No. 5. — *Preliminary Account of the Fossil Mammals from the White River Formation contained in the Museum of Comparative Zoölogy.* By W. B. Scott and Henry F. Osborn.

This paper is a brief abstract of a memoir upon the Cambridge collection of Miocene Mammals, which is now in preparation. This collection was made by Mr. Samuel Garman in Nebraska and Dakota, and has been very kindly placed in our hands by Professor Agassiz for preparation and description. The work of excavating, cleaning, and mounting the fossils has been for the most part performed by Dr. Franklin C. Hill, Curator of the Geological Museum at Princeton, and to him our best thanks are due. The drawings were all executed by Mr. R. Weber.

Geological Museum, Princeton, N. J., July 9, 1887.

RODENTIA.

Palæolagus Haydeni, Leidy. Several specimens of jaws and teeth represent this species in the collection, but add nothing to our previous knowledge.

Ischyromys typus, Leidy. Isolated teeth.

CREODONTA.

Hyænodon horridus, Leidy. A most valuable and indeed unique specimen of this species, belonging to the Cambridge collection, has already been described by one of us elsewhere.* Here it will suffice to recapitulate some of the more important facts established by it. The posterior dorsal and lumbar vertebræ show the characteristically creodont feature of involuted zygapophyses, such as are not found in any known carnivore. The scaphoid and lunar bones are separate, and a distinct central is found; the manus is plantigrade and pentadactyl, and the ungual phalanges are deeply cleft. This specimen renders it perfectly certain that *Hyænodon* was a typical creodont, and that it was in all probability an aquatic form. It also shows that *Hyænodon* is not at all allied to *Mesonyx*, as has been supposed, but rather to *Pterodon*, *Protopsalis*, and *Oxyæna*.

* Scott, Journ. Acad. Nat. Sci. Phil., Ser. 2, Vol. IX. No. 2.

Hyænodon leptocephalus, Scott.* This species is peculiar for the long, narrow cranium, and for the position of the posterior nares, which are roofed in by the entire length of the palatines and by the pterygoid plates of the alisphenoid. In size it slightly exceeds the *H. crucians* of Leidy. This species was established upon two fine skulls in the Cambridge collection.

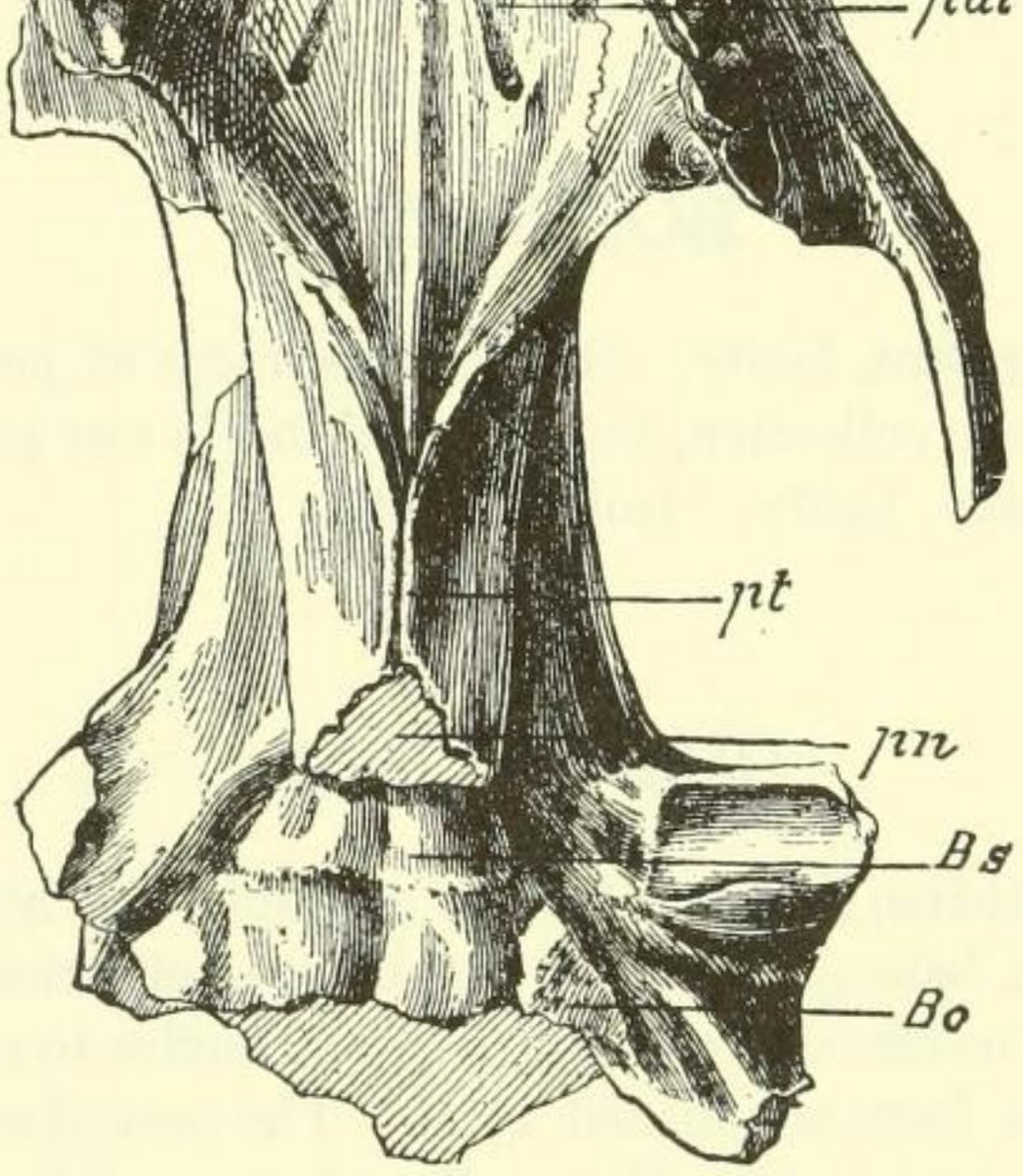


FIGURE 1. – Skull of *Hyænodon leptocephalus*, from below upon the under surface.

CARNIVORA.

CANIDÆ.

Cynodictis (Amphicyon) gracilis, Leidy. With the possible exception of some specimens from the Uinta eocene, the genus *Amphicyon* has not been found in America. *Galecynus*, as has been lately shown,† cannot be separated

* *Loc. cit.*

† Huxley, P. Z. S., 1880, p. 280 ; Lydekker, Brit. Mus. Cat. Foss. Mam., Vol. I.

from *Canis*. The American species which have been referred to *Amphicyon* and *Galecynus* in reality belong to *Cynodictis*, which has the same dental formula as *Canis*, but differs in the construction of the teeth.

CRYPTOPROCTIDÆ.

Dinictis felina, Leidy. This genus has usually been placed in the same family with *Hoplophoneus;* but the materials now at command show that it is quite distinct, and more nearly allied to the recent Madagascar form *Cryptoprocta*. There are several cranial and skeletal fragments in this collection which are of much interest. The radius has the same shape as in *Hoplophoneus*, with a concave disk-shaped head and expanded distal end. The tibia has a very much flattened astragalar facet, and the astragalus has not such a deeply grooved trochlea as in *Hoplophoneus;* the phalanges of the second row have an excavation on the outer side, showing that the claws were retractile. A very fine specimen in the Princeton Museum, of which an account will shortly be published, brings out the resemblance to *Cryptoprocta* very clearly; as in that animal, the foot is pentadactyl and completely plantigrade, and the ungual phalanges were simple, compressed, and without bony hoods.

NIMRAVIDÆ.*

Hoplophoneus (Drepanodon) primævus, Leidy. Numbers of fine specimens of this species are preserved in the collection, which with some of the Princeton material enable us to give a restoration of this very interesting type. The vertebræ are for the most part like those of the true cats, but with some resemblances to *Cryptoprocta*. The scapula has a prominent spine, with acromion and metacromion. The humerus is remarkable for the great prominence of the deltoid ridge; there is a very prominent internal condyle and large epicondylar foramen; the trochlea is like that of the true cats. The ulna and radius are essentially feline, and need no especial description. The carpus is also feline, but has a small vertical diameter; the scaphoid and lunar have coalesced (the first case reported from the White River formation), though the line of junction is still clearly visible. The metacarpals are five in number, the pollex very much reduced, and the other digits small and slender. The ungual phalanges show an unexpected degree of specialization; they are compressed, curved, and have a large lamina of bone reflected over their base as in the higher *Felidæ*, and a strong process for the tendon appears below the articular facet. These phalanges are very different from those of *Cryptoprocta*, *Dinictis*, and *Proœlurus*. The pelvis is in general like that of the *Cryptoproc-*

* If Cope's definition of this family (Tert. Vert., p. 948) be accepted, *Hoplophoneus* cannot be included in it. We do not consider, however, that the absence of the hallux is a good family character, while the foot structure of *Hoplophoneus* shows that it should be placed in a separate family from *Dinictis*, for which the name *Nimravidæ* may be retained.

tidæ. The femur is rather long and slender, and has a distinct third trochanter, which is also to be seen in *Cryptoprocta*, *Dinictis*, *Procælurus*, and *Amphicyon*, and is probably an inheritance from their creodont ancestry. In appearance the femur of *Hoplophoneus* closely resembles that of *Procælurus* as figured by Filhol.* The tibia is stout, laterally compressed, and curved forward; the distal end is broad, and not very deeply grooved, and with heavy malleolus. The fibula has a slender shaft and expanded distal end. The tarsus is feline, but with some differences; the astragalus is more flattened than in the true cats, and the calcaneum has the arctoid character of a conical process on the outer side near the distal end (found also in *Amphicyon*, *Procælurus*, and *Dinictis*). The metatarsals, five in number, are slender and weak; the three external ones are strongly interlocked, as in the cats.

