No. 3. — *Preliminary Account of the Fossil Mammals from the White River and Loup Fork Formations, contained in the Museum of Comparative Zoölogy.* Part II. *The Carnivora and Artiodactyla by* W. B. Scott. *The Perissodactyla by* Henry Fairfield Osborn.

This paper, the second upon the Fossil Mammals of the Museum of Comparative Zoölogy, is a continuation of the one published by the writers[1] in August, 1887, upon the White River Mammalia, and includes a number of additions to and corrections of the results there described. It is, however, especially devoted to a consideration of the upper Miocene or Loup Fork mammals collected in Nebraska by Messrs. Garman and Clifford, and in Kansas by Mr. Sternberg. The specimens from these different localities exhibit a considerable range of specific variation.

The Loup Fork species here described have for the most part been long established, but these collections add much to our knowledge, and enable us to determine very fully the structure of forms which have been known hitherto only from fragments. Of such new observations we may mention: (1) the determination of the foot structure of *Merycochœrus;* (2) of *Blastomeryx;* (3) the restoration of *Cosoryx;* (4) discovery of the mandible of *Ælurodon hyænoides;* (5) the discovery of an exceedingly large feline animal; (6) observations upon the molars of the equine series; (7) the manus and pes of *Aceratherium;* (8) the skeletal characters and restoration of *Aphelops fossiger;* (9) the homologies of the elements of the molar teeth in the rhinoceroses; (10) the brain characters of *Aphelops* and *Mesohippus;* (11) the discovery of a Loup Fork species of *Chalicotherium.*

We have again to express our thanks to Dr. F. C. Hill, Curator of the Geological Museum at Princeton, for his skilful excavation and mending of the specimens, and to Mr. R. Weber for the very accurate series of drawings which accompany this paper.

[1] The authors, as initiated in their Memoir upon the Uinta Mammalia, have divided the subjects for their present and future joint papers.

CARNIVORA.

CANIDÆ.

ÆLURODON, Leidy.

(Syn. *Epicyon*, Leidy. *Canis*, Leidy, in part. *Palhyœna*, Schlosser.)

The dogs of this genus are the most abundant of the Loup Fork *Canidæ*, and, as their relations and systematic position have been very generally misunderstood, it will be well to describe them in some detail. The special peculiarity of the genus is to be found in the development of a large anterior basal lobe on the superior sectorial, as in the cats. The postero-internal cone (metaconid) of the lower sectorial is much reduced, and in some species almost disappears. The talon of this tooth is rather short, and consists of an internal and external cone or tubercle, being of the basin-like character. The premolars are remarkably heavy, and possess well developed basal conules. There are four well marked species of this genus, of which the best known is

Ælurodon sævus, Leidy (Cope).

(Syn. *Canis sævus*, Leidy. *Ælurodon ferox*, Leidy. *Ælurodon sævus*, Cope.)

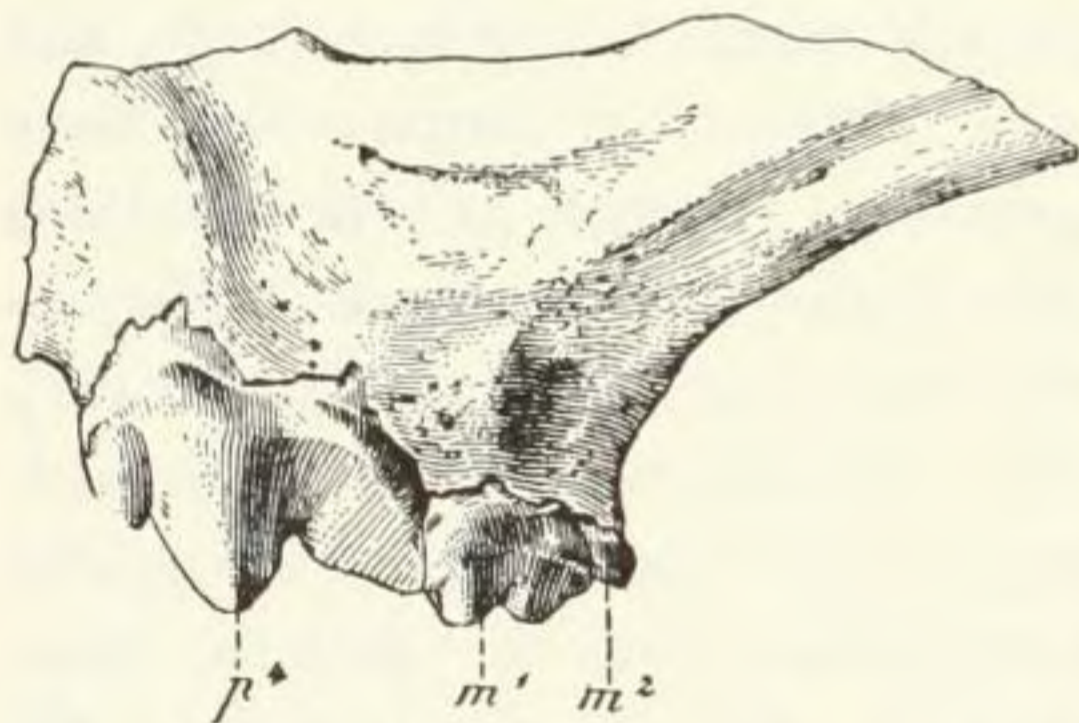This species is characterized by the very small size of the internal cusp of the upper sectorial, and by the nearly straight and slender mandible; the incisors are rather small, and the first upper molar is very large and subtriangular in shape. The skull as figured by Cope (American Naturalist, XVII.) presents a rather short, narrow muzzle, and is in general quite bear-like in appearance. Notwithstanding its peculiarities of dentition, this animal is an unmistakable dog,

FIGURE 1. — *Ælurodon sævus*, fragment of right superior maxillary × ⅔.

and the structure of the skull, vertebræ, limbs, and feet is characteristically cynoid. The metapodials are, however, somewhat less elongated proportionally than in existing dogs.

Ælurodon Haydeni, Leidy.

(Syn. *Canis Haydeni*, Leidy. *Epicyon Haydeni*, Leidy.)

This species is very large, and is remarkable for the short, massive mandible and the strong upward curvature of the posterior portion of the alveolus, so that the inferior tubercular molars may almost be said to be inserted in the ascending ramus. In Dr. Leidy's type of the species (Ext. Mam. Fauna, Dak. and Neb., Plate I. fig. 10) the third lower molar is inserted by two fangs, and in

nection between these American genera and the *Amphitragulus, Dremotherium,* etc. of St. Gérand le Puy is obvious from the most superficial comparison.

The collection contains specimens probably indicative of other species of *Cosoryx,* some of them much larger than *C. furcatus;* but in the absence of associated teeth, it is not possible to refer them to their proper categories.

PERISSODACTYLA.

ANCHITHERIIDÆ.

MESOHIPPUS, MARSH.

THE BRAIN.

Mesohippus had a large and well convoluted brain. The length and breadth indicate that it weighed about one third as much as the brain of the recent horse, while if we estimate the body weights of the fossil and recent animals by the relative size of the humeri, the brain of the Miocene species was proportionally heavier. The cerebrum of the horse is, however, much more highly convoluted, and the frontal lobes are relatively broader. The *Mesohippus* brain is distinguished in a marked manner by the longitudinal direction of the parietal and occipital sulci, and by the deep transverse frontal sulci, as contrasted with the oblique sulci of all recent ungulates. In fact, in this respect it bears a marked general resemblance to the brain type of recent Carnivora, and conforms with the higher Ungulata of the Eocene.

FIGURE 10. — Brain of *Mesohippus Bairdii* × ⅔. From above, and from side.

