, keeps the incisors of glires always sharp; they even have an enamel so tender, that without the different direction of its fibres, one might confound it with ivory.

These slight differences in the characters of the tusks, which had not imposed on the genius of Aristole *, have inclined some ancient and some modern philosophers to dispute their title to the name of teeth: but among true naturalists, there is no discussion except with respect to the class of teeth to which we should refer them. Linnæus and Wiedemann preferred to consider them canine rather than incisor teeth, because they come out of the mouth like the canine teeth of the wild boar; but the four incisors of the rat-taupe also come out of the mouth; so that it would be a mere dispute about words; it is clear that the tusks of the elephant are implanted into the incisive bone, and that, on that account, it is to the incisors of the glires they correspond †.

The molar teeth of elephants give them, still more perceptibly than their incisors, a resemblance to the glires; for it is only in these latter animals that we find molar teeth consisting of transverse plates parallel to each other; such are those of the sea-hogs (cabiais), field mice, and hares; several of these teeth may be mistaken for those of an elephant in miniature ‡.

In a word, in the entire head of the elephant, there is but the shortness of the bones of the nose, caused by the necessity of affording room and giving play to the muscles of the trunk, which finds any resemblance in the tapir; again, the connexions are not the same; and, whilst in the tapir, as in the rhinoceros, the maxillary bone comes to interpose itself at the edge of the external nares, between the nasal and intermaxillary bones, in the elephant these two last bones touch, as in the glires and most other quadrupeds.

This resemblance in the heads does not exist, as much as one might suppose, in the other parts of the body.

The scapula of the elephant however resembles only that of the hare, by the bifurcation of its acromion.

Article I.

General Description of the Osteology of the Elephant, principally taken from the Elephant of India.

1.—*Of the Head.*

One might get an idea of the general form and of the details of the parts of the head of living elephants from our fig. 1, pl. 7; 2 and 3,

* Aristot. Hist. an., lib. ii, c. xi; Plin. lib. viii, c. iv; Philostrat. Vita Apoll. lib. ii, c. iv, acknowledge the tusks to be teeth. Juba, quoted by Pliny, loc. cit. and Pausanias, lib. v, c. xii, stated that they considered them as horns; but this whimsical idea did not merit the support of Ludolphi (Æthiop., lib. i, cap. x), nor that of Perrault (Description of the elephant of Versailles).

† I have not been able to understand what M. Tilesius means to say in his note on the article relative to the mammoth of M. Adams (Mem. de Petersb., tome v, p. 456). After quoting the passage where Linnæus says that the elephant has no incisors, but that his upper canine teeth are elongated, and that wherein I say on the contrary that it is his upper incisors that are elongated into tusks, he reproaches me with having adopted the error of Linnæus. With regard to the errors committed by M. Tilesius himself in saying that these tusks are not teeth, that they have no enamel, &c., I shall not take up my time in refuting them.

‡ M. Tilesius was no less mistaken on the molars of elephants than on their incisors, when he said loc. cit. p. 457, *Quales in nullo alio animalium genere inveniuntur.*

pl. 8; 9 and 10, pl. 10; for the sutures it will be necessary to consult fig. 1 and 2, pl. 18; for the vertical section fig. 5, pl. 10 *.

The very extraordinary and anomalous form of this head is owing, 1st, to the elevation and almost vertical direction of the alveoli of the tusks, and to the height resulting therefrom for the intermaxillary bones. See pl. 18, fig. 1, 2 and 3, *a b*. 2nd. to the corresponding elevation of the maxillary bones, *b c*, at this part; 3rd. to the shortness of the bones of the nose, *d*, necessary to the mobility of the trunk. 4th. and principally, to the enormous tumor produced at the upper, temporal, and posterior part of the cranium, *e f g*, by the great cells, or the innumerable frontal sinuses occupying in these parts the substance of the bones. This tumor increases considerably with age, as may be seen on comparing fig. 2 with fig. 3.

The result of these different causes is, that the head of the elephant is more elevated vertically, and in proportion to its horizontal length, than any other head, not even excepting that of man; that the exterior opening of the nares, instead of being at the extremity of the muzzle, is placed in the middle of the anterior surface; that this anterior surface extends, whilst it inclines very little backward, from the edges of the intermaxillary bones, *a*, to the occipital ridge, *f*; that this ridge is raised to the summit of the head; that the occipital foramen, *h*, is in the middle of the posterior surface, which is also very little inclined; that the alæ pterygoideæ, instead of extending longitudinally, ascend almost vertically. The temple is enormous in comparison with the orbit; but, as may be seen in fig. 7, it does not approximate to the corresponding temple, and there is no sagittal ridge; the post-orbital process of the frontal bone is short and obtuse; the arch, *k l*, is straight and horizontal; the post-orbital process of the os malæ, *m*, is also short and obtuse, and remains considerably removed from that of the frontal bone: the two enormous alveoli of the tusks remain separated by a deep space, *n o*, fig. 7; the external opening of the nares is very considerable, much more broad than high, protected inferiorly by two nasal bones, *d d*, more broad than long, and forming in common a sort of mammillary protuberance; the rest of the anterior surface above the nose, formed by the frontal and parietal bones, is concave in the elephant of India, convex and shorter in the elephant of Africa; the occiput is very much rounded on the sides, and in the middle of it, a double depression, very deep, in the midst of which may be observed a longitudinal ridge almost similar to the crista galli of the ethmoid bone of some animals: it is here the cervical ligament, which is of an enormous size, is attached. The auditory fo-

* Recourse may also be had to the figures of elephants' heads already published, scil.: Daubenton, ap. Buff., tome xi, pl. v. front view (de face), pl. vi, en dessous, pl. iv, in profile with the entire skeleton, taken from the elephant of Africa; Pinel, Journ. de Phys., tom. xliii, July 1793, from the elephant of India: Cuvier, Mem. de l'Institut. Cl. des Sc. tome ii, pl. ii, from the elephant of India, and pl. iii, from that of Africa; Faujas, Essai de Geologie, tom. i, pl. xiii, profiles from the two species: Houel, Hist. Nat. des deux elephans du Mus. pl. vii, the profiles, faces and section from the two species: Camper, Œuvres, trad. fr. pl. xx, fig. 1, 3, and 6, from an elephant of India: Spix, Cephalogenesis, pl. vii, fig. 18, from the elephant of India.

ramen, *p*, is above the posterior base of the arch; the glenoid cavity is below, transverse, convex from before backwards, curved into a concave arch in its transverse dimension: it is found to correspond nearly with the middle of the height of the head. The mastoid process, *q*, is almost none, placed at the back part of the head, at the height of the auditory foramen, and the occipital condyle, but nearer the condyle. A rounded vault, *r*, separates the alveoli of the tusks from those of the molar teeth. The rest of the palate is considerably long, and narrow: the basilar region ascends. Such is the general description of the head of the elephant.

With respect to the sutures, there is first, *n o*, that which descends from the nares to the incisive edge, and which separates the intermaxillary bones from one another. These bones ascend on each side of the nose as far as the side of the root of the nasal bone, and have themselves, on the outside, the descending portion of the frontal bones, which bound the orbit before, *i s*. The maxillary bone is raised to a point, so as also to touch a little this portion of the frontal bone (between *s* and *b*). The suture *b c*, which separates the intermaxillary from the maxillary bone, descends obliquely along the external side of the alveolus, then turns its posterior edge, and ascends into the substance of the edges of the foramen incisivum; so that this foramen belongs to the two bones, and there is seen only the maxillary bone on the posterior surface of the alveolus of the tusk, and in all the vault which separates this alveolus from the molar teeth. However, the tusk itself is entirely in the intermaxillary bone. The foramen incisivum, of considerable breadth inferiorly and posteriorly, contracts into a long canal, which ascends, between the intermaxillary and the maxillary bones, to the floor of the nares. The lacrymal bone, *t*, is small, long, and narrow, directed horizontally between the frontal and maxillary bone to the internal edge of the orbit, and touches neither the intermaxillary, nor the os malæ; there is no lacrymal foramen. The suborbital foramen is of considerable breadth, and forms a very short canal in the anterior base of the arch. The os malæ, *v*, commences only towards the external edge of the orbit; it is then united by a long, nearly horizontal, suture, under the zygomatic process of the temporal bone, *l*, going as far backward as it, so as to reach nearly under the ear. The frontal bones are raised a little; so that they form a transverse, narrow band, in the form of the arc of a circle, *s*, *i*, *w*, *i*, *s*, fig. 1, descending from the two sides of the nose as far as the lacrymal bones, which are themselves lower than the nares. The suture, *s s'*, which separates in the orbit the frontal from the lacrymal and maxillary bones, is almost horizontal. It then remounts in the temple (at *x*), to separate them from the temporal, and returning transversely under the parietal bone A (see *x'*), it thus gives them on the side of the head a much broader portion than they had anteriorly. The temporal bone, *y q l*, is raised very high, and forms almost the entire lateral portion of the occipital ridge; it takes up on each side about one-sixth of the lateral portion of the head.

The superior occipital bone advances above the ridge, so that it appears at the anterior surface of the skull (at *z*, fig. 1); to it belongs the great depression of the posterior surface, of which we have already spoken.

This superior occipital, the parietal bones A, the frontal bones and upper part of the temporal bones unite very soon to form one single cap, which covers the upper part of the head, *e, f, g, l*, fig. 3. This junction is established even before the lateral occipitals are united to the superior occipital. I have not seen an interparietal.

The palatine bone advances as far as the middle of the space occupied by the molar teeth, a space of which the palatine fissure takes up one-fifth. Immediately behind the molar teeth, the palate bone is as it were enveloped by the pterygoid portion of the sphenoid bone, *a*, fig. 2, which is turned into a conical surface, so as also to embrace a portion of the maxillary bone; it thus ascends obliquely forwards, so as to be continued with one ridge of the frontal bone, *s' i*, which separates the orbit from the temple: hence it is that the palate bone can be discovered neither in the temple nor in the orbit, and that it remains at a very great distance from the lacrymal bone. In the posterior nares, it ascends, as in ordinary cases, but by a very narrow tongue. What appears there of the anterior sphenoid, between the two palate bones, is also very small. The point of this portion, in the form of an inverted cone, *a*, which holds the place of the sphenoidal ala, is occupied by a plate, which remains a considerable time separated, and which is the internal pterygoid process. The upper part, or the base of this cone, is completed behind, on the internal side of the glenoid surface (facette) by the caisse, which is flat, and situated nearly vertically like the ala itself. The basilar region ascends, as we have already said: the suture which separates the two lateral occipitals from the upper, and which continues long visible, is horizontal; that which separates them from the basilar disappears much sooner.

