

MAY 20, 1857.

Lieut. H. Thurburn, of the 42nd Regiment M.I., and James Salter, M.B., F.L.S., 6 Montagu Street, were elected Fellows. Dr. H. B. Geinitz, Professor of Geology and Mineralogy in the University at Dresden, was elected a Foreign Member.

The following communications were read :—

1. *Description of a small LOPHIODONT MAMMAL (Pliolophus vulpiceps, Owen), from the LONDON CLAY, near HARWICH.* By Prof. OWEN, F.R.S., F.G.S., &c.

[PLATES II., III., IV.]

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Remarks on the limb-bones.

Introduction.—The remains of Mammalia from Eocene beds below the Binstead, Gypseous, and Headon or Hordwell series have hitherto been very scanty, and for the most part fragmentary ; whether from the clays of London and Bracklesham, or from the equivalent sands, conglomerates, or “calcaires grossiers” of the Continent. The best evidence of *Pachynolophus*—a Lophiodont genus represented by species of small size, characteristic of the conglomerate of Mont Bernon (*Pachynolophus Vismæi*, Pomel) and of the “calcaire grossier” of Nanterre, Passy, and Vaugirard (*Pachynolophus Duvalii*, Pomel),—consists of portions of upper and lower jaws, with teeth. The *Dichobune suillum*, Gervais, from the “calcaire grossier” of Passy, if it be a true *Dichobune*, rests upon a fragment of mandible with three teeth, and on a few detached teeth, with an astragalus. The genus *Propalæotherium*, Gervais (*Palæotherium isselanum* and *Pal. aurelianum*, Cuv.), is represented by similar fragmentary evidences of jaws and teeth from the lacustrine calcareous deposits at Buchsweiler, on the Lower Rhine, at Issel in the department of Aude, and at Argenton. The fossil eocene Monkey (*Macacus* [*Eopithecus*] *eocænus*) is known only by a small fragment of the under jaw with two teeth, and by a detached mandibular molar from the lower eocene sand of Suffolk. The best and most instructive mammalian fossil hitherto obtained from the London clay has been the portion of cranium with the molar series of teeth on which the genus *Hyra-cotherium** was founded. But the subject of the present communication is an entire skull with the complete dentition of both upper and lower jaws (Plates II. and III.) and a portion of the skeleton of

* Trans. Geol. Soc. 2nd series, vol. vi. p. 203, pl. 24.

the same individual, including the right humerus, Pl. IV. figs. 1-4, the right femur, *ib.* figs. 5 and 6, a great part of the left femur, the left tibia, Pl. IV. figs. 10-13, and three metatarsal bones, *ib.* fig. 14, apparently of the same hind foot. There have, also, been extracted recognizable portions of the pelvis, and some fragments of ribs; other fragments of ribs, vertebrae, and small bones are left in the matrix. The osseous tissue is silicified and partly impregnated with pyritic matter.

This, therefore, is the most complete and instructive mammalian fossil of the age of the London Clay which has hitherto been discovered, and its study is replete with peculiar interest.

In the course of last winter Mr. Colchester, the able and successful explorer and collector of organic remains of the eocene sands at Kyson, Suffolk, brought to the British Museum for my inspection one of the nodules of the Roman-cement bed of the London clay, near Harwich, from which nodule a portion had been chipped off, exposing on the fractured surface the faint outline of a skull, in size and shape like that of a fox.

This appearance had arrested the further progress of the breaking-up of the nodule by the workmen, and the specimen came into the possession of the Rev. Richard Bull, M.A., Vicar of Harwich, by whom it was intrusted to Mr. Colchester for my opinion respecting the nature of the fossil, and by whose liberal permission the subsequent operations were carried out, by which I am enabled to communicate to the Society the following description of a new genus and species of perissodactyle pachyderm, for which I propose the name of *Pliolophus vulpiceps**, or Fox-headed Plioloph.

The nodule presented the common subspherical form, and was about a foot in diameter. On closely inspecting the fractured surface, indications of other bones, besides the skull, were detected, and as the work of exploration proceeded, it plainly appeared that the carcass, or great part of the carcass, of a quadruped, about the size of a fox, had formed the nucleus round which the clay, modified by the chemical constituents of the dissolving and decomposing flesh, had become aggregated and consolidated.

I have rarely broken up any septarian nodule of the London clay, which, thus altered, forms the chief material of the 'Roman cement,' without detecting some organic relic which seemed to stand in the relation of a nucleus to such compact spheroid mass.

The hardness and compactness of the matrix are extreme; but, by the aid of the lapidary's saw and the skilful and careful use of the chisel, Mr. Dew, by whom most of the Sewalik fossils in the British Museum were brought to their present instructive state, succeeded

* Accomplished Palaeontologists of France having included one of the elements of the term *Lophiodon* (λοφίον a small crest, ὀδὸν a tooth) in the names of subgenera of the Lophiodont family, as, *e. g.*, in *Pachynolophus*, the same principle has guided to the choice of the term *Pliolophus* for the present accession to the family. By it I simply mean that it is more near to the Lophiodont type than its close ally the *Hyracotherium*. But the sooner a term becomes an arbitrary sign the better.

in extricating entire the skull, and in relieving it from the surrounding closely adherent matrix, and subsequently in working out the other bones above specified.

Description of the Skull: Plate II.—The skull is moderately long, slender, tapering gradually from the zygomatic region to the muzzle, Pl. II. fig. 2, with an unusually straight upper outline, from the occipital crest to the end of the nasal bones, Pl. II. figs. 3 and 4. The bony rim of the orbit, fig. 3, *or*, is incomplete behind for an extent of about one-fifth of its circumference.

The occipital region is triangular, bounded by a strong occipital crest, 3, which is continued on each side into the upper border of the zygomatic arch, Pl. II. fig. 3, 27, and, by the middle of its upper part, with a parietal crest, 7. This latter, rising clearly above the calvarian surface, Pl. II. fig. 4, to an extent of from one to two lines, advances forward one inch nine lines, and bifurcates, subsiding to the level of the frontal surface, 11, each division diverging and curving outward, with the convexity forward, to the post-frontal process, 12, which projects backward and a little downward, terminating freely about 8 lines above the zygoma, 26, 27. The interorbital part of the frontal region, *ib.* 11, is nearly flat at its middle, and bends gently down on each side to the superorbital border. The long nasals, 15, form the rest of the upper surface of the skull, which is at first moderately convex transversely, and is then grooved along the mid-line to the free ends of the nasals. These bones are 13 lines across their base, and gradually contract to a breadth of 7 lines, which they retain for the terminal inch of their extent.

The zygomatic arch, springing outward and a little forward from its hinder root or pier, Pl. II. fig. 3, 27, describes a slight sigmoid flexure, first convex then concave upward, where it forms, 26, the lower border of the orbit; this border extends some 4 or 5 lines further outward than the upper border. There seems not to have been a zygomatic process rising toward the postfrontal, 12, but a mere convexity of the upper border of the zygoma behind the orbit. The extreme vertical diameter of the zygoma is 4 lines. The cerebral part of the cranium forming the inner wall of the temporal fossa shows the greatest expansion of the brain at about the middle of that fossa, behind which, on both sides, the concavity exhibits several irregular indentations and some vascular perforations. There is no superorbital foramen; a very feeble indent of the base of the post-orbital process is the sole indication of the place of issue of the super-orbital nerve. The antorbital foramen, Pl. II. figs. 3 and 4, *a*, about $1\frac{1}{2}$ line in diameter, is situated 9 lines in advance of the orbit, and between 2 and 3 lines above the alveolus of the second premolar.

The vertical outer plate of the maxillary, 21, slightly expands where it forms the sockets of the small canine, *c*. The sides of the bony nostril are almost straight, extending from a distance of 5 lines from the free ends of the nasal, *o*, obliquely downward and forward, and being formed by the premaxillary bones, Pl. II. fig. 4, 22: the vertical extent of the aperture is about 10 lines.

