MEMOIRS

OF THE

CARNEGIE MUSEUM.

VOL. IV. NO. 3.

A REVISION OF THE ENTELODONTIDÆ.[1]

By O. A. Peterson.

Introductory Remarks.

Since A. Aymard (**1**, pp. 227–242)[2] and S. A. Pomel (**73**, p. 307; **74**, p. 1083) described the genus *Entelodon* from the Tertiary deposits of France, much material has been found, which represents this unique family of mammals, especially in the Oligocene and Miocene formations of the North American Tertiary. The object of the present Memoir is first to give a systematic review of the known genera and species of this family; and secondly to describe and illustrate in detail the type specimen of *Dinohyus hollandi*, which was discovered in the Agate Spring Fossil Quarries, Sioux County, Nebraska, by the Carnegie Museum Expedition of 1905, and briefly described in Science (**78**, pp. 211–212) and the Annals of the Carnegie Museum (**81**, pp. 49–51).

At the very outset of his work the writer became fully aware of the fact that generic and specific determinations in this family have sometimes been based on rather inadequate types, which present few and unsatisfactory characters. Frag-

[1] Pomel's description (73, 74) of *Elotherium* did probably appear before that of Aymard on *Entelodon*, but, inasmuch as the type of the former was rather inadequate, no illustrations were published, and the type has been since lost (see page 43), the present writer is of the opinion that the latter name should be used, as both text and figures are clear.

[2] For the references in parentheses, see the Bibliography appended.

(Published May, 1909.)

mentary types, which very often are most exasperating to the student of paleontology, cannot be regarded as finally determining genera and species, and in the present case we must still await the slow process of discovery before a number of questions can be satisfactorily determined. The paper here presented can only claim to be a report of progress upon our knowledge of this most interesting family, which must be regarded as very distantly related to the *Suidæ*.

The types of the different genera and species of the family, though sometimes very fragmentary, clearly indicate diverging lines. These lines do not possess the radical variability met with for instance in the Merycoidodonts (Oreodonts) and the *Cameloidea*, but they are nevertheless of importance, when the conservative characters of the family as a whole throughout the lower Oligocene are considered.

This paper has been considerably delayed by the fact that the writer in the early part of the year 1908 was suddenly detailed to take charge of the field-work in the Agate Spring Fossil Quarries. The labors in these quarries were rewarded with unusually good success, as has been the case every season since they were first opened by the Carnegie Museum. Among other important material were found a number of portions of individuals of the genus *Dinohyus* which are of great value, as they help to clear up certain anatomical features of that genus which otherwise would have been left in obscurity in the present publication.

For the privilege of study and for aid otherwise given me, I am indebted to Dr. W. J. Holland, Director of the Carnegie Museum, at whose request the present work was undertaken. To Professors Osborn, Scott, Schuchert, and Lull I am indebted for free access to the splendid material of the American Museum of Natural History, the Princeton Museum, and the collection of the late Professor Marsh of Yale. To Dr. W. D. Matthew of the American Museum, Dr. Witmer Stone of the Academy of Natural Sciences, Philadelphia, Mr. J. W. Gidley of the National Museum, Dr. M. S. Farr of Princeton University, Professor John C. Merriam, and Mr. E. L. Furlong of the California University, and Miss Lucy P. Bush recently of Yale Museum, I here wish to extend my thanks and appreciation for important letters and information.

The excellent series of illustrations in the present paper are mainly due to the skilful work of Mr. Sydney Prentice. These illustrations explain many features which, without them, would be quite unintelligible. Most of the photographs except when otherwise stated, were made by Mr. Arthur S. Coggeshall.

Last, but not least, hearty acknowledgment should be expressed to Mr. Andrew Carnegie, the founder of the Institute, whose well-known generosity has made it possible to carry on the work done both in the field and the laboratory.

FAMILY ENTELODONTIDÆ LYDEKKER.[3]

The characters of this group of mammals from the Oligocene and Miocene formations of both the Old and New Worlds amply justified Lydekker (**53b**), Marsh (**64,** p. 408), and Scott (**87,** p. 322) in placing them in a separate family. The combination of the primitive bunodont dental structure with the highly modified limbs and feet gives to this group an unusual and quite unique appearance.

