ON THE

ANATOMY OF VERTEBRATES.

VOL. III.

MAMMALS.

BY

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enters the 'ventricle' becomes contracted to a very small extent of the base exterior to the crus. From this point begins the fold extending, as 'choroid plexus,' from one ventricle to the other by the fissure called 'foramen Monroianum' in Anthropotomy. On the interior surface of the hemisphere the pia mater is reduced to an epithelium, the cells of which are less flat in the lateral ventricles than in that continuation therefrom called 'third ventricle.' The part of the interhemispheral fissure overarched by the great transverse commissure is the 'fifth ventricle.' For other differentiated and definite parts in the archencephalous brain—the subjects of the 'bizarre' nomenclature of Anthropotomy—reference may be made to the minute and exact monographs which have been published on that part of the human structure.

§ 209. *Size of Brain.*—The brain grows more rapidly than the body, and is larger in proportion thereto at birth than at full growth. But there is a difference in this respect in different Mammalian orders. The brain of the new-born Marsupial is less developed relatively than in higher Mammals, and grows more gradually or equally with the subsequent growth of the body.[1] So, in the degree in which a species retains the immature character of dwarfishness, the brain is relatively larger to the body: it is as 1 to 25 in the pygmy Petaurist, but is as 1 to 800 in the Great Kangaroo; it is as 1 to 20 in the Harvest Mouse, but is as 1 to 300 in the Capybara; it is as 1 to 60 in the little two-toed Ant-eater, and is as 1 to 500 in the Great Ant-eater. The brain weighs 6 grains in the Harvest Mouse (*Mus messorius*), and the same in the Common Mouse (*Mus musculus*); but the weight of the Harvest Mouse is 112 grains, whilst that of the Common Mouse is 327 grains. The brain of a Porpoise, 4 feet long, may weigh 1 lb. avoird.; that of a Whale (*Balænoptera*) 100 feet in length does not exceed 4 lbs. avoird.[2] In Artiodactyles the brain of a pygmy Chevrotain (*Tragulus pygmæus*) is to the body as 1 to 80; in the Giraffe[3] it is as 1 to 800. In Perissodactyles the brain of the Hyrax is as 1 to 95, whilst that of the Indian Rhinoceros is as 1 to 764.[4] The brain of the Elephant may be three times heavier than that of the Rhinoceros, but a full-grown male would probably weigh down four Rhinoceroses. In Carnivora the brain of the Weasel is to the body as 1 to 90; in the Grisly Bear it is as 1 to 500; in Quadrumana the brain of the

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[1] LXXV′, p. 347, pl. vii. figs. 9–12.

[2] SCORESBY, in a *Balæna mysticetus* of 65 feet in length, found the weight of the brain to be 3 lbs. 12 oz.

[3] XCVII′.

[4] V″.

Midas Marmoset is to the body as 1 to 20; in the Gorilla it is as 1 to 200.

But such ratios do not show the grade of cerebral organisation in the Mammalian class: that in the Kangaroo is higher than that in the Bird, though the brain of a Sparrow be much larger in proportional size to the body: and the Kangaroo's brain is superior in superficial folding and extent of grey cerebral surface to that of the Petaurist. The brain of the Elephant bears a less proportion to the body than that of Opossums, Mice, and proboscidian Shrews, but it is more complex in structure, more convolute in surface, and with proportions of pros- to mes-encephalon much more nearly those in the human brain. The like remark applies to all the other instances above cited.

The weight of the brain, without its membranes, in a full-grown male Gorilla is 15 oz. avoird. I estimate that of the entire body as being nearly 200 lbs.: in the relatively larger brains of the small species of *Quadrumana* the convolutions are fewer, or may be absent, as in *Midas.*

In Man alone is a bulk of body, greater than in any Quadrumana save Gorilla, associated with a large size as well as with the highest stage of complexity of the cerebral organ. This is, perhaps, the most notable and significant fact in Comparative Anatomy.

The weight of the brain in the adult male averages about 49 oz. avoird., and ranges from about 35 oz. to 65 oz. In the adult female the weight of the brain averages about 43 oz. and a half, and ranges from 32 to 54 oz. The mean difference is thus about five ounces and a quarter. The brain has advanced to near its term of size at about ten years, but it does not usually obtain its full development till between twenty and thirty years of age, and undergoes a slight decline in weight in advanced life.[1]

The brain, without dura mater, of an Australian female, of 5 feet 3 inches high, weighed 32 oz.; that of a Bushwoman, 5 feet high, is estimated, in LIII″,[2] at 30·75 oz. In European females the brain has been found as low in size; but the requisite observations to determine the range and the average of cerebral development have hitherto been made only on Europeans.[3] The weight of the brain of the male Hottentot, 3 lbs. 2 oz. avoird., dissected by WYMAN,[4] encourages the expectation of analogous

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[1] If the capacity of a cranium in cubic inches be ascertained, a fair and instructive notion of the weight of the brain may be obtained by estimating that of a cubic inch of it at 259·57 grains.

[2] LVIII′.

[3] XLIX″, L″, LXI″.

[4] LVIII″.

The conch is small and erect in the Wild-hogs, larger and pendant in the domestic breeds.

In the Anoplothere the bony outer aperture of the ear was round and horizontal, the passage directed from the tympanum backward. The diameter of the semicircular canals, as in most other Ungulates, is relatively less than in most small Lissencephalous Unguiculates. The lower ridge of the petrosal is less marked in Camels than in true Ruminants. In these the stapes is usually arched, widely open, with thickish crura, grooved internally, fig. 175, C, *Bubalus*, the base a long oval. In the Ox the membrana tympani is oval; the handle of the malleus extends from above obliquely downward and forward to one-fourth of the long diameter from the small end, and lies near the anterior part of the circumference; consequently the posterior fibres diverging from the handle are longest: in the stapideus muscle is imbedded at the passage of the carneous into the tendinous part, a roundish ossicle, about three-fourths of a line in long diameter, and one-third of a line in short diameter. The tympanic bone is compressed and produced into a long auditory canal with a trenchant lower border, and the outlet almost horizontal. The ear-conch in Ruminants is commonly characterised by three vertical rows of hairs longer than the rest on the inner surface.

The external ears of the Horse, fig. 156, are most expressive appendages, in their extensive, rapid and various movements. The tympanic bulla is divided by an unusually regular series of radiating plates. The stapes, fig. 175, D, is an elongate triangle, with crura of unequal thickness, a produced cervix, and narrow oblong base. Both the stapideus and tensor tympani have thick fleshy portions: in the stapideus of the Horse there is an ossicle, smaller than in the Ox, and of a longish shape, thicker in the middle. The auditory chamber of the Tapir is small: the tympanic does not develope a meatus externus: the part supporting the membrane early coalesces with the squamosal and the post-tympanic part of the mastoid. The base of the stapes is elongate, fig. 179, E: the head of the malleus is compressed, its handle is bent. In the Rhinoceros, also, the tympanic, which is reduced to the frame of the membrane, is indistinguishable from the mastoid and squamosal with which it early becomes fused. The petrosal is very small. The stapes is triangular, with a moderate vacuity, and thick crura, ib. F: the crura of the incus are very short: the head of the malleus is bifid, its handle much curved. The conch is pedunculate, and expands into a moderate elliptical chamber, from the upper part of the head. The tympanic of *Hyrax* is swollen and continued into a short horizontal auditory tube: the base of the stapes is rarely ossified beyond the circumference: the crura of the incus are subequal and very divergent: the malleus has a long handle. The ear-conch is short and round.

This appendage, in *Carnivora*, enlarges and elongates progressively from the eared-seals and bears to the hyenas; exception being made for the aquatic *Mustelidæ* (*Lutra* and *Enhydra*) which are seal-like in its smallness, and for the Fennecs which show the opposite extreme; the character expressed by the subgeneric name *Megalotis* makes the Nubian species conspicuous in the old Egyptian frescos.

The seals offer a great contrast to the manatees in the relative size of the stapes, fig. 176, A, which is much smaller than the incus or malleus; but it presents a similar massive character, with inequality of thickness of the crura and a small perforation, ib. and fig. 170, D. In the walrus, ib. C, the stapes is imperforate. In all *Phocidæ*, the body of the incus is tumid with short subequal branches: the body of the malleus expanded, compressed, and its handle short. The tympanic is large and dilated: it coalesces with the petrosal and mastoid, and together they occupy a large interspace between the basisphenoid, basioccipital and squamosal. It is interesting and suggestive to find that with proportions and powers of the pinniform limbs that enable the Seals of the southern ocean to raise and move the trunk better than in most northern kinds, the ear-conch begins to be visible, whence the name '*Otaria*' for such sea-bears and sea-lions.

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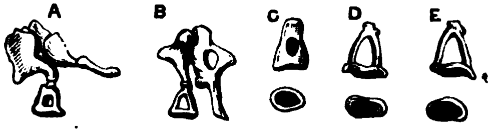

Stapes of *Carnivora*.

A. Seal. B. Otter. C. Bear. D. Dog. E. Tiger.

In Bears (*Ursus*) it has but a moderate perforation, fig. 176, C, showing the affinity to the Seals: the crura of the incus are of unequal length: the head of the malleus is subcompressed: its handle of moderate length, and its process short.

In the badger (*Meles*) the stapes is small, with an elliptic base and moderate vacuity; the crura of the incus are of unequal length: the malleus is large with a subcompressed head, and the handle terminally expanded. The tympanic is large and moderately inflated. The stapes of the kinkajou has a larger base anterior surface of the iris. The quantity of the aqueous humour is small: the lens, *d*, is subspherical, flatter in front than behind. The nucleus is seen in the posterior half and the surrounding laminæ are reflected inward and backward toward the middle of the anterior surface of the nucleus, leaving a funnel-shaped cavity in front of it which is filled by less dense substance. In *Hyperoödon* the pupil is transversely oblong with a moderate projection of the upper margin, reminding one of the skate's pupillary curtain (vol. i. p. 334). In the Grampus the choroid presents a greenish tinge: in the Porpoise it is a bluish white. In both, the pupil resembles that of *Hyperoödon*. The retina is thick.

In the Seals the sclerotic is chiefly remarkable for the sudden thinning at the part corresponding with the ciliary zone; it is moderately thick both in front and behind: the cornea is thin and flabby. The muscles of the eye-ball being inserted into the anterior part of the sclerotic may shorten the axis of the eye and bring the lens nearer to the back of the globe, thus adapting it to vision in air and water. In the *Sirenia* the eye is very small. In a *Rhytina* of 25 feet in length the eye-ball was but 1¼ inch in diameter: it is about 1 inch in diameter in the Dugong: the pupil is circular.

The eye of the Elephant is about 2 inches in diameter, reminding one of that in the Whale by its small relative size: there is likewise an unusual thickness of fibrous or sclerotic substance at the entry of the optic nerve, and a similar extent of light-coloured tapetum within the choroid, which tapetum presents the fibrous type of structure: the pupil is round, the cornea is larger and more convex than in *Cetacea*.

In the Rhinoceros the eyeballs are of small comparative size; in the Indian species which I dissected,[1] each measured in antero-posterior diameter one inch five lines, and in transverse diameter one inch three lines. Some dark-brown pigment lies under the conjunctiva for the extent of about a line from the circumference of the cornea: the same kind of pigment is also deposited upon the outside of the nictitating eyelid, and over a great part of the inner surface of the same part, covered of course by a reflection of the conjunctiva. The trunks of the venæ vorticosæ perforate the sclerotica half-way between the entry of the optic nerve and the edge of the cornea: their disposition, with the flocculent but somewhat firm connecting tissue of their radiating branches, presented that structure which most nearly resembled the figures given by Mr. Thomas of the parts he

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[1] v'', p. 56.

describes as 'processes having a muscular appearance, with the fibres running forwards in a radiated direction.'[1] On removing the anterior part of the sclerotica, whilst the eye was suspended in spirit, both the vitreous humour and the lens rolled out; and the capsule of the lens showed no particular mark of the insertion or fixation of the ciliary processes; their impressions, in remains of pigmental matter, were perceptible on the anterior part of the 'canal of Petit.' The transverse diameter of the lens was six lines, the antero-posterior diameter four lines. The pigment was not confined to the inside of the choroid; but in both Rhinoceroses dissected by me, I found on the outside of the chorion much loose cellular tissue, with dark pigment: this coloured flocculent tissue concealed at first the venæ vorticosæ, even when injected. The sclerotica is one line thick at the back part of the eyeball; and is thinnest near the middle of the ball, becoming thicker towards the cornea, which is two lines thick. The choroid adheres pretty strongly to the back part of the sclerotic, around the entry of the optic nerve, both by the entering vessels and by the tenacity of its outer flocculent coat, especially where the vessels penetrate the sclerotica. There is no tapetum lucidum. The lower eyelid has a special depressor muscle.[2]

The Tapir has a proportionally small eyeball. Of the Perissodactyle group the Horse has the largest eyes, in relation to its greater powers of locomotion. They are lateral, prominent, capable of directing against any object in the rear, without turn of the head, the outkick of the hind-leg. The cornea inclines to an oval figure, the larger end being toward the nose. The tapetum is of a light blue colour, and fibrous structure: the ciliary processes are long; more numerous than in the ox: the pupil is transversely oblong, rather wider on the nasal side, with a few processes from the upper margin.

In the Hog-tribe the cornea is oval, with the large end internal, or toward the nose; the sclerotic is thin; the pupil is round; the eyeball rather larger than the palpebral opening would indicate; the inner figure of the choroid is of a shining chocolate colour in the common Hog, but much darker in the Babyroussa. The eyes in Ruminants are large, lateral; the transverse exceeds the fore-and-aft diameter of the eyeball. In the Ox the latter is to the transverse diameter as 43 to 49; in the sheep as 32 to 35. The ciliary processes are short in most, especially in some Antelopes: the retina extends far forward.

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[1] cvi″, p. 157, pl. x., figs. 1-3.

[2] v″, p. 56.

feeding animal, allied to the viverrine and canine families, the true molars presenting the tuberculate modification, and the typical number and kinds of teeth being functionally developed, as in the *Hyænodon*. The series in the upper jaw are shown in fig. 267. The term 'tubercular' is as applicable to the three true molars of the *Amphicyon*, *m* 1, 2, 3, as the term 'carnassial' is to those of the *Hyænodon*.

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Dentition, upper jaw, *Amphicyon*.

§ 221. *Teeth of Ungulata.*—The most common characteristic of this dentition is the large size, cuboid shape, and complex structure of the crowns of the grinding teeth. The enamel not only incloses but dips or penetrates into the substance of the dentinal body, and the cement, which is thick, accompanies the enamel. Thus the massive grinding organ is made up of substances of different densities, and the working surface is irregular by the projections of the harder material, as in the mineral 'grit' that is thereby suitable as a millstone.

A. *Homologies of the parts of the grinding surface.*—The pattern of the grinding surface, especially of the upper molars, varies in each genus of Ungulata, and is eminently characteristic thereof. Nevertheless, two leading types may be recognised. One, of unsymmetrical character, was early shown in *Palæotherium*, and is traceable in secondary modifications characteristic of *Paloplotherium*, *Hipparion*, *Equus*, *Hyrax*, and *Rhinoceros*. A second was as early manifested in *Anoplotherium* and *Dichodon*; it is more symmetrical in pattern, and is traceable, with modifications, in *Dicotyles*, *Sus*, *Hippopotamus*, and *Ruminants*. Indications of a more generalised type of molar have been obtained from tertiary deposits antecedent in time to those characterised by *Palæo-* or *Anoplo-therium*: they are afforded by *Pliolophus*,[1] and *Coryphodon*.[2] The answerable parts of the grinding surface will first be illustrated in the unsymmetrical series. In *Palæotherium*, e. g. fig. 268, the tract of dentine, *a*, *b*, extending along the outer side of the crown, has two indents, *f*, *f*, whereby it is divided into two lobes, an anterior or 'ant-external lobe,' *a*, and a posterior or 'post-external lobe,' *b*. The tract of dentine along the inner side of the crown is also divided by two deeper and more oblique clefts or valleys into an 'ant-internal lobe,' *c*, *m*, and a 'post-internal lobe,' *d*: these lobes extend obliquely inward and backward from the outer ones, of which they are direct continuations. The anterior of the two inner clefts, *e*, *i*, extends from the middle of the inner surface of the crown obliquely outward and forward: the posterior one, *g*, *h*, enters at the posterior side of the crown, and extends nearly parallel with *e*, *i*: both valleys expand and deepen at their blind ends. At an early period of the attrition of the crown they intercommunicate, and extend to the anterior side of the crown, at *l*, as in the younger molar of *Paloplotherium*, fig. 269. But the shallow communicating passages between *h* and *i*, *i* and *l*, are soon obliterated, the dentine of lobe *d* becoming continuous with *b*; and that marked *e* with *a*. In *Paloplotherium* a branch valley, also, extends from *e* *i*, to the anterior side of the crown, *k*, cutting off the part of the ant-internal lobe *m* from the rest of *c*; but, by continued abrasion, this valley is also obliterated, and the tooth assumes more of the palæotherian pattern. In *Equus*, fig. 270, the valleys are of less equal depth than in *Palæotherium*, and are

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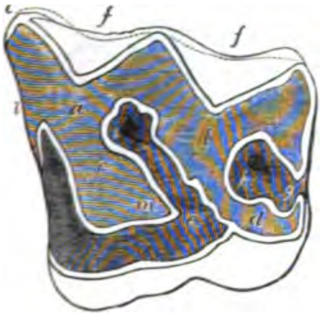

Upper molar (m 2): *Palæotherium magnum.*

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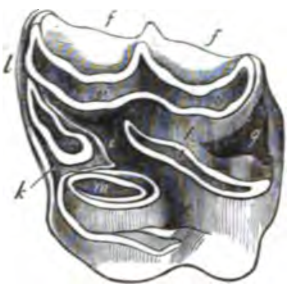

Upper molar (m 2): *Paloplotherium.*

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[1] cxv″. p. 54.