The mandible, 29, 30, had been dislocated, about 4 lines in advance of its place of articulation, prior to the consolidation of the surrounding matrix, by which it is now fixed with the lower teeth to the same degree in advance of their correspondents above, as in Pl. II. fig. 3. This dislocation enables the flattened surface of the major part of the glenoid cavity to be brought into view, at *g*, fig. 3. In figure 4 the mandible is figured as in its proper position.

The ascending ramus of the mandible develops a short recurved coronoid process, Pl. II. fig. 4, *r*; below this and the condyle *d*, it expands, gradually extending backward as it descends from the condyle, describing an irregular convex curve as it passes into the under border, and forming a broad angular plate, 29, for the implantation of the pterygoid and masseter muscles. The fossa indicating the insertion of the temporal muscle, fig. 3, *t*, is limited to the upper half of the ascending ramus, where it is bounded by a curved line or bank continued downward and forward from the outer part of the condyle: the anterior border of the depression subsides upon the part of the jaw which extends outward from the alveolus of the last molar. The outer side of the horizontal ramus of the mandible is lightly convex: the lower border, continued from the broad rounded angle, is at first gently concave, then as slightly convex. The ramus very gradually decreases in depth to the first premolar, below which the symphysis begins, Pl. II. fig. 1, *s*, *i*. Here the mandible is a little compressed and again expands slightly to form the alveoli of the canines, *c*, and incisors, *i*, 1, 2, 3. The line of the symphysis rises very gradually to the incisive border, *s* *i*, figs. 1 and 2, Pl. II.

The following traces of sutures are unmistakeable: the squamous, Pl. II. fig. 3, *g*, continued forward from the irregular depressions on the side of the cranium, at first straight, then with a downward curve; the straight part is 9 lines below the sagittal crest, 7: the interfrontal suture, Pl. II. fig. 2, 11, continued into the internasal one, *ib*. 15, along the midline of the facial part of the skull: the fronto-nasal suture, *ib*. *f*, describes a slight sigmoid curve, as it extends transversely outward and downward to the lacrymal, 73, fig. 3, Pl. II. The suture connecting this bone, 73, to the maxillary, 21, and malar, 26, shows that its facial plate is about 4 lines in vertical, and 3 in fore-and-aft, diameter. The malar, 26, forms the lower half of the fore part of the orbit; the anterior end of its almost horizontal suture with the squamosal, 27, begins just below the postorbital process. The naso-maxillary suture, Pl. II. figs. 3 and 4, *m*, is nearly straight, 1 inch in length; its continuation by the naso-premaxillary suture *n* is about 6 lines in extent; but this part of the lower border of the nasal, 12, is slightly convex downwards, with a corresponding curve of the suture. The maxillo-premaxillary suture, *p*, is almost a straight line, parallel with the lateral border of the nasal aperture.

The following are admeasurements of the skull of the *Pliolophus*, with some comparative admeasurements of that of the *Hyracotherium*:—

	<i>Pliolophus vulpiceps.</i>	<i>Hyracotherium leporinum.</i>
	in. lines.	in. lines.
Length of skull	5 0	
Extreme breadth of skull, at the zygomata	2 2	
Extreme breadth of cerebral part of cranium	1 3	
Breadth across postfrontal processes	1 6½	1 7
Breadth of upper jaw opposite first premolars	0 9	0 11
Vertical diameter of skull opposite first true molar	1 4	1 6½
Vertical diameter of orbit	0 9	1 0
From occipital crest to fore part of orbit	2 9	
From occipital crest to fore part of temporal fossa	2 2	
From the fore part of the orbit to the end of nasals	2 3	
Length of mandible	4 4	
Length of symphysis mandibulæ	1 0	
Breadth of ascending ramus	1 6	
Height of ascending ramus at the condyle	1 6	
Height of ramus below first true molar	0 7	
Extent of molar series, upper jaw	1 11	2 0
Extent of molar series, lower jaw	2 0	
Extent of three true molars, upper jaw	0 11½	1 1
Extent of the four premolars, upper jaw	0 11½	0 11
Extent of three true molars, lower jaw	1 0	
Extent of the four premolars, lower jaw	1 0	

Comparison of the Skull.—The extent and well-defined boundary of the temporal fossæ by the occipital, parietal, and post-frontal ridges, and their free communication with the orbits, give almost a carnivorous character to this part of the cranium of *Pliolophus*: but, as in the Hog, Hyrax, and Palæothere, the greatest cerebral expansion is at the middle and toward the fore part of the fossæ, with a contraction toward the occiput; the brain-case not continuing to enlarge backward to beyond the origin of the zygomata, as in the Fox.

The zygomatic arches have a less outward span, especially at their hinder pier, 27, than in the *Carnivora*. In this part of the cranial structure *Pliolophus* resembles *Palæotherium* more than it does any existing mammal; but the post-frontal processes are longer and more inclined backward.

The incompleteness of the orbit occurs in both *Anoplotherium* and *Palæotherium*, as in *Rhinoceros*, *Tapirus*, and the Hog-tribe; but, in the extent of the deficient rim, *Pliolophus* is intermediate between *Palæotherium* and *Tapirus*. The orbit, Pl. II. fig. 3, *or*, is not so low placed as in *Palæotherium*, *Tapirus*, and *Rhinoceros*, nor so high as in *Hyrax* or *Sus*. The straight upper contour of the skull is like that in the Horse-tribe and Hyrax, and differs from the convex contour of the same part in the *Anoplothere* and *Palæothere*. The size of the antorbital foramen, Pl. II. figs. 3 and 4, *a*, indicates no unusual development of the muzzle or upper lip. In the conformation of the nasal aperture by four bones (two nasals, 15, and two premaxillaries, 22), *Pliolophus* resembles the Horse, Hyrax, Hog-tribe, and *Anoplothere*, and differs from the *Rhinoceros*, *Tapir*, and *Palæothere*, which have the maxillaries, as well as the nasals and premaxillaries, entering into the formation of the external bony nostril.

The ungulate and herbivorous character of *Pliolophus* is most

distinctly marked by the modifications of the lower jaw, especially by the relative dimensions of the parts of the ascending ramus which give the extent of attachment of the biting (temporal, *t*) and grinding (masseteric and pterygoid, *20*) muscles respectively. In the shape of the mandible *Phiolophus* most resembles *Tapirus* among existing mammals, and the *Palæotherium* among the extinct ones in which that shape is known. Unfortunately no mandible of a true *Lophiodon* has yet been found so entire.

As far as the portion of the skull of the *Hyracotherium leporinum* permits the comparison to be made, there is a close general resemblance between it and *Phiolophus*; but the skull of the *Hyracotherium* is broader, at the orbital region, in proportion to the length of the antorbital or facial part*. The orbits are both absolutely and relatively larger; they are also rounder and have a lower position. The straight upper contour of so much of the skull of the *Hyracotherium* as has been preserved, the size and position of the antorbital foramen, the course of the maxillo-premaxillary suture, and the formation of the bony nostril by the nasals and premaxillaries exclusively, are further indications of the affinity of *Hyracotherium* to *Phiolophus*.

This affinity is decisively shown by the more important characters derived from the dentition.

Description of the teeth of Phiolophus: Plate III.—As in the *Hyracotherium*, and, indeed, as in almost every species of Eocene quadruped yet discovered, the *Phiolophus* presents the type-dentition of the placental Diphyodont series, viz. :—

$$i \frac{3-3}{3-3}, c \frac{1-1}{1-1}, p \frac{4-4}{4-4}, m \frac{3-3}{3-3} = 44.$$

The incisors, Pl. II., *i* 1, 2, 3, are preserved in the lower jaw with marks of attrition on their crowns demonstrating corresponding teeth of the same number, *s*, and of similar size, in the upper jaw, from which the alveolar part of the premaxillaries had been broken away.