Family Characters: Teeth bunodont. Muzzle long; cranium short. Limbs elongated; feet didactyl.

GENUS ENTELODON Aymard.

There has been much confusion both in Europe and America regarding the priority of the names *Entelodon* Aymard and *Elotherium* Pomel. Quite recently Miss Lucy P. Bush, who was one of Professor Marsh's assistants, wrote an article (**4,** pp. 97–98) which stimulated inquiry as to these two names. After carefully looking over the literature, it is quite plain that Aymard's paper on *Entelodon*, though perhaps written in 1846, was not published until late in 1847 or during the year 1848. The most conclusive evidence of this fact is found on page 247 of Vol. XII, of the Annales de la Société d'Agriculture, des Sciences, et de Commerce du Puy for 1842–1846, or on p. 23 in the reprint of this article. On these pages of Aymard's paper is a foot-note correctly referring to page 385 of the Bulletin de la Société Geologique de France, Vol. IV, which was published late in 1847; consequently Aymard's paper could not have been published in 1846. Pomel's description of *Elotherium* on the other hand was apparently published in 1847; but, in the first place, the type was rather inadequate, judging from Pomel's article; secondly, there is not in Pomel's paper, or elsewhere, any illustration of the specimen; and, thirdly, I am informed that the type is lost.[4] These facts collectively should, in the mind of the writer, exclude the use of the name "*Elotherium*" especially since Aymard's article on *Entelodon* is accompanied with good illustrations of satisfactory types. There was apparently not a great lapse of time between the appearance of the two publications, and it may yet possibly be established that Pomel's description was also delayed and not published before Aymard's paper actually appeared.

Principal Generic Characters of Entelodon: Upper and lower premolars relatively

[3] The family name *Entelodontidæ* was apparently first used by Lydekker in 1883 (53b, p. 146), while Edward Richard Alston in the Zoölogical Record for 1876, p. 18, refers to *Parahyus vagans*, *Helohyus*, and "*Elotherium*" under the caption *Elotheriidæ*, without any further note or comment.

[4] Inquiries made by Dr. W. J. Holland while recently in France reveal the fact that the type of *Elotherium* is lost. Professor Marcellin Boule, in a letter to Director Holland, states that he is under the impression that no one, except Pomel himself, ever saw the type. In this connection it is quite significant that in the Catalogue of Vertebrate Fossils in the British Museum, which acquired Pomel's collection, no mention is made of the type of *Elotherium*.

large; posterior portion of the crown of $P^{\underline{3}}$ porportionally heavier than in *Archæotherium*; the crown of $P^{\underline{4}}$ with antero-internal angle of comparatively greater development, which gives the outline of the tooth a more nearly square appearance

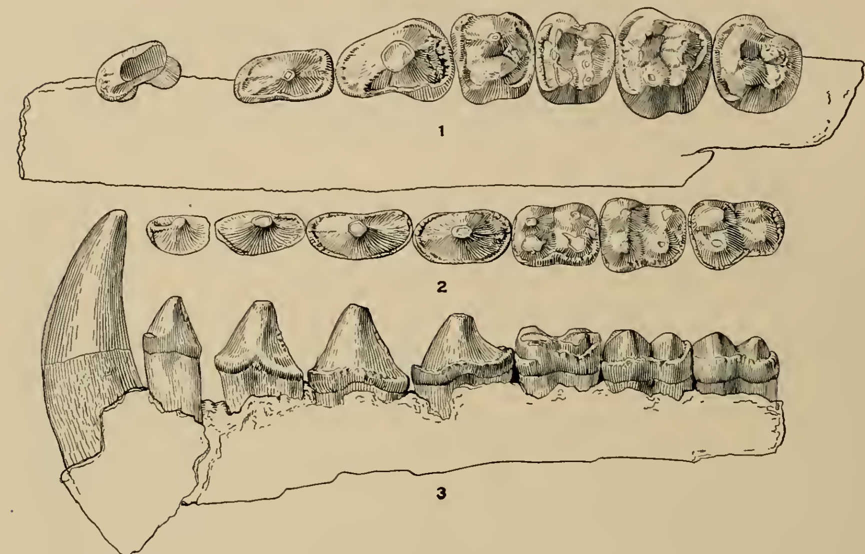

FIG. 1. Type Specimen of *Entelodon magnum* Aymard. ½ nat. size. (1) Crown View of Upper Dentition. (2) Crown View of Lower Dentition. (3) External View of Lower Dentition. (Drawn by Sidney Prentice from Casts of the Original, compared with the Figures given by Kowalevsky.)