[2] cxvi″. p. 299.

so shallow midway that, at an early stage of attrition, the entry of the posterior valley, *g*, is separated from its termination, *h*; and that of the internal valley, *e*, from its termination *i*; the blind ends of both valleys, moreover, are more extended and irregular, than in *Palæotherium*, with the tendency to curve, so as to produce the crescentic form of the islands, *i*, *h*, in fig. 270. The obliteration of the mid-part of the accessory valley, *k*, unites the dentinal tract, *m*, to the rest of the lobe, *c*, as in *Palæotherium*, fig. 268: but it long remains separate in *Hipparion*, as in *Paloplotherium*, fig. 269.

The *Rhinoceros* and *Hyrax* more closely adhere to the Palæotherium type: but the outer indents, *f*, *f*, are less marked. The horse approaches nearest to the symmetrical type of the Ruminants, in which the homologous parts of the crown can, mostly, be well defined.

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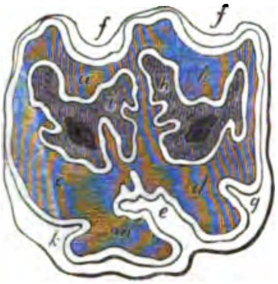

Upper molar (*m* 2), *Equus caballus*.

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Upper molar (*m* 2). *Megaceros*.

In the unworn crown of the Ruminant molar, fig. 271, the valley, *g*, *h*, extends across the crown more parallel with the long axis of the jaw, than in fig. 268, curving with the concavity outward: it communicates with the valley, *i*; and, as in *Paloplotherium*, this is continued to the foreside of the crown, as at *l*, fig. 269, severing the lobe *c* from *a*. In Ruminants, both the anterior and posterior entries to this antero-posterior double-curved cleft are so shallow that they are soon obliterated, and the lobe *b* is continued by a tract of dentine, with *d*, along the hind part of the crown: as the lobe *a* is continued into lobe *c* at the fore part, as seen in the worn molar of the deer, fig. 271: the middle of valley, *e*, is separated from the end *i*, as in the horse: but the course of this valley is more transverse, and more directly bisects the antero-posterior valley, *h*, *i*: thus the inner lobes *c* and *d* are more parallel with and similar to the outer lobes *a*, *b*. Whether the accessory lobule *m*, be a homologue of the end, so marked, of lobe *c* in *Palæotherium*, *Paloplotherium*, and *Equus*, or a special development at the entry of valley *e* may be doubtful.

In the Hippopotamus, fig. 272, the valley commencing at the inner side of the crown at *e*, extends straight across the tooth to *n*, bisecting the crown transversely: it is also bisected, antero-posteriorly, by a shallower valley, answering to *h*, *i*, fig. 271. At the stage of attrition shown in fig. 272, the remnant of the latter valley is seen at *h* and *i*: the deeper transverse valley, *e*, *n*, remains: the shorter indents, *f*, *f*, *g*, *k*, give the trefoil character to the two chief divisions of the crown characteristic of *Hippopotamus*.

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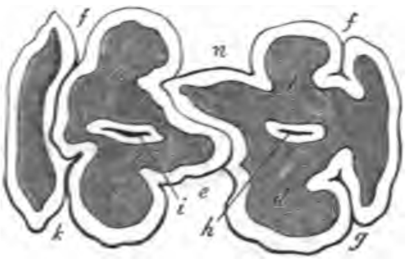

Upper molar (m 2), *Hippopotamus*

Another exposition of the homologous parts of the complex crowns of the Ungulate molars assumes the crucial division into four quarters or lobes to be the primitive modification. The fore-and-aft cleft has already begun to be filled by the mid-lobules in *Pliolophus*: the arrest of the outer end of the transverse cleft produces the continuity of *a* with *b*: that of its mid-part, of *d* with *e*: the obliteration of both ends of the antero-posterior cleft insulates that cleft, as in the Ruminant. The obliteration of the middle of the transverse cleft produces the continuation of *a*, *b*, with *d*, *c*; while the oblique continuation of *e* with *i*, and the retention of the continuity of *g* with *h*, leads to the type of *Palæotherium* and *Rhinoceros*.

A sub-type of grinding surface is produced by the existence of a transverse without an antero-posterior valley, dividing the crown into a pair of transverse ridges; as in the *Tapir*; which, however, is mainly the greater development, and more transverse disposition, of the tracts *b*, *d*, and *a*, *c*, in *Palæotherium*, fig. 268. The 'bilophodont' sub-type becomes more marked in *Dinotherium*, fig. 288, and in the anterior small molar of *Mastodon*: the successive multiplication of the transverse ridges completes the transition into the molar character of *Elephas*.

B. *Artiodactyla*. The extinct *Chæropotamus*, *Anthracotherium*, *Hyopotamus* and *Hippohyus*, had the typical dental formula, and this is preserved in the existing representative of the same section of non-ruminant Artiodactyles, the Hog. The permanent dental formula of the genus *Sus* is illustrated in fig. 273.

The upper incisors decrease in size from the first, *i* 1, to the third, *i* 3, receding from each other in the same degree; the first is relatively larger in the *Sus larvatus* than in the *Sus scrofa*; the basal line of the enamel is irregular; that substance extends more than an inch upon the outer side of the tooth, but only two or three lines on the inner side. The lower incisors are long, subcompressed, nearly straight; the second is rather larger than the first; the third is the smallest, as in the upper jaw.

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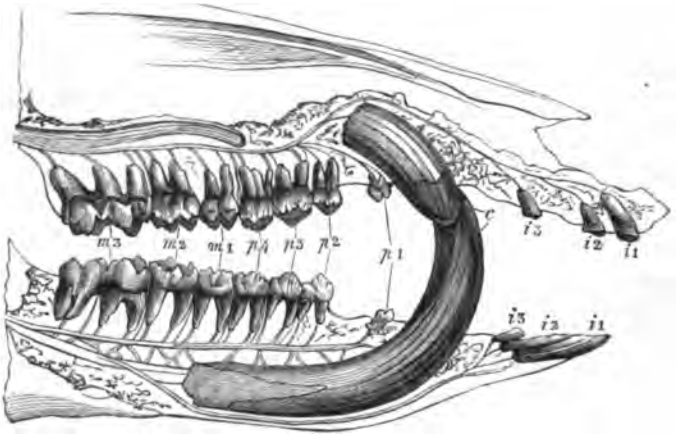

Dentition of Boar (*Sus*).

The upper canines, in the Wild Boar, fig. 273, *c*, curve forward, outward, and upward; their sockets inclining in the same direction, and being strengthened above by a ridge of bone, which is extraordinarily developed in the Masked Boar of Africa. The enamel covering the convex inferior side of this tusk is longitudinally ribbed, but is not limited to that part; a narrow strip of the same hard substance is laid upon the anterior part, and another upon the posterior concave angle forming the point of the tusk, which is worn obliquely upwards from before, and backwards from that point. In the Sow the canines are much smaller than in the Boar. Castration arrests the development of the tusks in the male.

The teeth of the molar series progressively increase in size from the first to the last. The first premolar, ib. *p* 1, has a simple, compressed, conical crown, thickest behind, and has two fangs. The second, *p* 2, has a broader crown with a hind-lobe, having a depression on its inner surface, and each fang begins to be subdivided. The third, *p* 3, has a similar but broader crown implanted by four fangs. The fourth, *p* 4, has two principal tubercles and some irregular vertical pits on the inner half of the crown. The first true molar, *m* 1, when the permanent dentition is completed, exhibits the effects of its early development in a more marked degree than in most other mammals, and in the Wild Boar has its tubercles worn down, and a smooth field of dentine exposed by the time the last molar has come into place; it originally bears four primary cones, with smaller subdivisions formed by the wrinkled enamel, and an anterior and posterior ridge. The four cones produced by the crucial impression, of which the transverse part is the deepest, are repeated on the second true molar *m* 2, with more complex shallow divisions, and a larger tuberculate posterior ridge. The greater extent of the last molar, *m* 3, is chiefly produced by the development of the back ridge into a cluster of tubercles; the four primary cones being distinguishable on the anterior main body of the tooth. The crowns of the lower molars are very similar to those above but are rather narrower, and the outer and inner basal tubercles are much smaller, or are wanting; the grinding surface of the last is shown in fig. 274.

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Grinding surface, (*m* 3) *Sus.*

The first or deciduous dentition of the Hog consists of—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 28 \text{ (fig. 294).}$$

The canines are feeble, and have their normal direction in both jaws, the upper ones descending according to the general type, which is not departed from until at a later period of life. The first deciduous molar is not succeeded by a premolar, but holds the place of such some time after the other deciduous molars are shed.

The dentition of the Wart-hogs is reduced by the suppression of certain incisors and of the first two premolars—the tooth-forming energy being, as it were, transferred to the last true molar, fig. 275, *m* 3, which is even more remarkable than in the common hog for its size and complexity in both jaws: it is perhaps the most peculiar and complex tooth in the whole class of *Mammalia.* The surface of the crown presents three series of enamel-islands, in the direction of the long axis of the grinding surface; the eight or nine islands of the middle row are elliptic and simple; those of the other rows are equal in number, but are sometimes subdivided into smaller islands. These islands or lobes are the abraded ends of long and slender columns of dentine, encased by thick enamel, and the whole blended into a coherent crown by abundant cement, which fills up all the interspaces, and forms a thick exterior investment of the entire complex tooth.

The milk-molars are $\frac{3}{2}:\frac{3}{2}$ in number; but only the two last are succeeded by premolars. These are small, and, after the wearing out of the first true molar, are shed, leaving the remnant of the second true molar, fig. 275, *m* 2, with the last large one, *m* 3, to which the work of mastication is confined in old Wart-hogs. This interesting modification, as to order and number, in the change of the dentition, has thrown important light on the more anomalous dentition of the Elephant.[1]

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Dentition, lower jaw, old Wart-hog (*Phacochoerus*).

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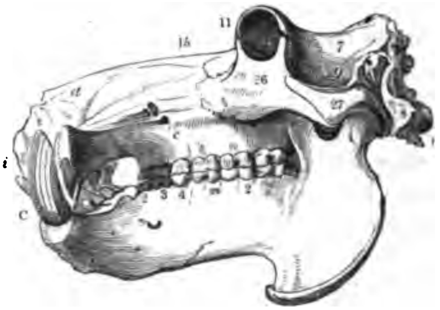

Dentition of Hippopotamus.

The tendency to excessive development which characterises the canine teeth in the *Suidæ,* affects both these and the incisors in the genus *Hippopotamus.* The two median inferior incisive tusks, fig. 276, *i,* are cylindrical, of great size and length; the two outer incisors are likewise cylindrical and straight, but much smaller. The upper canines curve downward and outward; their exposed part is very short, and is worn obliquely at the forepart; they are three-sided, with a wide and deep longitudinal groove behind. The lower canines, ib. *c,* are massive, curved in the arc of a circle, subtriedral, the angle rounded off between the two anterior sides, which are convex and thickly enamelled, the posterior side of the crown being almost wholly occupied by the oblique abraded surface opposed to that on the upper canine. The implanted base of each of these incisive and canine teeth is simple, and excavated for a large persistent matrix, contributing to their perennial growth by constantly reproducing the dental matter to

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[1] CLXXIII'', p. 495.

replace the abraded extremities. The direction of the abraded surface is in part provided for by the partial disposition of the enamel. The molar series consists of—

$$p\,\frac{4.4}{4.4};\ m\,\frac{3.3}{3.3} = 28.$$

The first premolar is small, far in advance of the second, and is soon shed: the others (fig. 276, 2, 3, 4) form a continuous series with the true molars (*m*, 2, 3). These have the double trefoil character shown in fig. 272. The crown of the last, in the lower jaw, is lengthened by a fifth cusp developed behind the normal pairs. The large tusks, fig. 276, *c*, exhibit the maximum of density in their component tissues. The enamel 'strikes fire' with steel like flint. The compact dentine has a high commercial value, especially for the fabrication of artificial teeth. It differs from true ivory by showing, in transverse section, the simple concentric instead of the 'engine-turned' or curvilinear decussating lines.[1]

The affinities of the Hippopotamus are clearly manifested by the character of its deciduous dentition; and if this be compared with the dentition at a like immature period in other *Ungulata*, it will be seen, by its closer correspondence with that of Artiodactyles, and more especially the Phacochere, that the Hippopotamus is essentially a gigantic Hog.

The formula of the teeth which are shed and replaced, is—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 24.$$

If the small and simple tooth, which is developed anterior to the deciduous molars, and which has no successor, be regarded, from its early loss in the existing Hippopotamus, as the first of the deciduous series, we must then reckon with Cuvier four milk-molars on each side of both jaws.

The incisors in both jaws are simply conical and subequal, with an entire cap of enamel on the crown. The deciduous canines scarcely surpass them in size in the upper jaw, and not at all in the lower. Projecting forward, here, from the angles of the broad and straight symphysis, they appear like an additional pair of incisors; and this character of equality of development was retained by the ancient form of Hippopotamus with the more typical number of incisors, $\frac{3}{3}:\frac{3}{3}$, which formerly inhabited India.

The first true deciduous molar, *d* 2, has a conical crown and two fangs in both jaws. That above has also a conical crown with one strong posterior and two anterior ridges. The second

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[1] In v. is described (p. 569) and figured (pl. 142), the lower tusk of a Hippopotamus which, after fracture, had been united again by a mass of 'osteodentine.'

deciduous molar, *d* 3, has a large trilobate crown, the first lobe small, with an anterior basal ridge; the second large, conical, with three longitudinal indentations; the third lobe still larger, and cleft into two half-cones by an antero-posterior fissure assuming the normal pattern of the true molars. The third deciduous molar, *d* 4, above more closely resembles the ordinary upper true molar; but its second pair of demi-cones are relatively larger. In the lower jaw the last deciduous molar, *d* 4, has a more complex crown than that of any other teeth of the permanent or deciduous dentition. It has three pairs of demi-cones, progressively increasing in size, from before backward, with an anterior and posterior basal ridge and tubercles. Like the last trilobate deciduous lower molar of the Hog, it increases in thickness posteriorly, instead of diminishing here, like the last true molar of the lower jaw of the adult Hippopotamus.

The upper incisors, and the first premolar of both jaws, are not developed in the typical Ruminants, rarely the upper canines: the dental formula being:—

$$i\,\frac{0.0}{3.3};\ c\,\frac{0.0}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 32 \text{ (vol. ii. p. 474, fig. 324).}$$

The gazelle, the sheep, the ox—respectively representing the families *Antilopidæ*, *Ovidæ*, and *Bovidæ*, which are collectively designated the 'hollow-horned ruminants'—all present this formula. It likewise characterises many of the solid-horned ruminants, or the deer tribe (*Cervidæ*), the exceptions having canine teeth in the upper jaw of the male sex, and sometimes also in the females, though they are always smaller in these.