The lower incisors, Pl. II. fig. 1, *i* 1, 2, 3, form a semicircle terminating the slender sloping symphysis mandibulæ, *s*, and projecting parallel with it, so as to be almost procumbent, Pl. II. figs. 3 and 4, *i*. Their crowns present the common wedge-shaped form, with the trenchant border obliquely beveled off, and the more so from the first, *i* 1, to the third, *i* 3: they slightly decrease in size, or at least in length of crown in the same course; but the outer incisor, *i* 3, is not so small relatively as in the *Tapir*. The degree of attrition to which they have been subject produces a certain breadth of the trenchant border.

The canines, *ib.* *c*, are small in both jaws: only the crown of the right lower one, Pl. II. fig. 3, *c*, is entire: it is about 4 lines long, in the form of a slender cone, inclined a little forwards, with the front border convex, the hind one more nearly straight. The lower canine is separated by an interval equal to its own basal breadth, viz. about 2 lines, from the outer incisor, and by an interval of 5 lines

* *Op. cit.* pl. 21. fig. 2.

from the first premolar. In the upper jaw the canine is separated by a rather wider space than in the lower jaw from the incisors, and by a rather narrower space from the premolars. In thickness of base and, apparently, in length and shape of crown, the upper canines resembled the lower ones. The premolars, *p*, and molars, *m*, form a continuous series on each side of both jaws; except that a space of about a line intervenes between the first and second premolars in the lower jaw.

The premolars increase in size and complexity to the fourth, which nearly equals that of the true molars. The last of these, *m* 3, in the lower jaw, presents a third lobe. In Pl. II. fig. 3, the premolars of the upper jaw are marked 1, 2, 3, 4: the true molars of the lower jaw are marked 1, 2, 3: the dislocation of the jaw carries these one tooth in advance. In the upper jaw, the first premolar, Pl. II. fig. 3, *p* 1, presents the common subcompressed conical shape, with the base of the crown swelling out below the fangs, and the protuberant part continued along the outside of the middle part to the apex of the cone; on each side of this prominence the crown presents a depression; and the surface, though polished, is broken by a few irregular longitudinal indentations, which give the enamel a slightly wrinkled character.

The second premolar, *p* 2, resembles the first; but is somewhat larger, especially thicker, and with the front and back parts of the base more produced; an outer longitudinal groove near the summit of the cone indents it deeply.

The third premolar, *p* 3, has two cones on the outer side, and an anterior basal talon; from this a slight ridge is continued upon the outer part of the anterior cone: the whole outer base of the posterior cone is girt by a similar low cingulum, continued into a rudimentary talon behind. The crown expands posteriorly, and its working surface is increased by an internal ridge, and the valley dividing it from the two outer cones.

In the fourth premolar, the crown, Pl. III. figs. 1 & 2, *p* 4, with an increase of thickness, presents greater complexity: the cingulum is uninterrupted along the outer side from its anterior well-developed talon, *c'*, to the back part where the ridge, *t*, represents the talon. The two outer cones resemble those of the true molars; but there is only one inner cone, and the crown of *p* 4 differs accordingly from that of *m* 1, in being triangular rather than square. A ridge, *r*, is continued from the interspace between the anterior talon, *c'*, and the outer anterior lobe obliquely inward and backward to the inner lobe, swelling into a small tubercle at the middle of its course; a lower rising, hardly to be called a tubercle, intervenes between the inner cone and the outer posterior cone. The cingulum forms a well-marked ridge, *t*, along the back part of the crown, and is continued more feebly round the base of the inner lobe, with a brief interruption at its most prominent middle parts: beyond this the cingulum is continued into the anterior basal ridge, which expands into the small antero-external basal tubercle, *c'*. The fourth upper premolar is implanted by two external and one internal roots.

The first molar, Pl. III. fig. 2, *m* 1, shows, as usual, a greater amount of attrition than the preceding premolar: its grinding surface presents four low thick cones, two internal as well as two external: each external cone is connected with its opposite internal one by a low ridge extending from the fore part of the external to the middle of the internal one, and swelling into a tubercle, *r* and *s*, at the middle of its oblique course. The cingulum, *c* *c*, seems to be continued uninterruptedly round the crown of this tooth, thickest at the fore and back part, and at the interspace of the inner lobes; and developing the small accessory antero-external tubercle, *c'*. The outer lobes are connected together by a low plate, internal to the cingulum.

The degree of attrition to which this tooth has been subject has exposed the dentine, which is surrounded by a belt of thick enamel upon the summits of the four principal lobes and of the intervening tubercles. This molar is implanted by two external roots and by a broad internal one, longitudinally indented at the middle, and which may divide where it lies deeper in the jaw.

The second molar, *m* 2, is similar to, but rather larger than, the first; and the tubercle on the oblique ridge connecting the two hinder lobes is less developed. The cingulum, *c*, is obliterated on the inner side of the posterior lobe. The implantation of the tooth is like that of *m* 1.

The last molar is rather narrower behind than *m* 2; the tubercle, *r*, on the anterior of the oblique connecting ridge is smaller: that on the posterior ridge is almost obsolete. The hinder of the two inner cones is relatively less and lower than in *m* 1 and *m* 2, and is scarcely defined from the oblique ridge *s*; the cingulum is interrupted at its inner base: the talon, *t*, formed by the back part of the cingulum is better marked than in the other molars. In all these teeth the enamel is wrinkled by longitudinal wavy impressions.

Of the mandibular teeth, Pl. IV. figs. 4, 5 & 6, only the molar series remain to be described.

The first premolar, Pl. II. figs. 3 & 4, *p* 1, is small, simple, sub-compressed, conical, like the one above; but it stands apart, an interval of about half its breadth dividing it from the second premolar.

This tooth, *ib.* *p* 1, of rather larger size, has a similar form, but with a better-marked hinder talon.

In the third premolar, Pl. III. fig. 6, *p* 3, the talon, *c*, is developed into a second lobe, which is lower than the first. The first or front cone, *a*, shows a small anterior or antero-internal talon, and the apex of the cone is cleft; a ridge from the inner division, *b*, being continued obliquely down to the inner angle of the base of the low hinder cone, *c*.

In the fourth premolar, fig. 6, *p* 4, the division and development of the anterior lobe has proceeded to establish a pair of cones, one external, *a*, the other internal, *b*, connected anteriorly by a basal ridge, in front of which is the fore part of the cingulum. The low posterior lobe, *c*, shows the rudiment of a second internal cone, *d*. The cingulum is developed at the fore part, and feebly between the

two outer cones. The posterior one, *c*, is connected by a ridge, which advances inward and forward, to the interspace between the anterior pair of cones.

The first molar, *m* 1, with an increase of size over the last premolar, also shows an equal development of both fore and hind pair of lobes; the summits of the two outer lobes are more abraded than those of the two inner ones, and the dentine is exposed in each. The same oblique ridge is continued from the fore part of the postero-external lobe to the interspace between the anterior pair: the cingulum is not developed upon the internal part of the tooth, but it is upon the external part, and especially upon the anterior lobe: posteriorly it forms a kind of low talon wedged into the interspace of the hinder pair of lobes.

The second molar, *m* 2, shows an increase of size; but its chief and most interesting modification is the development of a tubercle, *e*, between the two anterior lobes, making three cones on the same transverse line, and thus repeating the character of the molar tooth above. The oblique ridge from the outer and hinder lobe, *c*, abuts against the intermediate anterior tubercle, *e*. The inner surface or plane of the inner and hinder cone, *d*, inclines as it extends forward toward the middle of the crown: the fore parts or prolongations of the hinder cones thus converge as they pass forward toward the middle of the crown. The cingulum extends from the back part of the crown along the outer side to the fore part. Both this and the preceding molar are implanted by four roots.