A very small portion of the anterior sphenoid, or the orbital ala, is concealed in the orbit, behind the spheno-frontal ridge, *i s'*, of which we have spoken; the foramen opticum, which is small, the spheno-orbital foramen, which includes also the rotundum, and is of considerable size, are also concealed in this depression; there is, at the base of the ala of the sphenoid, a large vidian foramen; the foramen ovale is confounded with the foramen carotidæum; that, which is analogous to the spheno-palatine foramen, is in the broad and short sub-orbital canal; that of the pterygo-palatine is concealed close by the spheno-orbital; the height of the molar teeth causes this foramen to give rise to a very long canal: the condyloid foramen seems to me to be confounded with the jugular.

The section of the head of the elephant (*pl.* 10, *fig.* 5,) is very remarkable by the enormous interval *b b c*, which separates the two plates of the cranium, before the occipital ridge, and which equals the cerebral cavity *c* in thickness: by the direction of the canal of the nares, which, far from continuing parallel to the palate, ascends before the entire elevation of the alveoli of the tusks; by the very great length of the incisive canal; by the form of the cerebral cavity, which is very convex before, so that the cribriform plate is there placed below, as in man. But the posterior portion is as flat, and even flatter, than in any quadruped, and the occipital foramen is directed backwards, as in ordinary cases. This cavity is as broad from right to left, as it is long, a proportion of which we have no instance except in the cetacea.

There is no osseous tentorium; the middle fossæ are of considerable depth; still the separating ridges of bone are not at all acute. The sella turcica is well marked, but the clinoid processes are very little so; the cribriform plate is tolerably large, of moderate depth, and has a thin and prominent crista galli.

2.—*Of the Lower Jaw.*

The lower jaw of the elephant is as distinctive for this genus, as any other of its parts.

See it in profile, pl. 7, fig. 1; pl. 8, fig. 2 and 3; and pl. 18, fig. 2 and 3; as seen from above, pl. 11, fig. 2 and 3.

Its two rami form together anteriorly an angle of more than sixty degrees. They are extremely thick, convex on the sides, rounded at their lower edge, and unite anteriorly in a semi-cylindrical canal terminated by a pointed beak.

Viewed in profile they are very high vertically, and terminate anteriorly each by a line (*a b*, *pl.* 8, *fig.* 2,) which descends obliquely forwards to the beak, and forms the edges of the canal just now mentioned.

The ascending ramus is nearly as high as the dental ramus is long. There is no well marked posterior angle; but the form posteriorly (*c d e*, same *fig.*) is a portion of a circle, and the posterior edge is full and rounded.

The coronoid process *f* is rounded, less elevated than the condyloid *g*, from which it is separated by an arch of but little depth, ascending obliquely backwards. Its anterior edge is inclined forwards, and sharp.

The condyloid process *g* has its articular surface nearly in the form of a segment of a sphere. (See *pl.* 11, *fig.* 2 and 3.)

The foramen for the maxillary nerve is very large and situate very high under the condyle, near the posterior edge of the ascending ramus, and at its internal surface; the mental foramina (*h*, *fig.* 2, *pl.* 8), two in number, are small, and pierced on the outside near the anterior canal.

3.—*Of the Bones of the Trunk**.

The spine of the elephant consists of seven cervical vertebræ, twenty dorsal, three lumbar, four sacral, and twenty-four or twenty-five coccygeal vertebræ.

This animal has only five true ribs, and fifteen false.

Its ribs are in general known by being less curved and thinner downwards than those of any other large animal. Their entire sternal half has its two edges sharp, and is almost straight. The vertebral third only is perceptibly arched, almost cylindrical, and hollowed by a semicanal at the anterior edge. Their tubercles have but little prominence. The two first on each side are nearly straight, and considerably widened towards the sternum.

The rhinoceros has its ribs more arched, and thicker; this is true,

* That part of the body consisting of the back bone, ribs, &c.

particularly of the first two. In all, the canal of the anterior edge descends lower. The hippopotamus has them straighter and less flat, particularly towards the sternum.

The *cervical vertebræ* are characterized, independently of their size, by their extreme thinness in the direction of their axis, whence results the extreme shortness of the neck. The *atlas* has its annular part thicker, in proportion than it is in man, and pierced by two foramina; but its tranverse processes have no canal: they are in the form of tubercles, and not of alæ, which prevents this vertebra from being confounded with the atlas of any other large quadruped.

The *axis* also has many points of resemblance with that in man. Its spinous process is larger, and ascends more towards the head. Its superior articular surfaces unite more with its tooth-like process.

The third and fourth cervical vertebræ have no perceptible spinous process. The others have them small, pointed, increasing a little towards the seventh.

The dorsal spinous processes are on the contrary very long, and terminate in large tubercles to receive the cervical ligament. The third is the longest. It is 0m,35 (more than a foot.) They then go on diminishing to the sacrum, which has them very small.

The dorsal vertebræ have also many points of resemblance with those of man, in respect of their small length compared with their size. This resemblance with man is greater in the elephant than in any other great quadruped; the same may be said of their form, which is more cylindrical, and less caréenéd downwards. Their transverse processes however are shorter and more enlarged upwards.

The transverse processes of the lumbar vertebræ are small and depressed without any convexity; their spinous processes are slanting backwards like all those of the dorsal vertebræ, with which they form a regularly decreasing series.

The three sacral vertebræ, to which the ossa ilium are attached, are broad and flattened below.

The caudal vertebræ, as far as the seventh, have an annular portion with spinous and transverse processes; the spinous processes being very much slanted. There remain some transverse processes as far as the twelfth, and vestiges of articular processes as far as the fifteenth. The caudal vertebræ that follow are in the form of simple quadrangular prisms.

4.—*Great Bones of the Anterior Extremity.*

The scapula (*pl.* 14, *fig*. 6), independently of its size, might be distinguished from that of every other living animal: 1st, because its posterior edge *a b*, which is a re-entrant curve, is the shortest of the three, and the anterior *c d* and the spinal *a c* are nearly equal; 2nd, because from this it is evident that this bone, broader in proportion to its dorso-humeral length than the scapula of any other large quadruped, has its posterior angle *a* nearly opposite the middle of this length, and this angle is nearly right, whilst the anterior *c* would be acute, if it were not blunted by the rounding of the edge; 3rd, because the spine, besides its acromial prominence *e* has towards the middle of its length a sort of hook *f*, which is directed backwards, curving a little downwards. Its coracoid prominence *d* projects but little, and is obtuse;

its humeral surface *b d* is slightly concave, oblong, and its length is double of its breadth.

The *humerus* (*pl.* 7, *fig.* 3 and 4) is easily distinguished from that of the other great quadrupeds: 1st, because its external condyloid ridge *a b*, ascends to above the third of its height, and terminates there by a sensible angle, and an edge which is suddenly re-entrant; 2nd, because its deltoid ridge, *d*, which is obtuse, descends lower than the centre of the bone: in these two respects, there is some resemblance with that of the bear. The external tuberosity *c* is raised above the head, and is flat and compressed. From before backwards (*c fig.* 3) it is as large as the entire head transversely. The bicipital groove is deep, and continued forward. The inferior pully, *b e* is a simple shallow canal: the bone has no foramen above the internal condyle.

The *fore-arm* (*pl.* 13, *fig.* 20, 21, 22, 23,) has a very remarkable character, and one of which I know no other instance in living animals; it is that the upper head of the *radius*, *a*, is grasped, and as it were enchased between two apophyses of that of the cubitus, which are two productions of the sigmoid surface. As this head is not round, the motion of rotation is impossible. The radius passes obliquely over the anterior surface of the cubitus, in order to terminate at its internal side by a head *c*, larger than its upper head, but less than the inferior head of the cubitus *d*; this radius is rather slender, and slightly arched. The *cubitus* besides this bifurcation of the sigmoid cavity, is enlarged at the two extremities; at the olecranon a little elongated above, large at the end; the lower head increased in size.

5.—*Great Bones of the Posterior Extremity.*

The *pelvis* of the elephant (*pl.* 7, *skel.*, and *pl.* 13, *fig.* 3 and 4,) is very remarkable by its transverse, or rather vertical disposition, which causes the pubis to be as far forward, as the summit of the os ilium, and the latter to extend from right to left, and in width at the same time that it attains great size, instead of remaining narrow and of being directed from before backward, as in most quadrupeds. Its ventral surface is concave, as in man; its anterior edge *a b*, proceeding from the sacrum to the spine, is broadest and most convex; the spine forms a hook, as in man, but more considerable.

The rhinoceros alone bears a slight resemblance to the elephant in the pelvis, but it has the neck of the ischium much longer in proportion.

The female elephant has the pelvis more open than the male, and the edges of the strait are sharper.

The *femur* (*pl.* 11, *fig.* 7 and 10) is singularly flattened from before backwards, especially in the lower half, and is distinguished from that of other large animals by the simplicity of its forms. Almost all at once, tolerably enlarged at the extremities, its rotular pully ascends considerably forward, is there nearly symmetrical, and occupies only the third of the breadth of the lower head. A broad fissure separates the two condyles behind. The two diameters of the lower head are nearly equal. Above, the great trochanter is elevated less than the head: the small one is almost obliterated. There is no third trochanter. The fossa behind the great trochanter has but little depth. It is quite impossible to confound the femur of the elephant with that of the rhinoceros, by reason of the enormous third trochanter of this latter.