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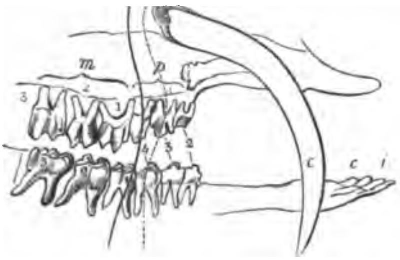

Dentition, Moschus moschiferus.[1]

The upper canines attain their greatest length in the Muntjac (vol. ii. p. 478, fig. 328, *a a*) and the small Musk-deer, and especially in the typical species (*Moschus moschiferus*, fig. 277.) These teeth, indeed, in the male Musk, ib. *c*, present proportions intermediate between those of the upper canines of the Machairodus and of the Morse. The inverse relationship in the development of teeth and horns, exemplified by the total absence of canines in the Ruminants with persistent frontal weapons, by their first appearance

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[1] The line traverses the Cuvierian 'dents carnassières'; the interrupted line traverses the Blainvillian 'dents principales'.

in the periodically hornless deer, and by their larger size in the absolutely hornless Musks, is further illustrated by the presence not only of canines, but of a pair of laniariform incisors, fig. 278, *i*, in the upper jaw of the *Camelidæ.*

In the Camel and Dromedary the upper canines, fig. 278, *c*, are formidable for their size and shape, but do not project beyond the lips like the tusks of the Musk-deer; they are more feeble in the Llamas and Vicugnas, and are always of smaller size in the females than in the males. The inferior canines, *o*, moreover, retain their laniariform shape in the *Camelidæ*, and are more erect in position than in the ordinary Ruminants. They are separated by a short diastema from the incisors in the *Auchenia.*

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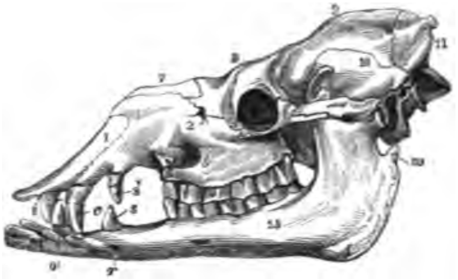

Dentition of Camel (*Camelus bactrianus*).

The true nature of the corresponding canines in the ordinary Ruminants, in which they are procumbent, and form part of the same series with the incisors, is always indicated by the lateness of their development, and often by some peculiarity of form. Thus in the *Moschus*, fig. 277, *c*, they are smaller and more pointed than the incisors; in the Giraffe they have a much larger crown, which is bilobed. The laniariform tooth in the premaxillary bone of the *Camelidæ*, fig. 278, 1, which represents the upper and outer incisor, *i*, is smaller than the true canine, *c*, which is placed behind it in the Camel and Dromedary; but in the Vicugna it is as large as, or larger than, the true canine.

Most of the deciduous molars of the Ruminants resemble in form the true molars; the last milk-molar, for example, fig. 279, *d* 4, in the lower jaw, has three lobes like the last lower true molar, *m* 3. The deciduous molars in existing true Ruminants are three in number on each side, and, being succeeded by as many premolars, the ordinary permanent molar formula is—

$$p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3};$$

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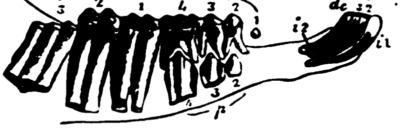

Deciduous and permanent teeth of a Sheep.

but there is a rudiment of *d* 1 in the embryo Fallow-deer, and in one of the most ancient of the extinct Ruminants (*Dorcatherium*, Kaup) the normal number of premolars was fully developed.

The characteristic complexity of the Ruminant grinder, fig. 271, is seen, in the permanent series, only in the three posterior teeth of both upper and lower jaws, which are the true molars; the three first, or premolars, having more simple crowns than those which they displace. The complexity in question is the result of peculiar plications of the formative capsule, some of which are longitudinal, or project inward from the sides of the capsule, and form peninsular folds of enamel upon the grinding surface of the tooth, whilst others depend vertically from the summit of the matrix into the body of the tooth, and form islands of enamel when the crown begins to be worn. Of the longitudinal folds, two in the upper true molars are external, broad, but shallow, and often sinuous, and one is internal, narrow, and deep, extending quite across the summit of the crown of the tooth, and decreasing in depth toward the base of the crown. The corresponding fold of enamel in the completed tooth, accordingly, extends more or less across the crown, from within outward, as the tooth is less or more worn. The whole circumference of this complex molar is also invested by a coat of enamel and a thinner layer of cement. In some Ruminants, e.g. Ox, Deer, and Giraffe, a small vertical column, fig. 271, *m*, is developed at the internal interspace of the two lobes of one or more of the upper true molars, varying in height, and rarely reaching the summit of the new-formed crown, but longest in the *Bovidæ*. Different genera of Ruminants also differ in the depth and sinuosity of the two outer longitudinal folds, *f*, and in the depth and complexity of the two vertical folds, *h*, *i*, which likewise are united in some species by a longer common base than in others, producing thereby a continuity of the enamel, and complete antero-posterior bisection of the grinding surface during a longer period of attrition. The molars of the Camel present the most simple condition of the Ruminant type of these teeth; the transverse fold dividing the crown being short, the dentine of the two lobes soon forms a continuous tract. The common base of the crescentic vertical folds of the capsule being likewise short, the enamel islands are soon separated from each other. They include a shallow or narrow crescentic cavity, with a simple but slightly sinuous contour. The two outer shallow longitudinal depressions of the crown have no middle rising; and there is no columnar process at the interspace of the two inner convexities.

The lower molars are like the upper ones reversed. The single median longitudinal fold is external, and divides the convex outer sides of the two lobes. The base of the fold extends, in some species, across the molar for some distance before it contracts in breadth, retreating toward the outer side, and the two lobes of the crown accordingly continue to be completely divided for a longer period, as in the Elk and Giraffe. The inner surface of the molar is gently sinuous, the concavities being rarely so deep as those of the outer surface of the upper molars. The lower molars are always thinner, in proportion to their breadth, than those above, and the crescentic islands are narrower and less bowed. The differences which the lower molars present in different genera of Ruminants are analogous to those in the upper molars, but are less marked. The accessory small column, when present, as in *Bos*, *Urus*, *Megaceros*, and *Alces*, is situated at the outer interspace of the convex lobes, and nearer the base in the *Cervidæ* than in the *Bovidæ*. It is not developed in the Antelopes, Sheep, or Camel, and is wanting in most of the smaller species of Deer. The last true molar of the lower jaw is characterised in all Ruminants by the addition of a third posterior lobe. This is very small and simple in the Camel and the Gnu, is relatively larger in the *Bovidæ* and *Cervidæ*, and presents, in the *Megaceros* and *Sivatherium*, a deeper central enamel island or fold, which also characterises the smaller third lobe in the Giraffe. The lower molars of the genus *Auchenia* are peculiarly distinguished by the vertical ridge at the forepart of the anterior lobe, which does not exist in the Camels of the Old World.

In all Ruminants, the outer contour of the entire molar series is slightly zigzag, the anterior and outer angle of one tooth projecting beyond the posterior and outer angle of the next in advance. All the three lower premolars have compressed, subtrenchant, and pointed crowns in the small Musk-deer (*Tragulus*). The true Musk (*Moschus*) more resembles the ordinary Deer in its premolars. The aberrant *Camelidæ* deviate most from ruminant type in the position, shape, and number of the premolars: the anterior one, fig. 278, *s*, is laniariform in both jaws.

As phenomena of dentition serve to determine, or indicate, the age of Hoofed beasts, a table is subjoined in which the characteristic teeth are indicated by the symbols adopted in my 'Odontography' (V), and illustrated in figs. 279 and 294, with reference to those domesticated varieties raised for food, which are usually exhibited, in competition, of prescribed ages, at the great cattle shows. The range of variety, for which allowance may be made, is noted in the Ox and Sheep.

Table of the Times of Appearance of the Permanent Teeth in the Ox, Sheep, and Hog.

Symbols.	OX.				SHEEP.				HOG.	
	Early.		Late.		Early.		Late.			
	Year.	Month.	Year.	Month.	Year.	Month	Year.	Month.	Year.	Month.
i 1	1	9	2	3	1	0	1	4 to 8	1	0
i 2	2	3	2	9	1	6	2	0 to 4	1	6
i 3	2	9	3	3	2	3	2	9 to 12	0	9
c	3	3	3	9	3	0	3	6	0	9
m 1	0	4	0	6	0	3	0	6	0	6
m 2	1	3	1	8	0	9	1	0	0	10
m 3	2	0	2	3	1	6	2	0	1	6
d or *p* 1	0	0	0	0	0	0	0	0	0	6
p 2	2	6	2	8	2	0	2	6	1	0
p 3	2	6	2	8	2	0	2	6	1	0
p 4	2	8	3	0	2	3	2	6	1	3

c. *Perissodactyla.*—The Horse is selected as the first example of the dentition of the hoofed Quadrupeds with toes in uneven number, because it offers in this part of its organisation some transitional

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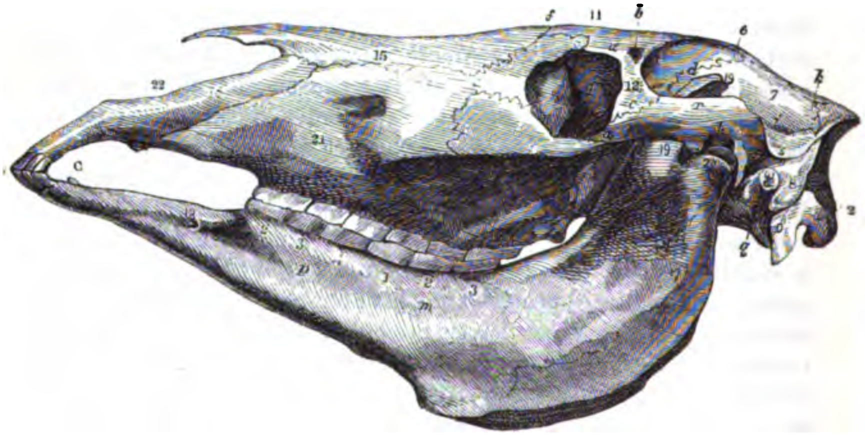

Dentition of Horse (*Equus*).

features between those of the dental characters of the typical members of the artiodactyle and of those of the perissodactyle *Ungulata.*

All the kinds of teeth are retained, in nearly normal numbers, in both jaws, and with almost as little unequal or excessive development as in the Anoplothere; but the prolongation of the slender jaws carries the canines, figs. 280, *c,* and incisors, ib. *i,* to some distance from the molars, and creates a long diastema, as in the Ruminants and Tapirs. The first deciduous molar is very minute and is not succeeded by a premolar; yet, remaining longer in place than the larger deciduous molars behind, it represents the first premolar, and completes the typical number of that division of the grinding series. If the dental formula of the genus *Equus* be restricted to the functionally developed permanent teeth, it will be—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3};\ = 40.$$

The outer side of the upper molar of the Horse (*Equus Caballus*, fig. 269) is impressed, as in the Palæothere, fig. 267, by two wide longitudinal channels: the other evidences of the perissodactyle type of grinding surface, and the modifications thereof, are given at p. 341. In the lower jaw, the teeth, as usual, are narrower transversely than in the upper jaw; they are divided externally into two convex lobes by a median longitudinal fissure, and on the inner side they present three principal unequal convex ridges, and an anterior and posterior narrower ridge; but the crown of the molar is penetrated from the inner side by deeper and more complex folds than in the Rhinoceros or Palæothere.

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Section of Incisor Horse.

The incisors, figs. 280, 285, *i*, are arranged close together in the arc of a circle at the extremity of both jaws. They are slightly curved, longitudinally grooved, with long simple subtrihedral fangs tapering to their extremity, fig. 280. The crowns are broad, thick, and short. The contour of the biting surface, before it is much worn, approaches an ellipse. These teeth, if found detached, recent or fossil, are distinguishable from those of the Ruminants by their greater curvature, and from those of all other animals by the fold of enamel (ib. *c′*), which penetrates the body of the crown from its broad flat summit, like the inverted finger of a glove. When the tooth begins to be worn, the fold forms an island of enamel inclosing a cavity, *s*, partly filled by cement and partly by the discoloured substances of the food; this is called by horse-dealers the ‘mark.’ In aged horses the incisors are worn down below the extent of the fold, and the mark disappears. The cavity is usually obliterated in the first or mid-incisors at the sixth year, in the second incisors at the seventh year, and in the third or outer incisors at the eighth year, in the lower jaw. It remains longer in those of the upper jaw, and in both the place of the 'mark' continues for some years to be indicated by the dark-coloured cement or osteo-dentine.

The canines are small in the stallion, less in the gelding, and rudimental in the mare. The unworn crown is remarkable for the folding in of the anterior and posterior margins of enamel, which here includes an extremely thin layer of dentine. The upper canine is situated in the middle of the long interspace between the incisors and molars: the lower canine, fig. 280, *c*, is close to the outer incisor, as in the Ruminants, but is better distinguished by its cuspidate form.

The most obvious character by which the horse's molars may be distinguished from the complex teeth of other *Herbivora* corresponding with them in size, is the great length of the tooth before it divides into fangs. This division, indeed, does not begin to take place until much of the crown has been worn away; and thus, except in old horses, a considerable portion of the whole of the molar is implanted in the socket by an undivided base. This is slightly curved in the upper molars. It provides for mastication during a longer life than in the cow.

The following is the average course of development and succession of the teeth in the *Equus Caballus*:—The summits of the first functional deciduous molar[1] ('first grinder' of veterinary authors) are usually apparent at birth; the succeeding grinder[2] sometimes rises a day or two later, sometimes together with the first. Their appearance is speedily followed by that of the first deciduous incisor, fig. 282, *d* 1 ('centre nipper' of veterinarians), which usually cuts the gum between the third and sixth days; but occasionally protrudes at birth. The second deciduous incisor, ib. *d* 2, appears between the twentieth and fortieth days, and about this time the rudimental molar,[3] comes into place, and the last deciduous molar[4] begins to cut the gum. About the sixth month the inferior lateral or third incisors, ib. *d* 3, with the deciduous canine make their appearance. The lower minute canine is shed about the time that the contiguous incisor is in

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Deciduous Incisors of 1-year old Colt.
Lower jaw.

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[1] The homologue of *d* fig,2 . 287. [2] Ib. *d* 3. [3] Ib. *d* 1. [4] Ib. *d* 4.

place. The upper deciduous canine is shed in the course of the second year. The rise to working level of the third deciduous incisors or 'corner nippers' completes the stage of dentition called the 'colt's mouth' by veterinary authors, fig. 282. The deciduous incisors are not only smaller than the permanent ones, but are whiter, have a better marked 'neck,' the fang more slender and pointed, and are devoid of the median longitudinal groove. The first permanent molar, *m* 1, appears between the eleventh and fourteenth months. The 'second' molar, *m* 2, follows at the twentieth month or the second year. The first functional premolar, *p* 2, displaces the deciduous molar, *d* 2, at from two years to two years and a half old.[1] The first permanent incisor, fig. 283, *i* 1, displaces *d* 3, and protrudes from the gum at between two years and a half and three years. At the same period the second or penultimate premolar, *p* 3, pushes out the penultimate milk-molar, and the penultimate true molar, *m* 2, comes into place. The last premolar, *p* 4, displaces the last deciduous molar at between three years and a half and four years; the appearance above the gum of the last true molar, *m* 3, is usually somewhat earlier. The second incisor, fig. 284, *i* 2, pushes out its deciduous predecessor at about three years and eight months. The permanent canine or 'tusk,' *c*, next follows; its appearance indicates the age of four years and a half; but it sometimes comes earlier. The third, or outer incisor, fig. 285, *i* 3, pushes out the deciduous incisor, *d* 3, about the fifth year, but is seldom in full place before the horse is five years and a half old; the last premolar is then usually on a level with the other grinders. Upon the rising

283

Incisive dentition of 3-year old Colt.
Lower jaw.

284

Incisive dentition of 4-year old Colt.
Lower jaw.

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[1] The homologous teeth in the young Hyrax, fig. 287, are indicated by the same symbols, and the sole developmental difference from the Horse is the displacement of *d* 1 by a *p* 1 of functional size.

of the third permanent incisor, or 'corner nipper,' the 'colt' becomes a 'horse,' and the 'filly' a 'mare,' in the language of the horse-dealers; after the disappearance of the 'mark' in the incisors, at the eighth or ninth year, the horse becomes 'aged.'

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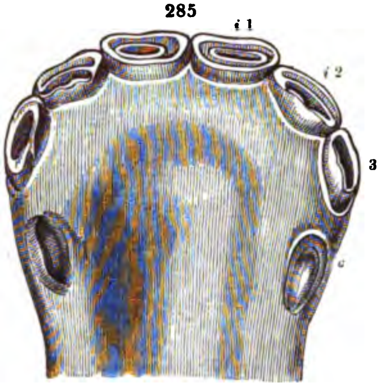

Incisive dentition, 5-year old Horse. Lower jaw.