The third molar, *m* 3, is distinguished by its greater fore-and-aft extent, due to its additional or third lobe. The ordinary two pairs of cones resemble those of the preceding molar, but the intermediate tubercle between the anterior pair is reduced to a short connecting bar. The hind lobe appears to have been divided into two small cones, but this part of the tooth was fractured in the attempt to remove the very hard and adherent matrix.

I beg to express my obligations to the accomplished artist, Mr. Ford, for the pains which he has bestowed in attaining the utmost accuracy in the figures above referred to.

Affinities of the Pliolophus vulpiceps as shown by the skull and teeth.—Before proceeding with the description of the other parts of the little quadruped which have been extricated from the septarian nodule, it may be convenient to record here the deductions as to the nature and affinity of the *Pliolophus vulpiceps* which may be drawn from the skull and teeth.

The form of the articular surface for the lower jaw, and above all that of the mandible itself, demonstrate the ungulate and more or less herbivorous nature of *Pliolophus*. Amongst recent non-ruminant Ungulates, *Tapirus* offers the nearest resemblance in the disposition and form of the zygomatic arch, and in the general form of the lower jaw: amongst the extinct Ungulates, *Palæotherium* most resembles *Pliolophus* in the same parts of the skull, with a nearer approach than the *Tapir* makes, in the production of the nasal

bones; but in this character, and in the important one of the more simple formation of the nostril, *Anoplotherium* offers a closer resemblance to *Pliolophus*. In the almost straight upper contour of the skull, the Horse and the *Hyrax*, amongst existing Ungulates, resemble *Pliolophus*, and both these Perissodactyles add the corresponding character of the juncture of the premaxillaries with the nasals, which *Pliolophus* presents in common with the Anoplotherioids. But the orbit is circumscribed by bone in the above-cited existing Perissodactyles, whilst it opens behind into the temporal fossa in both *Anoplotherium* and *Palæotherium*, as in *Pliolophus*. *Microtherium* resembles the small Musk-deer in the entire bony frame of the orbit.

The form of the skull in *Lophiodon* proper has not yet been ascertained; but the comparative simplicity of the premolars in *Pliolophus*, and the configuration of the surface of the upper true molars, especially the last, Pl. III. fig. 2, *m* 3, demonstrate that the present small Eocene quadruped has the nearest affinity to the Lophiodont family, amongst the known extinct and recent members of the class. To a Lophiodont mammal, indeed, of the same size from the marls of the 'Calcaire grossier' in the vicinity of Paris (*Lophiodon leptognathum*, Gervais*, *Hyracotherium de Passy*, De Blainville†), on which M. Pomel subsequently founded his subgenus *Pachynolophus*, I felt most inclined, at first, to refer the *Pliolophus*; and it was in the prosecution of this comparison that I determined to sacrifice the entireness of one side of the fossil skull, in order to obtain a more complete and satisfactory view of the grinding surface of both upper and lower molars than could otherwise be got.

For the comprehension of the following comparison, Pl. II. figs. 3 & 4, and Pl. III. fig. 2, of the present memoir should be examined by the side of the views of the upper molar teeth and of the right mandible and teeth of the *Pachynolophus* (*Lophiodon*) *Duvalii*, Pomel, which M. Gervais has given in his excellent 'Zoologie et Paléontologie Française,' 4to, pl. 17. f. 1, 1 *a* & 2. Unfortunately the grinding surface of the upper molars only of *Pachynolophus* has been figured, and with these I proceed to compare the same teeth of *Pliolophus vulpiceps*.

I may premise that the generic or family character of the upper molars in *Lophiodon* is the development of the outer wall of the true molars and last premolar into two cones, and by the continuation, therefrom, in the true molars, of two oblique ridges which thicken and rise into rather smaller and lower cones on the inner side of the crown. In the last premolar the oblique ridge is continued only from the anterior of the two outer cones, and expands into a single large cone forming the inner half of the crown.

In *Pachynolophus* as in *Pliolophus* the oblique ridges are lower at their commencement, in comparison with their inner terminal cones, than in *Lophiodon*, and accordingly a degree of attrition

* Comptes Rendus de l'Acad. des Sciences, Paris, vol. xxviii. p. 547.

† Ostéographie, Lophiodonts, p. 190, pl. 2.

which affects the enamelled summit of the whole ridge in *Lophiodon*, abrades only the summits of the inner cones in *Pachynolophus* and *Pliolophus*; moreover the oblique ridges in *Pachynolophus* appear from M. Gervais's figure to dilate a little in breadth at their beginning, but this swelling is not so marked and circumscribed as in *Pliolophus*, and consequently an intermediate island of enamel, as at *r* and *s*, Pl. III., between an outer and inner cone, is not presented in any of the molars of *Pachynolophus*, although the first of these, *m* 1, in the specimen figured by M. Gervais, has been as much worn down as in the corresponding molar of *Pliolophus*. In this respect *Pliolophus* presents the next transitional step in the passage from the type-dentition of *Lophiodon* to that of *Hyracotherium*, in regard to the modification of the working surfaces of the molar teeth.

The hinder half of the last molar, *m* 3, presents a minor area, as in *Pachynolophus*, and a more simple configuration; the ridge from the postero-internal cone being simple, not expanding into an accessory tubercle.

M. Gervais calls attention to the seeming quadrilobate character of the outer side of the crown in the true molars of *Pachynolophus*, produced by the development of the cingulum into a tubercle at the fore and back part of that side of the tooth. *Pliolophus* resembles *Pachynolophus* in the tubercle at the fore part of the outer wall, but the cingulum is not so expanded at the back part as to give the appearance of a fourth cone. In this respect *Pliolophus* resembles *Lophiodon* proper.

In regard to the lower jaw, the lower contour of the symphysis is in the same line with that of the lower border of the ramus in *Pachynolophus*, and the symphysis with the incisor teeth are more prominent even than in *Pliolophus*: the diastema between the premolars and canine is twice as long, and the consequent modification of the mandible led M. Gervais to propose the specific name *leptognathum* for the small *Lophiodont* of the 'Calcaire grossier,' which M. Pomel had previously dedicated to his friend M. Duval. But a distinction of more decided generic importance between *Pachynolophus* and *Pliolophus* is presented by the absence of *p* 1 in the former, which reduction of the number of the molar series to six, M. Gervais regards as normal, and assigns as the chief generic distinction from *Lophiodon*; adopting in this respect the conclusions of M. Pomel. The demonstration, which the rare perfection of the skull and teeth of the *Pliolophus vulpiceps* from the London Clay affords, of the retention of *p* 1 in the lower jaw, and consequently of the typical dental formula, justifies the same generic distinction of *Pliolophus*, as of *Lophiodon* proper, from the small *Lophiodont* called *Pachynolophus* by Pomel. The generic distinction of *Pliolophus* from all previously known *Lophiodonts* is more decisively established by the singular modifications of the grinding surface of the lower molar teeth.

This surface, in *Pachynolophus*, seems not to have been figured: M. Gervais describes it, in the penultimate molar (*m* 2), as present-

ing "two transverse eminences connected by a diagonal crest*," and such is described as the type of the lower true molar teeth in *Lophiotherium* † and *Tapirus* ‡. This is, in fact, the structure of the lower molar teeth in *Lophiodon* proper, and that by which it so nearly resembles the existing Tapirs.