On either side of the longitudinal fissure is a long deep fissure forking anteriorly and marking off the median gyrus, *m*, of the parieto-occipital region. Parallel with this is a short fissure, which separates the two medilateral gyri, *ml, ml'*. The third fissure extends to the posterior transverse, and thus entirely separates the supersylvian gyrus, *ss*, from the medilateral. The fourth fissure is shallower. There are three transverse frontal fissures (FR. 1, 2, 3) which divide this lobe into three gyri; the median fissure extends almost to the longitudinal fissure, and sug-
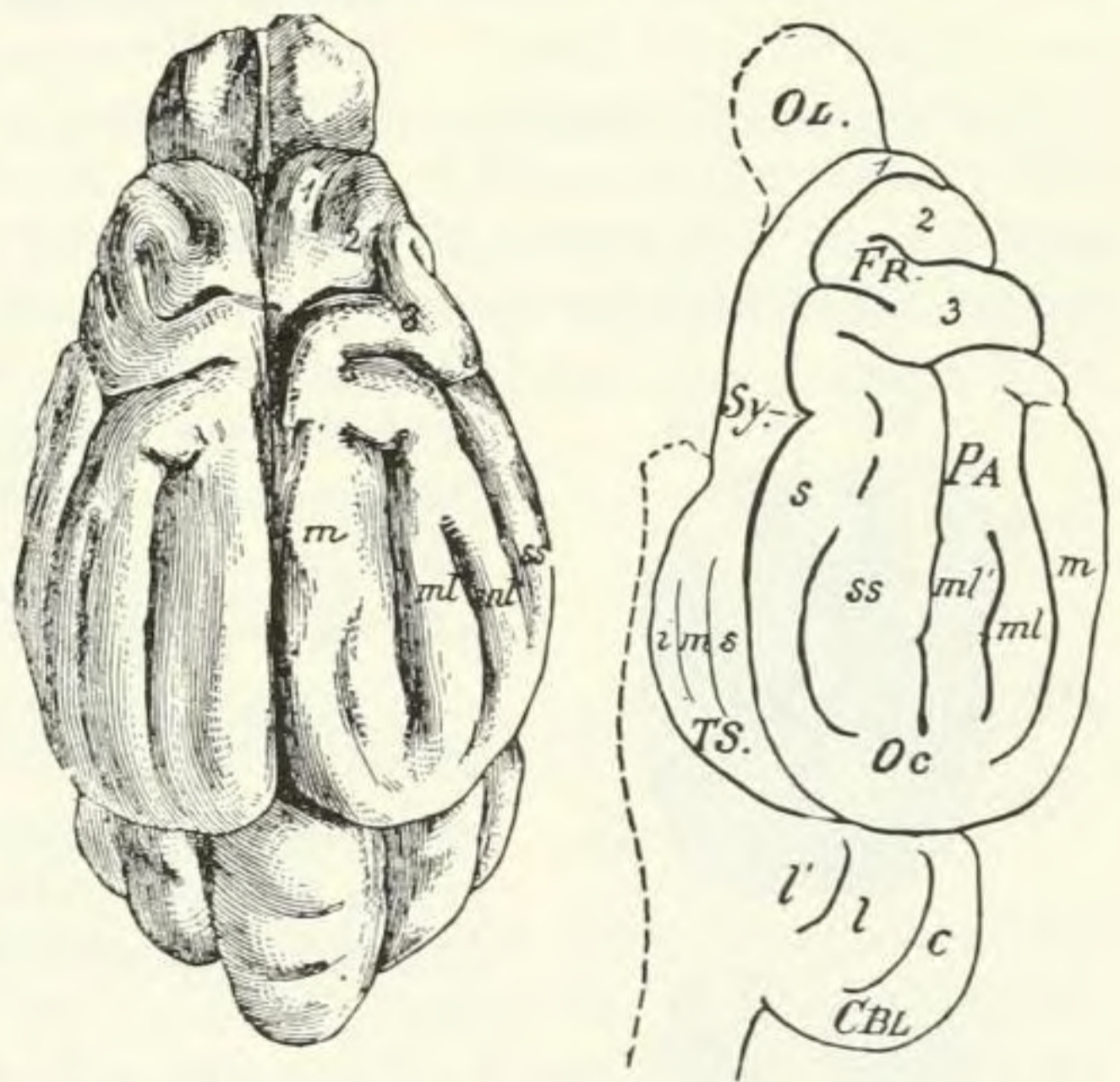
gests the crucial sulcus of the Carnivora. The sylvian fissure is very shallow. The temporo-sphenoidal lobe is very prominent, and is divided into three gyri (*s*, *m*, *i*) by two sulci. Beneath the third frontal gyrus is a vertical sulcus, parallel with the sylvian.

The cerebellum has a large central lobe with transverse simple furrows.

The Dentition.

There are a few new points to be noted in regard to the teeth of *Mesohippus*, which bear upon the dentition of the horses in general, and are clearly shown in
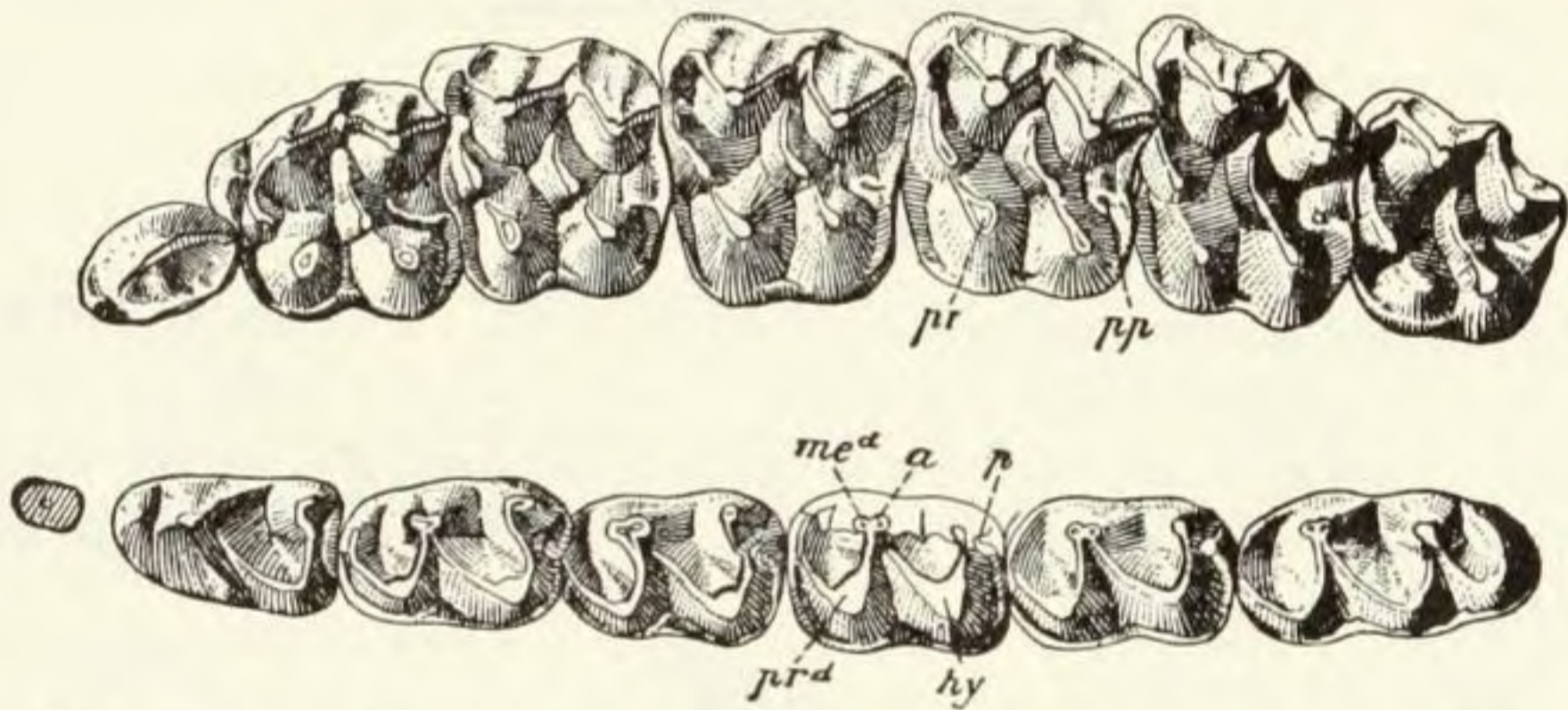

FIGURE 11. — Superior and inferior molars of *Mesohippus Bairdii* × ¼.

a series of unworn crowns of the upper and lower jaws. Scott has already pointed out that the incisors in this genus are simple, there being no indication

FIGURE 12. — Superior molar of *Anchitherium longicriste* × ¼. Superior and external view. Cope collection.

of the infolding of the enamel, such as is seen in *Anchitherium aurelianense*. In some of the John Day species of *Anchitherium* the enamel is not infolded, as observed in the lower jaw of a specimen referred to *A. equiceps*, Cope.
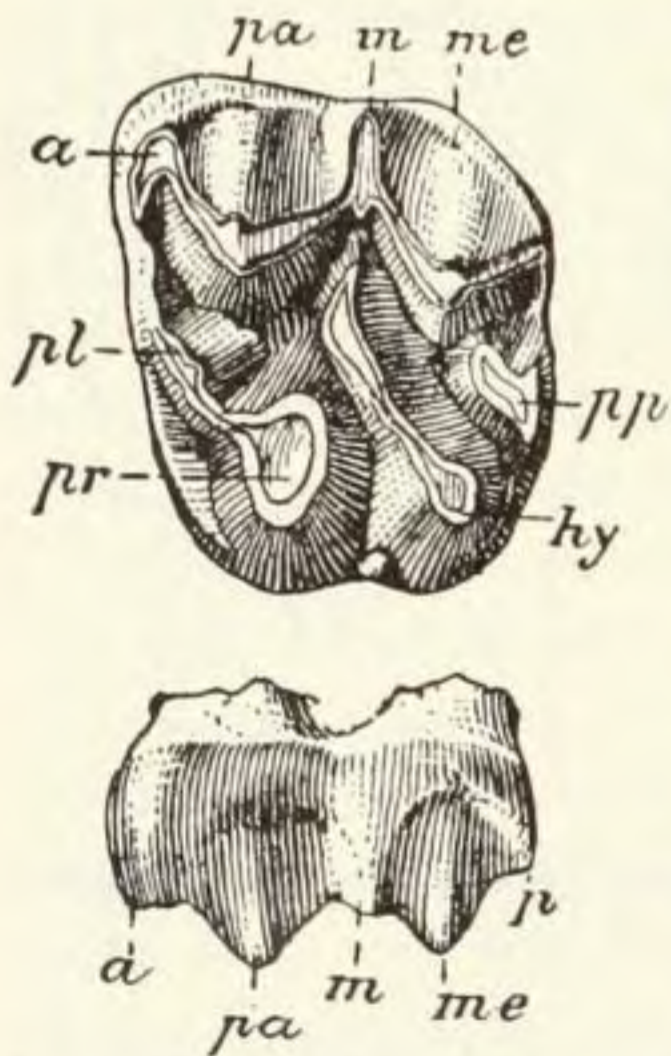
The upper molars of *Mesohippus* clearly show the first step in the formation of the *posterior pillar, pp*, which is so conspicuous a feature in *Anchitherium*, in the posterior valley. This can also be observed in a still simpler stage in a specimen of *Anchilophus* from the French Phosphorites. Step by step with the development of this cusp appears the *posterior pillar, p*, in the lower molars, behind the entoconid ; this accessory cusp can be traced back to the teeth of *Epihippus*. When it finally unites with the entoconid, in *Hipparion*, it forms the posterior twin cusp (*b, b*, Rütimeyer), which is analogous to the anterior pair formed by the union of the metaconid and *anterior pillar, a* (*a, a*, Rütimeyer).