The *tibia* (*pl.* 13, *fig.* 10, 11 and 12,) is triangular only towards its middle. Its superior articular surface presents two transverse ovals separated by a conical transverse ridge on the fore part. Its anterior surface has towards its upper part a considerable rough, concave impression. The anterior ridge is rounded, and becomes entirely flattened towards the lower third. The posterior surface is very concave towards the upper part, and looks obliquely outwards. The external tubercles of the lower head are tolerably prominent. The inferior articular surface represents a semicircle convex behind, the exterior point of which is raised to give support to the fibula. The fibula is slender and compressed; its lower head, very much enlarged, presents two surfaces, one to the astragalus and tibia, the other to the os calcis; the upper head is less so, and has but one small round surface for a lateral projection of the head of the tibia.

The *patella* is oval, broader above, very convex and rough anteriorly; its posterior surface is slightly convex in the longitudinal direction, and concave transversely. It is impossible to confound any of these parts with those corresponding to them in the rhinoceros and hippopotamus, which have forms and proportions totally different; but it is certain that they present in general a form which is not destitute of resemblance to that of man.

6.—*Bones of the Carpus.*

The bones of the carpus in the elephant are remarkable in this, that they are nearly cut square, and that the second row does not enter by its prominences into the intervals of the first, or reciprocally, as in other animals.

Each row has four bones as in man.

The *scaphoid* is more high than broad, narrower above than below, compressed on the sides; its external surface is rough and lateral; its upper surface is small and semicircular, and descends obliquely inwards; the lower surface, which corresponds to the trapezium, and trapezoid, is elongated, elliptical, and a little convex longitudinally; on its internal edge in front there is a small semicircular surface corresponding to a similar one of the os semilunare.

The *os semilunare* has its anterior surface rectangular, more broad than high; the superior or radial surface triangular, with the angles blunted (mousses); under the anterior external angle there is a small descending surface; the inferior differs little from the superior, and corresponds almost entirely with the os magnum; on the two edges anteriorly there are some small semicircular surfaces which correspond with that of the scaphoid and cuneiform bone.

The *cuneiform* bone has also its anterior surface almost rectangular, but still much broader in proportion to its height than that on the semilunar bone: its upper line is undulating and a little concave on its external third; its inferior external angle is prolonged into a blunt point: the upper and lower surfaces are triangular, but longer on the anterior side, and the posterior angle is truncated; under half the external edge of the upper surface there is a triangular surface for the pisiform bone.

The *pisiform* bone is long, not broad, concave on the posterior edge, a little enlarged at the two ends; it has at its base a triangular surface for the cuneiform bone, and a small oblong surface for the ulna.

The *trapezium* is nearly as long as it is broad, and passes the remainder of the second range by two-thirds of its length downwards; it has, above, a semicircular surface for the scaphoid, on the inside an almost square surface for the trapezoid, and a small semicircular surface for the metatarsus of the index.

The *trapezoid* is nearly square anteriorly, however a little more broad than high, and a little higher towards the external edge; its upper and lower surfaces are in the form of an oblique triangle; and both slightly convex, and they touch entirely, the one the scaphoid, the other the metatarsal bone of the index; its trapezian connexion includes all the external surface; that which touches the os magnum occupies but a part of the internal surface, and is rounded: this bone terminates in a point behind.

The *os magnum* is nearly square anteriorly, but a little irregular: posteriorly it is truncated, and only a little narrower than anteriorly, so that its superior and inferior surfaces are trapezoids; the posterior internal angle projects a little obliquely; the upper surface is slightly convex: the inferior nearly full, with a vestige of a ridge anteriorly; the surface for the trapezoid extends all along the superior internal edge, but is much broader anteriorly; that for the cuneiform bone is of the same length, but it becomes broad, at the two ends.

Above, the os magnum is entirely in contact with the semilunar; the posterior internal angle alone is articulated with the scaphoid; below, it corresponds to the metacarpal bone of the digitus medius, and by the internal edge, which is a little raised, it corresponds to that of the index.

The *unciform* bone anteriorly has the form of the trapezium, more broad than high, and contracting towards the external side; the lower edge is a little fissured for a projection of the metacarpal bone of the digitus annularis; its posterior surface is triangular, more high than broad: its superior surface is convex, descending and terminating in a point at the outer extremity; it corresponds entirely to the cuneiform bone; the inferior surface is divided into two parts, an internal convex for the metacarpal bone of the fourth toe, and one, a little concave, ascending outwards for that of the little toe; the articular surface corresponds in figure with that of the os magnum, which it touches.

7.—*Bones of the Tarsus.*

The *astragalus* of the elephant (*pl.* 7, *fig.* 2, I, and *pl.* 8, *fig.* 6 and 7, *a*) is very easily distinguished from every other, particularly from those which approach it in size; its pully is very flat, and this resemblance with man will also have sometimes contributed to make the bones of elephants be taken for giants' bones, even by professed anatomists; but this pully is rhomboidal, a little broader anteriorly towards the exterior; the anterior part of its edge is curved a little back, by being rounded in order to correspond with the internal malleolus, which projects a little; the rest of the internal surface is enlarged into a considerable tubercle towards the external aspect; the two posterior thirds of the border of the pully are curved back to form a peroneal surface of the figure of a half crescent. The neck is much shorter than in man; and in length has neither the third of its width, nor of that of the pully. The anterior surface is semi-oval, slightly convex in the transverse direction, and corresponds entirely to the scaphoid bone; beneath its lower part are two surfaces for articulation with the os calcis, separated by an oblique furrow from before backwards, and from within outwards; the one internal and anterior, contiguous before with the scaphoid surface; the other external and posterior, also greater, contiguous posteriorly and on one side with the pully; all, too, are nearly in the same plane.

All the other great quadrupeds have the fissure for the pully of the astragalus very deep, and most of them have the anterior surface divided by a prominence into two portions, the one scaphoidian, the other cuboidian.

The *os calcis* of the elephant (*pl.* 8, *fig.* 6 and 7, *b*) is distinguished from all others by its shortness and breadth. Its body is one-third broader than it is long, and its posterior (talonniere) apophysis is not longer than its body: the rhinoceros alone would approach it a little with respect to shortness, but it differs considerably in figure. In the elephant the two surfaces, which correspond to those of the astragalus, are plane, as these are, and separated in the same way by a broad oblique furrow; the edge of the external one is curved back into an oblique surface which forms with the semi-cresentic surface of the astragalus, already mentioned, a comple crescent, to receive the lower head of the fibula; the anterior edge of the internal one is curved back in the same way into a small scaphoidal surface; the tubercle of the heel terminates in an oblique enlargement. There is another tubercle on the inferior surface in front, under the anterior facette. This is oval, slightly concave, and corresponds to the superior external surface of the cuboid.

The *scaphoid* of the tarsus (*pl.* 8, *fig.* 6 and 7, *c*) has the ordinary form of a plate, concave towards the astragalus, convex towards the metatarsus; but it also has peculiar characters easily ascertained. It does not at all articulate with the cuboid by a lateral facette, but by a portion of its anterior surface, which is thus divided into four; to wit, this cuboidal surface, and those of the three cuneiform bones. Its upper face is entirely connected to the astragalus, except a small flat posteriorly, which corresponds with the os calcis. Its transverse dimensions is double its antero-posterior, and nearly five times that of its height.

The *cuboid* (*pl.* 8, *fig.* 6 and 7, *d*) does not deserve this name in the elephant; its height is but one-third of its breadth. Its upper surface has two facettes, one external and greater for the os calcis, an internal and smaller one for the scaphoid bone; the inferior has also two for the two last metatarsal bones. The internal face has but one small transverse surface on the inferior edge for the third cuneiform bone. Below it terminates in a tubercle.

The *cuneiform* bones, which correspond to the second and third metatarsal, (*pl.* 8, *fig.* 6 and 7, *f g*) possess nothing very remarkable; the last is the greatest. The *cuneiform bone of the thumb* (ibid., *e*) is more high than broad. It has on its side, which looks upwards and towards the tarsus, a transverse facette for the cuneiform bone; below and anteriorly an oval facette for the second metatarsal.

The cuboid and the two cuneiform bones which precede it form a transverse band of equal height, so that the tarsus of the elephant has as regular divisions as its carpus.

8.—*Bones of the Metacarpus and Metatarsus.*

The metacarpus and metatarsus of the elephant have each five bones, which it would be well to describe together, the better to establish their characters.

For both the three bones of the centre are nearly in the form of triangular prisms; of which one surface is anterior, the other lateral, and a posterior ridge; this is rounded.

They are absolutely larger at the metacarpus, and proportionally longer. The length equals twice and a half their breadth. In the metatarsus it is but double, and the metatarsal bones are one-fourth shorter.

The metacarpal bone of the thumb is one-third less every way than the others. Its trapezian surface is oval and slightly concave. It has no lateral surface. Its anterior surface is rounded and not flattened as that of the others. The metacarpal bone of the index has superiorly a large concave triangular facette, for the trapezoid; on the internal side of its head anteriorly a small triangular vertical surface, for the trapezium; on the external side a long surface nearly vertical and semi-oval, for the metacarpal bone of the middle toe.

This has superiorly for the os magnum a considerable triangular facette, the anterior edge of which undulates a little, to accommodate itself to that of the os magnum; on the internal edge a vertical facette, proceeding from before backwards the entire length of this edge, for that of the metacarpal bone of the index; at the external edge another which is also long, but broader in front, for that of the fourth toe (annulaire).

The metacarpal bone of the fourth toe has for the unciform bone a great triangular facette a little convex, and marked in front with a prominent ridge, which corresponds to a depression in the unciform bone. Its facette for the metacarpal bone of the middle toe corresponds to it in form and unequal breadth. This for the metacarpal bone of the little toe is a semi-ellipse, and extends the entire length of the external edge.

The metacarpal bone of the little toe is shorter than the others and also wider; it is compressed at its external border which forms an arch of an ellipse. Its superior surface is triangular and concave, and its external angle is raised to embrace the external part of the unciform bone. Its surface for the metacarpal bone of the fourth toe is semi-oval, and less vertical than the lateral surfaces of the preceding.

These bones may be recognized, even by their lower head: they are all convex, without marked prominent ridges. That of the middle toe is nearly symmetrical and square; that of the index a little oblique and considerably narrowed in front; those of the fourth and little toe are oblique and rhomboidal; that of the thumb the same, but much smaller. All these obliquities are directed towards the middle toe, so that those of the thumb and index are in a contrary direction from those of the fourth and little finger.