Pliolophus differs from all previously known Lophiodonts by the division of the part of the tooth answering to the "colline transverse" into two distinct cones, Pl. III. fig. 6, *a*, *b* and *c*, *d*; and the penultimate molar, *m* 2, more especially differs from that tooth in all hitherto known eocene or later forms of hoofed Mammals, in having a third cone, *e*, interposed between the two anterior cones, and thus exhibiting three cones on the same transverse line, as in the upper molars;—a structure which we have hitherto seen only in the small mammal of the Lower Oolite described under the name of *Stereognathus ooliticus* §. I expressed my regret, at that period, when I could only cite the upper molars of *Hyracotherium* and of a few other eocene Ungulates as manifesting the three transverse cones, that the structure of the lower molars in *Hyracotherium* was then unknown. As the *Pliolophus*, though in some respects intermediate between the *Lophiodon* and *Hyracotherium*, has a closer affinity to the latter, we may, with some confidence, regard the modifications of its lower molars as significant of those that the same teeth of *Hyracotherium* will present when found. And the unlooked-for confirmation of my expectation of some further illustration of the affinities of *Stereognathus* by the lower molars of *Hyracotherium*, through the now acquired knowledge of the structure of those in the nearly allied *Pliolophus*, adds, in the same degree, probability to the inference which was founded upon the resemblance between the lower molars of *Stereognathus* and the upper ones of *Hyracotherium*. In offering this remark, however, I am quite sensible how uncertain any inference from a single lower molar is shown to be by the degree of resemblance in the structure of the lower molar teeth which exists in *Tapirus*, *Macropus*, *Lophiodon*, *Dinotherium*, and *Manatus*, and, again, in those of *Hippopotamus* and *Halitherium*. The reference by Cuvier of detached teeth of the *Halitherium* to the genus *Hippopotamus*, and of detached teeth of *Dinotherium* to the genus *Tapirus*, just and exact as were these references, viewed as expressions of the correspondence detected by a comparison of the fossil with the recent teeth, ought to warn us against placing too much confidence in dental characters, exclusively, as proofs of the closer degrees of determination which Cuvier has shown must depend upon an empirical study of coincidences, rather than on the rational deductions from correlations.

The same caution I now feel to be instructively reiterated by my reference of the *Hyracotherium*, on the ground of similarity of modi-

* "♂ deux collines transverses reliées par une crête en diagonale." Paléontologie Française, descr. of pl. 17.

† Ibid. pl. 11. f. 10–12.

‡ Ibid. pl. 24.

§ Quart. Journ. Geol. Soc. vol. xiii. Part I. February 1857, pp. 1, &c. pl. 1.

fication in the grinding surface of its upper molars, to the same secondary group of *Ungulata* as includes the *Chæropotamus*.

Most comparative anatomists who have studied the unique evidences of that old eocene genus, since my description of them, have arrived at and have recorded the same conclusions*. The only dissentient from them was Mr. H. N. Turner, jun., a most promising and acute naturalist and anatomist, who died too soon for the interests of science. In a very able and characteristic paper "On the Evidences of Affinity afforded by the Skull in the Ungulate Mammalia †," Mr. Turner points out the basal expansion of the nasal bones, the absence of the superorbital foramen and groove, and the slightly marked depression for the origin of the obliquus inferior oculi, within the orbit, as indications of the perissodactyle affinities of the *Hyracotherium*: he, also, most acutely discerned in the rudimentary oblique ridges upon which the small intermediate tubercles were developed in the molar teeth rudimental homologues "of the bent transverse ridges in the *Rhinoceros*, *Tapirus*, *Palæotherium*, and other allied genera;" but the degree of resemblance of the molars to those of the *Anthracotheria* and *Chæropotami* was such as led Mr. Turner, in regard to the question of the artiodactyle or perissodactyle affinities of the *Hyracotherium*, to admit, "to whichever group, then, this little animal be referred, the teeth will present marked exceptional characters, and, therefore, it becomes more necessary to seek for further evidence ‡."

This evidence I believe to be now afforded by *Phiolophus*, on the ground of the following illustrations of its close affinity to *Hyracotherium*.

Like that genus, its upper true molars exhibit the modification of the Lophiodont type of dentition in the more circumscribed and better-developed enlargement of the middle of the connecting oblique ridges: it also shows the more simple structure of the last premolar by the same non-development of the postero-internal cone. *Hyracotherium* differs from *Phiolophus* in the more distinct development of the intermediate tubercles, especially of the second or posterior one in *p* 4: the cingulum girds the crown uninterruptedly in the true molars and last two premolars. *Hyracotherium* differs, also, in the wider interval between the first and second premolar.

It may be questioned whether these differences are of generic importance, or whether, with those before pointed out in the configuration of the skull, they may not merely indicate another species of this genus which seems to be peculiar to our London Clay. In resolving this question I have been influenced by comparing the

* De Blainville, Ostéographie des Anthracotheriums et Chæropotames, fasc. xxi. p. 194. *Hyracotherium* described and figured "d'après un plâtre assez bon, envoyé à la collection du Muséum, par M. R. Owen."

Gervais, Summary of *Ungulata* observed in France:—

11. CHÆROPOTAMINA. *Entelodon*, *Chæropotamus*, *Hyracotherium*. Pal. Franç. descr. of pl. 36. p. 6.

† Ann. and Mag. Nat. Hist. Dec. 1850, 2nd ser. vol. vi. p. 397.

‡ Loc. cit. p. 408.

degree of difference in their dental characters with that which has influenced MM. Pomel and Gervais in subgenerically separating *Pachynolophus* from *Lophiodon*; and by the fact of the mandibular teeth of the *Hyracotherium leporinum* being yet unknown.

Lophiodon, *Pachynolophus*, *Pliolophus*, and *Hyracotherium* seem thus to form so many subgeneric modifications of the same natural family of Perissodactyle Ungulates; and in the modifications of their dentition, especially in the comparative simplicity of their premolars as compared with those of the subsequently introduced *Palæotheria*, and in the progressive approach to the molar type of the Chæropotamoids made by *Pliolophus* and *Hyracotherium*, they exemplify the tendency to a closer adherence to the general ungulate type. The third trochanter on the femur of the *Pliolophus*, Pl. IV. fig. 5, *t*, and the association of three metatarsals, in one portion of the matrix, fig. 14, which appear to belong to the same hind-foot, confirm, however, the essentially perissodactyle affinities of that genus, and, therefore, of its close ally the *Hyracotherium*.

In stating that these modified Lophiodonts are the most artiodactyloid of the Perissodactyles, no particular hypothesis is advocated: there can be but one inference from this and the numerous analogous facts that have already been made known. So, likewise, in regard to the typical character of dentition, as manifested by the number and kind of teeth, we find in this last eocene mammal which has come to light a repetition of that remarkable adherence to a more general mammalian character. The older Oolitic Mammals exemplify a tendency to a type of dentition of a still higher generality than the Mammalian class, as, for example:—

Mammalia of which the dentition resembles the general vertebrate type by the back teeth exceeding 7 in number:—

Genera.	Formations.
<i>Thylacotherium</i>	Lower Oolite.
<i>Spalacotherium</i>	Upper Oolite }
<i>Triconodon</i>	Upper Oolite } Purbeck.

Mammalia resembling the Mammalian diphyodont type in the dental formula of

$$i \frac{3-3}{3-3}, c \frac{1-1}{1-1}, p \frac{4-4}{4-4}, m \frac{3-3}{3-3}; \text{ or } p \frac{3-3}{3-3} \text{ and } m \frac{4-4}{4-4} = 44.$$

Genera.	Formations.
<i>Palæocyon</i>	Sables de Bracheux (or somewhat older).
<i>Coryphodon</i>	Plastic clay.
<i>Pachynolophus</i>	Calcaire grossier moyen.
<i>Lophiotherium</i>	Marnes lacustres d'Âlais (Gard).
<i>Pliolophus</i>	London clay.
<i>Hyracotherium</i>	London clay.
<i>Palæotherium</i>	Paris gyps.
<i>Anoplotherium</i>	Paris gyps.
<i>Anchitherium</i>	Lignites de la Débruge, près Apt.
<i>Dichobune</i>	Binstead.