Thus the transition from the *Mesohippus* to the *Anchitherium* molars is very gradual, as shown in the accompanying figures. By tracing back the rise of

the eleven elements which compose the upper *Equus* molar, we find that six belong to the primitive sextubercular bunodont crown. Two elements of the ectoloph, the *anterior pillar* and *median pillar*, rise from the simple primitive basal cingulum of the *Hyracotherium* molar; the same mode of development, we have just seen, is true of the *posterior pillar*. The eleventh element, the fold of the postero-external angle of the crown, *p*, is not prominent until we reach *Equus*. The term "posterior pillar" is taken from Lydekker; the other terms, "median" and "anterior," are applied to parts which have an analogous origin from the basal cingulum. The remaining coronal cusps are readily identified with their homologues in the primitive tritubercular molar.

? Anchitherium parvulus, Marsh.

(Syn. *Equus parvulus*, Marsh.)

Among the Loup Fork specimens collected by Clifford are found two lower molars, m_1 and m_3, which are almost identical in size with those of *Mesohippus Bairdii*. The crown of m_1 measures: antero-posterior, .011 m.; transverse, .009 m. Unlike the *Mesohippus* molars, there is no external cingulum. The "posterior pillar" has the same degree of development as in *Anchitherium*. The fangs are separate. There is no trace of cement. Marsh has described a diminutive horse (*Equus parvulus*), estimated at two feet in height, from the same beds, and it is highly probable that these teeth belong to this species. The generic reference is of course very uncertain. The brachydont crowns point either to *Merychippus* or *Anchitherium*, but the stage of development of the coronal pattern approximates most closely that in the latter genus, being a little more advanced than in *Mesohippus*.

RHINOCERIDÆ.

ACERATHERIUM.

The Manus and Pes.

The characteristics of the pes of *Hyracodon* from the lower White River beds have been fully enumerated by us.[1] They are principally as follows: cuboid not supporting astragalus anteriorly; lateral digits reduced and not spreading; ectocuneiform not articulating laterally with mts. II. We may subsequently find that the feet of the later species of *Hyracodon* varied in some of these respects, although this is not probable, owing to the fixity of foot-types once established. We have, however, no present means of distinguishing between the *Metamynodon* and *Aceratherium* foot-bones.

On page 169 of the first Bulletin a high, rather slender tarsus was described,

[1] See Scott, E. M. Museum Bulletin, No. 3, May, 1883, p. 19. Also, Osborn, Mammalia of the Uinta Formation, May, 1889, Part IV. "Evolution of the Ungulate Foot," p. 549.

which probably belongs to the *Aceratherium* of the lower beds. It differs widely in its proportions from other specimens found in this collection, which belong either to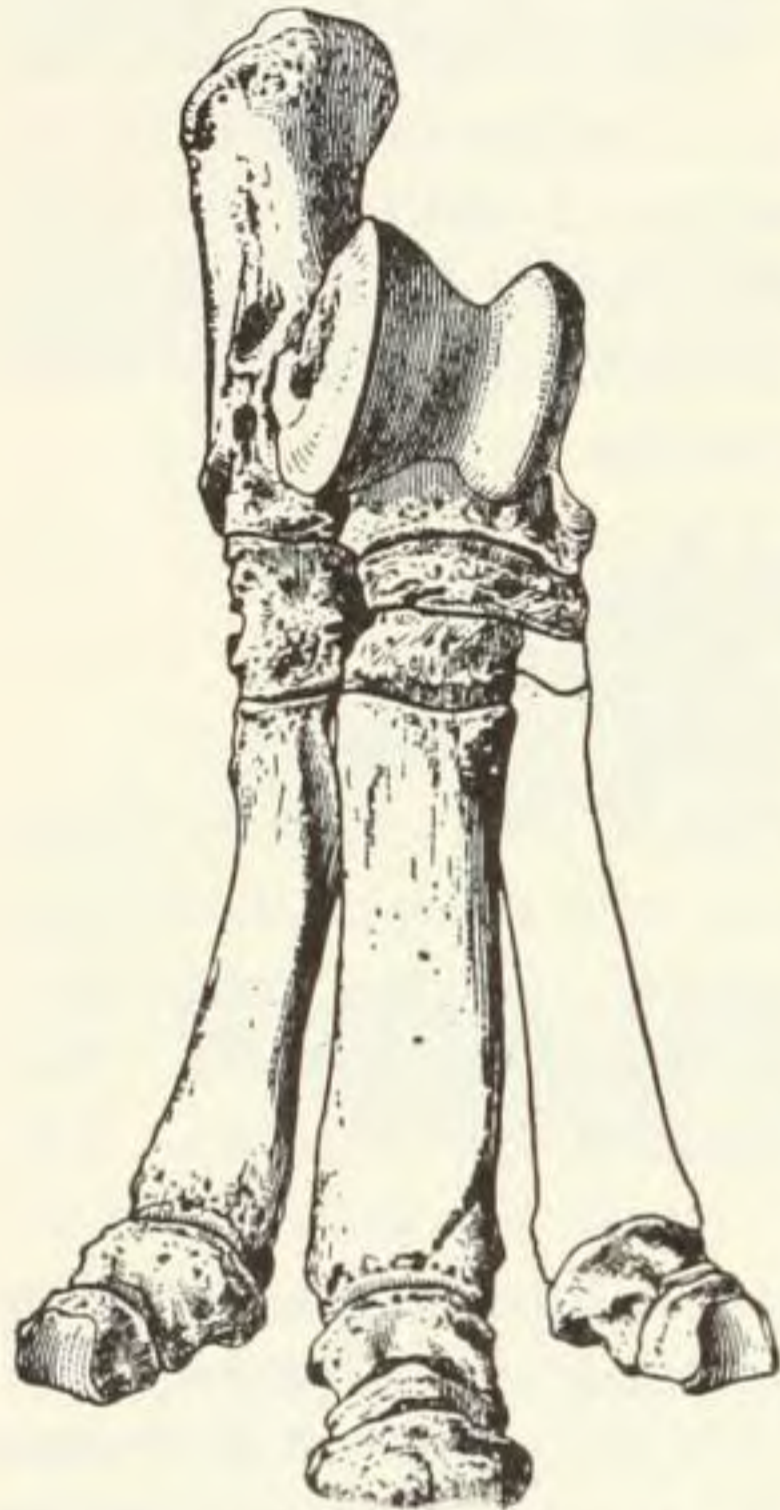 the *Aceratherium* of the higher beds, or to *Metamynodon*. The best preserved specimen of this second type (marked a^3) is comparatively short and broad, with spreading digits and rugose surfaces for muscular attachment (Figure 13). The proportions of the metapodials to the tarsals are similar to those in *Ceratorhinus*. The calcaneum has a powerful tuber; the ectal astragalar facet is very convex; the sustentaculum is narrow, and its oval facet is continuous with the inferior; the cuboidal facet is nearly horizontal. About one fifth of the astragalus rests upon the cuboid. The relations of the cuboid, navicular, and ectocuneiform repeat those observed in *Rhinocerus*. The mesocuneiform is very short, giving mts. II. a wide articulation with the ectocuneiform. The metatarsals are powerful, the lateral pair having approximately the same length as in *R. indicus*. This type of foot is related directly to that of *Aphelops*.

The manus and pes of a third specimen (marked a^6) show several interesting differences. In the pes, the metatarsals are of the same proportions, but the calcaneo-cuboidal facet is oblique and narrow, resembling that in *Hyracodon*, and the sustentaculum is very small. The remains of the carpus show that the species to which this specimen belonged had a greatly reduced fifth digit, constituting a functionally tridactyl manus. The evidence for this is in the greatly reduced lunar-magnum facet, which is invariably characteristic of tridactylism.[1]

It may be noted here that among the carpals of *Titanotherium* there is a well preserved lunar, which has its magnum facet much reduced anteriorly, so there is little question that we shall yet discover a tridactyle species of the genus.

FIGURE 13 — Right pes of *Aceratherium* × ¼.

The Rhinoceros Molars.

The peculiarities of the molars of *Aphelops* will be made more clear by a few observations upon the molars of the rhinoceroses in general. The three main crests of the lophodont crown may now be distinguished in part by terms which express their homologies with the elements of the sextubercular superior and quadritubercular inferior molars of the primitive ungulate, *Phenacodus*. In the upper molars, the outer crest is formed by the union of the primitive paracone

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[1] See Osborn, Mammalia of the Uinta Formation, p. 567. It is possible that these feet belong to *Metamynodon*.