The entire thumb of the posterior member is reduced to a single small bone, a little pointed, which adheres to the first cuneiform bone by an oval surface, which is a little concave.

The metatarsal bone of the second toe has above a large triangular surface slightly convex, for the second cuneiform; on the internal side and forwards a small triangular surface, separated from the edge, descending obliquely and projecting, for a corresponding surface of the first cuneiform bone; on the inner side a long narrow facette contiguous with the edge of the great one, terminating in a point at the two-thirds of the length of this edge, for the metatarsal bone of the third toe.

The latter has above a large surface in the form of a plane isosceles triangle, for the third cuneiform bone. Its external lateral surface is long and narrow, as that of the second metatarsal bone to which it corresponds. The inner is shorter, semi-oval, occupying but half the length of the edge of the upper surface. The internal and external are contiguous with the great surface, and descend almost vertically. Under the external the bone has a slight tuberosity.

The upper surface of the fourth metatarsal bone is divided into two by a ridge, which corresponds to a fissure of the cuboid bones; its internal lateral facette corresponds with that of the third in figure and position. The external is not very perceptible, and is not very distinct from the great upper surface.

The metatarsal bone of the little toe is singularly shortened, and as thick as it is long; it has above an oval facette, slightly concave for the external inferior surface of the cuboid bone. The internal edge is reflected back a little to touch the fourth metatarsal bone.

The lower heads of the four great bones of the metatarsus give rise to the same remarks nearly as those of the metacarpus.

The bones of the metatarsus and metacarpus of the elephant, taken generally, are easily distinguished from those of the rhinoceros, which are flattened from before backward, and not in triangular prisms; with respect to those of the hippopotamus, they have a symmetry altogether different, and their surfaces are in other respects very distinct.

9.—*Bones of the Phalanges.*

The first phalanges of all the feet are a little more long than broad, and a little flattened from before backward. Their upper surface is slightly concave; the lower, which is pully-shaped, is but little developed.

The others are much more broad than long.

The last are small, and semi-circular or oval.

There would be a mode of referring each of them to its own foot and its own toe, by sensible marks and characters; but we do not conceive it necessary for our object to enter into so minute a detail.

Let it suffice here to observe what we already declared in our preliminary discourse; it is, that there is not in the elephant one bone, nor a head of bone, which may not be distinguished from those of all other animals, and which does not consequently indicate, beyond dispute, the species to which it belongs.

Let us further add that, by a remarkable singularity, several of the bones of the elephant resemble those of man much more than they do the corresponding bones of any other great quadruped, and especially than those of the great quadrupeds of our country, oxen and horses. Such are the atlas, all the vertebræ of the neck, the bodies of the vertebræ of the back; the scapula and pelvis, by reason of the width; the femur in respect of its length and the simplicity of its form; the astragalus, the os calcis, the bones of the metacarpus and metatarsus. We should then be the less surprised that professed anatomists, who had not seen the skeleton of the elephant, should sometimes have taken fossil bones of this genus for human bones, and consequently for giants' bones.

10.—*Principal Dimensions.*

To conclude this description, and that it may serve as a basis for the comparisons of the fossil bones, with which we shall have frequent occasion to entertain our readers, we deem it right to give here the table of the principal dimensions of the bones of a skeleton of an adult female elephant, of the Indian species, of the *Komaréa* or squat variety, 8 feet 6 inches or 2,76 (mètr.) high at the withers.

Length of the bead from the edge of the occipital foramen to the edges of the incisive bones	0,883
Vertical height of the head	1,070
Distance between the occiput and the end of the bones of the nose	0,580
Distance between the nasal fissure and the edge of the incisive bones	0,562
Length of the interval when deprived of teeth	0,316
——— lower jaw	0,681
Height of its condyle	0,550
——— coronoid process	0,376
Breadth of its ascending ramus	0,280
Depth of the posterior palatine fissure	0,083
Height of the occiput, reckoning from the lower edge of the occipital foramen	0,345
Its width	0,712
Separation of the two zygomatic arches	0,710
Length of the cervical part of the spine	0,400
——— of its dorsal part	1,354
——— lumbar part	0,200
——— sacral part	0,250
——— coccygean part*	1,500
Breadth of the atlas of one transverse process to the other	0,345
Height of the spinous process of the 3rd and 4th dorsal vertebræ	0,356
Height of the spinous process of the 11th and 12th	0,280
Length of the scapula	0,720

* These parts were measured on a skeleton, where the intervertebral cartilages were not supplied.

Its greater breadth	0,635
Breadth at the neck	0,191
Length of the spine	0,700
Its greatest height	0,172
Length of the humerus	0,835
Distance of the posterior extremity of the head to the anterior extremity of the great tuberosity	0,246
Breadth between the two condyles	0,235
Antero-posterior diameter of the superior head	0,185
Smaller diameter of the body	0,105
Length of the radius	0,675
———— cubitus	0,730
———— carpus	0,124
———— greatest bone of the metacarpus	0,150
———— os ilium	0,924
Breadth at its widened part	0,416
——— of its neck	0,132
Distance between the spines of the two bones	1,127
Length of the femur	0,980
Breadth above	0,255
——— below	0,185
Diameter of the body at the middle part	0,120
———— upper head	0,130
Length of the tibia	0,566
Breadth above	0,180
——— below	0,146
Length of the fibula	0,560
———— posterior process of the os calcis	0,083
———— metacarpal bone of the middle toe	0,120

Article II.

Special Observations on the Structure, Growth, and Succession of the Molar Teeth of the Elephant, and on their Differences from Age and Position.

We made these observations on the three elephants of India, which we had an opportunity of dissecting; but we must say, that we were guided by the excellent work of our respectable confrère, the late M. Tenon, on the teeth of the horse. What we saw particular with respect to those of the elephant, is owing merely to their size and their peculiar character of configuration, which renders their variations in form much more striking.

We must also acknowledge, that excellent observations had been already made before us, on the particular subject of the teeth of the elephant, by M. Pallas*, Pierre Camper and his son Adrian†, M. Corse, Sir Everard Home‡, and M. Blake§: the three latter in particular

* Acad. Petrop. Nov. Com. xiii, p. 472.

† Descrip. Anat. d'un Elephant.

‡ Phil. Transact. for 1790.

§ Essay on the Structure and Formation of the Teeth in Man and various Animals, by Robert Blake, M.D. Dublin, 1801. 8vo.

have nearly exhausted the subject, each of them having discovered something important.

With respect to the manner in which the teeth in general grow, our observations appear to us to confirm the theory of Hunter, rather than that of any other writer, in what concerns the part of the tooth called osseous. But this great anatomist does not seem to us equally happy in regard to the enamel; and he has entirely misunderstood the nature of the third substance, peculiar to certain herbivorous animals. In these two respects, M. Blake seems to us to have approached nearer the truth; whilst we do not think, with him, that there are vessels in the osseous substance.

In fact, each molar tooth of the elephant, as every other tooth whatever, is produced, and, as one may say, conceived in the interior of a membranous sac, which we shall call, with several anatomists, its *capsule*.

This sac, seen externally, is in the elephant of a rhomboidal form, less high behind than before; it is shut on every side, if we except the small openings for the nerves and vessels.

It is lodged in a bony cavity of the same form as itself, hollowed out in the maxillary bone, and which is one day to form the alveolus of the tooth.

It is but the external plate of the capsule which has the simplicity of form we have just now mentioned. Its internal lamina forms on the contrary, as in *herbivorous* animals in general, several folds; but to render them intelligible it is necessary to describe another part.

I mean to speak of the *pulpy kernel* of the tooth. It has in every animal a peculiar figure. To represent that of the elephant in particular, let us suppose, that from the bottom of the capsule, taken as a base, there proceed species of walls or partitions, all parallel, all transverse, and directed towards the part of the sac, ready to make its egress from the alveolus.

These little walls adhere only to the bottom of the capsule; their opposite extremity, or, if you wish, their summit, is free from all adhesion.

This free summit is much thinner than the base: one might call it their edge; it is still more deeply cleft on its breadth, into several points, or dentuli, which are very acute.

The substance of these little walls is soft, transparent, very vascular, and seems to possess much of the nature of gelatine; it becomes hard, white, and opaque, in spirit of wine.

We may now easily figure to ourselves the folds of the internal membrane of the capsule; let us figure to ourselves that it forms productions which penetrate all the intervals of the small gelatinous walls, which I am after describing. These productions adhere to the surface of the capsule, which correspond to the mouth, and to the two lateral surfaces, but they do not adhere to its fundus, from which arise the small walls or gelatinous productions. Consequently we may, without difficulty, conceive a vacuum continued, though infinitely folded on itself, between all these gelatinous walls (descending for the upper teeth, ascending for the lower) and these small membranous partitions (ascending in the upper teeth, descending in those below).

It is in this vacuum, which is very readily conceived, that the matters which are to form the tooth are to be deposited, to wit, the substance commonly called *osseous*, which is to transude through the gelatinous productions coming from the bottom of the capsule, and the enamel, which shall be deposited by the membranous partitions, and in general by the entire inner surface of the capsule and its productions, the base alone excepted*.

It must, however, be remarked, that between the osseous substance and the enamel there is still a very fine membrane, which I think I have discovered. When there has as yet no part of the first substance transuded, this membrane immediately envelopes the small gelatinous wall, and the serre very closely.

In proportion as this small partition transudes through this substance, it, as it were, shrinks and retires inwards and separates from the membrane, which nevertheless always serves it as a tunic, but as a tunic common to it and to the substance which it has transuded under it.

The enamel, again, is deposited on this tunic by the productions of the internal lamella of the capsule, and it so presses it against the inner or osseous substance, which it separates from it, that this tunic soon becomes imperceptible in the hardened portions of the tooth, or at least that it appears there only on cutting it, as a greyish very fine line, which separates the enamel from the inner substance. But we then always see that it is it only which attaches these hardened parts to the fundus of the capsule; for without it there would be a solution of continuity.

The substance called osseous and the enamel are produced, then, by a sort of juxta position.