Genera.	Formations.
<i>Xiphodon</i>	Lignites de la Débruge.
<i>Dichodon</i>	Hordwell.
<i>Microtherium</i>	Marnes calcaires lacustres, Puy du Dôme.
<i>Amphitragulus</i>	Marnes lacustres en Velay.
<i>Amphimeryx</i>	Lignites de Débruge.
<i>Dorcatherium</i>	Miocène d'Eppelsheim.
<i>Chalicotherium</i>	Miocène d'Eppelsheim.
<i>Aphelotherium</i>	Marnes calcaires de Barthélemy.
<i>Anthracotherium</i>	Marnes miocènes de Moissac.
<i>Hypopotamus</i>	Binstead and Hordwell.
<i>Anchilophus</i>	Calcaire grossier de Batignolles.
<i>Bothriodon</i>	Miocène de Moissac.
<i>Palæochærus</i>	Calcaire lacustre de Cournon.
<i>Chæropotamus</i>	Paris gypsum, and Binstead.
<i>Chæromorus</i>	Calcaire lacustre, Sansan.
<i>Pœbrotherium</i>	Eocene (upper ?), N. America.
<i>Hippohyus</i>	Miocene, Sewalik Hills.
<i>Hippotherium</i>	Miocène d'Eppelsheim.
<i>Hipparion</i>	Marnes fluviales de Cucuron.
<i>Heterohyus</i>	Miocene, Sewalik Hills.
<i>Entelodon</i>	Lignites de Soissonnais.
<i>Hyænodon</i>	Eocène supérieure du Gard ; Hordwell.
<i>Pterodon</i>	Lignites de Débruge.
<i>Arctocyon</i>	Eocène inférieure à la Vère.
<i>Galethylax</i>	Paris gyps.
<i>Amphicyon</i>	Miocène de Sansan.
<i>Chærotherium</i>	Miocène du Bourbonnais.
<i>Rhagatherium</i>	Eocene of Mauremont, Switzerland.

All general rules in organic nature have their exceptions, and differ in that respect from inorganic phænomena, in regard to some of the general laws of which no exceptions have been as yet discovered.

I shall, on a future occasion, discuss the value of the exception to the inference from the body of facts above cited which has been adduced from the *Plagiaulax* *, and conclude the present paper with some remarks on the bones of the limbs of *Pliolophus*.

Description of some of the Bones of the Extremities. Humerus. Pl. IV. figs. 1 to 4.—The humerus, from the right fore limb, measures 4 inches in length. The convex articular surface of the head of the bone, Pl. IV. fig. 3, is subtriangular in shape, rather flattened above towards the outer side. The great tuberosity is of equal breadth with, but rises above, the articular head. It is slightly grooved obliquely near its outer part, but is not so widely or deeply notched there, as in the Tapir or Hyrax : it terminates by a single convexity. The small tuberosity is not quite so large relatively as in the Tapir and Hyrax, but it is situated, as in them,

* Quart. Journ. Geol. Soc. vol. xiii. p. 276.

at the fore and inner part of the articular head, and not so low down as in the humerus from the "terres noires du Laonnais," ascribed to *Lophiodon* by Cuvier*.

The deltoid surface is short: a smooth oblique tract separates it from a second low oblique (pectoral) ridge; the shaft of the bone rapidly contracts below the head, where it is not so compressed or so broad from before backwards, as in *Palæotherium*; it is thicker transversely than in *Hyracotherium*.

The supinator ridge begins at about the lower third of the bone, is moderately sharp for about 9 lines, and then subsides into a rather rough flattened surface above the inner condyle; it is very slightly produced. The bone is perforated above the lower articular surface; this surface has one depression and two prominences, as in the Perissodactyles. The general shape and proportions of the bone are like those of the humerus of the Hyrax.

Femur: Pl. IV. figs. 5 to 9.—The femur is rather more than 5 inches in length: its most important character, as indicative of the affinities of the *Pliolophus* in the ungulate series, is the continuation of the outer ridge of the great trochanter vertically down the outer border of the shaft and its development into a third trochanter, †, which subsides before it reaches the mid-length of the bone. The great trochanter rises in an obtusely pointed form 5 lines above the articular head; and it develops a tuberosity at the fore part of its base. The neck sinks behind the head before it rises into the trochanter. The small trochanter is a longer ridge than in the Hyrax: the shaft below the trochanter becomes less flattened than in the *Palæotheres* or *Lophiodons*: the transverse section gives a kind of semi-ellipse with the flatter side slightly convex: it shows a compact wall of bone of about a line or a line and a half thick; and a medullary cavity of from 3 lines to 4 lines in diameter. At about 2 inches from the distal end the shaft begins to expand and become three-sided, the hind- and the out-sides being less convex and broader than the inner side; then an anterior surface is established by the beginning of the rotular groove, about an inch and a half from the lower end: the inner border of the groove is produced and sharp; the outer border was broken off in the extraction of the bone: the condyles are produced backward, but not so much forward as in *Palæotherium*: the inner surface of the expanded condyloid end of the bone, Pl. IV. fig. 8, is flat, with a much less prominent part for the internal lateral ligaments than in *Tapirus*, *Hyrax*, or *Palæotherium*. The popliteal depression is very slightly concave transversely: it is divided from the intercondyloid fossa by a ridge continued inward from the back of the outer condyle.

Tibia: Pl. IV. figs. 10–13.—The tibia, which was extracted

* Ossemens Fossiles, ed. 8vo, tom. iii. p. 411. pl. 79. f. 6 & 7.

† "Les pachydermes qui offrent cette particularité sont les rhinoceros, les tapirs, les chevaux et jusqu'à un certain point les damans, c'est-à-dire les genres que j'ai désignés comme formant une petite famille distincte, et à système de doigts impairs au pied de derrière; et c'est précisément à cette famille qu'appartiennent les *Palæotheriums*, par tous les autres rapports."—Cuvier, *Ossemens Fossiles*, ed. 1835, 8vo, tom. v. p. 287.

almost entire from the septarian nodule, was of the left leg; its length is 4 inches 9 lines. The proximal articular surface, Pl. IV. fig. 11, is more equally triangular than in *Palæotherium*. The outer facet is slightly convex; the inner one slightly concave transversely. The back part of the proximal end of the bone, fig. 10, shows a broad and deep concavity, bordered by sharp margins; the outer part is somewhat less concave; the inner part is slightly convex; the rotular ridge was not extracted entire, but was evidently well developed, and extended an inch and a half down the bone. The most characteristic feature of the tibia is the articular surface at the distal end, fig. 13, of which sufficient is preserved to show the obliquity of its course across that end, corresponding with the obliquity of the articular trochlea of the astragalus which is common to the odd-toed hoofed quadrupeds. From these the even-toed group are distinguished by the rectangular disposition of the ankle-joint.

Metatarsæ: Pl. IV. fig. 14.—The portion of matrix containing the part of the calcaneum, c, and three metatarsals, shows the latter dislocated, and with only one articular end entire—the lower one—in one of them. This is, however, as characteristic as any of the distinctive features of the before-described bones, by the unsymmetrical form of the distal trochlea, due to the position of the ridge near one of the borders of the bone. Both this configuration and the position of the metatarsal show it to have been the outermost of the three: the proximal end is broken off: the length of the bone preserved is 1 inch 5 lines. Of the mid-metatarsal only a small part is exposed, from which the articular end is broken away. Of the innermost metatarsal 1 inch 8 lines is exposed, but both articular ends are wanting. The difference in the diameter of the three metatarsals is less than in the *Palæotherium*, the middle one being only very little thicker than the other two. In the *Tapir* the middle metatarsal is less expanded than in the *Palæotherium*. In the *Hyrax* the three metatarsals are of equal thickness; and the *Phiolophus*, and probably other Lophiodonts, thus resemble the *Hyrax* and *Tapir*, more than the *Palæotheria* did.