and metacone, to which is joined the anterior pillar (see *Mesohippus*, p. 88); it may be called the *ectoloph*. As the anterior crest is formed by the union of the protocone, protoconule, and paracone, it may be termed the *protoloph*. The posterior crest, which unites the primitive metacone, the metaconule, and the hypocone, may be termed the *metaloph*. The outer surface of the ectoloph in the primitive molar of the Rhinoceros is marked by three vertical ridges corresponding to its three primitive component elements, *me, pa, ap;* one or all of these disappear in the flattening of the surface. It will be observed that nothing corresponding to the 'median pillar' of the superior molar of the horse is developed. In the lower molars (the paraconid disappearing), the union of the metaconid and protoconid forms the anterior crest, or *metalophid*, while the hypoconid and entoconid unite to form the *hypolophid*.
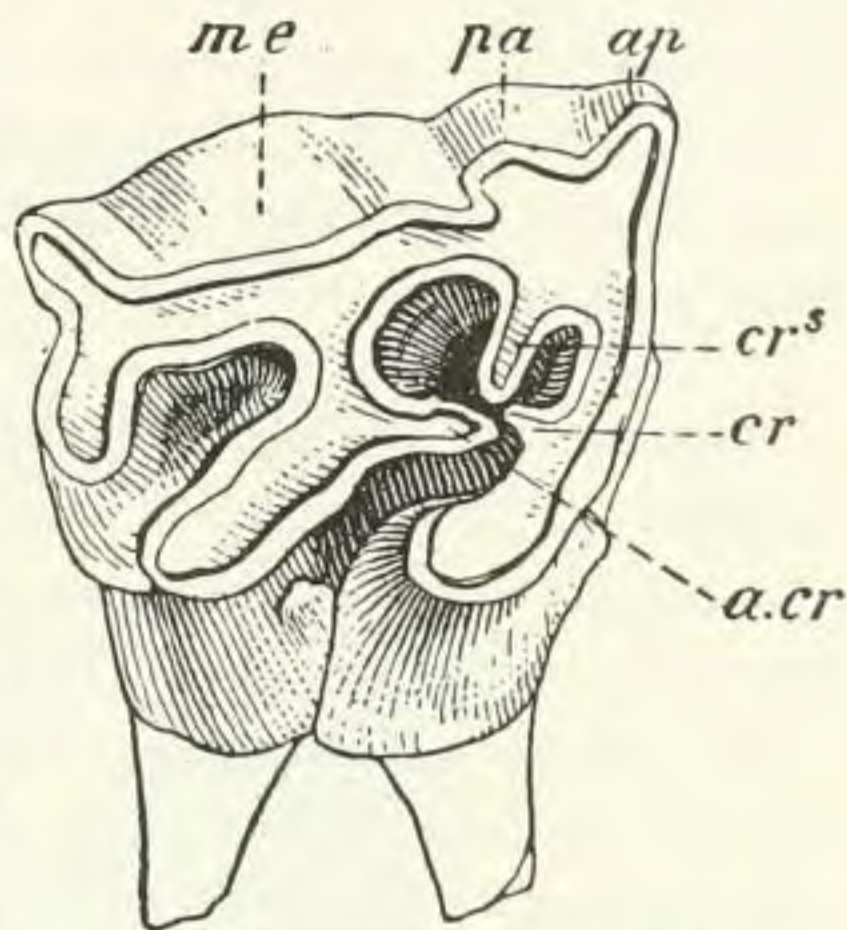

FIGURE 14. — Superior molar of Rhinoceros (sp. indet.) × ½. After De Blainville.

The secondary enamel folds, which are developed from the three crests, bear a most interesting analogy to those observed in the horse series, beginning with *Protohippus;* they are outgrowths of the same regions of the crown and subserve the same purpose. They are moreover of like value in phylogeny. The useful descriptive terms introduced by Busk, Flower, and Lydekker, should be adopted in part.[1] These secondary elements consist, first, of three folds projecting into the median valley, one from the ectoloph, the *crista;* one from the protoloph, the *crochet;* one from the metaloph, the *anticrochet*. Secondly, the ectoloph unites with the posterior cingulum and metaloph. Thus the anterior and posterior valleys may be cut off by the union of these folds into from one to three 'fossettes,' precisely analogous to the 'lakes' in the horse molar, except that they are not filled with cement.

The accompanying diagram is taken from a fossil molar figured by De Blainville. (Osteogr. Gen. Rhin, Plate XIII.) It is remarkable in exhibiting all the primary and secondary elements, for they are very rarely combined in a single tooth. Similar accessory folds are frequently developed in the lower molars.

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[1] The terms 'protoloph' and 'metaloph' are, however, substituted for 'anterior collis' and 'posterior collis' of Lydekker. The term 'anterior pillar' = 'first costa,' and 'paracone' = 'second costa.' The mode of evolution of the 'pillar' must have been similar to that in the horses, where Lydekker has proposed this term for the 'posterior pillar.' It is very appropriate, because the pillars in their earliest development can be shown to rise independently from the cingulum (see *Mesohippus*, p. 88), and not as folds of the main elements of the crown, as we should infer from their fully developed stage.

APHELOPS, Cope.

The generic characters of *Aphelops* have been given by Cope as follows. Dentition, I. $\frac{2-1}{1}$, C. $\frac{0}{1}$, P. $\frac{4-3}{3}$, M. $\frac{3}{3}$; post-glenoid and post-tympanic processes in contact but not co-ossified; digits, 3–3; nasals hornless. To these characters may be added: magnum not supporting lunar anteriorly; absence of the 'crista' and invariable presence of the more or less strongly developed 'crochet' and 'anticrochet' in the superior molars.

The specific nomenclature of *Aphelops* is in confusion. The type of *A.* (*Rhinoceros*) *crassus*, Leidy,[1] is a last upper molar, which is closely similar to that of *A. megalodus;* the characters of the milk molar associated with this type cannot be used in definition.[2] The penultimate upper molar, the type of *A. meridianus*, Leidy,[1] corresponds in the development of the two 'crochets' to the same tooth in *A. fossiger*, Cope, but the posterior 'fossette' is not enclosed by the strong cingulum as in the latter species. *A.* (*Aceratherium*) *acutum*, Marsh, is identical with *A. fossiger*. *A. malacorhinus*, Cope, resembles *A. meridianus* in the open posterior fossette and the development of the 'crochets.' It is impossible, however, to clear up this synonymy without bringing the original types together for comparison. General characteristics of all these types are the invariable development of the 'crochet,' absence of the 'crista,' usual development of the 'anticrochet.' The specific names proposed by Cope are here adopted because they are established upon a very complete knowledge of the skull as well as of the teeth.

Aphelops fossiger, Cope.

Dentition: I. $\frac{1}{1}$, C. $\frac{0}{1}$, P. $\frac{4}{3}$, M. $\frac{3}{3}$. First premolar simple, conical, sometimes absent; nasals not overhanging premaxillaries; foramen lacerum medium confluent with foramen ovale; occiput broad and low; limbs short and bulky; molars with well developed 'crochet' and 'anticrochet.'

In the figure given by Marsh (Am. Journ. Sci., Oct., 1887, p. 3) and by Cope (Am. Nat., Dec., 1879, p. 771 *e*), the third and fourth premolars have both the 'crochet' and 'anticrochet.' There is some ground for the supposition that the skull here described belongs to a different species, since the 'anticrochet' is not developed in the premolars. This reference is therefore provisional.

This is apparently the only species which is represented in this collection. All the specimens are from Kansas, and include several skulls and well preserved bones from all parts of the skeleton, enabling us to give a complete description and restoration of the animal.

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[1] See Ext. Mamm. Fauna, Dak , p. 228.

[2] Cope has nevertheless employed the 'cristæ' developed in this milk molar in his definition of *A. crassus*. "On the Extinct Species of Rhinoceriidæ of North America," etc., Bull. U. S. Geol. Survey, Vol. V. No. 2, p. 237.

THE BRAIN.

One of the most interesting features of *Aphelops* is the very large size of the brain. The walls of the cranium are solid. There are no vacuities or air-cells in the diploë of the mid-region of the brain-case, such as attain from 1 to $1\frac{1}{2}$ inches in thickness in *Ceratorhinus*. Thus the brain is relatively much larger
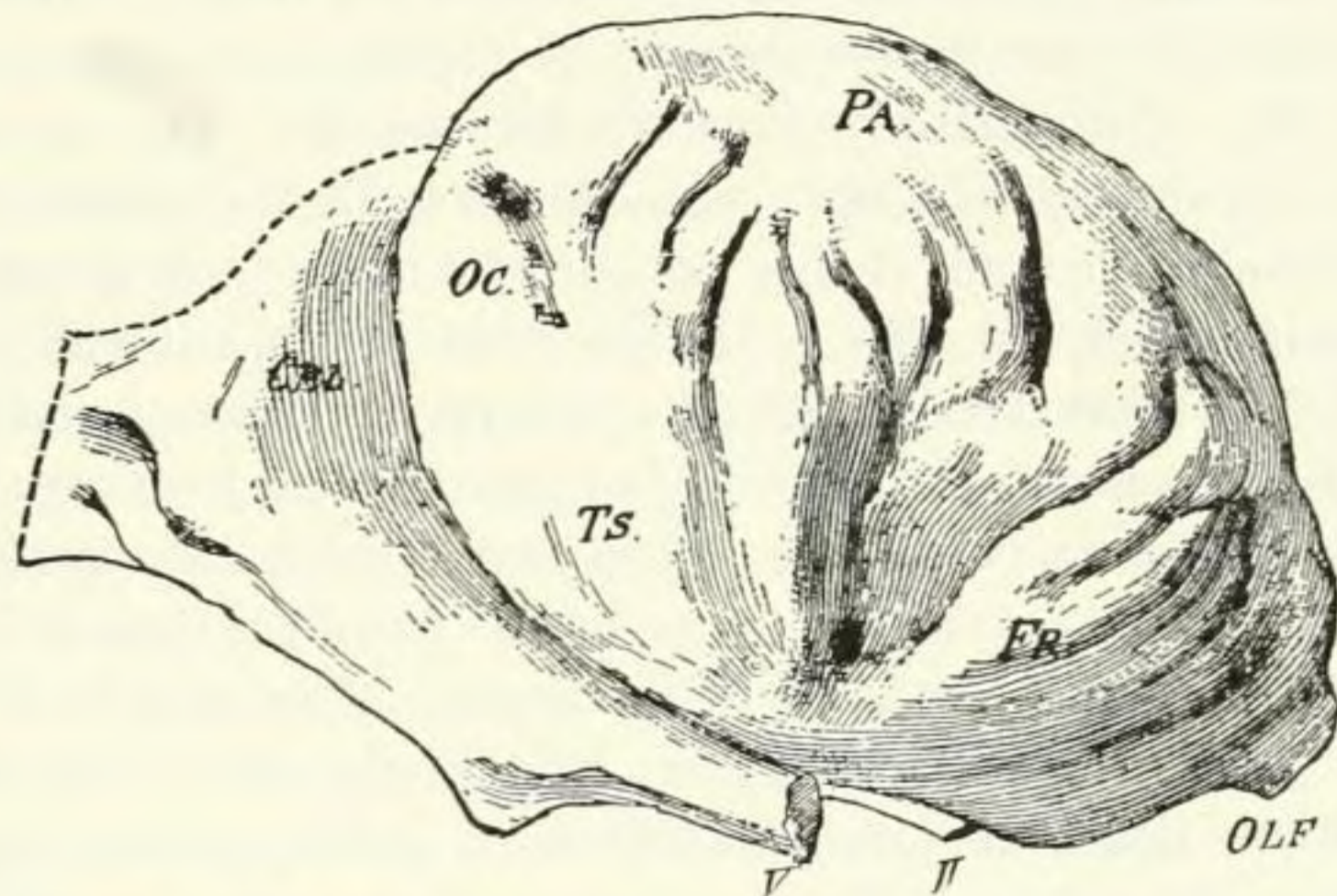
FIGURE 15 — Brain of *Aphelops fossiger* × $\frac{1}{3}$. Lateral view of intracranial cast.