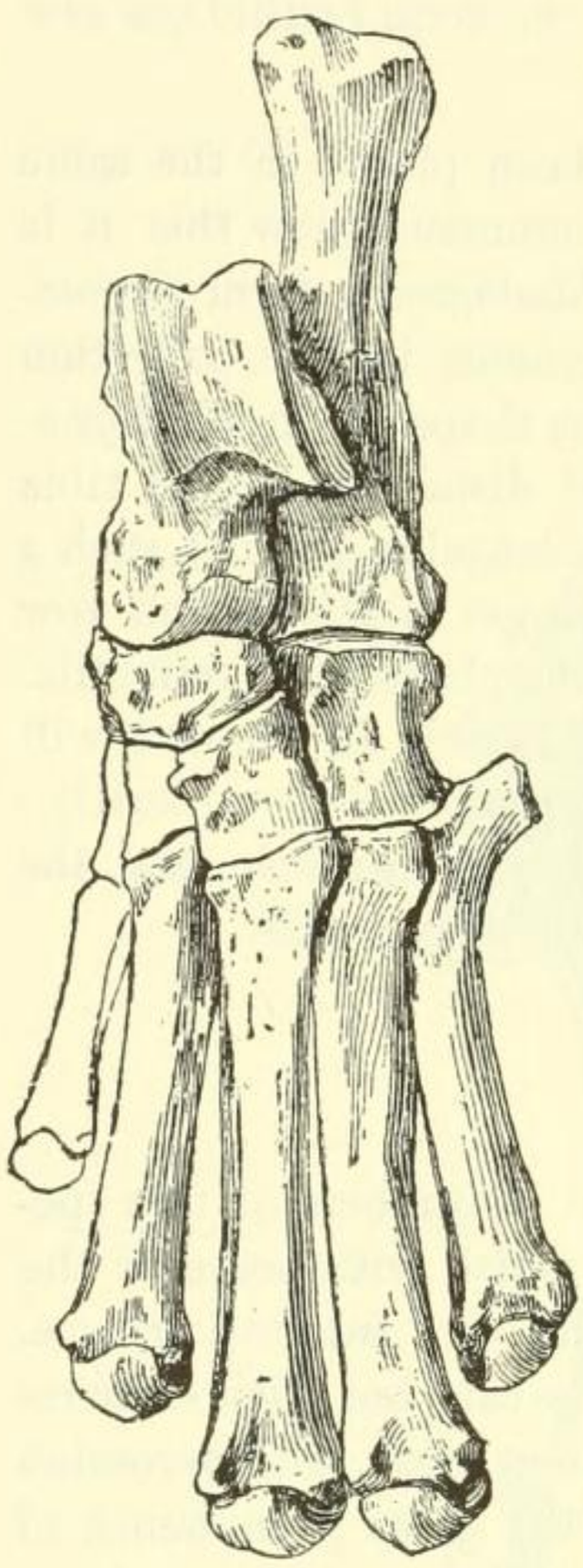


FIGURE 2. — Left hind foot of *Hoplophoneus*, viewed from in front.

Restoration (see Plate I.). — This animal had a very striking appearance, with its short rounded head and exceedingly long and trenchant canine tusks; the neck is long, the trunk, especially the lumbar region, is short as compared with *Cryptoprocta;* the tail is very long, as in nearly all of the early flesh-eaters; the limbs were stout, the feet on the contrary very weak, as in the creodonts. The structure of the foot renders it all but certain that this animal was digitigrade, though some features of its plantigrade ancestry, as the articulation of the astragalus with the cuboid, are retained. *H. primævus* was a small animal, standing hardly more than 18 inches high and about 33 inches long, exclusive of the tail.

Hoplophoneus occidentalis, Leidy. This is a larger species, equalling the puma in size, and with a more robust skeleton.

ARTIODACTYLA.

OREODONTIDÆ.

Oreodon Culbertsoni, Leidy. This very common and well-known species is represented by numerous skulls and parts of the skeleton.

Oreodon gracilis, Leidy. Little has hitherto been known as to the

* Soc. Sc. Ph. et Nat. Tours, 1880, Pl. V. fig. 3.

skeleton of this species ; it is relatively lighter and more slender than in the larger species, but otherwise not different from it. Most important is a specimen containing all the metacarpals and phalanges in undisturbed position, and this shows most distinctly the presence of the pollex, as one of us* had previously shown to be true in the case of *O. Culbertsoni*. This correspondence between the two species removes all suspicion that the pollex in the specimen first described might be a case of abnormal polydactylism. The discovery of a five-toed artiodactyl is of the utmost importance, as it furnishes the demonstration of what has long been surmised, that the ungulates of both odd and even-toed series have been derived from pentadactyl forms.

Eucrotaphus (Oreodon) major, Leidy (*Eporeodon major*, Marsh). This genus differs from *Oreodon* in the presence of large inflated tympanic bullæ, and also (*fide* Marsh †) in the absence of a pollex. The dentition and character of the skull are identical in the two genera.

Agriochœrus latifrons, Leidy. Isolated jaws and teeth.

SUIDÆ.

Hyotherium (?) americanum, sp. nov. There is in the Princeton Museum a suilline skull from the White River formation, which cannot be correlated with any of Dr. Leidy's genera. It agrees very closely and is probably identical with the *Hyotherium* of Europe, and will be provisionally referred to that genus. In the Cambridge collection there is a suilline hind foot, which may be referred to the same species. The astragalus is very oblique, the external condyle greatly exceeding the internal in size ; the neck is short and the distal end broad ; the calcaneal facets are confluent. The cuboid is low, broad, and deep (antero-posteriorly). The metatarsals are very suilline in character, the median pair short and massive, the laterals shorter and especially more slender ; the proximal ends are all on the same transverse line, and the articular faces nearly plane ; the trochlear ridges on the distal ends are confined to the posterior aspect, thus differing from *Sus*, *Dicotyles*, and other recent genera. The phalanges of the median digits are heavier but not much longer than those of the lateral digits.

Measurements.

	M.
Astragalus, length (outer side)	.032
" width trochlea	.019
Cuboid, length	.016
" width	.015
Metatarsal II., length	.048
" III. "	.063

* Scott, Proc. Am. Ass. Adv. Sci., 1884, p. 493.

† Dinocerata, p. 187, fig. 162.

Metatarsal IV., length	.068
" V. "	.055
Proximal phalanx, digit IV., length	.025
" " " IV., width proximal end	.013
" " " V., length	.022
" " " V., width proximal end	.011

Entelodon (Elotherium) Mortoni, Leidy. Represented by several skulls in good preservation, one of which is particularly interesting as showing the milk dentition. This will be fully described in our final paper.

HYOPOTAMIDÆ.

Hyopotamus americanus, Leidy. Represented by fragments of lower jaws with molar teeth.

CAMELIDÆ.

Pœbrotherium Wilsoni, Leidy. Two skulls, one of which exhibits the milk dentition, represents this species.

TRAGULIDÆ.

Leptomeryx Evansi, Leidy. Rütimeyer* has recently questioned the propriety of referring this genus to the chevrotains, and considers it more allied to the *Camelidæ*. In consequence of this opinion from such a distinguished source, we have carefully examined the dentition and skeleton of the genus, and are now in position to give a nearly complete account of it, which will be done in the final paper. Here we need only record the conclusion reached, that *Leptomeryx*, though exhibiting several points of divergence from the modern genera of the family, is nevertheless a true traguline. We thus reach a different conclusion from Rütimeyer on this subject, and agree with Schlosser.†

GENUS INCERTÆ SEDIS.

Hypisodus minimus, Cope. This minute ruminant is the earliest known hypsodont form found in America. Professor Cope gives the dental formula as I. $\frac{?}{3}$, C. $\frac{?}{1}$, Pm. $\frac{?}{4}$, M. $\frac{3}{3}$; and states that "in the mandibular series the six incisors, two canines, and two first premolars form an uninterrupted series of ten subequal teeth, and are followed by a long diastema."‡ The genus has hitherto been known only from the dentition, but there is fortunately in this

Abh. d. schweiz. pal. Gesell., Bd. X. p. 98.

† Morph. Jahrb., Bd. XII. p. 75.

‡ U. S. Geol. and Geogr. Surv. Terr., 1873, p. 501.

collection the well-preserved facial part of a skull, together with the lower jaws; hardly enough, however, to make the systematic position of the animal entirely clear. The orbits are very large and deep-set, as in the tragulines, and separated by a mere septum; the lachrymals have a considerable extent vertically, but extend little on the side of the face, and do not reach the nasals; the maxillaries are proportionately higher than in *Leptomeryx;* the nasals are much contracted; the palate is well arched from side to side, and the palatines seem to be shaped much as in *Tragulus;* the mandible is very slender.

The last upper premolar is composed of an external and internal crescent, enclosing a valley between them; the third and second are very small and apparently secant, without internal cusps; the first, if present at all, was evidently separated from the second by a considerable diastema.

PERISSODACTYLA.

MENODONTIDÆ.

MENODUS, Pomel.

Syn. *Titanotherium*, Leidy. *Megacerops*, Leidy. *Brontotherium*, Marsh. (? *Symborodon*, Cope.) *Diconodon*, Marsh.

Generic Characters. — Dentition: I. $\frac{2}{2}$ (variable), C. $\frac{1}{1}$, Pm. $\frac{4}{3}$, M. $\frac{3}{3}$. The incisors are small and variable in number. The upper and lower median incisors are usually wanting. Molars and premolars alike, resembling those of *Chalicotherium* in pattern. A stout pair of transversely placed horns developed from the frontals and nasals.