Remarks on the Bones of the Extremities.—On a retrospect of the characteristics of the limb-bones above described, it will be seen that the humerus testifies to the ungulate character, and the bones of the hind-leg to the perissodactyle modification, of *Phiolophus*, with a demonstration that the odd number of hind-toes was “three” instead of “one” or “five.”

The great size, position, and altitude of the proximal tuberosities of the humerus, with the shape of the sessile head of the bone, indicate the limited extent and direction of motion of the humerus, and that it belonged to a limb not capable of being rotated or bent outward, as in the action for seizing, striking, climbing, or burrowing. The comparatively small size of the distal end, and the little-developed supinator ridge equally indicate the want of size in the supinator or pronator muscles in a limb where the rotation of the wrist or the fore-arm is abrogated. The third trochanter on the femur, the oblique

articular fossa for the astragalus on the tibia, and the three metatarsals of the left hind-foot, all concur with the indications afforded by the skull and teeth in the determination of the true position and affinities of *Philophus* and, most probably therefore, of *Hyracotherium* in the ungulate series.

DESCRIPTION OF PLATES II., III., & IV.,

Illustrative of the *Philophus vulpiceps*, Owen.

PLATE II.

- Fig. 1. Under view of the lower jaw and incisor teeth.
2. Upper view of the cranium.
3. Right-side view of the cranium and lower jaw, as attached together in the matrix.
4. Left-side view of the cranium, with the lower jaw and teeth brought back to their proper place.

PLATE III.

- Fig. 1. Grinding surface of the molars and last premolar, upper jaw.
2. The same, magnified 4 diameters.
3. The first and second molar, upper jaw of an older individual. From the London clay, Valley of the Thames.
4. Inside view of the molars and last two premolars, lower jaw.
5. Grinding surface of the molars and last two premolars, lower jaw.
6. The same, magnified 4 diameters.

PLATE IV.

- Fig. 1. Outer-side view of humerus.
2. Front view of humerus.
3. Proximal articular end of humerus.
4. Inner-side view of proximal end of humerus.
5. Front view of right femur.
6. Upper articular end of right femur.
7. Back view of right femur.
8. Inner-side view of lower end of right femur.
9. Lower articular end of femur.
10. Back view of tibia.
11. Upper articular end of tibia.
12. Outer-side view of upper end of tibia.
13. Part of lower articular surface of tibia.
14. Portion of matrix, with the calcaneum and three metatarsals of the left hind-foot.

[All the figures are of the natural size, except where otherwise expressed: the letters and figures are explained in the text.]

Fig. 3.

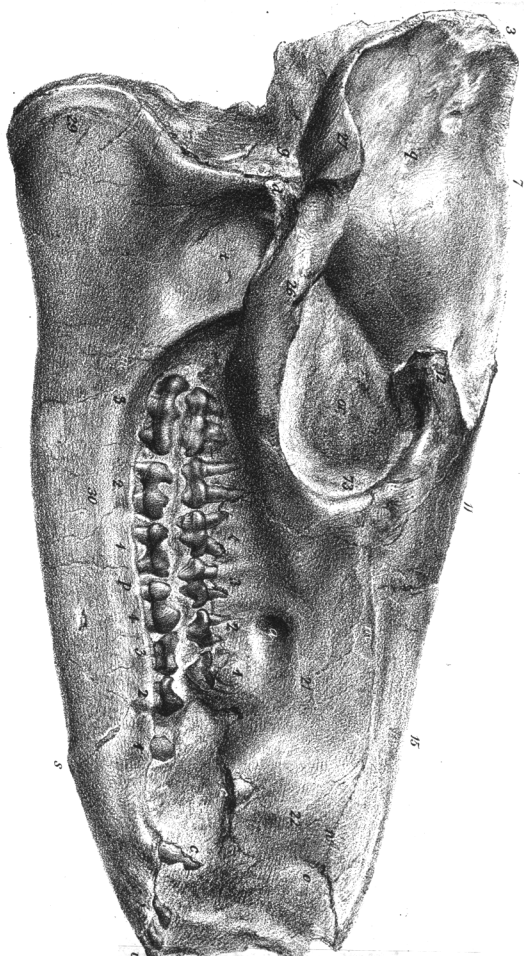


Fig. 1.



Fig. 2.

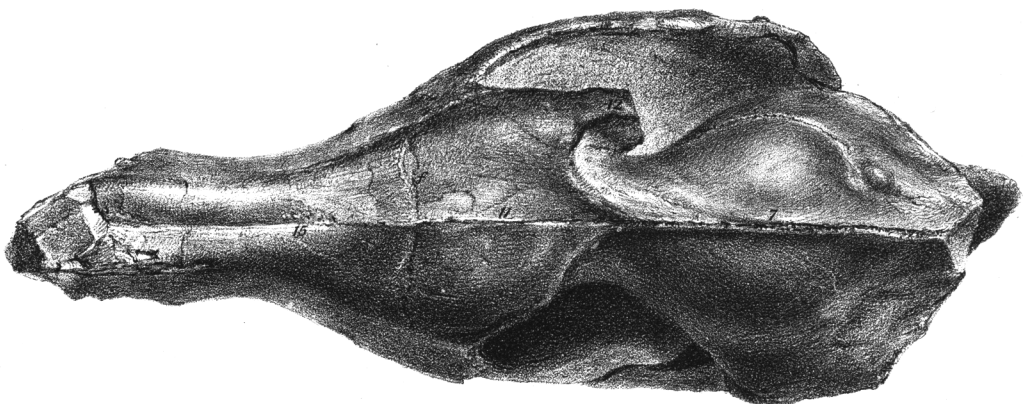


Fig. 4.



PLIOLOPHUS VULPICEPS.

Fig 6.

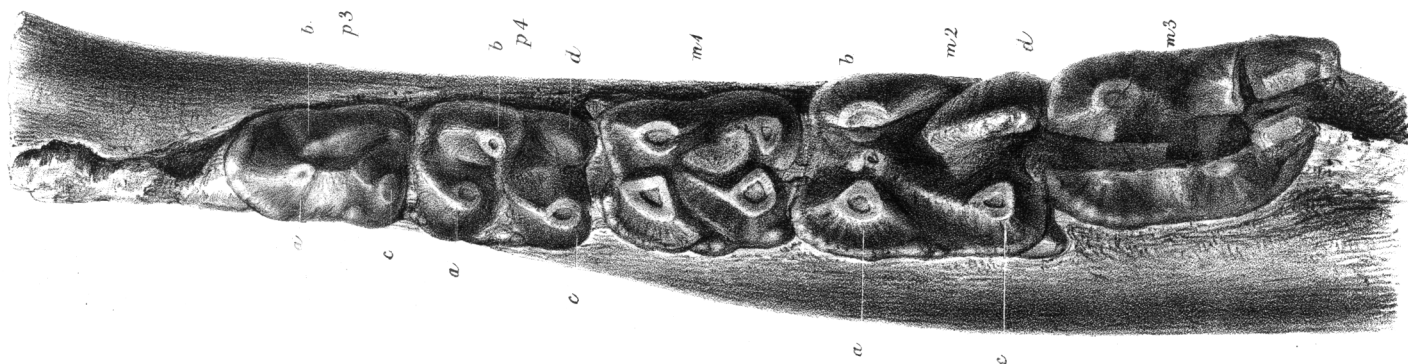


Fig 1.



Fig 2.