The first is formed in layers from without inwards; the inner layer is that last formed, and it is also the most extended, precisely as in shells; and its formation commencing by the most prominent points of the gelatinous nucleus of the tooth, it is on these points that this substance is thickest: it continues diminishing in thickness, according as it becomes more distant from them.

Let us now carry back our thoughts to the period when this transudation commences; it may be readily conceived that there is formed a small cup (calotte) on each of the denticuli, which divide the edges of the small gelatinous partitions already so often mentioned.

In proportion as new layers are added interiorly to the former, the cups (calottes) are changed into conical horns (cornets); if the new and inner layers descend to the bottom of the fissures of the edges of these small partitions, all the horns unite into one single tranverse lamella; in fine, if they descend to the base of the small partitions themselves, all the tranverse lamellæ will be united into a single crown of a tooth, which would present the same eminences and the same undulations as were seen in the gelatinous nucleus, if, during the time when these layers were transuding, other substances had not been deposited above, and so filled up in part the intervals.

At first the enamel is deposited, as I said, on the surface of the

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* See, for the production of the enamel, the Preliminary Discourse in the work of M. F. Cuvier, entitled, *Des dents des Mammifères considérées comme caractères zoologiques, &c.*

substance called *osseous*, by the inner membrane of the capsule, in the form of small fibres or rather of small crystals, all perpendicular to this surface, and forming there, at first, a sort of fine velvet. When we open a capsule of a germ of a tooth, we find the small molecules of the future enamel, still very slightly adhering to the internal surface of this capsule, and very easily detached from it. A part floats even in a liquor interposed between the capsule and the germ. I have not seen the small vesicles adhering to the capsule, from which Herissant states the substance to proceed, which must on drying become the enamel. The opinion of Hunter that the enamel is but the sediment of the liquid interposed between the tooth and its capsule, is inaccurate, inasmuch as he leaves too much out of view the capsular membrane, from whence the molecules of the enamel really proceed; but it is very true, that these molecules are at first between this membrane and the tooth before it becomes attached to the latter. With respect to the other opinion, which makes the enamel to issue, as it were, by efflorescence, from the pores of the osseous substance, though it has been received by many anatomists, it has not the slightest foundation in observation.

But let us return to the teeth.

A thick layer of enamel investing, then, the crown on every side, fills a part of the intervals, which the transverse lamellæ and their denturi (dentelures) had at first left between them.

The rest of these intervals is entirely filled by a third substance, called by M. Tenon *the bony cortex* (cortical osseux), because it envelopes all the others, and it resembles an ordinary bone in its chemical nature and its hardness, still more than the two other parts of the tooth. M. Home also calls it *bone*, whilst he gives the name of *ivory* to the substance ordinarily called osseous. M. Blake gives this cortical part the name of *crusta petrosa*.

Its production has something in it very remarkable. M. Tenon considered that it came from the ossification of the inner lamella of the capsule, when this capsule had produced the enamel. M. Blake thinks that this lamella, after having given the enamel by one of its surfaces, yields the cortex by its opposite surface. M. Home has not expressed himself at all clearly on this subject.

For my part, I have satisfied myself that the cortical part is produced by the same lamella and the same surface, which produced the enamel; the proof is, that this lamella remains outside the cortical part, as it was at first outside the enamel, and that it remains there soft and free as long as this cortical part allows it room. It only changes as to its tissue; as long as it yielded only enamel, it was soft and transparent; in order to yield the cortical part, it becomes thick, spongy, opaque and reddish. The cortical part which is formed is not in close threads, but as it were in small drops, which might have been thrown out by mere chance.

The membranous productions of the capsule of the tooth tend towards the summit and sides, according as the cortical part which they deposit on the enamel fills all the empty space which remained between the different lamellæ of the tooth. The summits of these lamellæ are covered with the cortical part, as well as the remainder, so long as they are not used. One and the same production of the capsule oftentimes deposits its cortical portion on the upper part of the lamella, though as yet it deposits only enamel on the lower part.

It also happens that the upper part of the interval of the lamellæ is already filled by the cortical part, when the lower part is still separated: then the lower part of the capsular production is found separated from the upper, and no longer receives its nourishment, except by its lateral adhesions with the capsule.

The deposition of the enamel commences almost with the transudation of the osseous substance, and that of the cortical part follows soon after; so that the summit of each lamella is terminated in its three substances long before its base, and the neighbouring lamellæ are soldered together by their summits, before they are yet hardened at their bases.

To all we have now said, let us add that these different operations are not executed simultaneously in all the parts of the tooth, but that they take place much sooner before than behind: it will be seen that the anterior lamellæ will be already united together at their summits, and even at their bases, when the intermediate lamellæ will be still separated from each other, at least at their bases, and when the posterior ones will not be even formed, and will present only pointed and distinct horns, which must become the summits of their dentuli (dentelures.)

From what we have just said it also follows, that the substances of which the teeth are composed are all formed by excretion and by layers; that the inner substance in particular has nothing in common with the ordinary bones but its chemical nature, consisting equally of gelatine and phosphate of lime, but that it resembles them neither in its tissue, nor in its mode of deposition, nor in that of growth. Its tissue presents neither cells nor fibres, but merely lamellæ inlaid, the one in the other: those who compare it to the diploë of the cranium, and suppose cells to be in it, give a very false idea of it. It is not formed in a primary cartilaginous nucleus, which might be successively penetrated by earthy molecules: it does not grow by a general and simultaneous development of all its parts, preserving still the same form: in a word, it is not penetrated either by vessels or nerves. Those who thought that the vessels of the pulpy nucleus pass into the body of the tooth were deceived: and those still more so, who maintain a passage of the vessels of the periosteum of the alveolus into the substance of the roots. There does not pass the least fibril of the pulpy nucleus to the substance called osseous: and the latter is not connected to the remainder of the body, except merely by its mechanical inclosure. Thus, no portion of the tooth is regenerated when it has been removed: and if cleft teeth are again consolidated, it is only because new layers forming within are agglutinated to the external, and the latter to them.

We shall again see new proofs of all this in treating of the ivory, and we shall there refute the objections derived from diseases of the teeth; but in the mean time, we must say that most anatomists have very improperly given the name of *osseous substance* to the inner substance of the teeth, and that they have designated by that of *ossifica-*

tion, the operation which developes and hardens them. This is confounding two things essentially different, and giving, by ill-applied names, false ideas which may even influence practice.

But let us return to the molar teeth of the elephant.

When all the parts of the body of the tooth are formed and consolidated, and that it proceeds from its alveolus, it experiences entirely new changes.

As the elephant is herbivorous, its teeth are used in masticating, as are those of all the animals subjected to the same kind of food. It is even known that it is necessary for their teeth to be used, that their surface should be in a state of grinding the vegetable substances. This general fact, put very recently in the clearest light by the works of M. Tenon, might prove to him of itself, and independently of all those which we are after developing, that the teeth are not organized as bones are. Who is not well aware to what consequences the latter are exposed, when they are cut into, or only exposed?

The summits of the small denturli (dentelures) of the lamellæ will be first used; once used as far as the internal substance, each of these summits will present a circular or oval disc of this substance, surrounded by a circle of enamel and a circle of the cortical part: and there will be a range of these small circles for every lamella.

If detrition penetrates to the bottom of the fissures which produce the denturli (dentelures), all these small circles will be united with a single riband of bony substance, surrounded by a double line of enamel, and the cortical substance will form all the round of the plane of the tooth, and will occupy all the intervals of the ribands. Each riband will be the section of one of the transverse lamellæ which compose the tooth.

And if detrition could go as far as where the lamellæ are united all into one single base, the entire tooth would now present merely a very large disc of osseous substance, surrounded on every side by a small border of enamel, and another of the cortical part.

But detrition can never go entirely so far, because it is never made at the same time on all the crown, just as the consolidation was not so made there; and here is the reason:—

The tooth, by its rhomboidal form in the vertical direction, and by its very oblique position, presents its anterior part to mastication much sooner than its posterior portion. The plane or table produced by mastication forms, then, with the common surface of the summits of all the lamellæ, an angle open behind; and thence it comes that when the lamellæ before are cut into deeply and form entire ribands, the intermediate lamellæ still present merely transverse rows of circles or ovals, and those behind are entirely untouched, and present the summits of their denturli (dentelures) in the form of round nipples.

The anterior lamellæ are even altogether destroyed, before those behind are cut much before, and thence results another phenomenon which is also peculiar to the elephant; it is this, that his teeth diminish in length at the same time that they diminish in height.

Whilst the exterior part of the tooth is used and diminishes, the portion of the root which corresponds to it is used in another manner, which is more difficult to conceive. On examining what remains of it, we see that it is as it were gnawed; it presents on its surface small irregular fossetts, as if it had been dissolved by an acid thrown on it in drops. It is a sort of caries similar to that which the teeth undergo in man, when they are deprived of their enamel. We shall inquire into the cause of this farther on. It always happens that the tooth is thereby successively deprived, in the different portions of its length, of segments or slices, which occupied its entire height.

Hence again results another singular effect: it is this, that as the anterior part of the jaw must be always filled, the tooth moves from behind forwards in the horizontal direction, at the same time that it is carried in the vertical direction from above downwards, or from below upwards, according as it belongs to the upper or lower jaw.

This is the reason why each tooth, at the time it falls, is found to be very small, however large it may have been originally.

This movement of the tooth now in action makes room for that which is formed in the posterior jaw, and which is to succeed it; this second tooth aids, by its development, in pushing the first forward; and we might say that the secondary teeth in the elephant come behind its milk teeth, instead of coming above or below them as in other animals.

Patrick Blair*, who perceived separate transverse lamellæ in the back-jaws of the elephant, and who called them very properly *rudiments of teeth*, was not disposed to believe that these lamellæ came afterwards to form a tooth which was to replace that behind which he found them. He was then reduced to seek various imaginary uses of them.

The number of the teeth of elephants has been a subject of dispute; the Royal Society of London perceived, in 1715, that it varies from one to two on each side, and that the place of the division varies also: that is to say, that the first tooth is more or less long in proportion to the second, according to the individuals†.