The modifications which the upper molars of *Hyrax*, fig. 286, present, as compared with those of *Paleotherium*, will be readily understood by the remarks in the section on the homologies of the grinding surface, as illustrated by figs. 268–270. The present genus is a miniature form of the family, and, like the primitive eo- and miocene hornless rhinoceros (*Acerotherium*), retains large incisors, with a type molar series, e.g.

$$i\,\frac{1.1}{1.1};\ c\,\frac{0.0}{0.0};\ p\,\frac{4.4}{4.4};\ m\,\frac{3.3}{3.3} = 32.$$

There are no canines. As to the incisors in *Hyrax* or *Rhinoceros* the species vary, not only in regard to their form and proportions, but also their existence; and in the varieties of these teeth we may discern the same inverse relation to the development of the horns which is manifested by the canines of the Ruminants. Thus, the two-horned Rhinoceroses of Africa, which are remarkable for the great length of one (*Rh. bicornis, Rh. simus*) or both (*Rh. Keitloa*) of the nasal weapons, have no incisors in their adult dentition; neither had that great extinct two-horned species (*Rh. tichorinus*), the prodigious development of whose horns is indicated by the singular modifications of the vomerine, nasal, and premaxillary bones, in relation to the firm support of those weapons. The Sumatran bicorn Rhinoceros combines, with comparatively small horns, moderately developed incisors in both jaws. The incisors are of larger size in the unicorn Rhinoceroses (*Rh. Indicus* and *Rh. Sondaicus*); still larger, relatively, in the hornless Acerotherium and Hyrax, figs. 286, 287, *i*.

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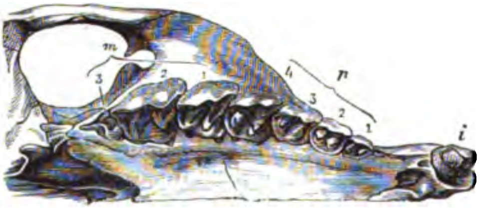
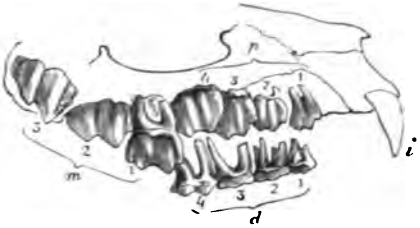


Dentition, upper jaw (*Hyrax*).

The deciduous molars of the Rhinoceros are, in number as well as in shape, similar to those in *Hyrax*, which bears the same relation to the great Rhinoceros as the small existing Sloth does to the extinct Megatherium. The change of dentition of the *Rhinocerotidæ* is, therefore, here illustrated by the young *Hyrax capensis*, fig. 287.

287



Deciduous and permanent teeth, *Hyrax*. Nat. size.

The four premolars, *p* 1, 2, 3, 4, are exposed above the four deciduous molars, *d* 1, 2, 3, 4, which they push out; the first true molar, *m* 1, is in place; the second, *m* 2, and third, *m* 3, molars are in different states of forwardness. The first premolar differs from the rest only by a graduated inferiority of size, which, in the last premolar, *p* 4, ceases to be a distinction between it and the true molars.

The dental formula of the Tapir is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{3.3};\ m\,\frac{3.3}{3.3} = 42 \text{ (vol. ii. p. 449, fig. 300, immature).}$$

The median incisors above have a broad trenchant crown, *k*, separated by a transverse channel from a large basal ridge; the wedge-shaped crowns of the opposite pair below fit into the channel, and have no basal ridge; the outer incisors above are very large and like canines; those below are unusually small. The canines, *l*, have crowns much shorter than their roots, and not projecting, like tusks, beyond the lips; they are pointed, with an outer convex, separated by sharp edges from an inner, less convex, surface. The lower canines form part of the same semicircular series with the incisors. The first three premolars above have the outer part of the crown composed of two half-cones, the posterior one having a basal ridge; the anterior basal ridge rises into a small cusp in the second premolar, which increases in size in the third and fourth; in this tooth the transverse depression divides at the base of the anterior and outer demicone, and the posterior division is continued into the interspace of the two demicones; these, therefore, now become in *m* 1 and *m* 2 the outer ends of the two transverse wedge-shaped eminences, giving their summits a curve whose concavity is turned backward; the last molar, *m* 3, may be known by the shorter and more curved posterior eminence. In the dentition of the lower jaw the double transverse ridged structure prevails throughout the molar series, the anterior talon being most produced and compressed in the first tooth, *p* 2.

Certain huge fossil bilophodont grinders, which seemed to indicate a gigantic Tapir, are now known, by the discovery of the cranium, and the enormous tusks of the lower jaw, fig. 288, *i*, to belong to a genus connecting the tapiroid with the proboscidian families.

The permanent dentition of the genus *Dinotherium* is—

$$i\,\frac{0.0}{1.1};\ c\,\frac{0.0}{0.0};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3} = 22.$$

The two deciduous molars *in situ* on each side of the fragment of the upper jaw of the young *Dinotherium*, which Professor Kaup[1] has figured, answer to the third and fourth of the typical series. The crown of the anterior milk-molar supports two transverse ridges with an anterior and posterior basal ridge; its contour is almost square; the last milk-molar has a greater antero-posterior extent, and supports three transverse eminences with an anterior and posterior basal ridge, the anterior ridge being developed into a pointed tubercle at its outer end. The two premolars, fig. 288, *p* 3 and 4, conform to the general rule in being more simple than the teeth which they displace and succeed. The transverse diameter of the second premolar exceeds the antero-posterior one, the proportions being the reverse of those of the deciduous molar, which it displaces. The first true molar, *m* 1, repeats the structure of the hindmost deciduous molar, its crown

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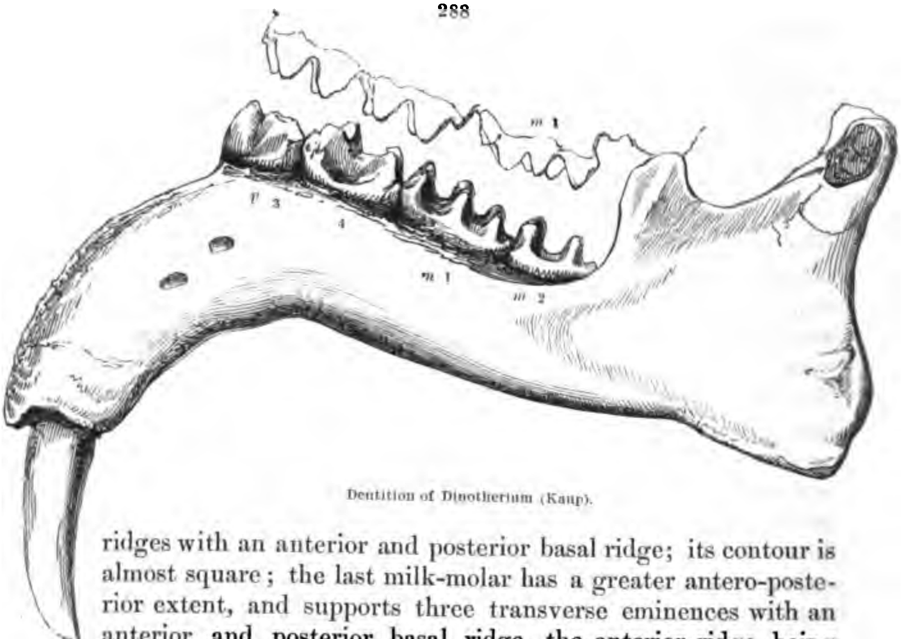

Dentition of Dinotherium (Kaup).

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[1] CLXIX″, p. 401; and CXIII″. Tab. I.

having a disproportionate antero-posterior extent, and supporting three transverse eminences, with an anterior, posterior, and internal basal ridge. The Dinothere resumes the tapiroid character, and differs from the Mastodon, inasmuch as the posterior molars, *m* 2 and 3, instead of having an increased antero-posterior extent and more complex crowns, increase only in thickness, and support two instead of three transverse eminences; they have also an anterior and a posterior basal ridge. In the lower jaw the first premolar, *p* 3, is implanted, like that above, by two fangs; but it has a smaller and simpler crown, which is narrower in proportion to its antero-posterior extent, and is almost entirely occupied by the antero-posterior ridge, only the posterior of the two inner tubercles being developed; thus the crown presents more of a trenchant than of a grinding character; the second premolar, *p* 4, supports two transverse ridges. The third of the permanent series, which is the first true molar, *m* 1, has three transverse ridges, like the one above, but is relatively narrower; the second, *m* 2, and third, *m* 3, true molars have each large square crowns, with two transverse ridges, and an anterior and posterior talon, the latter being more developed than in the corresponding molars of the upper jaw.

The generic peculiarity of the *Dinotherium* is most strongly manifested in its tusks. These, fig. 288, *i*, are two in number, implanted in the prolonged and deflected symphysis of the lower jaw, in close contiguity with each other, and having their exserted crown directed downward and bent backward, gradually decreasing to the pointed extremity. In jaws with molar teeth of equal size, the symphysis and its tusks offer two sizes; the larger ones, which have been found four feet in length, with tusks of two feet, may be attributed to the male Dinothere; the smaller specimens, with tusks of half size, to the female. The ivory of these tusks presents the fine concentric structure of those of the Hippopotamus, not the decussating curvilinear character which characterises the ivory of the Elephant and Mastodon. No corresponding tusks, nor the germs of such, have yet been discovered in the upper jaw of the *Dinotherium*.

D. *Proboscidia.*—The dentition of the genus *Elephas*, the sole existing modification of the once numerous and varied Proboscidian family, includes two long tusks, fig. 289, one, *i*, in each of the premaxillary bones, and large and complex molars, ib., *d* 4, *m* 1, *m* 2, in both jaws: of the latter there is never more than one wholly, or two partially, in place and use on each side at any given time, the series being continually in progress of formation and destruction, of shedding and replacement: and all the grinders succeed one another, like true molars, horizontally, from behind forwards.

The total number of teeth developed in the elephant appears to be $i\,\frac{2-2}{0-0}, m\,\frac{6-6}{6-6} = 28$: the two large permanent tusks being preceded by two small deciduous ones, and the number of molar teeth which follow one another on each side of both jaws being not less than six, of which the last three answer to the true molars of other mammals.

The deciduous tusk appears beyond the gum between the fifth and seventh month; it rarely exceeds two inches in length, and is shed between the first and second year.

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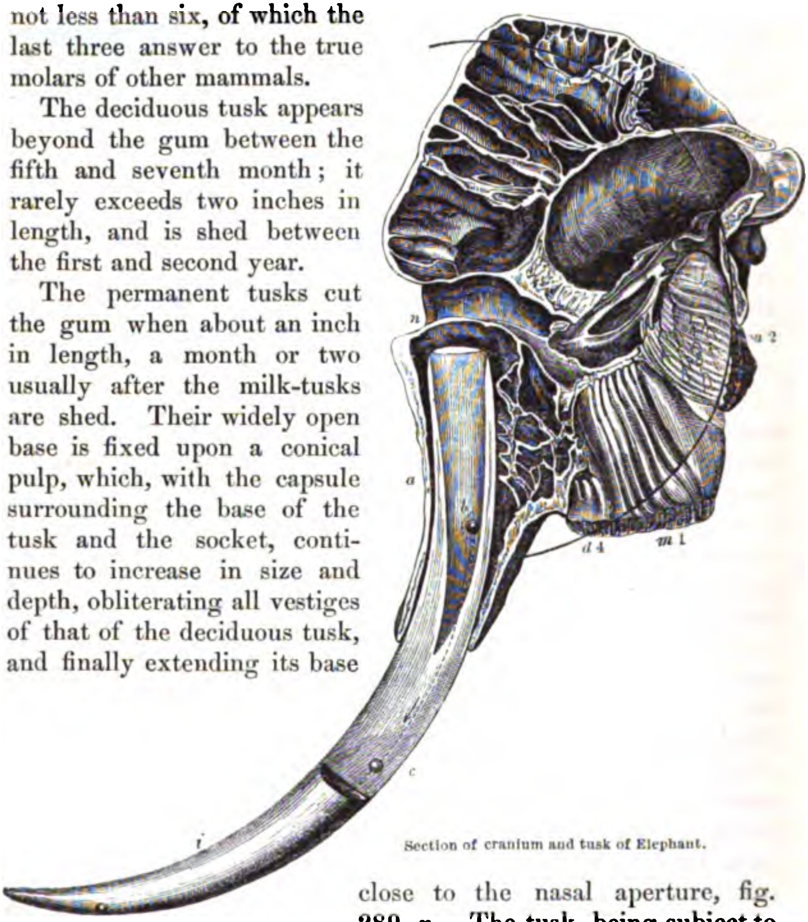

Section of cranium and tusk of Elephant.

The permanent tusks cut the gum when about an inch in length, a month or two usually after the milk-tusks are shed. Their widely open base is fixed upon a conical pulp, which, with the capsule surrounding the base of the tusk and the socket, continues to increase in size and depth, obliterating all vestiges of that of the deciduous tusk, and finally extending its base close to the nasal aperture, fig. 289, *n*. The tusk, being subject to no attrition from an opposed tooth, but being worn only by the occasional uses to which it is applied, arrives at an extraordinary length, following the curve originally impressed upon it by the form of the socket, and gradually widening from the projecting apex to that part which was formed when the matrix and the socket had reached their full size.

These incisive teeth of the elephant not only surpass other teeth in size, as belonging to a quadruped so enormous, but they are the largest of all teeth in proportion to the size of the body; representing in a natural state those monstrous incisors of the rodents, which are the result of accidental suppression of the wearing force of the opposite teeth, fig. 239.

The tusks of the elephant, like those of the mastodon, consist chiefly of that modification of dentine which is called 'ivory,' and which shows, on transverse fractures or sections, striæ proceeding in the arc of a circle from the centre to the circumference in opposite directions, and forming by their decussations curvilinear lozenges. This character is peculiar to the tusks of the Proboscidian Pachyderms.

In the Indian Elephant the tusks are always short and straight in the female, and less deeply implanted than in the male: she thus retaining, as usual, more of the characters of the immature state. In the male they have been known to acquire a length of nine feet, with a basal diameter of eight inches, and to weigh one hundred and fifty pounds: but these dimensions are rare in the Asiatic species.

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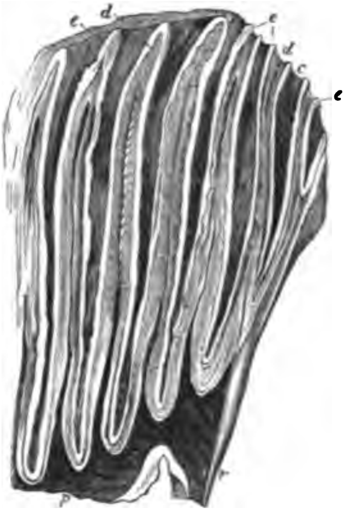

Section of molar, Elephant.

The elephant of Africa, at least in certain localities, has large tusks in both sexes; and the ivory is most esteemed by the manufacturer for its density and whiteness.

The molar teeth of the elephant are remarkable for their great size, and extreme complexity of their structure, fig. 290. The crown, of which a great proportion is buried in the socket, and very little more than the grinding surface appears above the gum, is deeply divided into a number of transverse perpendicular plates, consisting each of a body of dentine, *d*, coated by a layer of enamel ib., *e*, and this again by the cement, ib., *c*, which fills the interspaces of the enamelled plates, and here more especially merits its name, since it binds together the several divisions of the crown before they are fully formed and united by the confluence of their bases into a common body of dentine. As the growth of each plate begins at the summit, they remain detached and like so many separate teeth or denticules, until their base is completed, when it becomes blended with the bases of contiguous plates to form the common body of the crown of the complex tooth from which the roots are next developed.

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Molars, African Elephant.

The plates of the molar teeth of the Siberian Mammoth (*Elephas primigenius*) are thinner in proportion to their breadth, and more numerous in proportion to the size of the crown than in the existing species of Asiatic Elephant. In the African Elephant, fig. 291, the lamellar divisions of the crown are fewer and thicker, and they expand more uniformly from the margins to the centre, yielding a lozenge-form when cut or worn transversely, as in mastication. From this modification the gradation is close in the many extinct species to the three-ridged Mastodons and two-ridged Dinotheres.

The first molars of the Asiatic Elephant include four plates, are in place and use at three months, and are shed when the elephant is about two years old.

The eight or nine plates of the second molar are formed in the closed alveolus, behind the first molar by the time this cuts the gum, and they are united with the body of the tooth, and most of them are in use, when the first molar is shed.

The third molar has the crown divided into from eleven to thirteen plates; it averages four inches in length, and two inches in breadth, and has a small anterior, and a very large posterior root; it begins to appear above the gum about the end of the second year, is in its most complete state and extensive use during the fifth year, and is worn out and shed in the ninth year. Its remains about this period are shown in fig. 289, *d* 4. The three preceding teeth answer to the deciduous molars, *d* 2, *d* 3, and *d* 4, in the Hyrax, fig. 287, and Hog, fig. 294.