than that of the recent rhinoceros, and presents a marked advance upon that of *Aceratherium occidentale*. The bulk of the fore- and mid-brain, or the divisions in front of the cerebellum, is approximately as follows :—

Aceratherium, 420 c.c. *Aphelops*, 1240 c.c. *Ceratorhinus*, 720 c.c.

The bulk of the entire brain is: *Aphelops*, 1470 c.c. *Ceratorhinus*, 850 c.c. The relative body weight of the two animals can be roughly estimated from a comparison of the femora as *Aphelops* 4, *Ceratorhinus* 3. It thus appears that the steady brain growth of the ungulates during the Eocene and early Miocene periods reached its highest point in some families of the later Miocene, and was followed by a degeneration.

The cerebellum in *Aphelops* is small and partly overhung by the hemispheres. The lateral view of the hemispheres shows a very marked predominance of transverse sulci, which radiate from the vertical sylvian fissure, S, so that in the basal view of the frontal lobes the fissures are antero-posterior. The dorsal surface of the cast is somewhat imperfect, giving an incomplete reproduction of the parietal and occipital regions. The superior
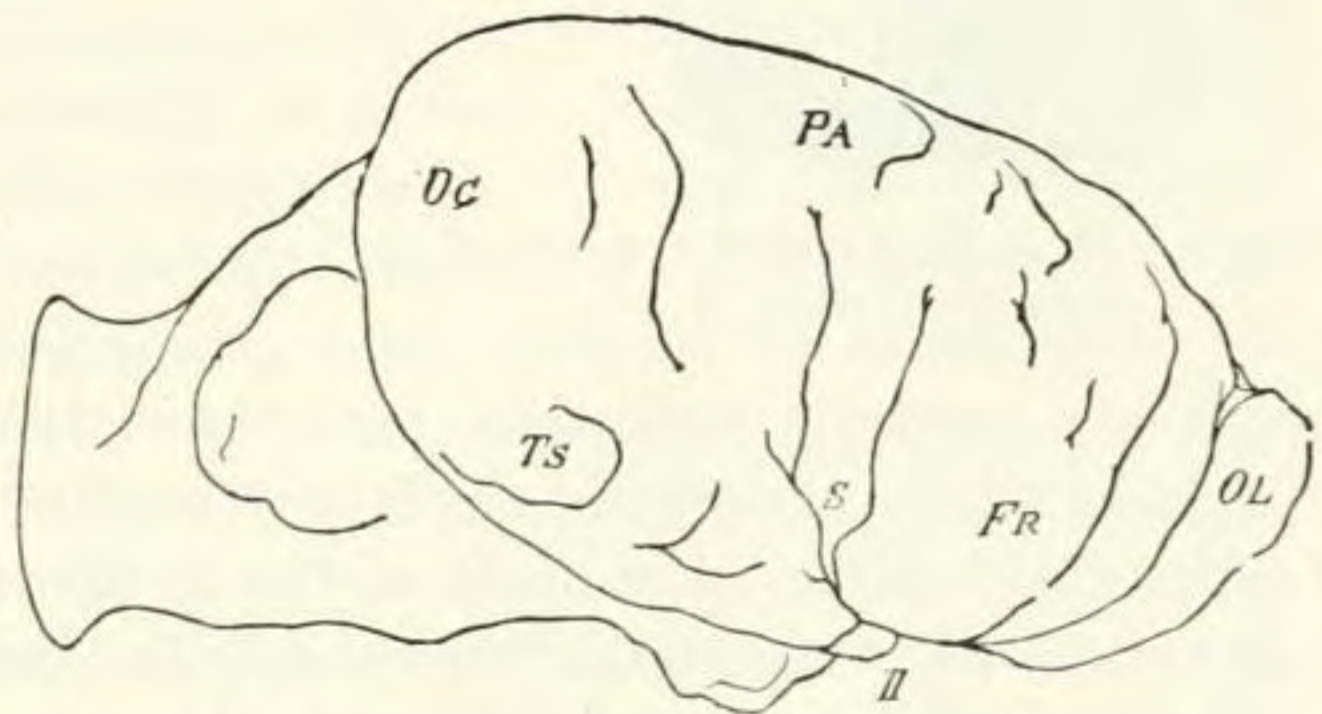
FIGURE 16 — Brain of *Ceratorhinus Sumatrensis* × $\frac{1}{3}$. Lateral view of cast.

sulci of the frontal lobe are directed obliquely backwards to the longitudinal fissure, thus reversing the direction observed in the recent ungulates.

THE SKULL AND DENTITION.

The *skull* (Plate III.) is broad in relation to its length, owing to the shortening of the ant-orbital region and the recession of the nasals. The maxillaries spread very widely for the powerful series of molars, while the *premaxillaries* are slender. The orbit is placed above the first molar. The *nasals* are compressed anteriorly, and extend only so far as to overhang the premaxillary suture. A marked feature of the skull is that the upper surface is in a nearly straight line from the supra-occipital ridge to the tip of the nasals, while in *A. megalodus* it is concave. The orbit is very slightly overhung by the supra-orbital process. The zygomatic arch is deep vertically, but compressed laterally. The postglenoid process is deep and narrow; it has contact with the post-tympanic of variable length. The remarkable feature of the post-tympanic is its extension into a broad flat plate behind the auditory meatus. The occiput is broad and low, and does not overhang the condyles; it is deeply cleft in the median line. On the base of the skull, the foramina rotundum and spheno-orbitale are confluent, as observed by Cope. The foramen ovale is either confluent with or separated by a slender ridge of bone from the foramen lacerum medium.

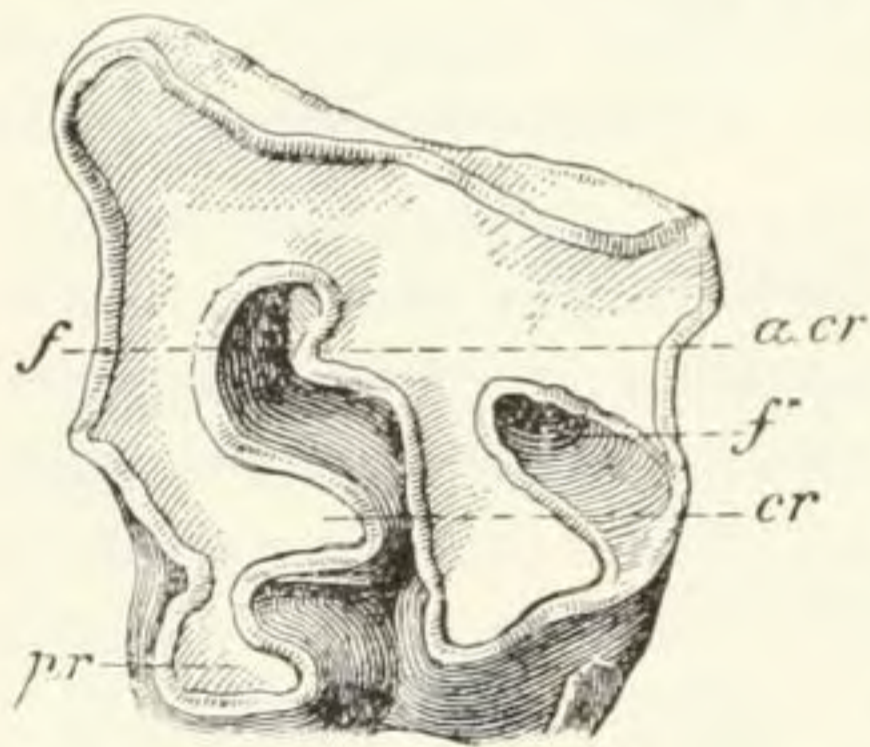The *molars* and *premolars* are remarkable for the extreme flattening of the outer surface of the ectoloph, all trace of the three vertical ridges having disappeared. The first premolar is a simple conical tooth implanted by a single fang; it is apparently inconstantly developed, for Marsh makes no mention of it in his description of *A. (acutum) fossiger*. The inner angles of the protoloph and metaloph unite by the 'crochet' in pm^2 and pm^3 to enclose the median valley, as in *Aceratherium*. The fourth premolar resembles the molars except in the non-development of the 'anticrochet.' The true molars are characterized as follows: by the constriction of the inner portion of the protoloph into a separate column; by the strong development of the 'crochet,' which in m^1 and m^2 unites early with the metaloph to enclose the anterior 'fossette'; by the development of the 'anticrochet' at the inner angle of the metaloph and ectoloph; by the complete enclosure of a posterior 'fossette' in the first and second molars.