than in the American form; para- and metaconids completely united showing no evidence of separations as in young and unworn teeth of *Archæotherium*. The general appearance of the dentition of *Entelodon magnum* seems to point toward a more specialized type, which either represents a later or a more advanced form, so far as the dentition is concerned, than *Archæotherium* from the lower Oligocene of America. Occipital condyle of proportionally great vertical diameter; supra-occipital greatly expanded superiorly and much contracted immediately above the condyles; paroccipital process far in advance of the condyles, relatively compressed antero-posteriorly, and expanded transversely; no evidence of the external auditory meatus immediately in front of the paroccipital process as in *Archæotherium*.

If Kowalevsky's observations[5] regarding the union of the foramen ovale and lacerum medius, as in the recent *Suidæ*, is correct, this is of considerable importance,

[5] Professor Scott (87, p. 284) seems inclined to doubt Kowalevsky's statement that "foramen ovale . . . mit dem foramen lacerum medium versmolzen war, wie bei den heutigen Suidæ und bei Hippopotamus."

since all the known American forms have the foramen ovale separate. In the European genus the manus is relatively low and broad; the magnum and unciform articulate by facets at the dorsal borders; the fibula is free; and the tarsus is low and broad.

Entelodon magnum Aymard.

Type: Fragments of skull, lower jaws, vertebræ, and femur.

Horizon: Oligocene of Ronzon, near Puy-en-Velay, Department of Haute-Loire, Southern France.

Location of Type: Museum National d'Histoire Naturelle, Paris, France.

Two or more specimens were used by Aymard in his original description (**1**, pp. 227–242), and Entelodon is characterized by him as follows:

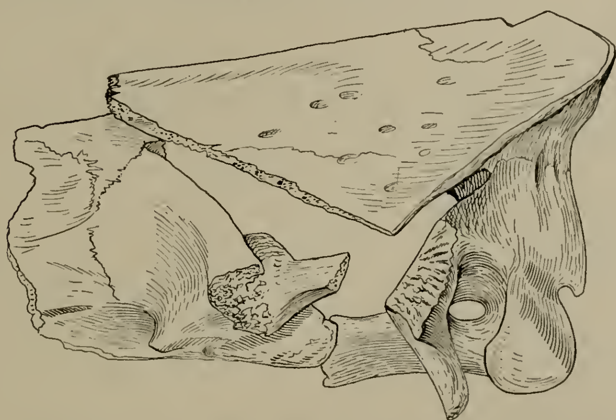

FIG. 2. Lateral View of Skull of *Entelodon magnum* Aymard. ½ nat. size. (After Kowalevsky.)

"Le système dentaire ordonné comme il suit: $\frac{3+1+7}{3+1+7}$ dont $\frac{3+1+3}{3+1+3}$.

"Toutes les dents plus ou moins marquées de fortes stries ou dentelures aux arêtes longitudinales; à collet cernant en partie la base de toutes les molaires inférieures, entourant également en partie les trois premières supérieures, très développé au côté antérieur et au côté postérieur de la molaire principale et des trois arrière-molairs d'en-haut.

"Les incisives d'en-bas subtriangulaires, peu déclives, subterminales, contiguës entre elles et à la canine, et augmentant, en grandeur, de la première a la troisième; les supérieures en cône subtriangulaire, assez épais avec un collet au bord interne.

"Les canines, peu arquées, se déversant peu en dehors; la supérieure moins forte que l'inférieure.