The fourth molar, figs. 289 and 292, *m* 1, presents a marked superiority of size over the third, and a somewhat different form: the anterior angle is more obliquely abraded, giving a pentagonal figure to the tooth in the upper jaw. The number of plates in the crown of this tooth is fifteen or sixteen: its length between seven and eight inches; its breadth three inches. The fore-part of the grinding surface of this tooth begins to protrude through the gum at the sixth year: it is in full use and place at the fifteenth year (fig. 289, *m* 1): the tooth is worn away, and its last remnant shed, about the twentieth or twenty-fifth year. It is the homologue of the first true molar of *Hyrax*, fig. 287, *m* 1.

The fifth molar, ib., *m* 2, with a crown of from seventeen to twenty plates, measures between nine and ten inches in length, and about three inches and a half in breadth. It begins to appear above the gum about the twentieth year: its duration has not been ascertained by observation.

The sixth molar is the last, and has from twenty-two to twenty-seven plates; its length, or antero-posterior extent, following the curvature, is from twelve to fifteen inches: the breadth of the grinding surface rarely exceeds three inches and a half.[1]

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Molars, lower jaw, Indian Elephant. Æt. 15 years.

The molar teeth succeed each other from behind forward, moving in the arc of a circle, shown by the curved line in fig. 289. The position of the growing tooth in the closed alveolus, *m* 2, is almost at right angles with that in use, the grinding surface being at first directed backward in the upper jaw, forward in the lower jaw, and brought, by the revolving course, into a horizontal line in both jaws, so that they oppose each other, when developed for use. The imaginary pivot on which the grinders revolve is next their root in the upper jaw, and is next the grinding surface in the lower jaw; in both, towards the frontal surface of the skull. Viewing both upper and lower molars as one complex whole, subject to the same revolving movement, the section dividing such whole into upper and lower portion runs parallel to the curve described by that movement, the upper being the central portion, or that nearest the pivot, the lower, the peripheral portion: the grinding surface of the upper molars is consequently convex from behind forward, and that of the lower molars concave: the upper molars are always broader than the lower ones.

The bony plate forming the sockets of the growing teeth is more than usually distinct from the body of the maxillary, and

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[1] In my 'Odontography' I was led to conjecture that 'this molar, if it makes its appearance about the fiftieth year, would, from its superior depth and length, continue to do the work of mastication until the ponderous Pachyderm had passed the century of its existence:' but I would now merely suggest, to all who may have the opportunity, the desirability of making and recording observations supplementary to those in the text made on captive Asiatic elephants in European menageries.

participates in this revolving course, advancing forward with the teeth. The partition between the tooth in use and its successor is perforated near the middle; and, in its progress forward, that part next the grinding surface is first absorbed; the rest disappearing with the absorption of the roots of the preceding grinder.

There are few examples of organs that manifest a more striking adaptation of a complex structure to the exigencies of the animal endowed with it, than the grinding teeth of the elephant. We perceive, for example, that the jaw is not encumbered with the whole weight of the massive tooth at once, but that it is formed by degrees as it is required; the division of the crown into a number of successive plates, and the subdivision of these into cylindrical processes, presenting the conditions most favourable to progressive formation. The fore and most abraded part of the tooth is fitted for the first coarse crushing of the branches of a tree: the transverse enamel ridges of the succeeding part of the tooth divide it into smaller fragments, and the posterior islands and tubercles of enamel pound it to the pulp fit for deglutition. The structure and progressive development of the tooth not only give to the elephant's grinder the advantage of the uneven surface which adapts the millstone for its office, but, at the same time, secure the constant presence of the most efficient arrangement for the finer comminution of the food, at the part of the mouth which is nearest the fauces.

The central part of the tusk especially near the base of such as have reached their full size, is occupied by a slender cylindrical tract of modified ivory, perforated by a few vascular canals, which is continued to the apex of the tusk. It is not uncommon to find processes of osteo-dentine or imperfect bone-like ivory, projecting in a stalactitic form into the interior of the pulp-cavity, apparently the consequence of the partial inflammation of the vascular pulp.

The musket-balls and other foreign bodies which are occasionally found in ivory, are immediately surrounded by osteo-dentine in greater or less quantity. It has often been a matter of wonder how such bodies should become completely imbedded in the substance of the tusk, sometimes without any visible aperture, or how leaden bullets may have become lodged in the solid centre of a very large tusk without having been flattened. The explanation is as follows:—A musket-ball, aimed at the head of an elephant, may penetrate, at *a*, fig. 289, the thin bony socket and the thinner ivory parietes of the wide conical pulp-cavity occupying the inserted base of the tusk; if the projectile force be there spent, the ball will gravitate to the opposite and lower side of the pulp-cavity, as indicated in fig. 289, *b*. The hole *a* is soon healed and filled up by ossification of the periosteum of the socket, and of the pulp next the thin wall of ivory which has been perforated. The ball sinks below the level of this cicatrix, and the presence of the foreign body exciting inflammation of the pulp, an irregular course of calcification ensues, which results in the deposition around the ball of a certain thickness of osteo-dentine. The pulp then resuming its healthy function, coats the surface of the osteo-dentine inclosing the ball, together with the rest of the conical cavity into which that mass projects, with layers of normal ivory.

By the continued progress of growth, the ball so inclosed is carried forward, in the course indicated by the arrow in fig. 289, to the middle of the solidified exserted part of the tusk, *c*. Should the ball have penetrated the base of the tusk of a young elephant, it may be carried on, by the uninterrupted growth and wear of the tusk, until that base has become the apex, and be finally exposed and discharged by the continual abrasion to which the apex of the tusk is subjected.

Yet none of these phenomena prove the absolute nonvascularity of the tusk, but only the low degree of its vascularity. Blood circulates, slowly no doubt, through the prolongations of the pulp into the minute vascular canals which are continued through the centre of the ivory to the very apex of the tusk: and it is from this source that the fine tubular structure of the ivory obtains the correspondingly minute villi carrying the plasmatic colourless fluid by which its low vitality is maintained.[1]

The modification of dentine called 'ivory,' is characterised partly by the minute size of the tubes, which, at their origin from the pulp cavity, do not exceed $\frac{1}{15000}$th of an inch in diameter, in their close arrangement at intervals scarcely exceeding the breadth of a single tube, and, above all, on their strong and almost angular gyrations, which are much greater than the secondary curvatures of the tubes of ordinary dentine.

The dentinal tubes of ivory, as they radiate from the pulp-cavity, incline obliquely towards the pointed end of the tusk, and de-

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[1] I had the tusk and pulp of an elephant at the Zoological Gardens longitudinally divided, soon after the death of that animal in the summer of 1847. Although the pulp could be easily detached from the inner surface of the pulp-cavity, it was not without a certain resistance; and when the edges of a co-adapted pulp and tooth were examined by a strong lens, the filamentary processes from the outer surface of the pulp could be seen stretching as they were withdrawn from the dentinal tubes before they broke. They are so minute that, to the naked eye, the detached surface of the pulp seems to be entire, and Cuvier was thus deceived in concluding that there was no organic connection between the pulp and the ivory. cxxxix. Ed. 1834, tom. i, p. 535.

scribe two slight primary curves, the first convex towards that end, the second and shorter one concave: these curves in narrow sections from near the open base of the tusk are almost obscured by the strong angular parallel secondary gyrations. The tubes divide dichotomously, at acute angles, and gradually decrease in size as they approach the periphery of the tusk.

The characteristic appearance of decussating curved striæ, with oblique rhomboidal spaces, so conspicuous on transverse sections or fractures of ivory, is due to the refraction of light caused by the parallel secondary gyrations of the tubes above described. The strong contour lines observed in longitudinal sections of ivory, parallel with the cone of the pulp-cavity, and which are circular and concentric when viewed in transverse slices of the tusk, are commonly caused by strata of minute opaque cellules, which are unusually numerous in the interspaces of the tubes throughout the substance of the ivory, and by their very great abundance and larger size in the peripheral layers of cement. The decomposition of the fossil tusks into superimposed conical layers takes place along the strata of the opaque cellules, and directly across the course of the gyrating dentinal tubes.

By the minuteness and close arrangement of the tubes, and especially by their strongly undulating secondary curves, a tougher and more elastic tissue is produced than results from their disposition in ordinary dentine; and the modification which distinguishes 'ivory' is doubtless essential to the due degree of coherence of so large a mass as the elephant's tusk, projecting so far from the supporting socket; and to be frequently applied in dealing hard blows and thrusts.

§ 222. *Homologies of Teeth.*—In Histology tissues differ according to the kinds and degrees of force which they exercise in the living body: some, the nervous and muscular, e.g. are 'active;' others, with lower endowments of elasticity, adhesiveness, hardness, &c., may be called 'passive,' and the classes of these tissues are less definite and distinct. In considering the homology of a tooth, in reference to its class of tissue, our view of it must not be restricted to its ordinary conditions in mammalia, where a central pulp-canal radiates a single system of dentinal tubes like the lacunal tubes from a Haversian canal, but should be extended to those less specialised states of tooth in which the body of dentine is traversed by several pulp-canals, either dichotomising, as in the molar of *Orycteropus,* vol. i. p. 369, fig. 247, or ramifying throughout the dentine, as in the laniariform tooth of *Lamna* (vol. i. p. 364, fig. 241).

A vascular matrix buds out in the shark from the membrane covering the jaw, as in the deer from that covering the cranium, and the blood-vessels, ramifying through such matrix, convey the phosphate of lime which hardens it; each ultimate ramification that radiates a system of dentinal tubes in the shark's tooth, corresponds with the same ramification of the artery radiating lacunal tubes in the matrix of the deer's antler.

After the tooth of the shark has been worn by the uses for which it was calcified, it is shed like the antler, and is succeeded by another. There is merely a difference in the place of succession, the new tooth rising close to, but not, as in the antler, directly under, the base of the old.

But the basis from which the matrix of both tooth and antler grows is homologically the same. In both instances the gum, or corium, is pushed out by the growing matrix: in the deer it forms the ' velvet ' which peels away from the ossified matrix, in the shark it is hardened into the enamel-like layer covering the matrix.

These are the differences that can be predicated in reference to the histological homology of the parts in question, and the shark's tooth answers to the deer's antler, *plus* the outer enamel-like covering, in mode of development, structure, growth, shedding, and succession. They correspond, alike, with osseous texture; and, under a less genus, with the parts of the dermo-skeleton.

But the tooth of a shark is homologous with that of a porpoise; therefore, teeth are referable to the dermo- or entero-skeletal parts of the osseous system.

Descending to the special homologies, we find that the idea of a recognition of answerable teeth in different animals has prevailed, more or less vaguely, in Anatomy, from an early period of the science.

When ' incisors,' ' canines,' and ' molars ' were predicated of the dentition in different species, homologous teeth were recognised so far as the characters of those classes of teeth were defined and understood.

The Cuviers[1] went a step further, and distinguished the molar teeth into 'false' and 'true,' into 'carnassial' and 'tubercular.' De Blainville pointed out a particular tooth by the name of 'principal,' which he believed himself able to trace from species to species.[2]

The first step in this inquiry is the elimination of those classes of *Vertebrata* and orders of *Mammalia* in which homology cannot be predicated of individual teeth. This limits the work to the group of mammals here termed ' Diphyodonts.'

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[1] cxx''. and cxxi''.

[2] The line ' Blainville' runs through that tooth in fig. 293.

Only in the Mammalian orders with two sets of teeth do those organs acquire fixed individual characters, supporting the application of special denominations; and this individualisation of the teeth is significative of the high grade of organisation of the animals manifesting it.

Originally, indeed, the name 'incisors,' 'laniaries' or 'canines,' 'molars,' 'tuberculars,' were given to the teeth in Man and certain Mammals, as in Reptiles, in reference merely to the shape and offices so indicated; but names of teeth can now be used as arbitrary signs, in a more fixed and determinate sense. In some *Carnivora*, e.g., the front teeth have tuberculate summits, adapted for nipping and bruising, while the principal back teeth are shaped for cutting, and work upon each other like the blades of scissors. The front teeth in the Elephant project from the upper jaw in the form, size, and direction of long pointed horns. In short, shape and size are the least constant of dental characters; and the homologous teeth are determined, like other parts, by their relative position, by their connections, and by their development.

Those teeth which are implanted in the premaxillary bones, and in the corresponding part of the lower jaw, are called 'incisors,' whatever be their shape or size. The tooth in the maxillary bone, which is situated at, or near to, the suture with the premaxillary, is the 'canine,' as is also that tooth in the lower jaw which, in opposing it, passes in front of its crown when the mouth is closed. The other teeth of the first set are the 'deciduous molars;' the teeth which displace and succeed them vertically are the 'premolars;' the more posterior teeth, which are not displaced by vertical successors, are the 'molars,' properly so called.

The premolars must displace deciduous molars in order to rise into place; the molars are a continuation, backward, of the primary or 'milk' series. It will be observed in fig. 294 that the last deciduous molar, *d* 4, has the same relative superiority of size to *d* 3 and *d* 2 which *m* 3 bears to *m* 2 and *m* 1; and that the crowns of *p* 3 and *p* 4 are of a more simple form than those of the milk-teeth which they are to succeed: this, however, is not a constant character (see fig. 287, *Hyrax*). Teeth of each of the kinds arbitrarily termed 'incisors,' 'canines,' 'false molars,' and 'molars,' have received other special names, having reference to certain peculiarities of form or other property. The premolars in the human subject have been called 'bicuspids.' The last upper premolar and the first true molar in the *Carnivora* are termed 'sectorials,' or 'molaires carnassières.' Teeth of an elongated conical form, projecting considerably beyond the rest, and of uninterrupted growth, are called 'tusks;' such, for example, are the incisors of the elephant, narwhal, dinotherium, and dugong, the canines of the boar, walrus, and hippopotamus. The long and large incisors of the rodents have been termed, from the shape and structure of their cutting edge, scalpriform teeth, chisel teeth, 'dentes scalprarii.' The lower incisors of the colugos (*Galeopithecus*), with the crown deeply notched like a comb, are termed 'dentes pectinati.' The canines of the baboons, which are deeply grooved in front like the poison-fangs of some snakes, are 'dentes canaliculati.' The compressed crowns of the teeth of short-clawed seals (*Stenorhynchus*) and of the extinct *Zeuglodon*, being divided into points like a saw, are 'dentes serrati,' &c. But a true knowledge of nature, a right appreciation of what is essential in her phenomena, tends to explode needless terms of art invented for unimportant varieties, and to establish those names that are the signs of true species of things.

As most zoologists have adopted the Cuvierian system of nomenclature and homology of the teeth in Mammalia, it may not be superfluous to explain what is objectionable in that system. In it the molar series of teeth, or those that follow the canines, are divided, according to their form, into three kinds, 'false molars,' 'carnassials,' and 'tubercular molars,' and the generic dental characters of the Mammalia are formulised according to this system. Thus, the genus *Felis* has—'fausses molaires' $\frac{2}{2}$:$\frac{2}{2}$, 'carnassières' $\frac{1}{1}$:$\frac{1}{1}$, 'tuberculeuses' $\frac{1}{0}$:$\frac{1}{0}=\frac{8}{6}$. This seems a natural way of expressing the homotypal teeth, or the answerable teeth in the upper and lower jaws. But to illustrate its error, the subjoined diagram, fig. 293, is appended, in which the dental system of the Cat-tribe (*Felis* v.) is associated with that of other Mammals, and in which the line marked '*Cuvier*' intersects the teeth in each jaw, called 'carnassières,' those anterior to them being the teeth called 'fausses molaires;' those behind—a single tooth in the upper jaw of *Felis*—being the 'tuberculeuses.' In this genus the tooth, *p* 4, above chiefly plays upon the tooth, *m* 1, below, which has a similar sectorial or carnassial modification of form; they fit, indeed, almost as Cuvier describes, like the blades of a pair of scissors. The two teeth in advance of the carnassial in the upper jaw, *p* 3, *p* 2, in like manner are opposed to the same number of 'fausses molaires' in the under jaw, and the canine, *c*, above plays upon the canine below:

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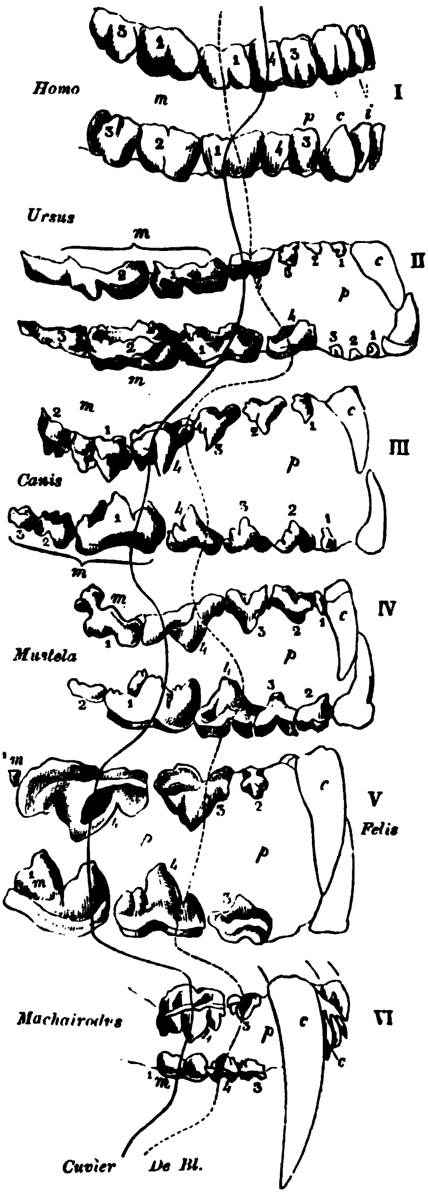

Homologies of Teeth.

all seems fitting and symmetrical, save that the little tubercular, *m* 1, above has no opponent in the lower jaw. And, perhaps, the close observer might notice that, whilst the upper canine, *c*, glides behind its homotype below, the first upper false molar, *p* 2, passes anterior to the crown of the first false molar, *p* 3, below; and that the second false molar, *p* 3, and carnassial, *p* 4, of the upper jaw are also a little in advance of those teeth, *p* 4, *m* 1, in the under jaw, when the mouth is shut.