Pallas was the first who taught the mode of their succession, which explains all these irregularities, by showing that they have at first only one tooth on each side; that a second, in developing itself, pushes on the first, so that for a certain time there are two of them; then the falling of the first causes them to be but one again‡.

I announced that this succession, and consequently this alternating change of number, was repeated more than once, because I still found separate germs in an elephant which had already two teeth. This latter point had in fact been already proved by Daubenton §, but for the upper jaw only; in fine, this great naturalist had perceived to a certain degree the necessity of this succession from behind forward, which Pallas more clearly developed.

M. Corse || apprized us that this succession is repeated as often as eight times in the elephant of India; that there is therefore thirty-two teeth, which occupy successively the different parts of his jaws.

The first appear eight or ten days after birth, are well formed in six

* Phil. Trans. vol. xxvii, No. 326.
† Phil. Trans. vol. xxix.
‡ Nov. Com. Petrop., xiii, p. 475.
§ Hist. Nat. tom. xi, in 4to.
|| Phil. Trans. for 1799.

weeks, and completely out at the end of three months. The second are well out in two years. The third appear at this period, and cause the second to fall on the sixth year; they are in their turn pushed out by the fourth in the ninth year. The following periods are not so well known.

In the two first elephants which I dissected, and in five dried heads, which I examined, I constantly found three teeth at once, to wit, a small molar tooth more or less ready to fall, a large one in its place, and in full activity, and a germ more or less large, more or less consolidated, occupying all the bottom of the back jaw; but in my last elephant, which was about forty years old, there was not more than two teeth, of which the second, which scarcely commenced to make its exit from the alveolus, filled all the back jaw.

We can easily judge by the depth of the detrition, whether a tooth which is found isolated, was situated before or behind in the jaw: those which were situated before never have any of their lamellæ entire.

The number of the lamellæ which compose each tooth, goes on increasing, so that each of them has more than the one which immediately preceded it.

M. Corse, who was the first to remark this, gives these numbers from his observations: the first have only four lamellæ, the second eight or nine; the third twelve or thirteen, and so on to the seventh or eighth, which have twenty-two or twenty-three of them. M. Corse never saw teeth which had more than this.

We are inclined to think, that these numbers are not very accurate; for we have a lower jaw, of which the first tooth has fourteen lamellæ, and the next fourteen germs of lamellæ. M. Camper has one precisely similar (Descript. Anat. d'un Elephant, p. 57, *pl.* 19, *fig.* 2).; but in the upper jaw, which corresponded to ours, there is in the active tooth thirteen lamellæ, and in the germ of the one next it eighteen.

Independently of the number, there are differences with respect to the thickness of the lamellæ: they are thinner in the first teeth than in the last: and as the jaws are shorter when they carry the first teeth, it happens that the number of the lamellæ in activity is nearly the same every time, that is to say, from ten to twelve.

When the elephant has grown, the space occupied by the lamellæ in activity is, to be sure, greater; but these lamellæ are themselves thicker, and always fill the space, whatever it be.

As it requires the same time to use the same number of lamellæ, the last teeth, which have much more of them, last much longer than the first. The replacements take place then at intervals, continually lengthening, in proportion as the elephant advances in years.

The elephant's teeth, as those of all other animals, do not push out their roots till the body is perfect: the roots are formed by layers, as the rest of the tooth: the thing could not be otherwise. But why this division in another direction, when the re-union of the cups (calottes) of all the gelatinous eminences seemed as if it should no longer produce but one single body?

To answer this question, which is one of general interest for all the teeth, it is necessary to add one circumstance to the description which I have given of the germ: I reserved this point for the present moment, in order to avoid confusion.

The base of this gelatinous body, (the productions of which, called *walls* (murs) by me, serve as nuclei for for the lamellæ of the tooth), does not adhere in all its points to the bottom of the capsule. There are, from space to space, solutions of continuity, and consequently the adhering parts of this base may be considered as very short pedicles. When the lamella of bony substance has covered all the productions or walls, and all the body of the nucleus of the tooth, it is always continued upon and between the pedicles; the parts of this lamella which go between the pedicles, from the lower part of the body of the tooth; the parts which envelope the pedicles, and which are consequently more or less tubular, form the first commencement of the roots.

These roots and the pedicles which serve them as nuclei are then prolonged, for two reasons: first, the progress of the lamellæ of bony substance, which, continually lengthening, force the tooth to raise itself and to make its exit from the alveolus; then the thickening of the body of the tooth by the formation of successive layers; which, by filling up the interior void, leave almost no more room for the gelatinous nucleus, and press it towards the interior of the tubes of the roots.

There is neither enamel, nor cortical substance produced on the roots, because the internal lamella of the capsule, which alone has the power of secreting these two substances, does not extend so far.

I conceive that it is partly to this absence of enamel, that we should attribute the corrosion which commences on the roots as soon as the portion of the crown corresponding to them has been worn down to them.

At this period the root has attained all the development which it could attain; the pulpy nucleus is entirely supplanted by the layers with which itself filled the cavity which it occupied. This force of the growth of the root ceases then to counterbalance the growth of the bony parietes of the alveolus, and the latter continually push out the root. It commences to become carious, as soon as, escaping out of the gum, it is exposed to the septic action of the air, of heat, and of the moisture of the mouth.

What gives, in my opinion, some probability to this idea, is, that the corrosion commences sooner at the junction of the root and the crown than at the point of the root. I have several proofs of it in my specimens. One may judge of it also by the small tooth described by M. Corse (Phil. Trans. 1799, tab. vi, *fig.* 3). Perhaps again the mechanical compression which the root experiences on the part of the alveolus contributes to its destruction, as we attribute the destruction of the roots of the milk teeth to the pressure they experience by the contraction of their alveolus, occasioned by the development of the teeth which are to succeed them.

Besides, it is always necessary that one part of these molecules should be absorbed; but it would not be the only phenomenon in which a body become foreign, would be taken up by the absorbents, and made to disappear. The thing is well known for liquids. For solids, I think that we have examples of it in some secretions. The essay of Alexander Macdonald on *Necrosis* may be seen on this subject.

The teeth of the two jaws of the elephant are easily distinguished by their form. Those of the upper jaw have their lamellæ so disposed that the summits are all in a convex surface: the table produced by their wearing is also convex. The contrary in both these points takes place in those of the lower jaw.

A character still more striking may be taken from the direction of the lamellæ with respect to the crown or triturating part.

Those from below are inclined backward, that is to say, the acute angle which they form with the plane of trituration is directed forward, at least in their radical part; for the summit of the anterior ones is curved a little backwards.

Those above, on the contrary, are inclined forwards, or the acute angle which they form with the plane of trituration is directed backwards.

It is always easy to distinguish the back of a tooth from the front: trituration wearing away much more in front than posteriorly, it is the end of the crown most deeply worn that is always anterior.

It is necessary to remark, however, that the inclination of the lamellæ on the crown diminishes in the two jaws in proportion as the detrition increases. The posterior lamellæ, which are worn much later, are worn a little more quickly, because their development towards the root continuing, when that of the anterior lamellæ has ceased, they are pushed out with more force, whence it happens that the plane of detrition becomes more and more perpendicular to the direction of the lamellæ.

The teeth belonging to each side may be still distinguished, because they are convex on their internal surface, and a little concave on the external.

I endeavoured to represent this progress of dentition in the figures of my plates 9 and 10.

Pl. 10, *fig.* 5, is a cranium of an elephant of India, cut vertically.

a. The entrance of the nares.

b, b. The enormous thickness of the sinuses, which separate the two parietes of the cranium.

c. The cavity of the brain.

d. The occipital foramen, and the right condyle of the same name.

e. The alveolus of the tusk.

f. The cavity of the tusk, opened to show the space occupied by its pulpy nucleus.

In the space from *f* to *g*, a portion of the maxillary bone has been removed, and all the palate bone, to shew the teeth, and their germs in situ, in all their extent.

h. Is the anterior tooth, reduced almost to nothing by detrition, and the pressure as well of the next tooth, as of its own alveolus.

i. The tooth in full activity, the roots of which begin to form at *k*, and of which the triturating part *l* is already worn down. The posterior lamellæ *m* are still untouched.

n. The germ of the back tooth, still inclosed in its membranous capsule, and this latter lodged in a cavity of the back jaw.

o. The nerve of the fifth pair, which gives filaments to the capsules of the teeth, and to their pulpy nuclei.

These same two teeth are represented in a large size, *pl.* 9. *fig.* 1. and 2.

Fig. 1. Is the tooth in action; *a, b,* the portion of its lamellæ already worn down; *b, c,* the portion still untouched; *d, e, f,* its roots, which are sunk between the productions of the alveolus, *g, h, i.*

All the inner surface of the roots, and of the base of the body of the tooth has been removed, to show the pulpy nucleus, *k, l, m.*

As the body of the tooth is almost entirely shut and filled, the little transverse walls, *n, o, p, q, r, s,* are almost entirely shortened and compressed; but to make up for this, the pedicles *t, u, v, x,* which serve for the formation of the roots, are already considerably lengthened.

Fig. 2. Is the germ of the back-tooth, drawn with its capsule from the cavity of the back jaw.

a. b. Remainder of the periosteum of the alveolus.

c, d. Anterior part of the external membrane of the capsule.

e, f. Portion of this external membrane, detached and thrown down, to show the inner membrane *g, h, i.*

k, k, k, k, &c. Transverse productions of this inner membrane, which separate the lamellæ of the tooth and the gelatinous walls on which these lamellæ are formed.

The portion of the membrane which united these productions are removed, in order to show the lamellæ of the tooth which they covered.

l, l, l. The body of the pulpy nucleus of the tooth.

m, m, m, m, &c. Its productions, or the small transverse walls which it sends between the productions of the capsule, and on which the lamellæ of the tooth are formed.

n, n, n, n, &c. Lamellæ called bony, transuded by these little walls which envelope them, and the aggregate of which is to form the tooth.

The posterior ones are much shorter, and do not envelope so completely their little walls, because the transudation commences later behind.

o, o, o, o, &c. The enamel deposited on these lamellæ, by the internal surface of the capsule. There is much less of it in the posterior lamellæ, for the same reason.