There are three skulls in this collection and the horns of several others, representing four or five species which may readily be distinguished. The chief difficulty is in deciding where to draw the generic lines, which is increased by the fact that the mandibles are seldom found associated with the skulls. As in *Uintatherium*, the variability in the various portions of the skull, especially in the region of the horns, is so extreme, that no two skulls are found which are exactly alike. But the dentition, which is constant among the *Dinocerata*, here greatly complicates the problems of classification. The premolars vary in number, and the incisors, always of relatively small size, and fairly constant in number in the upper jaw, vary from three to none in the lower jaw.* In all the lower jaws found in Professor Cope's collection of *Menodontidæ* from Northern Colorado there are no incisors, and the mandibular symphysis is extremely narrow. In the lower jaws of the Cambridge and Princeton collections, which are all from the Nebraska and Dakota exposures, the symphysis is broad, and the incisors where preserved are two in number, while in one of the Cambridge specimens no less than three incisor alveoli may be counted upon one side of the symphysis.

* One of the Cambridge skulls has but a single upper incisor, *M. coloradensis*.

We might infer from this that *Symborodon* can be clearly separated from *Menodus* by the absence of the lower incisors, accompanied by a narrowing of the symphysis; but Professor Cope has recently described a new species, *M. angustigenis*, from the Swift Current Creek region,* which combines the narrow type of symphysis with the presence of two incisors. The separation of these genera is rendered still more improbable by the parallelism which exists between the skulls from the Nebraska and Colorado localities, especially in respect to the conformation of the nasal bones and the horns. The genus *Symborodon* is however provisionally adopted at present to include the species with a narrow mandibular symphysis and no lower incisors.

The genus *Brontotherium*, Marsh, cannot be distinguished from *Menodus*. It rests in part upon the premolar formula, $\frac{4—4}{3—3}$, in the synopsis given by Professor Marsh,† as distinguished from *Menodus* with ? Pm. $\frac{4—4}{4—4}$. One of the lower jaws of the Princeton collection, however, has the premolar formula $\frac{3—4}{}$, demonstrating that the first lower premolar is a variable tooth, and cannot in this case be used in classification. The same rule applies to the second cone upon the last upper molar, the supposed generic character of *Diconodon*, Marsh. This is found in different species in all degrees of development, from a small prominence upon the basal cingulum to a well-developed cone (*M. Proutii*).

Such characters as the invariable absence of lower incisors may subsequently be found to separate one genus of the *Menodontidæ* from another; but our present evidence goes to show that they simply characterize the extremes of a closely related series of animals, from the same horizon, of which the intermediate forms are represented by numerous species. The safest basis of specific determination seems to be the correlation between the development and proportion of the horns and of the nasals, the rule being that where the horns are long the nasals are short, and conversely. The number of the teeth does not at present seem to be absolutely constant, even within the limits of the species.

The following determination of the species in the Cambridge collection is, for the above and other obvious reasons, provisional. The classification can be finally settled only when the lower jaws and skulls are found in association. If, for example, a large number of forms of the *M. coloradensis* type of skull are found with but a single upper incisor, they will undoubtedly represent a species distinct from both *S. trigonoceras*, Cope, and *M. ingens*, Marsh.

M. coloradensis, LEIDY, 1870. Syn. *M. ingens*, Marsh, Am. Journ. Sci. and Arts, 1874. *S. trigonoceras*, Cope, Synopsis New Vert. Col., 1873, p. 13.

The type of this species, a snout with horns and nasals, was figured by Pro-

* The Vertebrata of the Swift Current Creek Region of the Cypress Hills. Geol. and Nat. Hist. Surv. of Canada, 1886, p. 81 c.

† Am. Journ. Sci. and Arts, 3d Ser., XI. 339.

fessor Leidy * in 1873, and agrees closely with the corresponding portions of the smallest skull in the Cambridge collection, both in form and measurement. The skull is entire, and enables us to fully define this species.

Dentition : I. $\frac{1 \text{ or } 2}{}$, C. $\frac{1}{}$, Pm. $\frac{4}{}$, M. $\frac{3}{}$. No diastema behind the canine. Second upper incisor sometimes wanting. First upper premolar small. Last upper molar without distinct second cone. Upper premolars with a strong internal cingulum. Anterior nares transversely broad and shallow vertically. Nasals long and broad. Horns short and stout, obliquely compressed at the base so that their faces point in three directions, erect and slightly recurved when viewed from the side. The greatest diameter at the base is fore and aft. Orbits large, and widely open. Superciliary ridge not prominent. Zygomatic arches broad and powerful, but without flanges. Post-glenoid and post-tympanic processes separate or not broadly united.

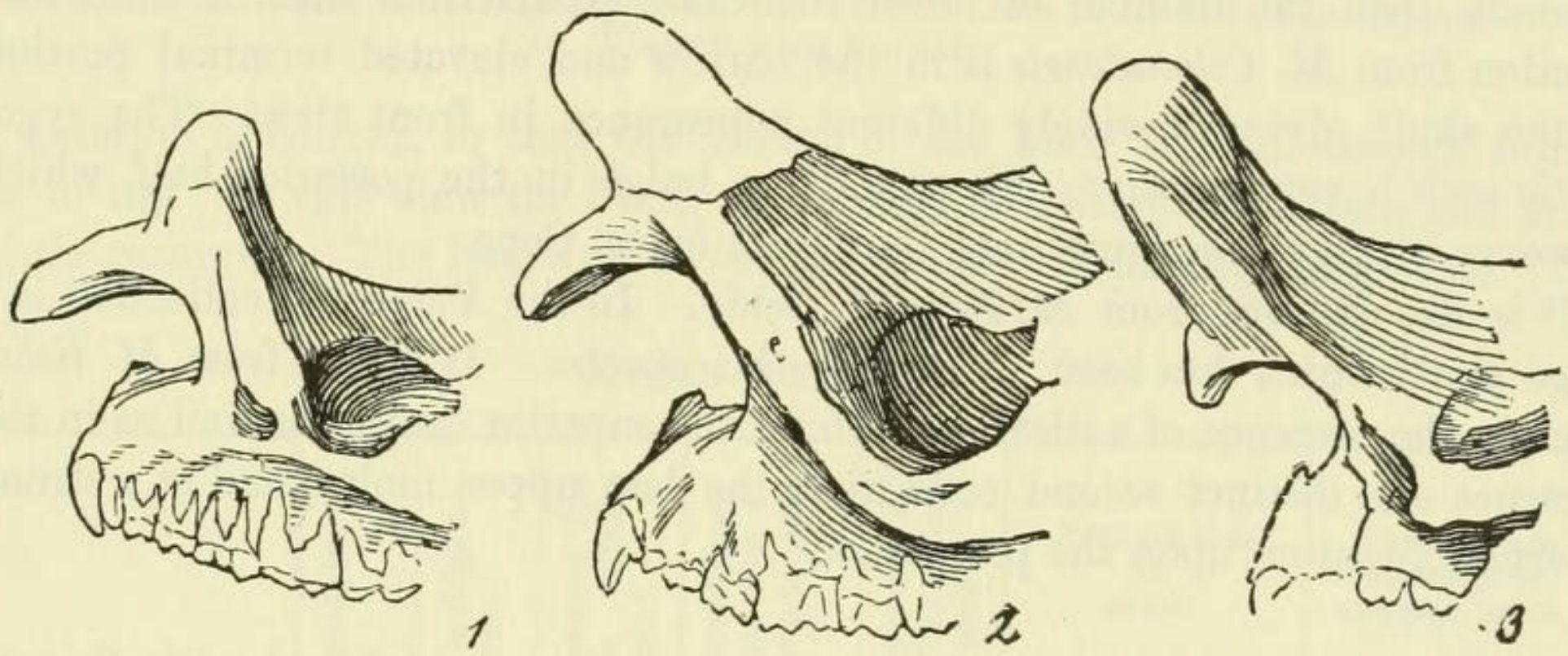


FIGURE 3. — Anterior portion of the skull of three species of *Menodus*, showing the relations of the nasals to the horns in side view. 1. *M. coloradensis.* 2. *M. tichoceras.* 3. *M. dolichoceras.*

The skull of this individual is considerably smaller than the type of *M. ingens*, measuring only $27\frac{1}{2}$ inches from the occipital condyles to the tips of the nasals. The superciliary ridges expand into small postorbital processes, which are wanting in the above type. The post-glenoid processes do not touch the post-tympanic. The *M. ingens* skull has two incisors, while this specimen has but one. It is possible that one or more of the above differences may prove to be of permanent specific value, but in the conformation of the nasals and of the horns, as well as in all other details of proportion, these skulls are apparently closely similar.

In comparison with the type of *S. trigonoceras*, Cope, the horns and nasals have somewhat similar proportions, but are less distinctly triquetrous at the base. The skull also resembles that of *M. angustigenis*, Cope.

M. tichoceras, sp. nov. This species may prove identical with *S. altirostris*, Cope. Dentition : I. $\frac{2}{2}$, C. $\frac{1}{1}$, Pm. $\frac{4}{?}$, M. $\frac{3}{?}$.† No diastema behind the canine.

* Extinct Vertebrate Fauna, etc., U. S. Geol. Surv., Vol. I. Plate I.

† The number of lower incisors is inferred from the distinctly worn tips of the upper incisors.

Second cone on last upper molar united with the cingulum. Probably two lower incisors. Upper premolars with a faint or no internal cingulum. Nasal bones intermediate in length and narrowing anteriorly. Horns elongate, subcylindrical in section at the base, and in side view inclined obliquely forward, so as to partly overhang the snout. Anterior nares transversely narrow and vertically deep, so that the snout is very elevated. Superciliary ridge prominent, rugose, and overhanging the temporal fossæ. Orbits rather small and enclosed. A post-orbital process. Zygomatic arches wide and partly flanged. Post-glenoid and post-tympanic processes widely united.