In passing to the dentition of the Dog, ib. III. *Canis*, formulised by Cuvier as 'fausses molaires $\frac{6}{8}$, carnassières $\frac{2}{2}$, tuberculeuses $\frac{4}{4} = \frac{1\,2}{1\,4}$,'[1] it will be observed that here the first upper false molar, *p* 1, differs from the first, *p* 2, in *Felis*, inasmuch as, when the mouth is shut, it preserves the same relative position to its opponent below, *p* 1, in III., which the upper canine does to the lower canine, and that the same may be said of the second and the third false molars; but that, with regard to the carnassial above, *p* 4, this tooth repeats the same relative position in regard to the fourth false

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[1] cxxi″. p. 95.

molar below, *p* 4, and not to that tooth, *m* 1, which Cuvier regarded as the lower homotype of the carnassial; and, indeed, the more backward position of the lower carnassial is so slight that its significance might well be overlooked, more especially as the two succeeding tubercular teeth above were opposed to two similar tuberculars below.

How unimportant size and shape are, and how significant relative position is, in the determination of the homologies of teeth as of other parts, may be learnt before quitting the natural order of *Carnivora*; e. g. by the condition of the dental system in the Bear, ib. II. *Ursus*. Here the lower tooth, *m* 1, instead of presenting the carnassial character, and resembling in form the upper tooth, *p* 4, which is the homologue of the upper carnassial in the dog, has a tubercular crown, and corresponds in size as well as shape with the upper tooth, *m* 1, to which it is almost wholly opposed, and with the same slight advance of position which we observe in the lower canine as compared with the upper one, and in the four lower premolars, *p* 1, *p* 2, *p* 3, *p* 4, as compared with their veritable homotypes above. F. Cuvier divides the molar series of the genus *Ursus* into 'fausses molaires $\frac{6}{8}$, carnassières $\frac{2}{2}$, tuberculeuses $\frac{4}{4}=\frac{12}{14}$.'[1] The tendency in every thinker to generalise and to recognise Nature's harmonies, has led him here to use the term 'carnassière' in an arbitrary sense, and to apply it to a tooth above (II. *p* 4), which he owns has such a shape and diminished size as would have led him to regard it as merely a false molar, but that the upper carnassial would then have entirely disappeared; and it has also led him to give the name 'carnassière' to a tooth below, *m* 1, which he, nevertheless, describes as having a tubercular and not a trenchant crown. In so natural a group as the true *Carnivora*, it was impossible to overlook the homologues of the trenchant carnassials of the lion, even when they had become tubercular in the omnivorous bear; and Cuvier, therefore, having determined and defined the teeth so called in the feline genus, felt compelled to distinguish them by the same names after they had lost their formal specific character. And if, indeed, he had succeeded in discovering the teeth which were truly answerable or homotypal in the upper and lower jaws, the term 'carnassial' might have been retained as an arbitrary one for such teeth, and have been applied to their homologues in Man and other diphyodonts, where they are as certainly determinable as in those aberrant Carnivores, in which they have equally lost their sectorial shape.

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[1] cxxi^v. p. 109.

But the inconvenience of names indicative of such specialties of form will be very obvious when the term 'tuberculeuses' comes to be applied to the three hindmost teeth in the *Hyænodon* (fig. 266), which teeth answer to the broad crushing teeth, *m* 1, *m* 2, and *m* 3, in the bear and some other existing *Carnivora.* The analogous term 'molar' having a less direct or descriptive meaning, is therefore so much the better, as the requisite arbitrary name of a determinate species of teeth.

Had Cuvier been guided in his determinations of the teeth by their mutual opposition in the closed mouth, and had studied them with this view in the *Carnivora* with the dentition most nearly approaching to the typical formula, viz. the Bear, he could then have seen that the three small and inconstant lower premolars, *p* 1, *p* 2, *p* 3, were the homotypes of the three small and similarly inconstant premolars above; that the fourth false molar, *p* 4 below, which, as he observes, 'alone has the normal form,'[1] was truly the homotype of the tooth above, *p* 4, which he found himself compelled to reject from the class of 'fausses molaires,' notwithstanding it presented their normal form; that the tubercular tooth, *m* 1, which he calls 'carnassière' in the lower jaw, was the veritable homotype of his first 'molaire tuberculeuse' above, *m* 1, and that the tooth in the inferior series, which had no answerable one above, was his second 'tuberculeuse,' *m* 3, in the present work. The true second tubercular above, *m* 2, is, however, so much developed in the Bear as to oppose both *m* 2 and *m* 3 in the lower jaw, and it might seem to include the homotypes of both those teeth coalesced. One sees with an interest such as only these homological researches could excite, that they were distinctly developed in the ancient *Amphicyon*, fig. 267, which accordingly presents the typical formula.

Thus the study of the relative position of the teeth of the Bear might have led to the recognition of their real nature and homologies, and have helped to raise the mask of the extreme formal modifications, by which they are adapted to the habits of the more blood-thirsty *Carnivora.* But the truth is plainly revealed when we come to trace the course of development and succession of these teeth. As the question only concerns the molar series, the remarks will be confined to those teeth. In the jaws of the young Bear, fig. 263, the first premolar is the only one of the permanent series in place; the other grinders in use are the deciduous molars, *d* 2, *d* 3, and *d* 4; *d* 2 will be displaced by *p* 2, *d* 3 by *p* 3, and *d* 4 by the tooth *p* 4, which, notwithstanding its

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[1] cxxi″. p. 111.

size and shape, Cuvier felt himself compelled to discard from the series of false molars, but which we now see is proved by its developmental relations to *d* 4, as well as by its relative position and similarity to *p* 4 in the lower jaw, fig. 292, II., *Ursus*, to be veritably the last of the premolar series, and to agree not in shape only, but in every essential character, with the three preceding teeth called by Cuvier 'fausses molaires.' So, likewise, in the lower jaw, it is seen that the primitive deciduous series, fig. 263, *d* 1, *d* 2, *d* 3, and *d* 4, will be displaced by the corresponding premolars, *p* 1, *p* 2, *p* 3, *p* 4; and that the tooth *m* 1, called carnassière by Cuvier, in the lower jaw, differs essentially from that, *p* 4, so called in the upper jaw, by being developed without any vertical predecessor or deciduous tooth.

The same law of development and succession prevails in the genus *Canis* as may be readily seen in the jaws of a dog of ten months' age. Although the tooth, *m* 1, III. fig. 293, in the lower jaw has exchanged the tubercular for the carnassial form, it is still developed, as in the Bear, behind the deciduous series, and independently of any vertical predecessor, fig. 262, *m* 1; and the tooth, ib. *p* 4, above, although acquiring a relative superiority of size to its homologue in the Bear, and more decidedly a carnassial form, is not the homotype of the permanent carnassial below, but of that premolar, *p* 4, which displaces the deciduous carnassial, *d* 4. The symbols in fig. 293, III., sufficiently indicate the relations of the other teeth, and the conclusions that are to be drawn from them as to their homologies.

In the genus *Felis*, fig. 260, the small permanent tubercular molar of the upper jaw, *m* 1, has cut the gum before *d* 4 has been shed; but though analogous in function, this tooth is not homologous with, or the precedent tooth to *m* 1, but precedes the great carnassially modified premolar, *p* 4. In the lower jaw the tooth, *m* 1, which is functionally analogous to the carnassial above, is also, as in the Dog, the first of the true molar series, and the homotype of the little tubercular tooth, *m* 1, above. And the homologues of the permanent teeth, *p* 4 and *m* 1 below, fig. 293, V., with those so symbolised in the Dog, ib. III., teach us that the teeth which are wanting in the feline, in order to equal the number of those in the canine dentition, are *m* 2 in the upper jaw, *m* 2 and *m* 3 in the lower jaw; *p* 1 in the upper jaw, *p* 1 and *p* 2 in the lower jaw; thus illustrating the rule, that, when the molar series falls short of the typical number, it is from opposite extremes of such series that the teeth are taken, and that so much of the series as is retained is thus preserved unbroken.

In the great extinct sabre-toothed Tiger, *Machairodus*, fig. 293, VII., the series is still further reduced by the loss of *p* 2, in the upper jaw.

In the common Cat, the deciduous incisors, *d i*, begin to appear between two and three weeks old; the canines, *d c*, next, and then the molars, *d m*, follow, the whole being in place before the sixth week. After the seventh month they begin to fall in the same order; but the lower sectorial molar, *m* 1, and its tubercular homotype above, *m* 1, appear before *d* 2, *d* 3, and *d* 4 fall. The longitudinal grooves are very faintly marked in the deciduous canines. The first deciduous molar, *m* 2, in the upper jaw is a very small and simple one-fanged tooth; it is succeeded by the corresponding tooth of the permanent series, which answers to the second premolar, *p* 2, of the Hyæna and Dog. The second deciduous molar, *m* 3, is the sectorial tooth; its blade is trilobate, but both the anterior and posterior smaller lobes are notched, and the internal tubercle, which is relatively larger than in the permanent sectorial, is continued from the base of the middle lobe, as in the deciduous sectorial of the Dog and Hyæna; it thus typifies the form of the upper sectorial, which is retained in the permanent dentition of several Viverrine and Musteline species. The third or internal fang of the deciduous sectorial is continued from the inner tubercle, and is opposite the interspace of the two outer fangs. The Musteline type is further adhered to by the young Feline in the large proportional size of its deciduous tubercular tooth, *d* 4. In the lower jaw, the first milk-molar, *d* 3, is succeeded by a tooth, *p* 3, which answers to the third lower premolar in the Dog and Civet. The deciduous sectorial, *d* 4, which is succeeded by the premolar, *p* 4, answering to the fourth in the Dog, has a smaller proportional anterior lobe, and a larger posterior talon, which is usually notched; thereby approaching the form of the permanent lower sectorial tooth in the *Mustelidæ*.

When the premolars and the molars are below their typical number, the absent teeth, as a rule,[1] are missing from the forepart of the premolar series and from the back-part of the molar series. The most constant teeth are the fourth premolar and the first true molar; and these being known by their order and mode of development, the homologies of the remaining molars and premolars are determined by counting the molars from before back-

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[1] In some instances the first premolar or first milk-molar remains, of small size, when *p* 2 and *p* 3 are lost.

wards, e.g. 'one,' 'two,' 'three'; and the premolars from behind forwards, 'four,' 'three,' 'two,' 'one.'

Examples of the typical diphyodont dentition are exceptions in the actual creation; but it was the rule in the earlier forms of placental Mammalia, whether the teeth were modified for animal or vegetable food.

Not only the *Hyænodon*, fig. 266, and *Amphicyon*, fig. 267, but the *Dichodon*, *Anoplotherium*, *Palæotherium*, *Chæropotamus*, *Anthracotherium*, *Hyopotamus*, *Pliolophus*, *Hyracotherium*, and many other ancient (eocene and miocene) tertiary Mammalian genera presented the forty-four teeth, in number and kind according to that which is here propounded as the typical or normal dentition of the placental diphyodonts. When the clue is afforded to their homologies, it infallibly conducts to the true knowledge of the nature both of the teeth which are retained, and of those which are wanting to complete the typical number. Thus may be deciphered the much modified dentition of the genus *Felis*; and the same clue will guide to the knowledge of the precise homologies of the teeth in our own species.

The known limits of the premaxillary in Man leads to the determination of the incisors, which are reduced to two on each side of both jaws; the contiguous tooth shows by its shape as well as position that it is the canine; and the characters of size and shape have also served to divide the remaining five teeth in each lateral series into two bicuspids and three molars. In this instance the secondary characters conform with the essential ones, as exhibited in the dissection of the jaws of a child of about six years of age, fig. 258. The two incisors on each side, *d i*, are followed by a canine, *c*, and this by three teeth having crowns resembling those of the three molar teeth of the adult. In fact, the last of the three is the first of the permanent molars; it has pushed through the gum, like the two molars which are in advance of it, without displacing any previous tooth, and the substance of the jaw contains no germ of any tooth destined to displace it; it is therefore, by this character of its development, a true molar, and the germs of the permanent teeth, which are exposed in the substance of the jaw between the diverging fangs of the molars, *d* 3 and *d* 4, prove them to be temporary, destined to be replaced, and prove also that the teeth about to displace them are premolars. According, therefore, to the rule previously laid down, we count the permanent molar in place the first of its series, *m* 1, and the adjoining premolar as the last of its series, and consequently the fourth of the typical dentition, *p* 4.

We are thus enabled, with the same scientific certainty as that whereby we recognise in the middle toe of our foot the homologue of that great digit which forms the whole foot, and is encased by the hoof, in the horse, to point to *p* 4, or the second bicuspid in the upper jaw, and to *m* 1, or the first molar in the lower jaw, of Man, fig. 293, I., as the homologues of the great carnassial teeth of the Lion, *p* 4, *m* 1, ib. V. We also conclude that the teeth which are wanting in Man to complete the typical molar series, are the first and second premolars, the homologues of those marked *p* 1 and *p* 2 in the Bear, ib. II. The characteristic shortening of the maxillary bones required this diminution of the number of their teeth, as well as of their size, and of the canines more especially; and the still greater curtailment of the premaxillary bone is attended with a diminished number and an altered position of the incisors.

The homologous teeth being thus determinable, they may be severally signified by a symbol as well as by a name. The incisors, e.g., are represented in the present work by their initial letter *i*, and individually by an added number, *i* 1, *i* 2, and *i* 3, counting from the medial line outwards; the canines by the letter *c*; the premolars by the letter *p*; and the molars by the letter *m*; these also being differentiated by added numerals. Thus, the number of these teeth, on each side of both jaws, in any given species, Man, e.g., may be expressed by the following brief formula:—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3} = 32\ ,$$

and the homologies of the individual teeth, in relation to the typical formula, may be signified by *i* 1, *i* 2; *c*; *p* 3, *p* 4; *m* 1, *m* 2, *m* 3; the suppressed teeth being *i* 3, *p* 1, and *p* 2.

The soundness of the foregoing conclusions as to the nature of the teeth absent in the reduced dental formula of Man, is exemplified by the mode in which the type is progressively resumed in descending from Man through the order most nearly allied to our own.

Through a considerable part of the Quadrumanous series, the same number and kinds of teeth are present as in Man, the first deviation being the sexual disproportionate size of the canines and the concomitant break or 'diastema' in the dental series for the reception of their crowns when the mouth is shut. This is manifested in Gorillas, Chimpanzees and Orangs, together with the sexual difference in the proportions of the canine teeth. Then comes the added premolar in the New World Monkeys, fig. 251, *p* 2, and the further additions in lower quadrupeds, until in the Hog genus we see the old primitive type of diphyodont dentition resumed or retained.

In the genus *Sus*, fig. 293 illustrates the phenomena of development which distinguish the premolars from the molars. At the stage exemplified the first premolar,[1] *p* 1, and the first molar, *m* 1, are in place and use, together with the three deciduous molars, *d* 2, *d* 3, and *d* 4; the second molar, *m* 2, has just begun to cut the gum; *p* 2, *p* 3, and *p* 4, together with *m* 3, are more or less incomplete and concealed in their closed alveoli.

The premolars displace deciduous molars in order to rise into place; the molars have no such relations; it will be observed, that the last deciduous molar, *d* 4, has the same relative superiority of size to *d* 3 and *d* 2 which *m* 3 bears to *m* 2 and *m* 1; and the crowns of *p* 3 and *p* 4 are of a more simple form than those of the milk-teeth which they are destined to succeed.