In the part *d, g, h,* the cortical substance has already covered the enamel, and agglutinated the lamellæ together.

p, p, p. The solutions of continuity which separate the commencement of the pedicles of the roots.

Fig. 3. Is the middle part of this same germ, seen at its posterior surface.

a a. Its base seen shortened.

b. One of the small transverse walls.

c. The lamella called osseous which still envelopes only its dentuli.

d. A dentulus whose envelope is not yet joined to the others.

e, e, e, e. The enamel which commences to be deposited on this lamella.

f. Remainder of the capsule.

g, g. Extremity of the transverse lamella of the capsule.

h, h. Bases of the small transverse walls of the pulpy nucleus.

i, i, i. Lamella of the tooth which envelope them.

k, k. Enamel which commences to be deposited on these lamellæ.

Fig. 4 represents the last small walls of the pulpy nucleus, detached from the rest and separated from each other.

a. The lamella horn-shaped, which had commenced to form on the denticuli of the most anterior.

b. Those which only arose on the denticuli of the penultimate.

c. The last of all, which had as yet no hard envelope.

Fig. 5. A lamella of the germ of the tooth of an elephant of India, seen on its broad surface.

a, a. Its part, which must soon pass out of the capsule and the gum, and where may be already seen the cortical part, spread as it were in drops.

b, b. Its middle portion, where there is as yet, on the substance called osseous, merely the enamel, like velvet-down.

c, c. Its portion of the base, where the substance called osseous is still exposed, without enamel or cortical substance.

Fig. 6. A similar lamella of the elephant of Africa.

a. The ridge (arête), which gives to the section of the lamellæ of this species the figure of a lozenge.

Article III.

On the Tusks of the Elephants, the Structure, Growth, distinctive Characters of Ivory, and on its Diseases.—Conclusion of the General Remarks on the Teeth.

We shall not stop to refute the opinion of some moderns *, that the tusks of the elephants are horns. This is an old notion maintained by Pausanias †, already completely refuted by Philostratus ‡, and one no longer entertained by any person.

On the contrary, most of the anatomists who think that the teeth grow, as ordinary bones, by a sort of intus-susception, take their proofs from ivory, from its diseases, and injuries.

However, ivory is formed, as the other teeth, of successive layers transuded (transudées) by the pulpy nucleus.

I myself opened the alveolus of the base of a tusk on a fresh elephant, and there I clearly saw a pulpy nucleus of enormous size and entirely destitute of all organic union with the tusk, which it had however secreted. Though the subject was perfectly fresh, there was not seen the least adhesion between the tusk and the nucleus: not the least fibre, nor the most minute vessel; no cellular connexion between them. The nucleus was in the cavity of the tusk as a sword in its scabbard, and itself adhered only to the fundus of its alveolus.

The tusk is then, in its alveolus, as a nail driven into a board; nothing retains it there but the elasticity of the parts which inclose

* Ludolph. Æthiop., lib. 1, cap. 10; Perrault, dans la Description de l'Elephant de Versailles, &c.

† Lib. v. cap. 12.

‡ Vita Apollinii, lib. ii, cap. 13.

it; so we may change its direction by gentle pressure. This is an experiment which succeeded with our second elephant: its tusks approximated so as to impede the motions of its trunk; they were gradually separated by means of an iron-bar, the middle of which was formed like a screw (en vis), and which was lengthened at pleasure. Every one knows that dentists do the same thing in a small way with children, for teeth which have but one root.

The successive layers of which ivory consists, leave but few traces on the section of a recent tusk: but here the fossile tuskt aid us much better in learning the structure of the parts. The tusks decomposed and altered by remaining in the ground, are arranged in conical thin lamellæ, all enveloped the one in the other, and thereby show what was their origin.

No bone properly so called is disposed in this way. Sloane is, I think, the first who made this remark.

Incisions made on the surface of a tusk, are never filled; they disappear only according as the tusk is used by friction.

It is true, we sometimes see balls in the interior of ivory, without seeing the hole through which they entered.

Our museum possesses three examples of this; we find others mentioned in different works *.

Some have concluded from this, that the course traversed by the balls must have been filled up by the very juices of the tusk and by its organizing strength †; or, as Haller says, by a species of stalactite ‡; but it is easy to see, on the contrary, that there had not been any hole, and that the ball had not entered at the side where it adheres. All the portion of ivory outside the ball is similar to the rest; it is only that which immediately surrounds it that is irregular: the reason is, that having come at the opposite side, it traversed the alveolus, and the still thin base of the tusk of a young elephant, and lodged in the pulpy nucleus, which was still in all its developement; it was then held by the layers transuded by this nucleus, and remained there.

Camper gave this explanation of it already (Descript. Anat. d'un Elephant, p. 54).

We can deduce no consequence from this fact, calculated to establish the nutrition of ivory by intus-susception.

For the same reason, it proved nothing against the opinion of Duhamel regarding the formation of bones by the hardening of the successive layers of periosteum, though Haller thence derived one of his principal arguments.

With respect to the diseases of ivory, those which regard the alteration of its tissue come obviously from a disease in the pulpy nucleus, at the time it secreted the altered portion; and what is called *exostosis* is always within, and never outside. It is the effect of a secretion momentarily too abundant in a certain point.

Besides, portions of the canine teeth of the *morse* (*trichecus rosma-*

* Blumenbach Manual d'Anat. Comp. Gallandat, Mem. de l'Ac. de Haarlem, ix, 352; Bonn, Thes. Hovian., p. 146; Camper, An. d'un. El. pl. xx. fig. xi and xii.; Haller, Op. min., 11, p. 554.

† Haller, Phys., viii, p. 319.

‡ Ib., p. 330.

rus) the texture of which is naturally close, have often been given for diseased ivory. There are some described under this title in Daubenton himself.

Diseases of the teeth are nearly in the same case as those of ivory.

What has been called *caries*, an almost necessary consequence of the removal of the enamel, is the decomposition which the internal substance would undergo, when it would be no longer adherent to the body, if it remained exposed to the heat of the mouth and to the action of the saliva, and of the different aliments; but it has no resemblance to caries of the bones.

The liability of some persons to have their teeth become carious arises from their substance not being of a good composition, and is owing to the bad state of the pulpy nucleus when it transuded through them.

The same may be said of the spots and softer layers observed in the substance of certain teeth. These are temporary affections of the pulpy nucleus.

Pains and inflammations are in the pulpy nucleus and not in the hard part of the tooth. It is the pulpy nucleus which is sensible to shocks, and to the temperature of bodies, through the envelope which the hard part forms for it.

One will be surprised, perhaps, that an envelope so thick and so hard does not deaden all sensation; but the pulp of the nucleus of the teeth is, next to the retina and the pulp of the labyrinth of the ear, the most sensible part of the animal body. Fishes, which have their labyrinth shut in the cranium, without tympanum or small bones, in a word without any communication open externally, hear by means of shocs communicated to the cranium; this is something much stronger in sensibility than what the teeth experience.

The exostoses of the teeth, and fungous growths, do not at all come to the surface of the enamel of the sound tooth, but in the cavities of the caries. They are productions of the pulpy nucleus, which have pierced the hard substance in the thinned fundus of these cavities.

The continued lengthening of the teeth, which have none opposite them to detain them, agrees with all these facts; the portion of the elephant's tusk once out is constantly lengthening, but not becoming thicker, nor is it hardening; it is because it is always pushed posteriorly by new layers, whilst itself cannot undergo any change. We know how far this prolongation is carried in rabbits which have lost a tooth, and whose opposite tooth is no longer used in mastication. Continuing to lengthen behind, it ends by preventing the animal from eating. It is in this sense that Aristotle said, that the teeth grow during the entire of life, whilst the other bones have determinate limits.

We must add, however, that the ordinary teeth also have a limit; it is when the entrance of their cavity is obliterated, and their pulpy nucleus no longer receives nourishment; but nature has taken care to leave passages always open in animals, which, making frequent use of their teeth, required to have them constantly repaired posteriorly: such are *rabbits* for their incisive teeth, and elephants for their tusks: the root not becoming narrower in these, its canal cannot be closed.

Article IV.

Of the different Species of Elephants at present existing; their distinctive Characters, and the Varieties in each of them.

1.—*Difference of the Molar Teeth.*

The molar teeth of the elephant of India, and of the elephant of Africa, were for a considerable time possessed by individuals, and described without any distinction, no comparison being made between them, and no one perceiving that they did not resemble each other at all. Thus the Royal Society of London, in 1715, procured some molar teeth of the elephant of Africa, to serve as an object of comparison with fossile molar teeth, which, as is known, resemble very much those of the Indian elephant, nor did any one insist on a difference which was quite palpable.

The accurate and judicious Daubenton did not even remark it, and neither Buffon nor Linnæus ever suspected that there could be more than one species of elephant. We do not even perceive any traces of the possibility of such a thing in Gmelin's edition of the *Systema Naturæ*, and in fact every thing found on the subject in the ancients, and in the accounts of travellers, was vague, and could refer only to mere varieties.

What follows is, for instance, what the ancients said on the differences of these elephants, and on their different degrees of fitness for war.

Polybius, book ii, c. 17, when speaking of the battle lost near Raphia, by Antiochus the Great against Ptolomey IV. Philopator, the year of Rome 535, 171 years before Christ, speaks of the superiority of the elephants of India over those of Libya. The victory seemed at first to incline to the side of Antiochus. The historian says on this occasion, that "the elephants of Libya dread those of India, and can neither look at them nor hear their cry, or rather, that it is the great size and strength of the latter which puts them to flight."

Titus Livy, book xxxvii, c. 39, relates something similar on the occasion of the battle of Magnesia, lost 27 years after, in the year of Rome 562, by the same Antiochus against the Romans, commanded by Scipio Asiaticus, and under him by Cn. Domitius, his lieutenant. He says, that "the Roman general, who had but sixteen elephants, placed them in the rear of the army, not only because they were not able to resist those of the king in consequence of their small number, the king having fifty-four, but also because being from Africa, they would not have been able, even with equal numbers, to sustain the combat against those from India, the latter race having at once more courage, and a much superior size."