Description of Skull. — The type of this species is a single large skull, with the dentition complete, and lacking the upper part of the horns and the crest of the occiput. The total length is 29 inches, while Professor Cope's type of *S. altirostris* measures but 25½ inches. The separation from the latter species depends upon the number of lower incisors. Apart from size, the chief distinction from *M. Coloradensis* is in the narrow and elevated terminal portion of the skull, giving a widely different appearance in front view. The zygomatic arch is very massive, and presents a bulge in the posterior half, which however is much less prominent than in *S. bucco*, Cope.

It is also distinct from *M. Proutii*, Leidy. In the Princeton collection is a large skull which has been referred to this species. It differs from *M. tichoceras* in the presence of a diastema behind the superior canine, as well as in the presence of a distinct second cone upon the last upper molar, and of a strong internal cingulum upon the premolars.

M. dolichoceras, sp. nov. This species may prove identical with *S. acer*, Cope. Dentition: I. ?, C. $\frac{1}{1}$, Pm. $\frac{4}{4}$, M $\frac{3}{3}$. Upper premolars with a faint internal cingulum. Nasal bones extremely short and obtuse. Horns extremely long and powerful, directed obliquely forwards and outwards, projecting beyond the nasals in side view. The section is sub-oval at the base, with the long axis obliquely transverse. Cranium very broad and saddle-shaped above the orbits, narrowing somewhat posteriorly. A prominent and overhanging superciliary ridge. Post-glenoid and post-tympanic processes united for a short distance. The skull which we have made the type of this species is much larger and more powerful than Professor Cope's type of *S. acer*. The horns are longer and more widely divergent at the base. The angle of inclination of the horns and the diminutive proportions of the nasals, as well as the form of the top of the cranium, all bring this specimen near *S. acer*, and separate it from other known species. Unlike *S. acer*, the horns are not united by a ridge. The specimen is incomplete in the supra-occipital region, the zygomatic arch is fragmentary, and the maxillary, palatine and basi-occipital regions are much distorted.

M. platyceras, sp. nov. The type of this species is a pair of horns with the nasal bones attached. All other portions of the skull are wanting.

The dentition is unknown. Nasal bones extremely short and obtuse, as in

M. dolichoceras and *M. acer*. The inner contour of the horns is concave; they are greatly flattened antero-posteriorly with a ridge-like outer margin, and connected by a well-raised median ridge. The posterior face is nearly plane,

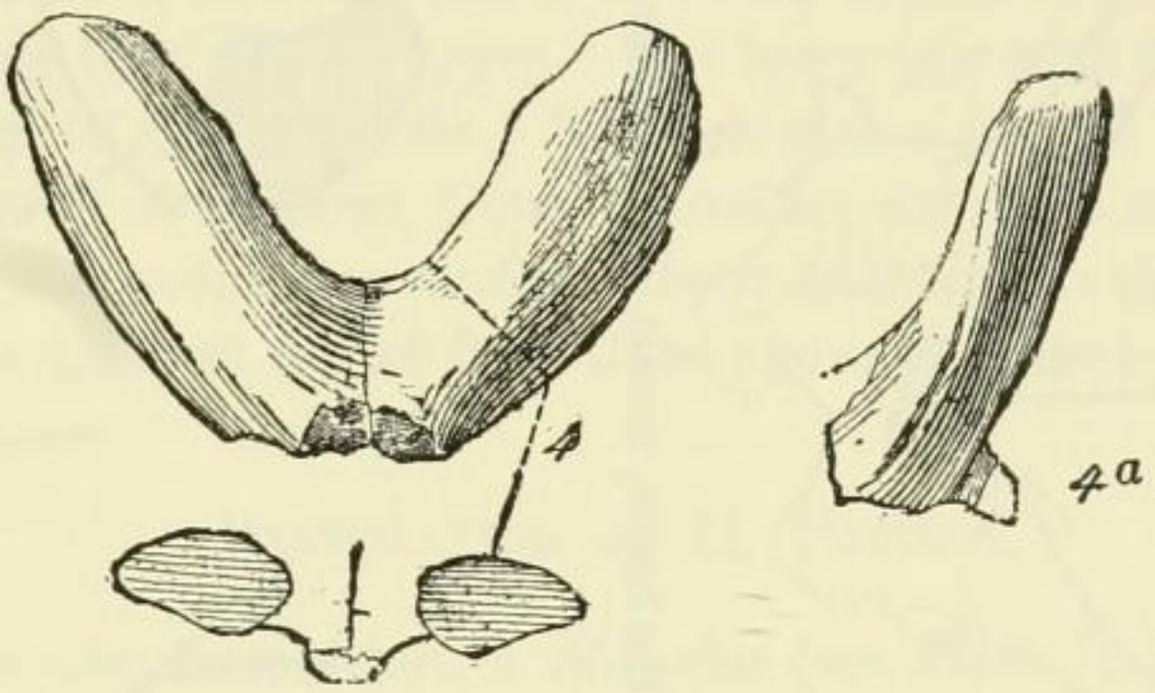


FIGURE 4. — Horns of *M. platyceras*. 4. Viewed from in front and in section. 4*a*. Viewed from the side.

the anterior is convex, so that the section of the horn is plano-convex from base to tip. In side view the horns completely overhang the nasals, and are slightly recurved. The long axis of the horn section is directly transverse.

MEASUREMENTS.

	Occipital condyles to nasal tips.	Nasal tips to ridge between horns.	Distance between tips of horns, outside measurement.	Length of horns measured from tips to median fronto nasal suture.	Antero-posterior diameter of the molar-premolar series.	Free portion of nasals.		Approximate diameter of anterior nares.	
						Length.	Breadth.	Vertical.	Transverse.
	M.	M.	M.	M.	M.	M.	M.	M.	M.
M. coloradensis	.70	.16	.33	.16	.31	.08	.12	.075	.135
M. tichoceras	.80?	.13	....	....	.34	.06	.13	.11	.09
M. dolichoceras	.74	.09	.58	.32	....	.04	.09	.075	.075
M. platycera	....	....	.42	.25	....	....	....	....	....
M. Proutii	.91?	....	....	.20	.37	....	....	....	....

The above measurements bring out very clearly the decrease in the proportions of the nasals *pari passu* with the gradual elongation of the horns. Another very interesting fact is brought out by the comparison of the transverse and longitudinal diameters of the horns at the base. As we pass from the short to the long horned types, through *M. coloradensis*, *tichoceras*, *dolichoceras*, and *platyceras*, there is a gradual rotation of the longer axis of the horn-section from a fore and aft to a transverse plane; the species last named representing the extreme of the transverse type.

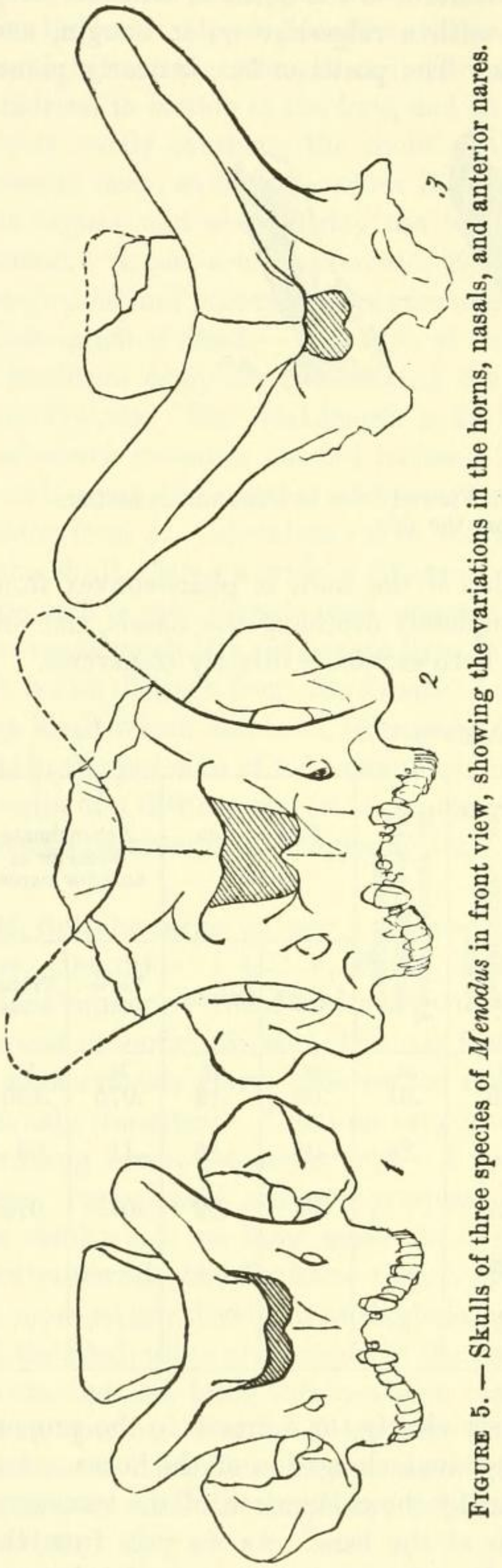


FIGURE 5. — Skulls of three species of *Menodus* in front view, showing the variations in the horns, nasals, and anterior nares.