FIGURE 17. — First superior molar of *Aphelops fossiger* × ½.

The inferior molars are of the simple rhinoceros pattern, there being no trace of accessory folds. The first premolar is missing; the second is separated by a rather narrow diastema from the large lateral tooth. Between the pair of large semi-procumbent caniniform teeth are two small incisors.

The lower jaws are very massive, with a strongly arched lower border. The condyles are broad and elevated. The posterior border is broad, but not rugose.

THE SKELETON.

(Plate III.)

Vertebræ. — The atlas resembles that of *R. unicornis,* with extremely broad transverse processes. A well preserved axis has a low tuberosity representing the spine; there is some doubt whether this is the normal adult condition, although the absence of the spine would accord with the low occiput and hornless nasals. The cervicals 3–6 have deeply opisthocœlous centra, rather high and narrow in proportion, with powerful zygapophysial processes. The inferior lamellæ of the transverse processes project downwards and forwards, and expand very slightly at the tip; the width of this lamella increases somewhat in C. 6; the superior lamellæ project opposite the vertebrarterial canal. The sixth and seventh cervicals apparently have slender elevated spines, in the remainder the spines are low or tuberous. The centrum of C. 7 is subcircular in front and broad posteriorly.

The dorsals are represented by a number of vertebræ in the mid-region. The centra are laterally compressed with distinct keels; the zygapophysial facets are very small and horizontal; the metapophyses are well developed. The length of the spines in the anterior dorsal region was apparently as in *R. javanus.* No lumbars are found in this collection.

Fore limb. — The *scapula* is very short and heavy. The general outline is triangular; the glenoid border is concave; the coracoid border is convex; the superior border rises to a point above the spine; the upper third of the spine shows a very stout recurved acromial process.

The *humerus* is remarkably short and heavy, and is distinguished by the unusually elevated position of the deltoid ridge, which is much higher upon the shaft than in the recent rhinoceroses. The tuberosities are heavy and sessile; the external condyle is unusually prominent. The *ulna* has a deep, powerful olecranon process and stout trihedral shaft, which is suddenly compressed inferiorly for the cuneiform articulation. The proximal and distal faces of the *radius* are subequal; the shaft is very slightly arched and closely united with that of the ulna, giving this segment a very massive appearance.

The structure of the *manus* is in keeping with the short and heavy upper segments; it is broader and more powerful than in any of the recent rhinoceroses. The three short, widely spreading digits are faced by rugose areas for the attachment of powerful muscles. Mtc. III. is much the largest; the lateral metacarpals, II. and IV., are short and directed outwards; the phalanges are short and wide, especially the distal series. As in all tridactyle forms the carpal displacement is extreme; the scaphoid covers the whole upper surface of the magnum anteriorly; the lunar is rather small, and rests anteriorly wholly upon the unciform; posteriorly the pivotal process of the magnum supports the lunar; the cuneiform is high and narrow. The trapezium is missing in both the carpal series before us, but is indicated by the usual facets upon mtc. II. and the trapezoid. The magnum is broad and quadrilateral. The unciform has an unusually wide mtc. III. facet, and is vertically compressed.

Hind limb. — There is a complete left innominate bone, which gives all the characters of the *pelvis.* The upper surface of the ilium, unlike that of *Ceratorhinus,* is nearly flat. The supra-iliac border is evenly arched, and, as the ischial and acetabular borders are of approximately the same length, the ilium is unusually symmetrical. The ischium and pubis are in a plane perpendicular to that of the ilium; the pubic symphysis is short; the obturator foramen is an elongate oval. The tuber-ischii is not very prominent. The border extending from the tuber to the symphysis is evenly rounded.

The *femur* is relatively longer and more slender than the humerus, having the form and proportions observed in *Ceratorhinus.* The great trochanter stands out widely; below this the shaft is of a broad flattened section; the lesser trochanter presents a long low ridge; the third trochanter is only half as prominent as in the recent rhinoceros, and is not recurved. The *tibia* is characterized by a marked asymmetry of the tuberosity; the internal malleolus is not prominent; the popliteal space is deeply excavated; the astragalar facets are shallow. The *fibula* is of the same proportions as in the recent rhinoceros.

The *tarsus* is unusually short and spreading. The astragalo-tibial facet is flattened laterally, and shows little fore and aft play; the ectal and sustentacular facets are either confluent or slightly separate; the inferior is distinct and separate; the cuboidal facet is extremely broad. The cuboid is shallow, with subequal calcaneal and astragalar facets; posteriorly it articulates with both the navicular and ectocuneiform, anteriorly with the latter only; it has a very deep posterior hook. The presence of the entocuneiform is indicated by the articular facets for it. The mesocuneiform is narrow and deep. The ectocuneiform is very broad; this bone and the navicular have the same proportions as in the rhinoceros. The middle digit is much the largest of the three, and Mts. III. has a considerable cuboidal facet.

The following measurements are made from specimens which belong to different individuals, *a, b, c,* etc.; they therefore cannot be used in estimating the exact proportions of the different parts. The proportions have, however, been very carefully determined in the accompanying restoration of the skeleton.

MEASUREMENTS.

Skull.

		m.
Spec. *s.*	Total length, sagittal crest to end of nasals	.490
"	Breadth, outside zygomatic arches	.360
"	Depth, penultimate molar to top of cranium	.235
"	Occiput, diameter of, transverse, .268 m.; vertical	.198
"	From occiput to anterior end of orbit	.340
"	Antero-posterior, diameter molar-premolar series (pm. 115 m., m. 150 m.)	.265
"	Diameter first molar, antero-posterior .057 m., transverse . .	.070
"	" second " " .068 "	.070
"	" third " " .058 " . . .	.052

						m.			m.

Spec. *s.* Diameter fourth premolar, antero-posterior .045; transverse . .065
"   "   third   "   "   .035   "   . . .050
"   "   second   "   "   .028   "   . . .032
"   "   first   "   "   .017   "   . . .017
"   Lower jaw, length, angle to front of canine 470
"   "   depth, tip of coronoid to inferior border 295

Vertebræ.

Spec. *h.* Atlas, greatest width, .356 m.; greatest depth 100
Spec. *pp.* Axis, greatest width, .18 m.; length of centrum 090
"   "   "   depth, spine to base of centrum, estimated . . .140
Spec. *p.* Fifth cervical centrum, antero-posterior .074 m., vertical .068 m.,
     transverse .076 m.
Spec. *o.* Twelfth dorsal centrum, antero-posterior .075 m., vertical
     .055 m., transverse .058 m.

Appendicular Skeleton.

Spec. *c.* Scapula, vertical diameter, approx., .295 m.; glenoid cavity, ant.
     post. 900
"   Humerus, length of, .308 m.; breadth, head and tuberosity . . .155
Spec. *a.* Radius, length, .285 m.; breadth, proximal, .093 m.; distal . .098
"   Ulna, greatest length, .36 m.; sigmoid facet to cuneiform facet .295
"   Carpus, greatest transverse diameter, .130 m.; ditto vertical . .057
"   Mtc. III., breadth . . .070 m.; length 116
"   " II.   "   . . .043   " 100
"   " I.   "   . . .040   " 092
Spec. *e.* Left innominate bone, diameter, antero-posterior 495
"   Length of pubis, .185 m.; of ischium, .20 m.; of ilium 340
Spec. *f.* Femur, length of, .46 m.; diameter, head and great trochanter . .165
Spec. *g.* Tibia, length of, .37 m.; width, proximal 140
Spec. *q* and *r.* Tarsus, tuber calcis to distal facet of mts. III., approx. . .220
"   "   transverse diameter 108
"   Second metatarsal, length 088

RESTORATION. (See Plate II.)

The restoration of *Aphelops fossiger* confirms Cope's statement that the pro-
portions of the animal were rather those of the hippopotamus than the rhi-
noceros. The body was long, the chest deep, the limbs and feet short and
massive, and supplied with powerful muscles. The skeleton is about 9 feet
long and 4 feet 6 inches high. Thus *Aphelops* presented a wide contrast to its
tall, comparatively slender predecessor, *Aceratherium*, of the lower Miocene.
The increase in brain capacity shows that its nervous organization kept pace
with its general muscular and skeletal development. We may infer that the
extinction of *Aphelops* was due to climatic changes, rather than to any defects
in its internal organization, because the brain, teeth, and feet are, in themselves,
as adaptive as in any of the present persisting types.

COMPARISON WITH ACERATHERIUM AND RHINOCERUS.

There is nothing, however, which precludes the supposition that the American lower and upper Miocene Aceratheria are genetically related.

All portions of the skeleton of *A. occidentale* are now known to us, excepting the scapula, pelvis, and dorso-lumbar vertebræ; they indicate an animal in the same stage of skeletal evolution as the recent tapir; the proportions are practically similar; the displacement of the carpals and tarsals is in a corresponding stage. The mode of progression was also probably similar, for all the articular facets and protuberances for muscular attachment present innumerable points of resemblance. Cope[1] first pointed out the tapir resemblances in *Aceratherium*, especially in the separation of the foramina spheno-orbitale and rotundum ovale and foramen lacerum medium; the separation of the post-glenoid and post-tympanic; and the form of the femur. We have shown that this resemblance applies to the carpus[2] and tarsus; it is also true of the humerus and forearm, and of the atlas and axis. The remaining cervicals are widely different; it is probable, also, that the pelvis and scapula were different. This is of course simply an instance of functional and structural parallelism. It follows that an enumeration of the differences between the recent tapir and rhinoceros would also embrace the majority of the features which distinguish *Aceratherium* from *Aphelops*, for the latter is in most respects a fully developed rhinoceros.