Appian gives the same reason for this manœuvre (de Bellis Syriacis, Amsterd. edition, 1760, 8vo. i. p. 172). According to him, "Domitius, judging that the elephants which he had from Africa would be of no use to him, because they were in smaller nnmbers, and less in size, *as being African* (οἷα Λιβύων), and because the small ones dread those that are large, he placed them in the rear (ἔστησεν ὀπίσω ἅπαντας)."

The inscription of Adulis, related by Cosmas, informs us that the kings of Egypt procured the elephants, which they equipped for war, from Ethiopia and the country of the Troglodytes, that is to say, from the countries situated towards the Indian sea*. Ptolomæus III., Euergetes, the author of this inscription, seems already to pride himself for having with these elephants made himself master of the elephants of India, possessed apparently by the king of Syria, Antiochus Theus, against whom it is known that he waged a successful war. The same Cosmas says, that the Ethiopians knew not how to equip these elephants.†

Thus though on all these occasions the armies which possessed only African elephants may have been victorious, the superiority of the Indian elephants, in size and in courage, was nevertheless a thing generally admitted among the antients. Diodorus‡, Pliny§, Philostratus||, and Solinus¶, speak of it in a general way; but none of these authors, nor the historians from whom they probably derived their statements, make known the sensible characters, from which one might conclude that this superiority was owing to a difference in species. Diodorus** even attributes it expressly to the circumstance of India furnishing them with better pastures. With respect to the distinction established by Philostratus between the elephants of *mountains*, of *plains*, and of *marshes*, and with respect to the differences in their natural constitution, and their ivory, one should suppose that if they are real, they constitute only mere varieties.

Amintianus, in his treatise on elephants, according to a scholiast of Pindar, quoted by Gesner, page 378, had however observed a positive and true character: " It is this, that the males only have tusks in the Indian species, and that the two sexes have them in that of Lybia and Ethiopia.

Cosmas had also expressed something similar.

" The elephants of India," said he, " have no long tusks, and when they should have them, the Indians would cut them, for fear that the weight of those arms might impede them in their combats."

" But Ethiopia has many elephants provided with long tusks, and some of them have been exported thence in vessels to India, Persia, into the country of the Homerites, and through the entire Roman†† empire."

But all these indications were too vague for naturalists, and excited no attention whatever in the moderns.

Thus the first distinction of elephants truly specific, that which is founded on the intimate structure of their molar teeth, is due entirely to P. Camper. Though he has not written any thing on it, the plates wherein he represented them, and testimonies of his son and of M. Faujas prove his title to it.‡‡

M. Blumenbach also remarked the circumstance; he characterized

* Cosmas, Indico-pleustes ap. Thevenot, divers voyages, tome i, p. 8, de Cosmas, et ap. Montfaucon, Coll. nov. patr. 11, 141.

† Ibid. 339.

‡ Diod. Sic., lib. 11, p. 121, Wechell's edition, 85 of Henry Stephens'.

§ Plin. Book viii, chap. 11.

|| Philost. Vit. Apollon. book 11, c. 6.

¶ Solin. c. 25.

** Diod. loc. cit.

†† Cosmas, Indico-pleustes ap. Montfaucon Coll. nov. patr. ii, 339.

‡‡ Descript. Anatom. d' un Elephant, p. 16 : and Faujas, Essai de Geologie, i, 246.

the two species by this sole difference, in his Manual, 6th edition, p. 121, and gave drawings of the two kinds of teeth in his *abbildungen*, pl. 19.

This difference consists in the form of the plates and in their number: it is observed from the germ.

The germs of *the elephant of India* are lamellæ, each of which is formed of two surfaces almost parallel, and merely furrowed along their length. (*See pl.* 9, *fig.* 5). In *the elephant of Africa* one of the surfaces (and oftentimes the two) produces in its middle, and along nearly its entire height, an angular projection; its furrrows are also much less numerous. (*See pl.* 9, *fig.* 6.)

The result of this structure of the germs is, that the section of the lamellæ, when the tooth has been used, presents in *the elephant of India* transverse narrow bands, of an equal breadth, the edges of which, formed by the enamel, are very much festooned, and in *the elephant of Africa*, lozenges, or bands broader in the middle than at the two ends, whose edges when cut seldom exhibit well-marked festooning.

To this difference in form there is added one in the number: the lamellæ of *the elephant of Africa* being broader, less is required to form a tooth of the same length; nine or ten of these lamellæ form a tooth as large as thirteen or fourteen of the species of the Indian elephant.

It appears that these two species observe the same proportion in the teeth of the same age, as in that of the same length. Thus on comparing our skulls of the Asiatic with those of the African elephant of nearly the same age, we find in the back teeth of the former fourteen or fifteen lamellæ, and in those of the others only nine or ten.

Thus we have never seen a tooth of the African elephant which had more than ten lamellæ, whilst those of the Indian, according to M. Corse, have them even as far as twenty-three, and we see some fossils with twenty-four or twenty-five.

2.—*Differences relative to the Tusks.*

The tissue of the tusks presents no important differences. It always presents on its transverse section those striæ which go in an arc of a circle from the centre to the circumference, and in crossing form curvilinear lozenges, which fill up its entire disc, and which are more or less broad, and more or less perceptible to the eye. This character, common to all the ivories of elephants, and depending immediately on the pores of their pulpy nucleus, is not found in the tusks of any other animal. It is observed in all the fossile tusks, and it refutes the opinion of Leibnitz*, adopted by some other writers, and even by Linnæus†, that the horns of the *mammoth* might come from the morse, (*trichechus rosmarus*). The tusks of the morse appeared all composed of small round grains heaped together.

The size of the tusks varies according to the species, according to the sexes, and according to the varieties; and as they increase during

* Protogœa, § xxxiv, p. 26. † Syst. Nat. ed. xii, p. 49.

the entire life, the age influences their dimensions more than any thing else.

The elephant of Africa has, at least in certain countries, large tusks in the two sexes. The African female, seventeen years old, which lived in the menagerie of Louis XIV., and whose skeleton we still possess, made by Duverney, has them larger than any Indian elephant male or female of the same size with which we are acquainted.

It is in Africa that we find most ivory, the largest tusks, and those of which the ivory is hardest, and preserves its whiteness best. Cosmas already remarked this, as we have seen.

There occurs, to be sure, in Sparmann*, a passage where it is said that at the Cape female elephants are known by the smallness of their tusks; but this expression is a little vague, and does not import precisely such a smallness, as that they would nearly not appear at all, as in the females of the Indian species.

In the Indian species there are several varieties which M. Corse has developed with more care than any other individual†.

First, no female there wears long tusks; they have them all small, and directed in a right line downwards (as Aristotle‡ has well expressed it in a passage since improperly contradicted), and some of these females have them so short, that one must raise the lips in order to see them.

Still more, all the males are very far from having them large. Tavernier says that in the isle of Ceylon it is only the first born of each female that has them so§. On the continent of India are distinguished the *dauntelah*, or elephants with long tusks; the *mooknas*, which have them very short; the latter always has them straight. Wolfs, who lived a considerable time in Ceylon, also says that in this island there are many males without tusks, and that they are there called *majanis*.||

Among the *dauntelah*, there are again distinguished, according to Corse, the *pullung dauntelah*, whose tusks are directed almost horizontally, and the *puttel dauntelah*, where they are directed straight down wards. Between these two extremes there are several intermediate kinds, and names have also been given to the individuals, one of whose tusks differs from the other, and who may have only one. But all these varieties have nothing constant, and are all blended up, the one with the other; they are found together in the same herds.

The differences in direction are even owing oftentimes to accidental circumstances; to the manner in which the individual is wont to use his tusks, or to rest on the one rather than on the other; we have had proofs of it in the elephants of our own menagerie.

In Bengal, according to M. Corse, the tusks scarcely exceed 72 livres in weight, and they do not exceed 50 in the province of Tiperah, which produces the best elephants. However, in London they have tusks, probably originally from Pegu, which weigh 150 livres. It is in fact from Pegu and from China that the largest elephants

* Voyage to the Cape, &c.

† Phil. Trans. 1799.

‡ Hist. Anim. lib. ii.

§ Tavernier, tom. 11, p. 175.

|| Voyage to Ceylon, in German, p. 106, quoted by Camper, Anat. of an Elephant.

come, and the largest tusks of the Indian species. The coast of Malabar, according to Pennant, does not yield any more than four feet long.

Here is a table which I have drawn up of the lengths, diameters, and weights of the longest tusks, of which authors have given the dimensions, or which I have been able to observe myself.

The tusks of the African species could not be then distinguished from those of India; and there is not all the certainty one could desire regarding the species of measures employed.

Authors who have cited the facts.	Their *Vouchers*, and the details regarding the origin of the tusks.	*Length* following the curve.	*Diameter* at the thick end.	Weight.
HARTENFELS. Elephantographia, pp. 47 & 48.	Tusk of Sumatra, according to Louis Vartoman, quoted by Jonston	..	..	168 *l.*
	Tusk mentioned by J. C. Scaliger, *de Reb. Ind.*	..	..	162
	Tusk from the Cabinet of Septal, quoted by Herzog.	..	..	160
	Tusk mentioned by Vielhauer, in his treatise *on foreign drugs.*	..	..	200
	— by Louis Barth *Rer. ind.*	..	..	325
	Tusk brought from India to Bale, quoted by Munster in his *Cosmographie.*	9′	..	100 thereabouts
	Id.	..	..	114
	Another tusk mentioned by J. C. Scaliger.	more than 5′	..	..
	Id. by Al. Cadamosto.	8′	..	..
	The largest tusks according to Gyllius.	10′	..	..
	A tusk possessed by a Venetian merchant.	14′	..	..
	The tusks taken by Aurelian, according to Flavius Vopiscus.	10′ rom.	..	..
Camper, Anat. descript. of an elephant.	The ordinary tusks of Guinea.	..	..	100 to 120
	A tusk belonging to M. Wolfers, merchant of Amsterdam.	8′ of the Rhine.	9″⅓	208
	Tusk belonging to M. Ryssnyder, merchant of Rotterdam, according to Klokner.	..	..	250
	Tusk sold at Amsterdam, according to the same.	..	..	350
	Tusk from the cabinet of Camper.	6″	7″	105