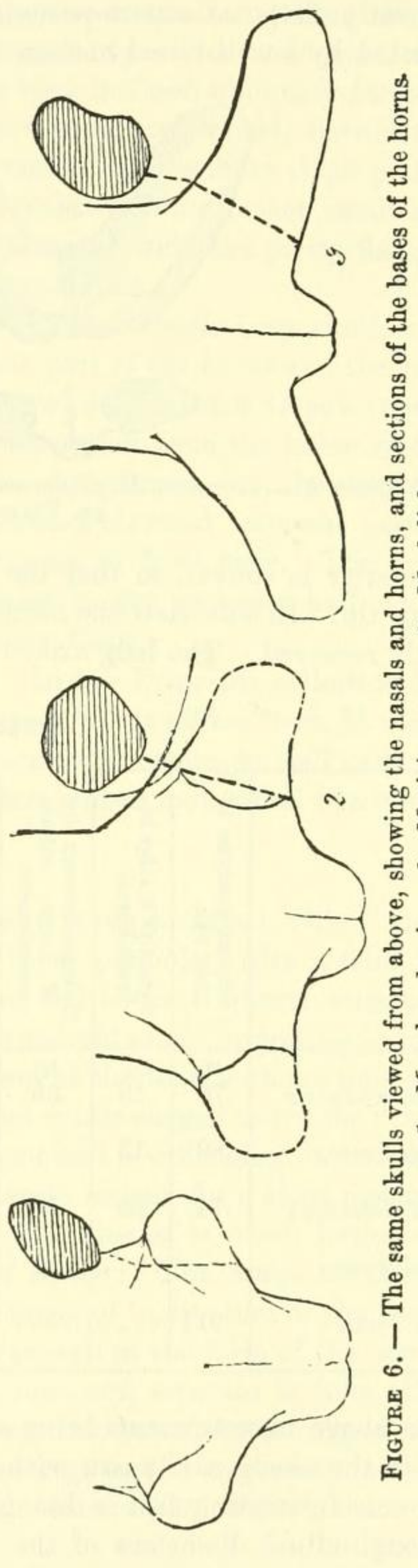


FIGURE 6. — The same skulls viewed from above, showing the nasals and horns, and sections of the bases of the horns.
1. *M. coloradensis.* 2. *M. tichoceras.* 3. *M. dolichoceras.*

The accompanying figures show the four types of skull as seen in the fronto-nasal region. The first type, with long nasals and short erect horns, is represented by *M. coloradensis* and characterizes also *M. ingens* and *M. angustigenis.* The second type, with medium nasals and short obliquely placed horns, is

represented by *M. tichoceras*, and characterizes *M. Proutii* and *M. altirostris*. The third, with short obtuse nasals and long horns, is represented by *M. dolichoceras*, *M. acer*, and *M. platyceras*.

There are doubtless other species of *Menodus* in this collection, but the foregoing are the only fully defined types. The lower jaw with three lower incisors probably belongs to a new species. There is also a pair of diminutive horns, resembling those of *S. heloceras*, Cope. Another pair of horns presents a small knob upon the antero-interior surface, about half-way to the tip, which gives the horn quite a different aspect from those above described.

Restoration of M. Proutii.

The accompanying restoration of *Menodus* (see Plate II.) is from materials in this collection, in the E. M. Museum of Princeton, and in the collections of Professor Cope, as follows: Mus. Comp. Zoöl., the fore and hind limbs and fore feet. E. M. Museum, the pelvis, hind feet, anterior dorsal vertebræ, the cervical vertebræ, the anterior ribs, and skull. The scapula and outlines of the processes of the cervical vertebræ and spines of the first and second dorsal vertebræ are from the Cope collection. The outlines of the phalanges of the fore foot are from specimens in the Cambridge collection, and from Professor Marsh's drawings. All the structures which are wholly or in part conjectural, such as the sternum, the outline of the scapula, the lumbar vertebræ, and sacrum, are drawn in plain or dotted lines without shading. On the other hand, several of the ribs which are known from the Princeton collection are not shaded, for the sake of uniformity. Several of the posterior dorsal vertebral centra are shaded for the relief effect. The proportions of the neck, back, and pelvis, with those of the skull, are known from the fact that these parts in the Princeton collection belong together, i. e. to one individual. The larger bones of the fore and hind limbs are also, for the most part from a single individual; and a number of vertebræ found with the head of a radius of another individual enable us to determine the proportion between the fore limb and the centra of the dorsal vertebræ. The size of the scapula, which belonged to an isolated series, was fixed by the proportions which obtain between this bone and the humerus in the *Proboscidia*, *Rhinoceridæ*, and *Dinocerata;* viz. that the scapula varies from $\frac{4}{5}$ to $\frac{5}{4}$ the length of the humerus. We have given it $\frac{4}{4}$ the humerus length.

The animal is placed in an erect standing position, the right leg being drawn slightly back. The fore limb is placed nearly at the maximum of extension; the angle of this limb, as indicated by the articular facets of the head and trochlea of the humerus, being intermediate between that of the elephant and rhinoceros. It was capable of being flexed to a much greater degree than is here represented, so as to bring the animal nearer the ground.

The skull and neck, to which the trunk and limbs are proportional, probably belong to *M. Proutii*, a species of about the medium size attained by these animals; for, judging by the measurements of the skulls which are known,

there were other species both smaller and larger. This animal was about eight feet high at the shoulder, and over twelve feet long. The height is greatly increased by the extraordinary development of the spines of the anterior dorsal vertebræ. These are well preserved, and in two cases complete to the tip, in the materials at our disposal. They are broad and flattened nearly to the tip, so as to fit closely together. The neck is longer than that of *Uintatherium*, but shorter than that of the rhinoceros. With the power of flexing the elbow, the head could readily be lowered to the ground in feeding. The arm, fore-arm, and shoulder-blade are decidedly rhinocerotic in character, although showing a greater proportional length and less flexion capacity. The thigh and lower leg, on the other hand, are rather elephantine in their shape and proportions, and indicate much less play at the knee-joint than in the rhinoceros. The limb bones are relatively shorter than in *Uintatherium*, but the metacarpals and tarsals are much longer and less spreading, thus adding considerably to the height. These segments, combined with the elongation of the dorsal spines, gave *Menodus* as great a height as was attained by the eocene genus, with its longer limbs.

AMYNODONTIDÆ.

Rhinoceros-like animals, as far as yet known, extending from the Middle and Upper Eocene (Bridger Beds) to the White River Miocene Beds; hornless; canines and incisors present in the typical number in both jaws; pattern of the premolar transitional to that of the molars; first upper premolars rudimentary or wanting; pattern of true molars like that of the rhinoceros, but with the transverse crests simple; skull with a powerful sagittal crest.

AMYNODON,* Marsh.

Probable syn. *Orthocynodon*, Scott and Osborn.†

Dentition: I. $\frac{3}{3}$, C. $\frac{1}{1}$, Pm. $\frac{4}{4}$, M. $\frac{3}{3}$. Upper canines obliquely placed; lower canines erect and placed immediately in front of the upper when jaw is closed. The third and fourth upper premolars only approach the molar pattern by the development of double transverse crests. First upper premolar small and single fanged. Post-glenoid and post-tympanic processes separate.

* This Eocene genus, owing to the imperfect condition of the type skull in Professor Marsh's collection at the time of description, was incorrectly defined, (Am. Journ. Sci. and Arts, 3d Ser., Vol. XIV. p. 251,) and the present writers, after a personal examination, were led to believe that the type specimen of *O. antiquus* represented a distinct genus. It now proves to be the same, as far as we know at present.

† E. M. Museum Bulletin, No. 3, May, 1883.

METAMYNODON, gen. nov.

Dentition : I. $\frac{3}{3}$, C. $\frac{1}{1}$, Pm. $\frac{3}{2}$, M. $\frac{3}{3}$. Upper and lower canines obliquely placed, the latter fitting somewhat internal to the former when the jaw is closed. The first upper premolar wanting; the second, third, and fourth premolars are of the molar pattern. Post-glenoid and post-tympanic processes widely united.