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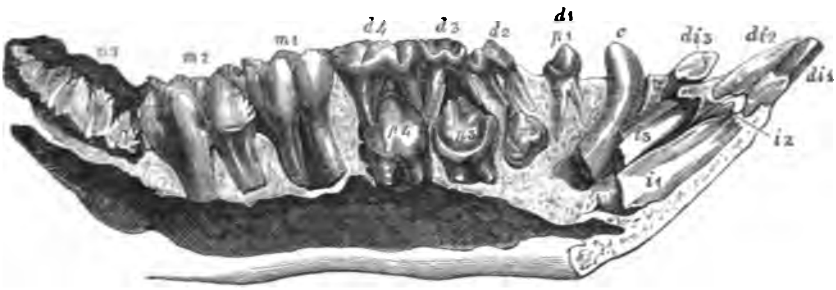

Deciduous and permanent teeth (*Sus*). Lower jaw

The premolars have a more simple structure as well as smaller size, than the true molars, in all Artiodactyles. In the Ruminants they represent only the moiety of the true molars, or one of the two semi-cylindrical lobes of which those teeth consist, with, at most, a rudiment of the second lobe. The Perissodactyles are distinguished by the size and complexity of more or less of the premolars. In *Equus*, *p* 2, *p* 3 and *p* 4, even exceed in size *m* 1, *m* 2 and *m* 3. In *Rhinoceros* and *Palæotherium* the proportions of the molars and premolars are reversed; but the structure is the same. In *Lophiodon*, *Coryphodon* and *Pliolophus* the premolars become more simplified as well as diminished, ap-

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[1] If this tooth have not displaced a minute milk-molar, it may be reckoned a *d* 1, which is longer retained than the rest of the deciduous molars; in this degree the type-dentition is departed from.

proaching to a common Ungulate type. In the Proboscidian group, the oldest species indicate retentions of type unknown in the dentition of existing Elephants. A premolar, fig. 295, *p* 3, displaces vertically the second deciduous grinder, *d* 3, in some Mastodons: and, that the third molar in the order of appearance, *d* 4, is also the last of the deciduous series, is indicated by the contrasted superiority of size of the tooth, *m* 1, that follows. The great extent and activity of the processes of dental development required for the preparation of the large and complex true molar teeth, would seem to exhaust the power in Proboscidians, which, in ordinary Pachyderms, is expended in developing the vertical successors of the deciduous teeth. In the miocene Mastodon above cited, this normal exercise of the reproductive force was not, however, wholly exhausted; and one premolar, fig. 295, *p* 3, of more simple form than its deciduous predecessor, was developed on each side of both jaws. Another mark of adhesion to the archetype was shown by the development of two incisors in the lower jaw in the young of some Mastodons, by the retention and development of one of these inferior tusks in the male of the *Mastodon giganteus* of North America, and by the retention of both in the European *Mastodon longirostris*, Kaup. No trace of these inferior homotypes of the premaxillary tusks have been detected in the fœtus or young of the existing elephants. In the gigantic *Dinotherium*, the upper incisors were suppressed, and the lower incisors were developed into huge tusks, which curved down from the symphysis of the massive lower jaw.

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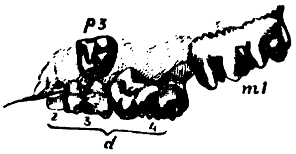

Deciduous teeth, Mastodon.

The chief modifications of the marsupial dentition have already been described and illustrated. The observed phenomena of the development and change of the teeth led to the generalisation that the marsupial differed from the placental Diphyodont mammals in having four true molars, i. e., $m\ \frac{4}{4}:\frac{4}{4}$ instead of $m\ \frac{3}{3}:\frac{3}{3}$; and also that they differed in having only three premolars, i. e. $p\ \frac{3}{3}:\frac{3}{3}$ instead of $p\ \frac{4}{4}:\frac{4}{4}$; the typical number of the grinding series, $\frac{7}{7}:\frac{7}{7}$, being the same; and it was convenient for comparison to symbolise them accordingly, in figs. 221–230. Since, however, there is reason to conclude that *m* 1 in the placental Diphyodonts, as, e. g., figs. 259 and 294, is a continuation of the deciduous series of molars, which might be symbolised as *d* 5, and only becomes a permanent molar because there is no premolar developed above it, so we may regard the tooth marked *m* 1 in figs. 221–230 as being an antecedent tooth of the deciduous series, rendered permanent by a like reason, the suppression, viz. of *p* 4. In other words, that *m* 1 in fig. 227 is the homologue of *d* 4 in fig. 294, and that the true homologue of *p* 4 is not developed in the *Marsupialia.*

The homologies of the teeth of the Kangaroo are illustrated in fig. 296, according to this idea of them; the dental formula of both the *Macropodidæ* and *Hypsiprymnidæ* being—

$$i\,\frac{3.3}{1.1};\ c\,\frac{1.1}{0.0};\ p\,\frac{1.1}{1.1};\ d\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3\cdot3} = 30:$$

instead of—

$$i\,\frac{3.3}{1.1};\ c\,\frac{1.1}{0.0};\ p\,\frac{1.1}{1.1};\ m\,\frac{4.4}{4.4} = 30.$$

The canines, which are confined to the upper jaw, are small or minute when retained; and disappear after being represented 'en germe' in most of the true Kangaroos.

In the deciduous dentition of the great Kangaroo (*Macropus major*) the canines are rudimental, and are absorbed rather than shed. No other of the deciduous series is calcified, save the molars *d* 2 and *d* 3, fig. 296, unless the permanent incisors be developed and retained milk-teeth. When the young animal finally quits the pouch the dentition is—

$$d\,i\,\frac{1.1}{1.1};\ d\,m\,\frac{2.2}{2.2} = 12;$$

the upper incisors being *i* 1, the molars *d* 2 and *d* 3 of the typical dentition. This stage is exemplified in the lower jaw at A (fig. 296). The next stage shows the acquisition of *i* 2 in the upper jaw, and *d* 4 in both jaws, and the formula is—

$$d\,i\,\frac{2.2}{1.1};\ d\,m\,\frac{3.3}{3.3} = 18,\ \text{ib. B.}$$

At one year old, the dentition is—

$$d\,i\,\frac{3.3}{1.1};\ d\,m\,\frac{3.3}{3.3};\ m\,\frac{1.1}{1.1} = 24;$$

the additional teeth being *i* 3 and *m* 1 (ib. C), in which the demonstration of the true deciduous character of *d* 2 and *d* 3 is shown by the germ of their vertical successor *p* 3, which is exposed in the substance of the jaw. The next stage is the shedding of *d* 2, and the acquisition of *m* 2 (ib. D). Then *d* 3 is shed by matters into sugar, which was commenced by the saliva. Bernard maintains that it also exercises the more important office of emulsifying or saponifying the neutral fatty matters contained in the food, by decomposing them into glycerine and their respective fatty acids, and so rendering them absorbable.[1] But the latest experimenters are agreed only in regard to the first result, and the chief office of the pancreatic secretion in digestion still awaits determination.

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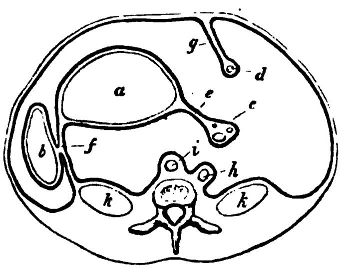

Transverse section of abdomen through the first lumbar vertebra; Human. CCXXXV.

§ 340. *Peritoneum and appendages in Mammalia.*—The abdomen, as a definite and circumscribed visceral chamber, is peculiar to the present class: the heart and other thoracic viscera are shut out by the complete transverse septum or 'diaphragm' from the major part of the trunk-cavity, to which the term 'abdomen' is now restricted. The serous membrane called 'peritoneum,' which lines this cavity, is reflected from the walls upon the principal abdominal viscera to some of which it gives a complete, to others a partial, investment. In the human subject the peritoneum, as in the section shown in fig. 387, passes over the fore part of the abdominal aorta, *i*, the postcaval, *h*, and the kidneys, *k*, *k*; but is reflected so as to inclose the liver, stomach, spleen, and major part of the intestinal canal: it is continued from the transverse fissure of the liver upon the lesser curvature of the stomach to form the gastrohepatic omentum. At the level of the section figured, one part, *f*, is seen passing forward from the left kidney to enclose the spleen, *b*, and the stomach, *a*: the opposite border, *e*, is the part of the lesser omentum inclosing the hepatic duct and vessels, *c*. Another fold of peritoneum is reflected from the upper and fore part of the abdomen upon the umbilical vein of the fœtus, which afterwards degenerates into the 'round ligament,' *d*; the supporting fold, *g*, being continued into the suspensory fissure of the liver, and forming its 'falciform' ligament: other folds continued from the diaphragm upon the opposed convexity of the liver are its 'coronary' and 'triangular' ligaments. The lesser omentum, more properly the 'mesogaster,' or peritoneal fold which mainly suspends the stomach and conveys thereto its vessels, also covers and suspends the spleen; and this part of the mesogaster is termed the 'gastrosplenic omentum,' of which, in Man, only the left or outer layer forms

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[1] CLXIV″.

the splenic covering. Both layers recede to include the stomach, fig. 388, *b*, whence they are continued from the line of the greater curvature over the fore part of the abdomen, and are folded back to the colon, in the form of a large flap or apron, including vessels and more or less fat, forming the ' great omentum,' ib. *o*, *o* : it is peculiar to the *Mammalia*, coexists with the diaphragm, and may have useful relations as insulating the peristaltically winding intestines from the constant respiratory movements of the abdominal walls. The posterior returning folds of the omentum meet the transverse arch of the colon, recede and embrace that intestine, as the anterior or descending folds had embraced the stomach; the colonic folds are continued back as a suspensory ' mesocolon ;' the upper layer of the fold passes over the fore part of the duodenum and pancreas to the posterior abdominal walls, the lower layer is continued a short way down those walls, and is again reflected forward to the small intestines as the anterior or upper layer of their suspending fold called ' mesentery.' The relations of the peritoneum to the pelvic viscera show no class-specialities. Large omental processes with accumulated fat are never continued from the urinary bladder, and rarely from the pelvic or other regions of the abdominal walls, as they are in most *Reptilia* :[1] small ones from the serous coat of the large intestine are developed in many Ungulates, and are called ' appendices epiploicæ' in the human subject. The serous sac of the abdomen communicates with the mucous canal of the oviducts or ' fallopian tubes,' but is elsewhere closed in the female, and is a shut sac in the male mammal. Productions of this sac, however, accompany the testes into the scrotum; but are insulated by obliteration of the canal of the spermatic cord in Man.

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Liver raised to show the stomach and great omentum, Human. CXLVIII".

The above leading features in the disposition of the peritoneum offer modifications in the present class. In the insectivorous

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[1] xx. vol. iii. pt. ii. p. 221.

species of the Ly- and Liss-encephala, with little or no cæcal distinction of the intestines, the suspensory fold of the abdominal alimentary canal may be almost as simple as in lizards; e. g., in the Shrews, fig. 389, *m*. The omentum is restricted to a very small duplicature from the spleen, *s*, supporting some processes of the ramified pancreas. When the cæcum and large intestines are more developed, then the peritoneum, reflected from the back of the abdomen, appears to make a half twist, fig. 380, *c*, to form the mesocolon, behind which the duodenum passes to become the loose jejunum, which, with the ileum, is suspended on the mesentery. The meso-duodenum, continued partly from the upper layer of the mesocolon, is here of a size characteristic of the peritoneum in many Mammals, but is reduced in *Quadrumana*, and is almost lost in Man. The great omentum or epiploön is larger in Rodents than in Shrews; but is transparent, and with little or no fat: it includes, in Rodents, pancreatic processes,

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Abdominal cavity, and mesentery. *Hydrosorex Hermanni*, nat. size. CLXVII".

ib. *o*, with the spleen. In the Kangaroo it is of moderate size, continued loosely from the stomach to the transverse colon, but not extended beyond that part. The posterior layer lies between the stomach and the intestines, and exemplifies one of the uses of the epiploön, as it prevents these parts from interfering with each other's motions. The anterior layer generally contains more or less fat. In the Petaurus the epiploön is continued from the great curvature of the stomach and the commencement of the duodenum. In the Phalangers it is of considerable extent and is usually loaded with fat. In the Opossums I have found it generally devoid of fat, when this substance has been accumulated in other parts. In the Phascogales and Dasyures the epiploön is of moderate size, and contains little or no fat. The epiploön is attached to the lower arches of the several divisions of the stomach in *Cetacea*, is always devoid of fat, and is of limited extent: the subdivided spleens, fig. 355, *h*, *i*, are scattered in it, as in a net: it is in parts reticulate. The epiploön is small and does not cover the intestines in *Sirenia*, *Proboscidia*, and *Perissodactyla*. It is, also, of limited extent in the Hog-tribe. In fatted Sheep it is larger and is reticulated with adipose matter. It is attached, in Ruminants, to the right side of the left division of the rumen, and along its anterior or ventral convexity, passing from the right of this to the abomasus and the beginning of the duodenum: it does not cover the intestines, and is commonly found crumpled up beneath the paunch. The reticulate structure of the great omentum appears to be natural and pretty constant in the Dog and some other *Carnivora*: in the Seal the omental fold is thin and devoid of fat.

The peritoneum lining the elastic ventral wall of the abdomen in the Elephant and Rhinoceros is of unusual thickness and strength, the areolar tissue connecting it to adjacent structures presents an aponeurotic firmness: the free surface of the serous membrane I found to be white and opaque:[1] it is generally transparent and opaline or colourless. In some hibernating Rodents a fold of peritoneum extends forward from each lumbar region, covering the lateral convolutions of the intestine as far as the umbilicus, and towards the beginning of winter becoming the seat of an abdominal deposit of fat: they may serve with the ordinary omentum the double purpose of nonconductors of heat and a store of nutriment.

[Since Sheets T–DD were printed off, the excellent Paper CLXXXVI" has appeared, showing that the deciduous teeth of the mole, though too minute to seem of use, are not shed until after birth. In other respects Mr. Spence Bate confirms the talpine formula given at p. 304.]

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[1] V". p. 37.

In half-grown specimens of Dugong[1] I found the foramen ovale completely closed, and the ductus arteriosus reduced to a thick ligamentous chord, permeable only for a short distance by an eye-probe from the aorta, where a crescentic slit still represented the original communication. In the smoothness and evenness of their exterior, and their general form, the auricles of the Dugong, ib. *a, d,* resemble those of the Turtle (*Chelone,* vol. i. fig. 335): the appendix can hardly be said to exist in either. The right auricle, *a,* is but little larger than the left, *e*: the musculi pectinati are well developed, especially in the left: they are irregularly branched, and with many of the small round fasciculi attached only by their two extremities to the auricular parietes. There is but one precaval and one postcaval orifice in the right auricle, with a smaller coronary inlet. The pulmonary veins terminate in the left auricle by a common trunk one inch in length. The free wall of the right ventricle scarcely exceeds at any part a line in thickness, and is in many places even less. The tricuspid valve is attached to three fleshy columns by chordæ tendineæ given off from the sides and not the extremities of those columns, both of which extremities are implanted, as trabeculæ, in the walls of the ventricles. There are several other columnæ carneæ passing freely from one part of the ventricle to another, like the musculi pectinati of the auricles, and which have no connection with the tricuspid valve. The mitral valve is adjusted to its office by attachments to two short and transversely extended mammillary columnæ. The thickness of the parietes of the left ventricle varies from half an inch to an inch. The valves at the origins of the great arteries, *c, f,* present the usual structure.

E. *Heart of Ungulata.*—In all hoofed beasts the ventricles are conical; the apex being longer and sharper in Ruminants than in most other Mammals. The auricles are relatively smaller to the ventricles than in the preceding groups. The three parts of the tricuspid valves are distinct from their confluent bases, and are pointed at the apex: the basal union of the two parts of the mitral valve is of a greater extent, forming there an annular valve about the left auriculo-ventricular opening. The smooth inner surface of the ventricles is but little interrupted by fleshy columns. The Horse resembles the Ruminant in the general shape and structure of the heart: but in the Tapir[2] it is shorter and broader, as it is in the Rhinoceros[3] and Elephant. The right auricle in the *Rhinoceros,* as in most Ungulates, has but one precaval orifice, and shows no valve at the termination of

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[1] CXVII″. p. 35.

[2] CLII″.