"Les trois avant-molaires, en haut et en bas, coniques, déprimées, portées sur deux racines d'autant plus serées que le dent est plus rapprochée de la canine. La première inférieure à peu pres uniradiculée ; la première supérieure se détachant des suivantes par une petite barre ; la troisième étroite [surtout celle d'en haut] relativement à son analogue des genres voisins, et s'élevant fort au-dessus de la série.

Fig. 3. Posterior View of Skull of *Entelodon magnum* Aymard. ½ nat. size. (Drawn by Sidney Prentice after the Figure given by Kowalevsky.)

"La molaire principale inférieure à couronne conique, simple, élargie en arrière. Celle d'en-haut formant une colline transverse à deux pointes, l'interne assez forte.

"Les trois dernières mâchelières divisées en deux collines transverses, chaque colline ayant trois pointes mousses à la mâchoire d'en-haut et deux à celle d'en-bas. Les supérieures de figure trapézoïde, la pénultième plus forte que la dernière. Celles d'en-bas plus longues que larges ; la dernière dépourvue de talon ou troisième colline.

"La première dentition de la mâchoire inférieure ainsi composée : trois incisives ayant même disposition qu'à la mandibule d'adulte, et à peu près même structure, sauf une épaisseur moins forte de la couronne ; une canine de même forme que les incisives, mais plus haute et plus pointue ; quatre molaires, la première uniradiculée, la seconde à deux racines, la troisième remarquable par la simplicité de sa couronne unicuspidée, et la dernière à trois paires de cônes mousses.

" Le système digital probablement paridigité.

Entelodon ronzonii Aymard.

Type: Isolated teeth.

Horizon: Oligocene of Ronzon, Department of Haut-Loire, Southern France.

Location of Type: Museum National d'Histoire Naturelle, Paris, France.

Aymard established this species on isolated teeth. His description is based principally on the smaller size of the teeth, a lower crown, and greater width posteriorly of M_3, than in his *Entelodon magnum*. Aymard's original description (**1**, p. 22) in full is as follows:

" Nous avons recueilli des dents isolées qui sembleraient indiquer une espèce d'entélodon plus petite que la précédente. Une troisième molaire inférieure, très bien conservée, présente, outre le collet et les arêtes dentelées caractéristiques du genre, une hauteur proportionnellement moindre de la couronne, et une plus grande largeur en arrière. Elle a, de plus, en avant et en arrière, des plis d'émail et des rugosités distinctifs. Si des découvertes ultérieures de pièces dentaires plus complètes venaient confirmir la valeur de ces caractères, on pourrait imposer à cette nouvelle espèce l'appellation d'*entelodon Ronzonii*, de la colline où sont enfouies ses dépouilles."

Genus ARCHÆOTHERIUM Leidy.

In 1850 Dr. Leidy published a description of the first American forms of the family *Entelodontidæ* under the name *Archæotherium mortoni* (**40**, pp. 93–94). Material of this genus which was subsequently collected from time to time by the early expeditions to the bad-lands of South Dakota and Nebraska was submitted to Dr. Leidy for study and was published by him in different publications under the generic names *Arctodon* (**41**, p. 278), *Entelodon* (**45**, p. 392), and *Archæotherium*. In 1857 (**48**, p. 175) Leidy recognized Pomel's name *Elotherium*, which he continued to use for the American forms in different publications, including his work "The Extinct Mammalian Fauna of Dakota and Nebraska." On Plate IX, figs. 3 and 4, in "The Ancient Fauna of Nebraska" are illustrations representing a fragment of a skull which agrees quite perfectly with Leidy's original description (**40**, pp. 92–93) and is undoubtedly that of the type. Other specimens figured and determined by Leidy as *Archæotherium mortoni* agree with a number of skulls, portions of skulls, and teeth in the Carnegie Museum, which were collected by the writer and others in the *Titanotherium* beds of the same general locality (Nebraska and South Dakota). The Oligocene of North America has yielded much material representing this genus, which is now scattered through the museums of America and Europe.