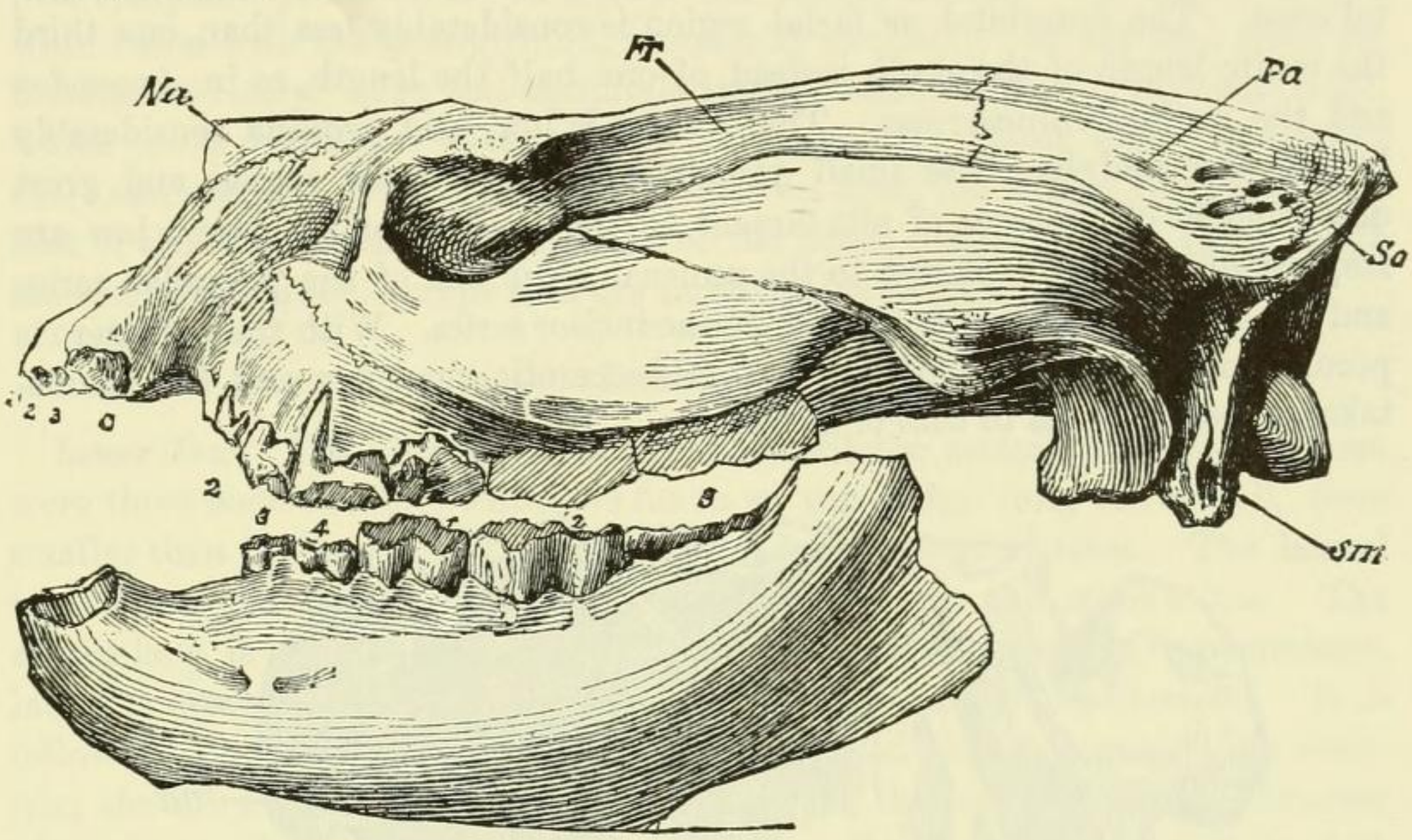


FIGURE 7. — Skull of *Metamynodon planifrons*, in side view, about one sixth natural size.

Metamynodon planifrons, sp. nov *Specific characters.* First upper molar with an incomplete internal cingulum. Lower median incisors small. The molars greatly exceeding the premolars in size.

This genus is represented by a single skull in fine preservation, and the anterior portion of the left mandibular ramus. The latter specimen was found some little distance from the skull, but for many reasons may be safely placed with it. The canine-incisor formula is the same, and the diameters of the canine fangs are similar. There is one less premolar, but the molar-premolar series as a whole has the same antero-posterior length.

Metamynodon is evidently a highly modified successor of *Amynodon*, of about double its size and strength. The dentition is reduced by the loss of one upper and two lower premolars. The pattern of the premolars presents a slight progression in the complication of the transverse crests of pm^2 ; but as a series they show a decided retardation of growth as compared with the molars which assume very large proportions. The mandibular symphysis is relatively much narrower. The sagittal crest is still more powerful. The skull is modified by the unusual shortening of the facial region, and the flattening of the cranium and broadening of the zygomatic arches, but without the develop-

ment of horns or other protective structures. It equalled in size the largest of the modern rhinoceroses, and belongs to a line which is quite distinct from that of either *Hyracodon*, *Aceratherium*, or *Diceratherium*. The great reduction of the premolar series separates it from the first, while the retention of the full canine-incisor series separates it from the last two lines of descent.

The *skull* is remarkably broad and flat, with powerful and widely extended zygomatic arches, and a long flattened cranium, surmounted by a strong sagittal crest. The antorbital or facial region is considerably less than one third the entire length of the skull, instead of one half the length, as in *Amynodon* and the modern rhinoceroses. The occiput is low, and projects considerably behind the condyle. The small proportions of the facial region and great development of the area of attachment for the muscles of the lower jaw are respectively in direct relation to the unusual reduction of the premolar series and the great size of the molar and canine-incisor series. With these numerous peculiarities, the skull still retains a rhinocerotic character and has unmistakable resemblances to that of *Amynodon*.

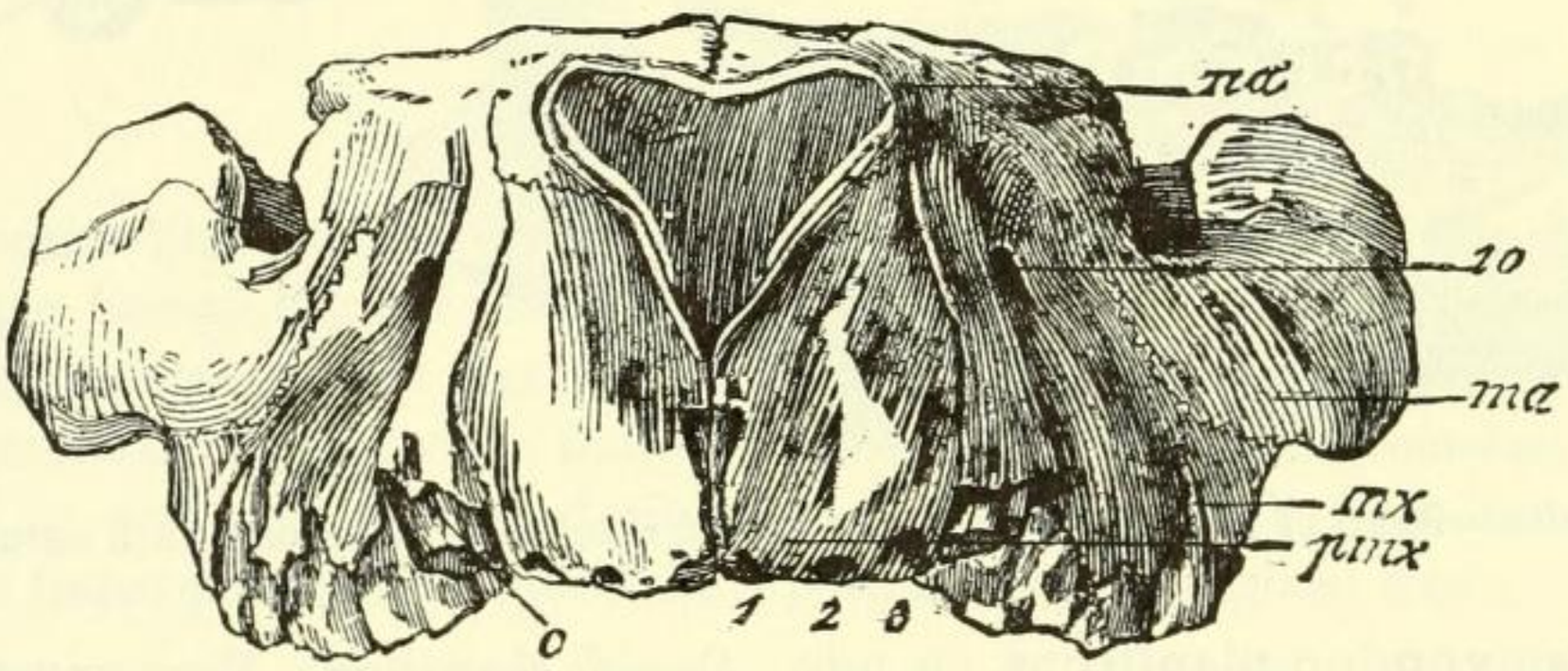


FIGURE 8. — Skull of *Metamynodon*. Front view.

The *premaxillaries* are broad and flattened above, and, bulging forwards, converge into the broad rounded alveolar border. They are quite distinct in the median line. The *anterior nares*, as viewed from in front, are triangular, bounded above by the short, flattened obtuse *nasals* which overlap the inner faces of the converging premaxillaries. The nasals viewed from above are smooth, short, and broad. The *maxillaries* form a wide union with the frontals, and are deeply excavated behind the canines to the large infra-orbital foramina. The sutures of the *lachrymals* cannot be distinguished; they probably had a short exposure upon the face. The lachrymal foramen is within the orbit. The *frontals* are very long, extending from the interorbital space to the middle line of the cranium. There are no post-orbital processes, but rugose supra-orbital processes widely overhanging the orbits, which they completely conceal from above. They are separated by a notch from the prominent ant-orbital rugosity. The orbits are thus small and deeply enclosed. The *malars* have a faint postorbital process. Their greatest diameter is vertical, but the zygomatic processes of the *squamosals* are twisted, so that they unite with the

skull with the greatest diameter horizontal (Fig. 7). The squamosals are low and widely united with the parietals. The articular facets for the mandible and post-glenoid processes resemble those in the rhinoceros, on a larger scale. The *parietals* are rather short, a considerable portion of the cranium being formed by the *supra-occipitals.* The occiput is low and broad, with powerful condyles, which are much extended transversely. The space between the condyles and post-glenoid processes is rather short. The paroccipital and post-tympanic processes are on a level and closely united. The latter forms a wide union with the post-glenoid, completely enclosing the external auditory meatus inferiorly. The basi-occipitals and sphenoids form a prominent ridge, which is not overlapped anteriorly by the *pterygoids.* These bones are rather short and obtuse. This region of the skull is, upon the whole, very similar to that of the rhinoceros. The relations of the bones composing the hard palate are also rhinocerotic, except that the incisive alveolus is much shorter.

Dentition.

Lower Jaw. The crowns of the entire mandibular series are wanting. There were three *lower incisors*, which, so far as we can judge from the alveoli, were smaller than the upper, and much crowded by the large canines. The lateral incisor was the largest, the series decreasing towards the middle line. The *canine* fang is completely preserved, and indicates a large, semi-procumbent, laterally compressed tooth, measuring $1\frac{1}{4}$ inches in transverse diameter. It is followed by a diastema of two inches. The first and second *premolars* are wanting; the third has two fangs, and has about half the antero-posterior diameter of the first molar. The fourth premolar is two thirds the diameter of the first molar. The three molars increase rapidly in size, covering a space equal to that occupied by the upper molars, and three times that occupied by the premolars. The last molar is the largest, and was apparently trilobed.