[3] V″. p. 46.

either the postcaval or coronary veins: the contrast presented by the Elephant, in this respect, is significant. The strong chordæ tendineæ of the tricuspid connect it, in most Ungulates, with three obtuse and transversely oblong carneæ columnæ: one rising from the movable wall, a second from the septum, and a third smaller one from the anterior interspace between the fixed and movable walls: the tendons diverge from each column to the two contiguous moieties of the divisions of the tricuspid—a provision ensuring the simultaneous action and outstretching of the three portions of the valve. Two smaller columns placed opposite to each other, one on the free, the other on the fixed wall, are connected in the Rhinoceros and many other Ungulates, by a single strong tendon passing across the cavity from the apex of one to the other.[1] In the Hog some of the tricuspid tendons pass to a thick short 'column' projecting from the free wall, others pass directly into the smooth convex fixed wall of the ventricle.

In most Ruminants, especially the larger kinds, there is a bent bone at the base of the heart, on the septal side of the origin of the aorta, and imbedded in the tendinous circle which gives attachment to muscular fibres of the ventricle; in the Giraffe this bone was two-thirds of an inch in length. Two such ossifications of the sclerous tissue have here been met with in Oxen and Red-deer: an ossified and an unossified piece of fibro-cartilage are more commonly observed: in the Horse these bodies at the septal side of the aortic ring are rarely ossified until extreme age.

F. *Heart of Carnivora.*—In the present group the heart is more obtuse at the apex, and the left ventricle forms a greater share thereof, than in Ungulates. The Eustachian valve is wanting in most *Carnivora*; where indicated, its remains have been found in the smaller kinds, as the Weasel, Polecat, Ichneumon, which by their size resemble the immature of the larger species. The inner surface of the ventricles, especially the right, is more fasciculated, and the number of carneæ columnæ is greater than in Ruminants. A condensation of the sclerous tissue of the aortic ring in the Lion and Tiger, at two points, indicates the homologues of the heart-bones in Ungulates. In these and other Felines the mammillary columns are continued from the septal end of a strong trabecular tract between the 'fixed' and 'free' walls of the right ventricle. The heart in *Phocidæ* is broad and somewhat flattened,

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[1] I have not found, in Ruminants, so exclusive an origin of the mammillary columns from the 'free' or external wall, as described in CCXXXIX. t. III. p. 502, after CLXXXV".

the gigantic extinct members of the order *Bruta* (*Megatherium*, fig. 279, e.g.) the claws and their core or supporting bone rivalled the horns of many Ruminants in bulk.

§ 364. *Horns.*—The horn of the Rhinoceros consists of a uniform compact agglutinate mass of epidermal fibres, the slightly concave base of which is attached to the dermo-perioste of as slightly elevated a rugous tract of bone: it is medial in position and symmetrical in shape.

The Asiatic continent and the Island of Java have the one-horned species called *Rhinoceros indicus* and *Rh. sondaicus* (vol. ii. p. 284, fig. 165): the same continent and the Island of Sumatra have the two-horned species (*Rh. sumatranus*): all the known kinds of *Rhinoceros*, four in number, of Africa are two-horned: in these one horn is behind the other in the same medial tract of the upper part of the skull.[1] The nasal bones support the constant or anterior horn: when a second is superadded it is attached to the frontals, and is, usually, shorter than the first;[2] in *Rhinoceros Oswellii* considerably shorter; but in *Rh. Ketloa* it is almost or quite as long as the first horn, but is straight. The horn or horns of the female Rhinoceros are usually shorter or smaller than in the male. In the young one-horned Rhinoceros living, from 1834 to 1849, at the Zoological Gardens, the new fibres of the growing horn were chiefly added to the front and sides, those at the back decaying, and by this direction of addition the horn preserved its relative position to the fore part of the growing head. This local decay and renovation became less conspicuous after the animal had gained its full size; and in the long horns of aged individuals the whole basal circumference presents the same smooth and polished surface, the reception of additional matter being then restricted to the completed area of the base.

Raise and prolong the bone covered by the vascular horn-forming tegument, and the next type of horn would result. In most Ruminants (Oxen, Antelopes, Goats, Sheep) a pair of processes extend from the frontal bones, the dermo-perioste of which develops a sheath composed of horny fibres: but the supporting process is long and conical, and the horn which sheaths it is correspondingly hollow, whence the Ruminants, so armed, are termed 'hollow-horned.' The bone is termed the 'core:' it has usually a rugous or grooved exterior: in *Bovidæ* and *Ovidæ* the frontal

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[1] The nasals of the fossil *Rhinoceros minutus*, Cuv., show a transverse pair of small and smooth conical processes, which cannot confidently be inferred to have sustained horns: like the *Rhinoceros incisivus*, I believe it to have been hornless.

[2] There are reports, needing confirmation, of a small third horn, as a rare variety.

sinuses extend therein: in *Antilopidæ* the core is solid or but slightly excavated at the base. In an Indian species (*Antilope quadricornis*, fig. 491) two pairs of horn-cores are developed from the frontals; the same peculiarity characterised the gigantic extinct Antelopes (*Bramatherium* and *Sivatherium*, vol. ii. p. 473, fig. 322), and they also combined the branched character of the horn in the hinder pair, which is at present restricted to the single pair borne by the Prong-horn Antelope (*Antilocapra Americana*, fig. 492).

490

Skull of Ox with horn-core, *a*, and horn, *b*.

491

Skull of four-horned Antelope.

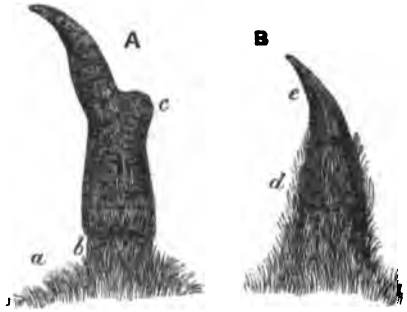
492

Branched horns of the Prong-horn.

In the true Oxen (*Bos*) the horn-cores spring from the posterior angles of the frontals, fig. 490: in the Bisons (*Bison*) their origin is a little in advance of these angles (vol. ii. fig. 320): in the Buffaloes and Bubaline Antelopes the horn-cores rise by broad and extended bases, meeting at the mid-line (*Bubalus Caffer*, *B. moschatus*, *B. Gnu*): in Antelopes the origin of the horns are more in advance. The shape, size, length and direction of the horns vary extremely in the hollow-horned Ruminants: in many they are transversely ridged or annulate; but several rings may be formed in one year: a periodical activity of growth is noticeable in most, as in the Ram and Goat, toward the period of the rut. Horns are usually present in both sexes; but in some genera of Antelopes (*Tragelaphus*, *Cervicapra*, *Cephalophus*, e.g.) only in the male. In *Antilocapra* the rudimental horns in the female are sometimes conspicuous, but are small, short, and simple, as in the yearling-buck.

The Prong-buck acquires its full-sized horns by progressive growth of the persistent core and by annual shedding and renewal of the extra-vascular sheath. The latter phenomena have been witnessed and recorded by two trustworthy observers. Mr. Bartlett noticed their fall in a young male at the Zoological Gardens, November 7th, 1865: the shed sheath was 8 in. long, and showed an obtuse beginning of the lower prong of the fork, fig. 493, A, *c*. The dermo-perioste of the core does not lose its vascularity: the shedding of the agglutinated fibres of the sheath, like that of the ordinary hair, is due to the obliteration of the matrices of these fibres and their extrusion from the dermo-perioste; which, in the meanwhile, has begun to develope a new coat of fibres, ib. *b*. These, on the shedding of the old mass, appear as an abundant covering of long, straight, silky and light-coloured hairs, ib. *d*, the growth of which mechanically uplifts and pushes off the old sheath. The new sheath, 4 inches long when so exposed, grew to 6 inches in the course of three weeks, at which time the fibres had begun to felt or agglutinate into a compact horn at the summit, fig. 493, B, *e*.[1]

493



Shedding and formation of horny sheath of horn, *Antilocapra Americana*. CCXXIV''.

Dr. Canfield observed in a young yearling male Prong-buck, which he had captive, at Monterey, California, the growth of the

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[1] CCXXIV''. p. 719.

first pair of horns commencing in July (1855), and attaining the length of ¾ths of an inch and the form of a mammillary knob; the sheath was shed, early in December, leaving the core ½ an inch long, and covered by fine silky hairs: in a week the agglutination of the summit into compact horn commenced. In October 1857, the animal being two years and a half old, the horns were 9 inches long, and the anterior prong was indicated by a protuberance, as in fig. 493, A, the agglutinate tip of which soon became confluent with that of the main stem. The phenomena noted between 1855 and 1857 indicated an annual shedding of the horn-core.[1] It is probable that such takes place, also, in the fully-formed horn and, in the month of November, as a rule.[2]

The Giraffe has a pair of small, short, cylindroid unbranched horns which consist of bone covered by hairy skin terminated by a tuft of coarser hair. The bones are not processes of the skull but are joined, like epiphyses, by 'synchondrosis' to both frontal and parietal bones, the base crossing the coronal suture. They are present in both sexes (vol. ii. p. 476, fig. 325); and the young is born with such horns, being the sole horned mammal that enters the world with these weapons.[3]

In Deer (*Cervidæ*) the horns consist wholly of bone which grows from the frontal, the periosteum and finely haired integument, called 'velvet,' co-extending therewith during the period of growth; at the end of which the formative envelope loses its vascularity, dries and is stript off, leaving the bone a hard insensible weapon. After some months' use, as such, the horns or more properly 'antlers,' having lost all vascular connection with the skull, and standing in relation thereto as dead appendages, are undermined by the absorbent process and shed; whereupon the growth of a succeeding pair commences. The shedding of

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[1] ccxxv″. p. 108.

[2] Thus Dr. Canfield observes:—'In the month of December and January I have never killed a buck with large horns; and at that time of the year all the bucks appear to be young ones, because their horns are so small, whereas in the spring and summer months almost all the bucks appear to be old ones, for their horns are then large and noticeable.' He also remarks:—'In the summer months the line of demarcation is very apparent and abrupt between the horn and the skin from which it grows, but that in winter there is no demarcation, the horn being very soft at its base, passing insensibly into cuticular tissues, and the horny substance being covered thinly with hair.' Ib. p. 108.

[3] ccxxvi″. p. 25. A broad obtuse eminence formed by thickening of contiguous parts of the two frontals at the part of the frontal suture, the base of which eminence is often irregularly excavated or undermined by vessels, has been mistaken for a third horn, articulated to the frontals. See xcvii′. p. 219; and section through this part, vol. ii. fig. 326.

§ 368. *Opening on the limbs.*—In certain Bats (***Emballonura***, e. g.) a glandular cutaneous sac, exuding a reddish mal-odorous secretion, opens upon the anterior border of the wing, near the head of the humerus. In *Saccopteryx* (at least in the male) a larger sac, with a plicate internal surface situated on the under part of the wing, near the ulna, opens by a fissure on the upper surface of the limb.

In the one-horned Rhinoceros (*Rh. indicus*, and probably in other species) there is a glandular orifice at the back part of each foot, situated about three inches above the callous sole: it is concealed in the middle of the transverse fold that runs parallel to the interspace between the carpus and metacarpus, and between the tarsus and metatarsus. The gland is of a compressed ovate figure, measuring one inch and a half in length, and one inch in breadth: it is hollow, with parietes from two to three lines in thickness, consisting of a compact congeries of follicles, surrounded externally by a muscular and tendinous capsule. The external orifice may be expanded to a width of eight lines.[1]

499

Interungulate gland, Sheep.[2]

In most bisulcate Ungulates a similar gland exudes its lubricating sebaceous secretion from an orifice at the upper and fore part of the cleft between the principal hoofs. In the sheep, fig. 499, the gland is elongate and bent forward at an acute angle upon its duct, (indicated by the bristle in the figure and preparation). These post-digital and interdigital glands, in ungulate quadrupeds, seem to relate to lubricating or greasing the hoofs.

The most remarkable of the 'peculiar glands' in the Mammalian class, and one that relates most closely to sex, is that which in the mature male Monotremes sends its duct to terminate in the hollow spur projecting from the heel. The character is not manifested in the young animal. A small spur concealed in a cavity or socket of the integument covering the heel, the bottom of which closely adheres to the accessory tarsal ossicle, exists in the immature of both sexes.[3] As the young animal advances to maturity the cutaneous socket increases in width and depth in the female, but without any corresponding growth of the rudimentary

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[1] v'', p. 34, pl. ix. figs. 1 and 2.

[2] xx. vol. iii. No. 2152 B.

[3] A magnified view of the part in the young male is given in LXXVIII'. pl. 32, figs. 1 & 5.

or posterior surface applied to the urogenital canal; two muscles, answering to the levatores penis in the male, converge and unite upon the upper or anterior part of the clitoris, and send their common tendon through a sheath to terminate near the glans: this is composed of a vascular corpus spongiosum.

§ 390. *In Perissodactyla.*—The ovaria, in *Rhinoceros Indicus*, are included within a large peritoneal sac, communicating with the general abdominal cavity: they are compact, oblong and subcompressed. The oviducts commence by wide orifices, having a richly fimbriated margin: their diameter at the expanded end equals two-thirds of an inch, but they gradually diminish in size as they pass in a slightly tortuous course along the parietes of the ovarian capsule towards the uterus: just before they enter the cornu their diameter does not exceed one-third of a line. They terminate in the extremity of the cornu upon a valvular protuberance about the size of a pea, which is divided into four or five processes. The 'cornua uteri' are each seventeen inches in length: the 'corpus uteri' only an inch and a half. The cornua are occupied by close-set longitudinal folds: the inner surface of the corpus is smooth. The vagina, about sixteen inches in length, is divided by a constriction from the urogenital tract, which is three inches long. The upper or uterine third of the vagina is occupied by broad transverse folds, the lowest of which is most extensive. About an inch above this fold, or nearer the uterus, a second and smaller fold is formed, which also descends from the upper and lateral parietes of the vagina, but passes across in an oblique direction: then follow in quick succession a series of shorter but equally broad semilunar folds, which become alternate in their relative position as they approach the uterus, so as to cause the cavity of the vagina to assume a spiral course: as these valvular folds also assume a thicker, softer, and more vascular texture, it is by no means easy to determine where the vagina ends or the uterus begins.[1] The structure resembles that in the Tenrec and some other *Lissencephala*. The urethra opens into the urogenital passage just beyond the vaginal constriction. The lateral apertures of the 'Malpighian canals' are about an inch and a half from the vulva. These canals expand, and then divide and subdivide, terminating in blind ends near the beginning of the vagina.[2] The 'preputium clitoridis' and urogenital canal open externally by distinct but approximate narrow elongate orifices: the vulva opens about five inches from the vent.

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[1] v. p. 52, pl. 18.

[2] Ib. *m, m.*

In the Tapir the ovaria are small subcompressed oval bodies, in a widely open peritoneal pouch; the oviducts have a tortuous course along the pouch near its margin to the uterine horns, which are long, and longitudinally multiplicate within: the body of the uterus is but two inches long, the 'os tincæ' not very prominent: the vagina is long; a constriction divides it from the urogenital passage, which is short. The clitoris and Malpighian canals resemble those of the Rhinoceros.

In the Mare the ovaries, of an elongate reniform figure, are inclosed and concealed in large peritoneal sacculi, fig. 574, *z*, to the mouths of which the fimbriated extremities of the oviducts are attached. The inner surface of the pavilions are characterised by numerous narrow, close-set, minutely plicated laminæ. The oviducts have a wavy course to the horns of the uterus, which are a little longer than the body or common cavity; short oblique wavy folds of the lining membrane, much developed in the impregnated state, fig. 575, *t*, project into the interior: a few similar folds are present in the body of the uterus, together with others which are broader and disposed more longitudinally at the cervix. The os uteri, ib. *l*, is denoted by the sphincteric thickening of the muscular coat and the contraction of the canal; but there is little or no valvular projection into the vagina. Of this canal, *k*, the inner surface is increased by numerous irregular longitudinal folds: a constriction defines the vagina from the urogenital passage, ib. *d*; the urethra, ib. *e*, opens near the constriction, behind a rugous prominence or flap, ib. *f*. The orifices of many follicles are dispersed over the comparatively smooth surface of the urogenital passage. The trilobate 'glans clitoridis,' ib. *a*, projects from its preputium close to the anterior margin of the vulva. It is provided with 'erectores' muscles and a 'plexus retiformis': the sphincter of the urogenital passage is very powerful. In the Filly the communication of the vagina with the urogenital canal is divided by a longitudinal septum or 'hymen.' The Zebra and Ass closely agree with the Mare in the structure of the female organs.

545

Ovarium of Sow; nat. size.

§ 391. *In Artiodactyla.* — The ovaria of the Sow, fig. 545, are large oblong bodies with an irregular and tuberculate surface: when the ovisacs enlarge, the stroma is scanty in proportion. Each ovarium is inclosed within a peritoneal sac, near the aperture of