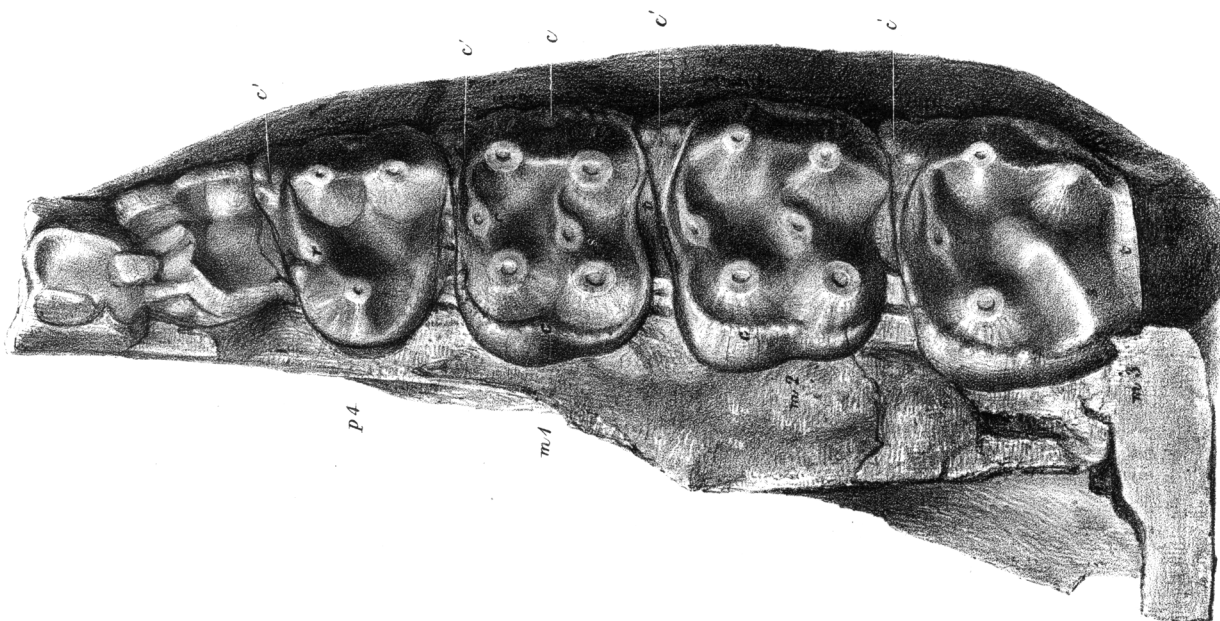


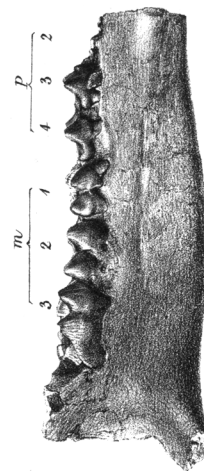
Fig 3.



Fig 5.



Fig 4.



Downloaded from <http://jgslegacy.lyellcollection.org/> at University of California-San Diego on January 16, 2017

Fig. 3.



Fig. 4.

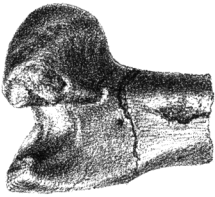


Fig. 6.



Fig. 7.

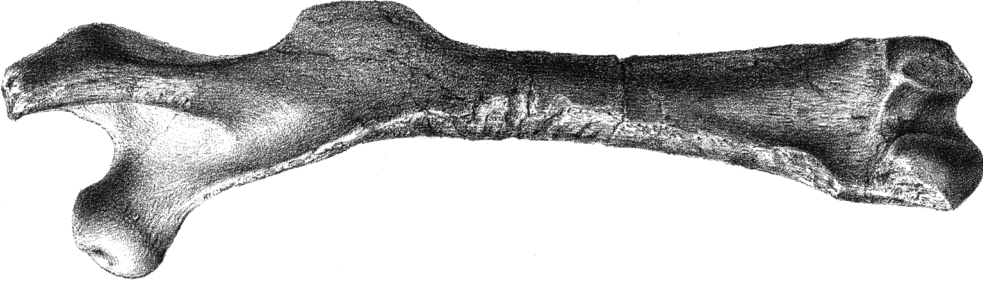


Fig. 5.

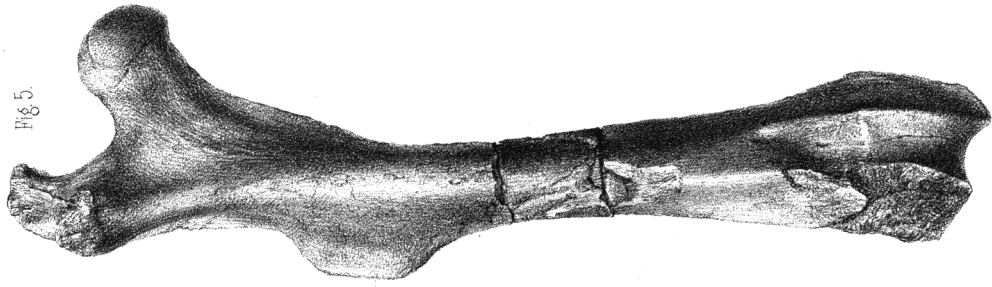


Fig. 2.

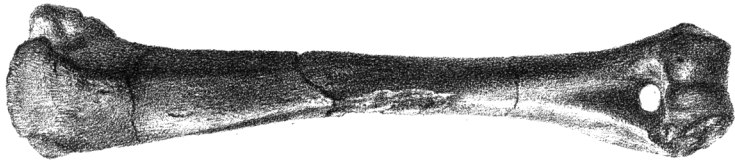


Fig. 1.

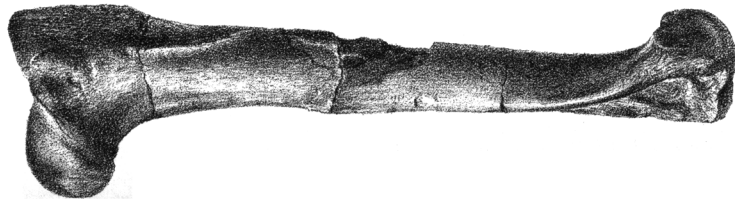


Fig. 8.

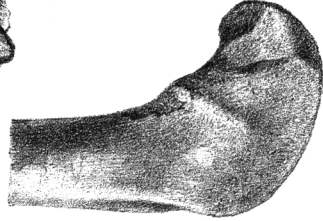


Fig. 14.

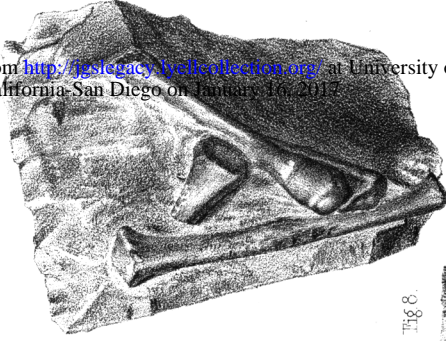


Fig. 11.

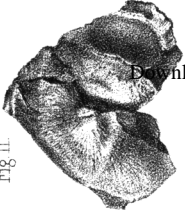


Fig. 12.



Fig. 10.

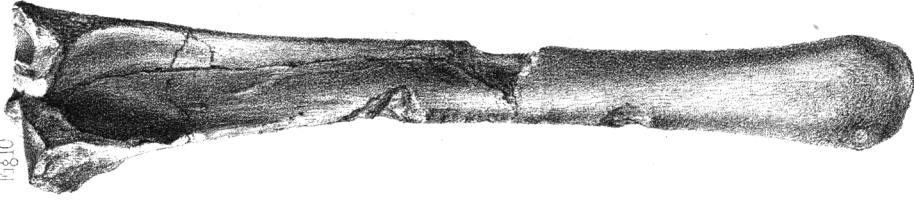


Fig. 13.



Fig. 9.



PLIOLOPHUS VULPICEPS