Upper Jaw. The *maxillary* series are better preserved, the inner faces of the molar crowns showing on one side or the other in all except the first and last of the series. The *incisors* were placed in a uniform curvature, the lateral incisor being separated from the canine by a narrow diastema. The median alveolus is the largest, and the series apparently decreased in size laterally, reversing the relations of size shown in the mandibular series. The *canines* were subequal in size, and inclined forwards like those in the mandible. A narrow diastema separates this tooth from the small two-fanged second *premolar*, the first premolar having entirely disappeared. The third and fourth premolars have a broad, swollen, anterior transverse crest, and somewhat narrower and much more slender posterior crests. The fourth premolar has a faintly developed combing crest, as in the third premolar of *Amynodon.* The *molars* show a sudden and remarkable increase in size, occupying a space three times as great as that taken by the premolars. The crown of the first molar is transversely oblong, measuring $2\frac{3}{4}$ by 2 inches; the second is subquadrate; the third is antero-posteriorly oblong. As in the premolars, the anterior crest in m^1 and m^2 is the largest, and without distinct "anti-crochet," but the pos-

terior crest is also strongly developed. In its great inward extension m^1 has lost the internal cingulum, which is well developed in m^2 and m^3, as well as in the premolars. The broken outer contour of the molars indicates that the outline was similar to that observed in the *Amynodon* molars.

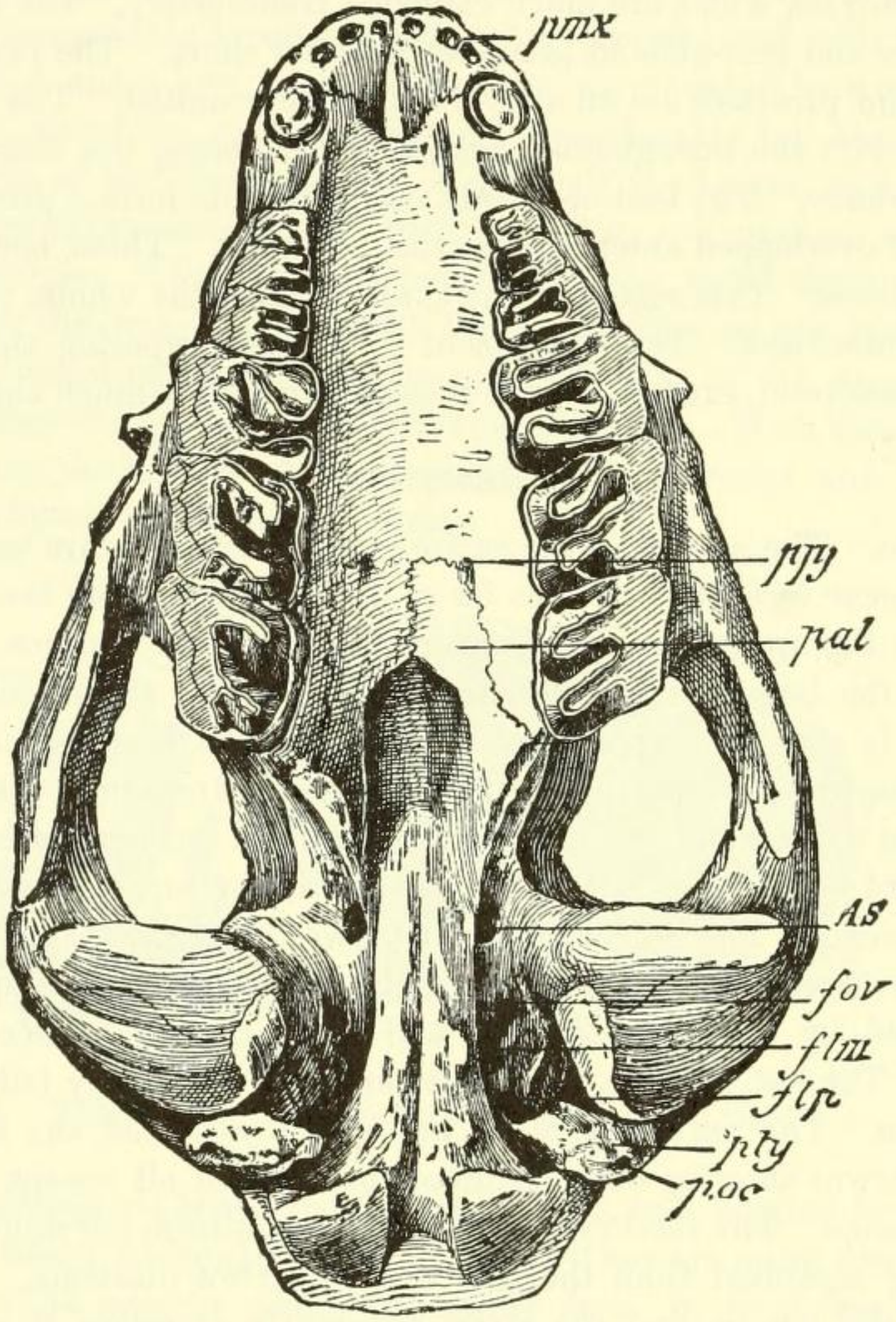


FIGURE 9. — Base of skull of *Metamynodon*. *ppf*, post-palatine foramen. *fov*, foramen ovale. *flm*, foramen lacerum medium. *flp*, foramen lacerum posterius. *As*, alisphenoid canal.

MEASUREM.

Skull.

	M.
Length of the skull from the incisor alveolus to the occipital condyles .	.550
Transverse measurement, outside of the zygomatic arches	.365
Height of the occiput	.165
Breadth " "	.190
Length of face, front of orbit to premaxillaries, anterior border . . .	.170
Length of cranium, front of orbit to occiput	.385

Upper Teeth.

	M.
Antero-posterior diameter of molar-premolar series (pm. .065, m. .160),	.225
Measurement of the canines, outside	.130
" " " inside	.056
Diameter of first molar, antero-posterior .047; trans.	.068
" third molar, " .060 "	.064
" fourth premolar, " .025 "	.045
" canine, " .035 "	.035

Lower Jaw.

Length of symphysis,	.130
Breadth of jaw opposite canines	.075
Diastema behind the canines	.050
Depth of jaw below first molar	.096
Antero-posterior diameter of molar-premolar series	.210
Measurement outside of the canines	.060
Transverse diameter of the canines	.030
Antero-posterior diameter of the canines	.037

RHINOCERIDÆ.

Aceratherium (Rhinoceros) occidentale, Leidy. This species is abundantly represented in the collection by skulls, teeth, and portions of the skeleton. Little more than the skull has been described as yet, but it is now possible to give a nearly complete account of the osteology of this species, as will be done in the final paper. The American species of *Aceratherium* are lighter, more slender, and retain more evidence of lophiodont ancestry than the European species, or any of the recent forms. The scaphoid does not cover the magnum so extensively as, and the lunar has a greater contact with the magnum than, in any of the modern genera, nor does the lunar rest so completely upon the unciform as in the latter. The metacarpals are heavier than in *Hyrachyus*, more slender than in the recent types; there were plainly four digits in the manus. The phalanges have about the same proportions as in the Sumatran rhinoceros. In the hind foot, compared with that of living species, we find that the tarsus is higher and narrower, the astragalus more deeply grooved, with longer neck and smaller cuboidal facet; the calcaneum is not so heavy; the metatarsals, especially the lateral ones, more slender.

In the limb bones the processes for muscular attachment, such as the deltoid hook of the humerus and third trochanter of the femur, are much less massively developed than in recent species.

HYRACODONTIDÆ.

Hyracodon nebrascense, Leidy. This species is very abundantly represented. Its osteology has already been partially described in another place,*

* E. M. Bull., No. 3, p. 17.

and it is therefore unnecessary to dwell upon it here further than to remark its very close resemblance in many important respects to the the eocene genus *Hyrachyus*. In general there are also certain analogies with the horse, in the delicate head, long neck, and elongated and narrow feet.

Hyracodon major, sp. nov. The type of this species is a fairly complete skeleton in the Princeton Museum, and in the Cambridge collection it is represented by a beautifully preserved fore-foot. Of this the carpus is high and narrow; the scaphoid is less produced laterally than in *Aceratherium*, the facet for the trapezium is very small and infero-lateral in position, those for the trapezoid and magnum much larger, and nearly equal in size. The lunar is contracted and anteriorly rests only upon the unciform, touching the magnum laterally, while in *H. nebrascense* there is apparently no anterior contact between the lunar and magnum. The cuneiform is high and much compressed, and the pisiform is short, compressed, and much expanded at the free end. The trapezium is a very small bone; it is pushed to the posterior side of the trapezoid so as not to be visible from the front, and has no contact with metacarpal II. The trapezoid is well developed, though relatively smaller than in the rhinoceros. The magnum is very large, in accordance with the development of the third digit, and is especially elongated in the vertical direction. The unciform is very high and narrow, and descends much below the level of the other carpals; owing to this compression the facet for metacarpal III. is entirely lateral instead of distal; there is an unusually extensive contact between the unciform and the magnum.

The lateral metacarpals are slender, narrow, and curved, the median one considerably longer and much heavier. Metacarpal II. abuts against the magnum by a considerable facet, while in *H. nebrascense* the facet is very small. Metacarpal V. is represented by a minute nodular bone, which is attached to the unciform and to the ulnar side of metacarpal IV.

Measurements.	*H. nebrascense.* M.	*H. major.* M.
Carpus, breadth	.040	.060
" height (median line)	.033	.050
Unciform; width	.020	.023
" height	.021	.033
Metacarpal II., length	—	.115
" III., "	—	.128
" IV., "	—	.105
" V., "	.010	—

Hyracodon (?) planiceps, sp. nov. This large species is distinguished from *H. nebrascense* by its extremely low and broad cranium, which is flattened upon the upper surface and entirely lacks the sagittal crest, which is represented by two ridges diverging from the supra-occipital border. This flattening alters the proportions of the occiput and temporal fossa. Comparing

this skull with that of *H. nebrascense*, we find about the same relative height as between the skulls of *Metamynodon* and *Amynodon*. The antero-external column is less sharply folded than in *H. nebrascense;* the first molar has a small conical tubercle at the entrance of the valley; the outer wall of the last molar extends beyond the posterior crest much more than in the other species of the genus, as in *Amynodon* and the *Lophiodontidæ*. The transverse crests are subequal and extend obliquely across the crown, thus differing from *H. arcidens*, Cope, in which the anterior crest is the longer and curves around the posterior.