Thus, if the descent from *Aceratherium* to *Aphelops* took place, it was accompanied by wide-spread modifications of the skeleton. In *Aphelops megalodus* we find a probable transition species. Its proportions are more intermediate. The narrow elevated occiput, the less degree of separation of the foramina of the skull, the lophodont character of the first upper premolar, the small development of the 'anticrochet' in the superior molars, — these characters all point towards *Aceratherium*.

A. fossiger is a highly modified form, with its broad occiput, simple first premolar, and confluent cranial foramina. In many respects the modifications it exhibits are simply steps towards the recent rhinoceros type; for example, its tridactylism, the extreme displacement of the podials, and the characters of the spinal column. But there are many points in which *Aphelops* differs from the recent rhinoceroses; namely, the sub-triangular shape of the scapula, the very elevated position and sessile character of the deltoid ridge of the humerus, the spreading manus, the oval obturator foramen, and the comparatively feeble development of the third trochanter. The marked peculiarity of the upper molars is the development of both the 'crochet' and 'anticrochet,' and absence of the 'crista.' This combination is very distinctive, since all the living rhinoceroses present combinations of the 'anticrochet' and 'crista.'[3] The molars of *Aphelops*

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[1] Bull. U. S. Geol. Surv., Vol. V. No. 2, p. 235. Also, "On Extinct American Rhinoceroses and their Allies," Am. Nat., Dec., 1879, p. 771 c.

[2] Osborn, "Evolution of the Ungulate Foot," Mem. Uinta Mamm., p. 550.

[3] See Flower, "On some Cranial and Dental Characters of the Existing Species of Rhinoceroses," Proc. Zoöl. Soc., 1876.

resemble in this respect those of *R. tichorhinus*. Briefly stated, in all living forms the protoloph is simple, and the accessory folds are developed, first from the metaloph, then from the ectoloph; while in the known extinct American forms the ectoloph is simple, and the protoloph develops a fold to which a fold of the metaloph is sometimes superadded.

In view of these facts, together with the numerous divergences in the skeleton, there is strong corroboration for the opinion advanced [1] by Scott in 1883, that *Aphelops* should not be regarded as ancestral to any of the recent foreign species, but rather as the last known of an extinct American series. The question is still an open one whether its distribution was confined to this continent.

CHALICOTHERIOIDIA.[2]

CHALICOTHERIUM, KAUP.

Specimens of this genus are rare in American formations, and have not as yet been reported from the Loup Fork. Marsh [3] has mentioned the occurrence of it in the John Day Miocene of Oregon, and in view of the discoveries of Forsyth Major and Filhol, it is altogether probable that the foot-bones from that formation, which Marsh has referred to the Edentata under the names *Moropus distans* and *M. senex*,[4] belong to the same genus. A third species of the same genus is announced by Marsh [5] from the Loup Fork, *M. elatus*, which is probably represented in the Garman collection from the Loup Fork of Nebraska.

Chalicotherium elatum? MARSH.

(Syn. *Moropus elatus*, Marsh.)

The specimen is a portion of a right superior maxillary containing the third and fourth premolars and the first molar. The premolars have a flattened ectoloph connected by two convergent crests, with a large internal cone which is cleft at the summit; the base of this cone is surrounded by a strong internal cingulum. The ectoloph is worn by two symmetrical incisions alternating with the transverse crests in the third premolar, but in the fourth these incisions are asymmetrical. The first molar is partly of the Titanotherium type, with its

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[1] E. M. Museum Bulletin, No. 3, 1883, p. 17.

[2] Gill, Arr. of the Fam. of Mammals, Smithsonian Misc. Coll., No. 230, p. 271. This order was properly defined by Gill, but was erroneously placed among the Artiodactyla, owing to the reduced condition of the superior incisors. Filhol's forthcoming memoir upon the Mammals of Sansan will probably enable us to determine its phylogenetic relations.

[3] American Journal of Science and Arts, 3d Series, Vol. XIV. p. 362.

[4] Ibid., pp. 249, 250.

[5] Ibid., pp. 250, 251.

protocone isolated, but the hypocone, as in all known Chalicotherioids, is united with the metacone by a low ridge (metaloph).
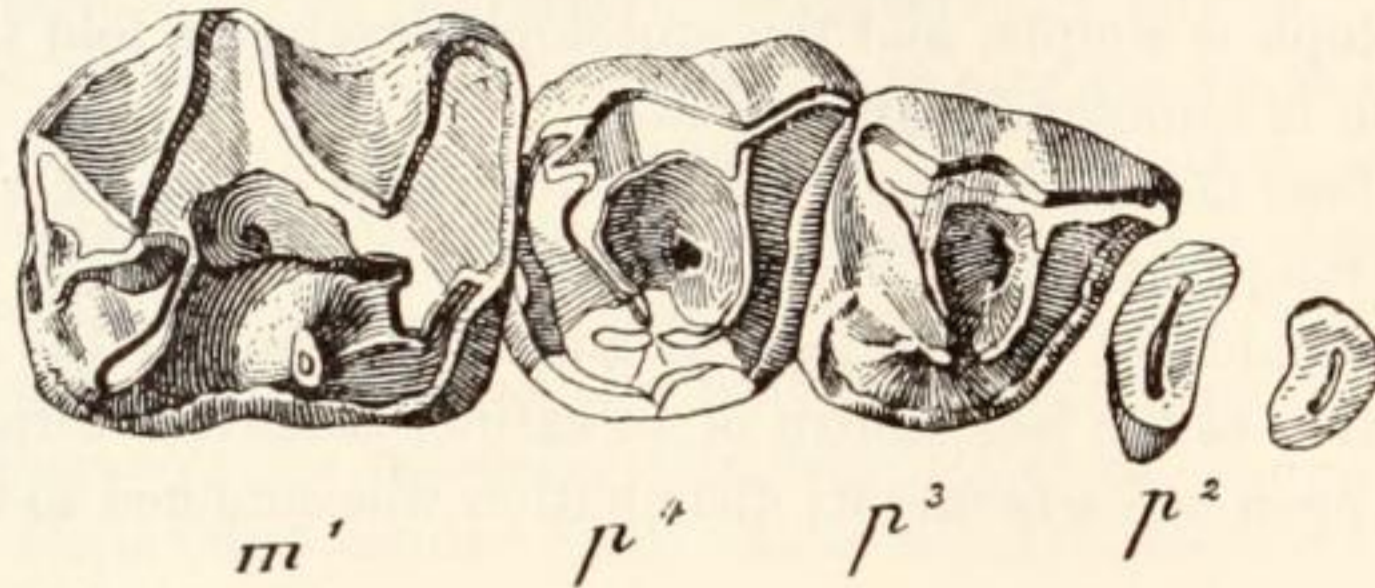

FIGURE 18. — Superior premolars and first molar of *Chalicotherium elatum* × ⅔.

The available figures and descriptions are so imperfect that the relationships of this species to those of the Old World cannot be definitely made out. It is, however, decidedly smaller than that which occurs at Pikermi (*Ancylotherium*).
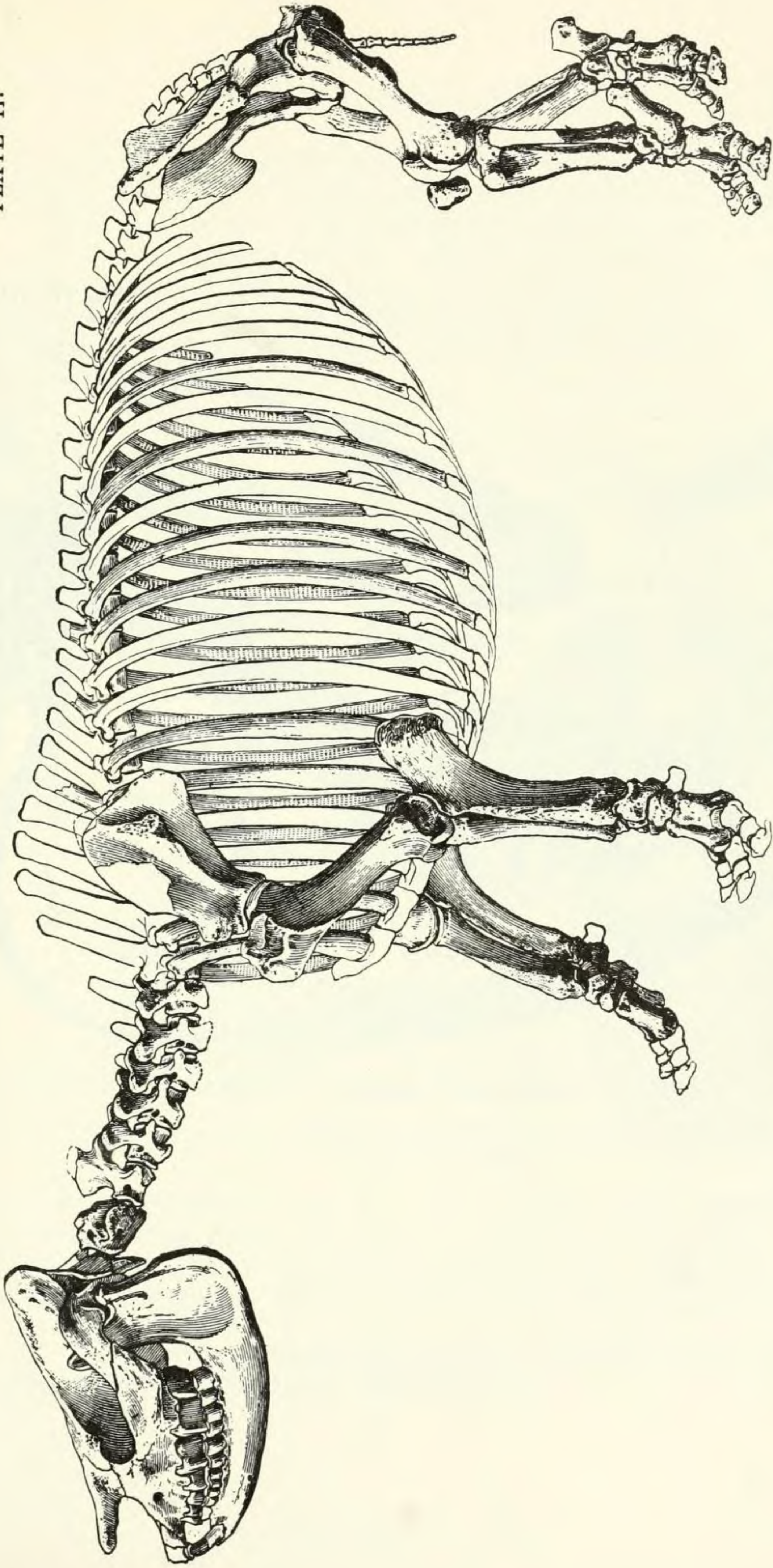
MEASUREMENTS.