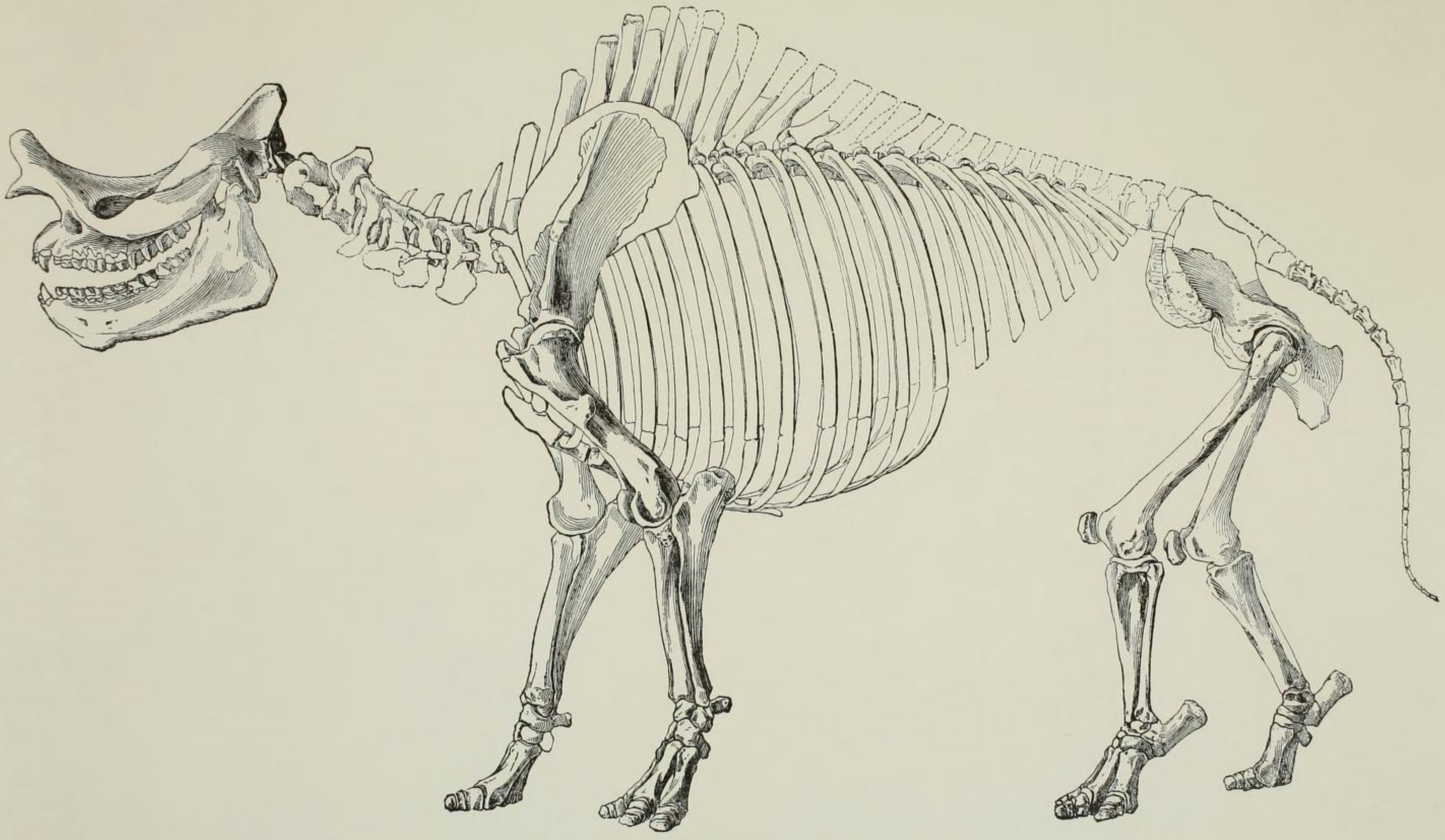
The skull, which was that of a young animal, lacks most of the facial portion. The extreme breadth across the zygomatic arches is $6\frac{1}{4}$ inches, while the height of the occiput is $2\frac{1}{2}$ inches; in a young specimen of *H. nebrascense* these measurements are $4\frac{3}{4}$ and 3 inches, a great difference of proportions. The periotic is exposed on the surface of the skull; the parietals are short; the post-glenoid and post-tympanic processes are separated below; the lachrymals extend considerably on the face.

Measurements.	*H. planiceps.* M.	*H. nebrascense.* M.
Upper molar series, length	.103	.070
First molar, width	.035	.026
Second " "	.036	.028
Third " "	.037	.026
Second molar, length	.035	.027
Third " "	.040	—

The proportions of the teeth thus differ considerably in the two species. In *H. planiceps* they increase in size from m. 1 to m. 3, while in the smaller animal m. 2 is the largest. In the former species the molars closely resemble those of *Amynodon*, but differ widely from the proportions found in *Metamynodon*. In fact, this animal may turn out to belong to a genus very different from *Hyracodon*, but at present we prefer to retain it provisionally in that group.

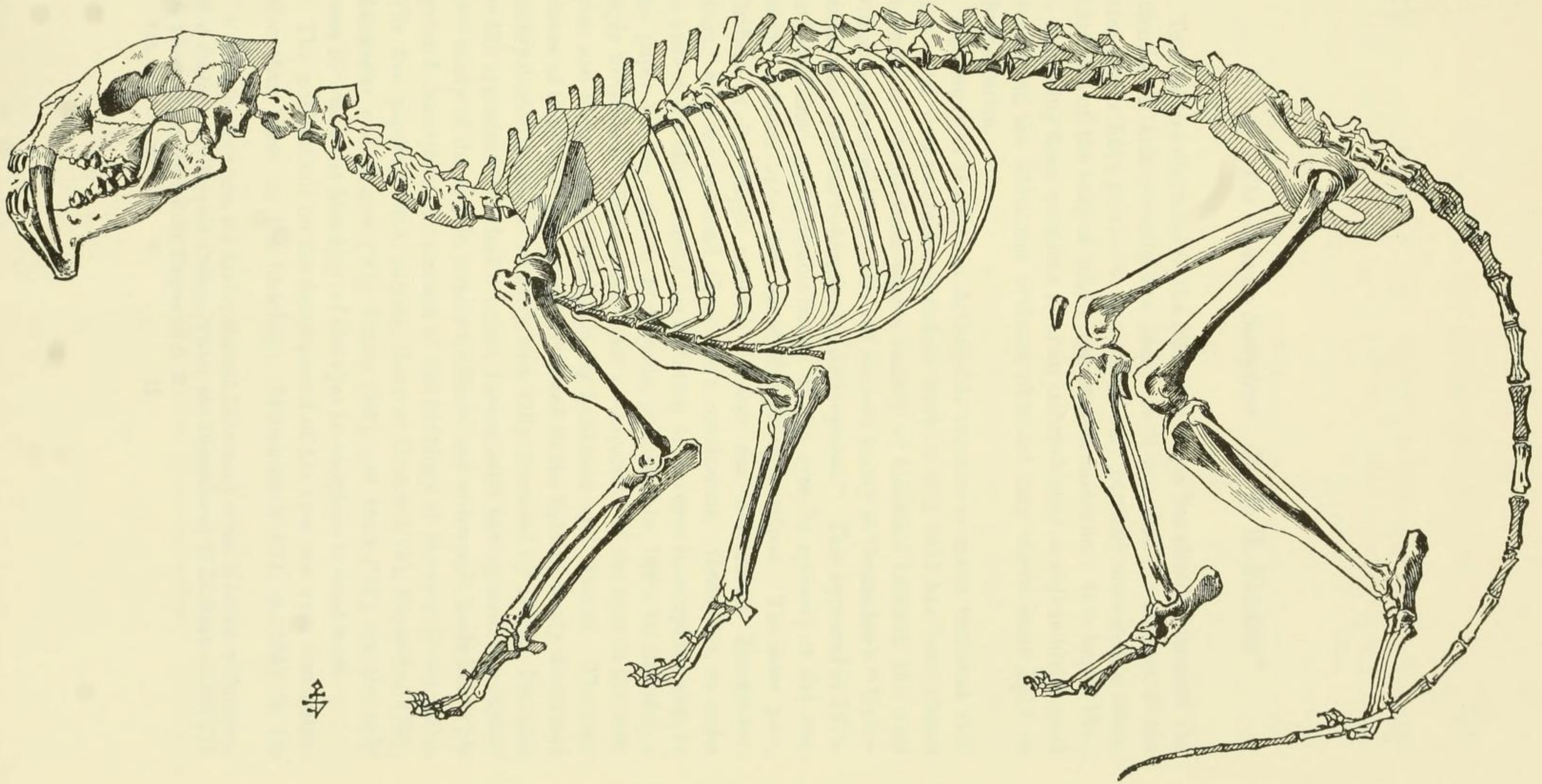
ANCHITHERIDÆ.

Mesohippus (Anchitherium) Bairdi, Leidy. The genus *Mesohippus*, Marsh, differs from *Anchitherium* in the structure of the incisor teeth, which have no enamel pit. The Cambridge collection contains an excellent skull and brain cast, the description of which is reserved for the memoir.



RESTORATION OF MENODUS PROUTII.

One sixteenth natural size.



RESTORATION OF HOPLOPHONEUS PRIMÆVUS.

One fourth natural size.