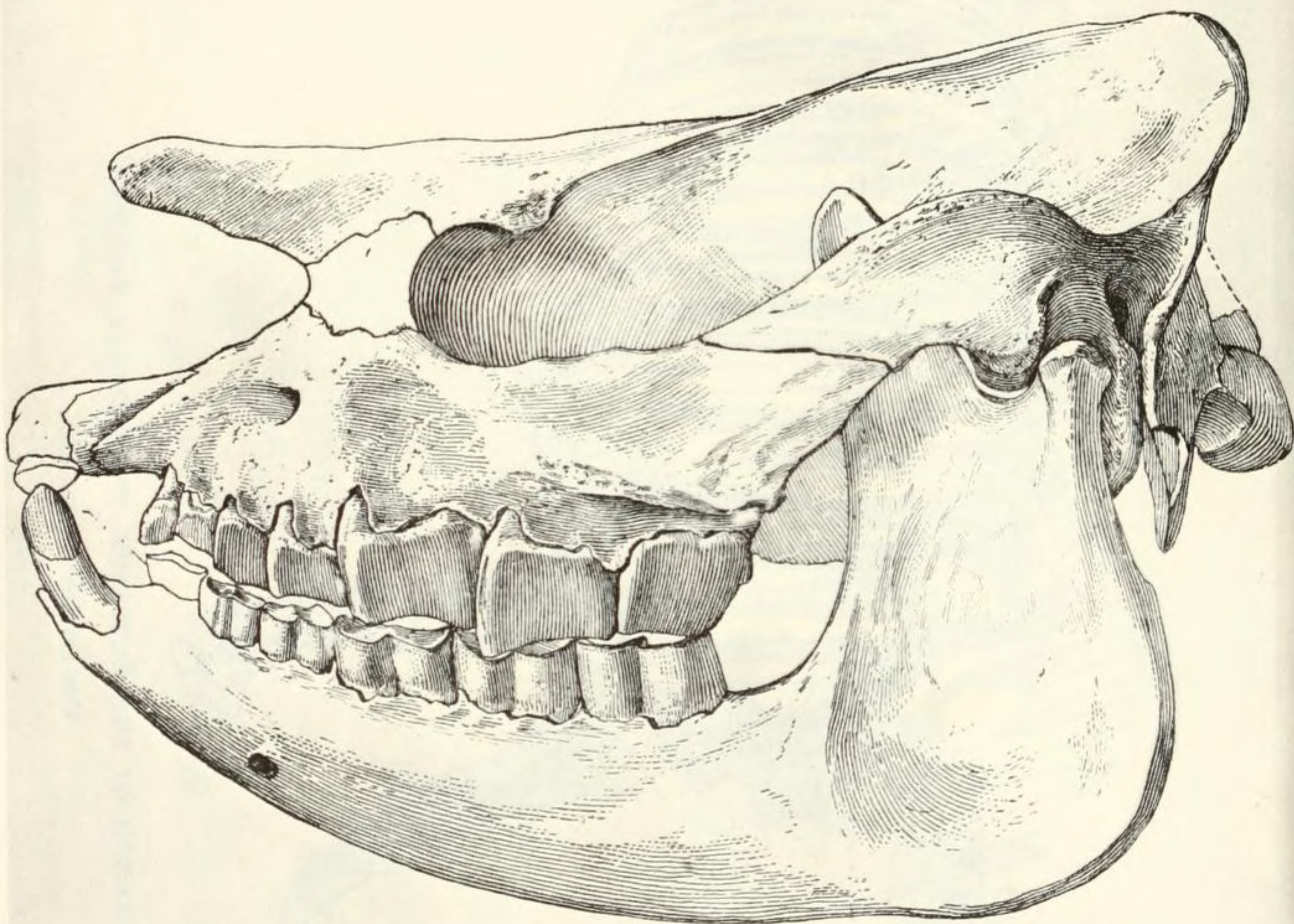|	m.		m.
Third premolar, antero-posterior diameter,	.024 ; transverse,		.025.
Fourth " " "	.025 ; "		.028.
First molar, " "	.036 ; "		.033.

PLATE I.
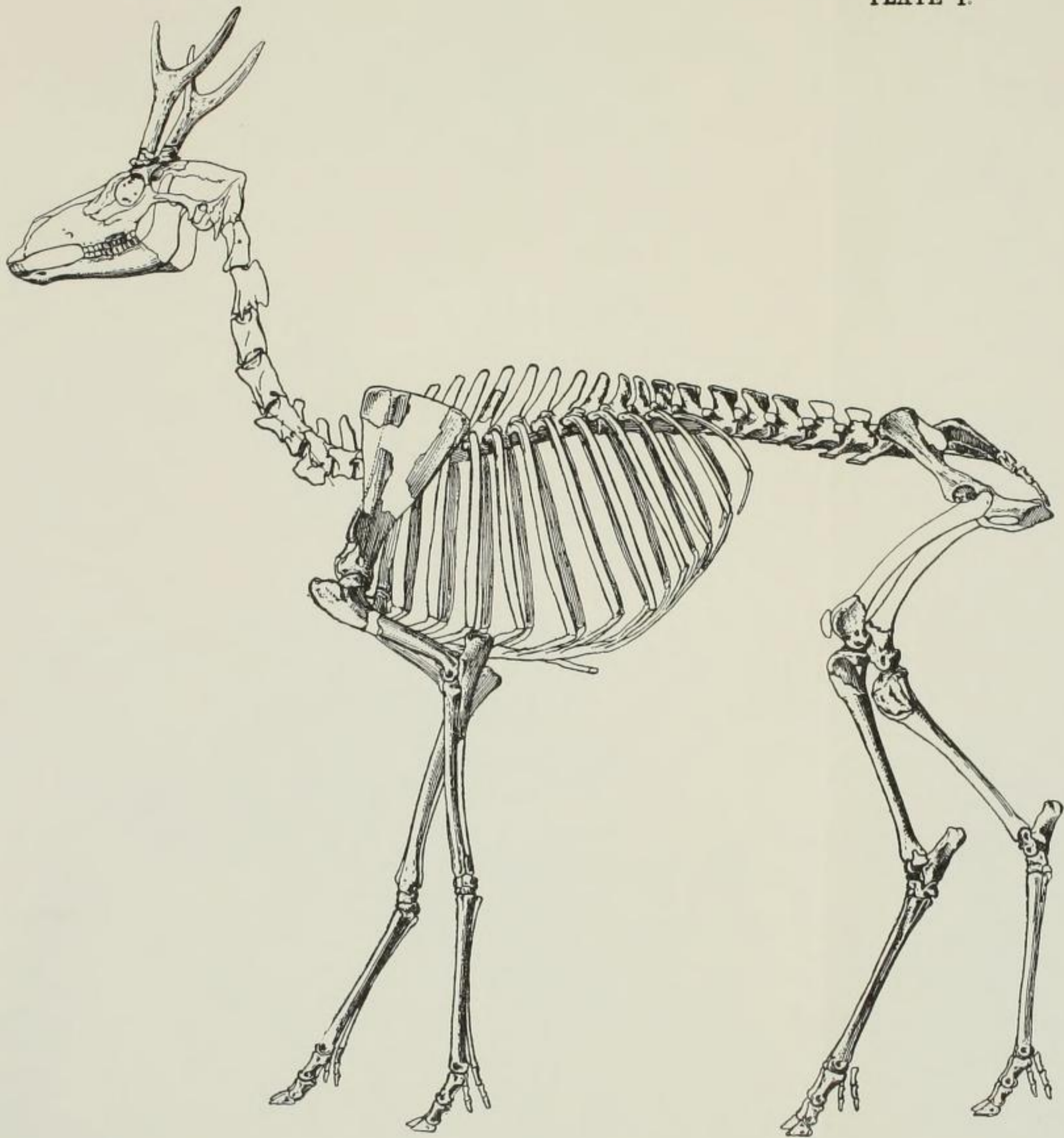
RESTORATION OF THE SKELETON OF COSORYX FURCATUS.

One sixth natural size.

PLATE II.

RESTORATION OF THE SKELETON OF APHELOPS FOSSIGER.

One twelfth natural size.

PLATE III.

SKULL OF APHELOPS FOSSIGER.

One sixth natural size.