Principal Generic Characters of Archæotherium: $P^{\underline{4}}$ of relatively small size, with small internal tubercle; the crown triangular in outline; $P^{\underline{1}}$, $^{\underline{2}}$, $^{\underline{3}}$ separated by diastemata; lower molars with the anterior much higher than the posterior tubercles and separated by broad cross-valleys; $P_{\overline{1}}$ separated from canine and $P_{\overline{2}}$ by diastemata; occipital condyles of proportionally small vertical diameter and no accessory facets on the basioccipital; foramen ovale separated from foramen lacerum; dependent processes on the jugal and the inferior border of the mandible; long alveolar border of the premaxillary and a long chin; limbs and feet proportionally long and slender; trapezium present; magnum and unciform articulating slightly with one another at the dorsal border; fibula free.

Archæotherium mortoni Leidy.

Type: A fragment of a skull with $P^{\underline{3}}$ and $P^{\underline{4}}$ in place, and the alveolus for $M^{\underline{1}}$.
Horizon: Oligocene (Titanotherium beds).

Locality: White River, South Dakota?

Locality of Type: Academy of Natural Science, Philadelphia.[6]

Principal characters of Archæotherium mortoni: The first and second incisors of this species are relatively large. The whole series is well spaced in both upper and lower jaws, which is due to the proportionally long alveolar border of the pre-

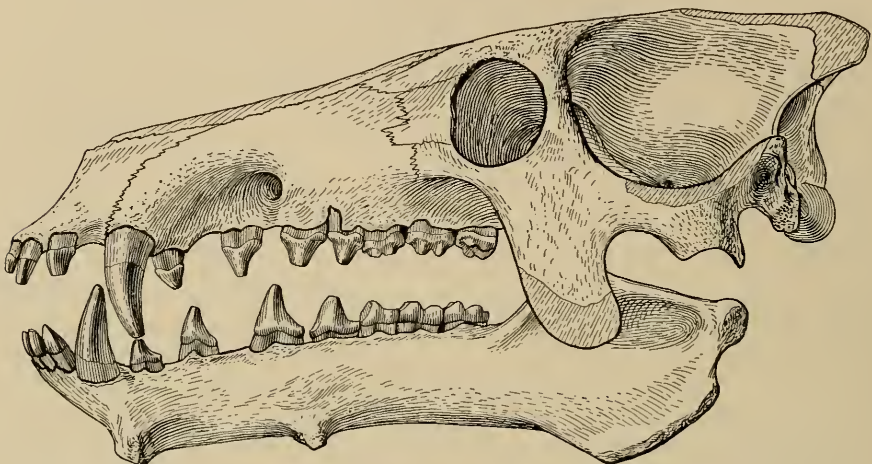

Fig. 4. Side View of Skull of *Archæotherium mortoni* Leidy. (Carn. Mus. Cat. Vert. Foss. Skull No. 1900, Lower Jaw No. 2097.) ½ nat. size.

maxillary and the long chin of the lower jaw. The canines are long and pointed, the premolars are compressed transversely and have comparatively high and pointed crowns. $M^{\underline{3}}$ has small posterior tubercles. The lower molars have proportionally higher and more developed proto- and metaconids, low and little developed hypo- and entoconids and broad cross-valleys. The posterior process of the jugal is com-

Fig. 5. Crown View of Left Inferior Dentition of *A. mortoni* Leidy. (Carn. Mus. Cat. Vert. Foss. No. 2097.) ½ nat. size.

paratively lightly developed and does not form a buttress on the anterior margin of the glenoid cavity, as in some of the later genera. The anterior protuberances of the inferior margin of the lower jaws are slightly more developed than those further back. The skull represents a comparatively small-sized animal. A specimen,

[6] The specimen at this writing has no catalog number.

fragments of skull and lower jaws (No. 2011, Carnegie Museum Cat. Foss. Vert.), was collected in the Oreodon beds near Dickinson in the Little Bad-lands of North Dakota by Earl Douglass. This has the entoconid of M_3 well represented, the anterior tubercles of the lower molars very high, as in *A. coarctatum*, the premolars rather small, but P_3 separated from P_4 by a diastema as in *A. mortoni*. The upper molars are relatively longer and narrower than those in the typical specimens of *A.*

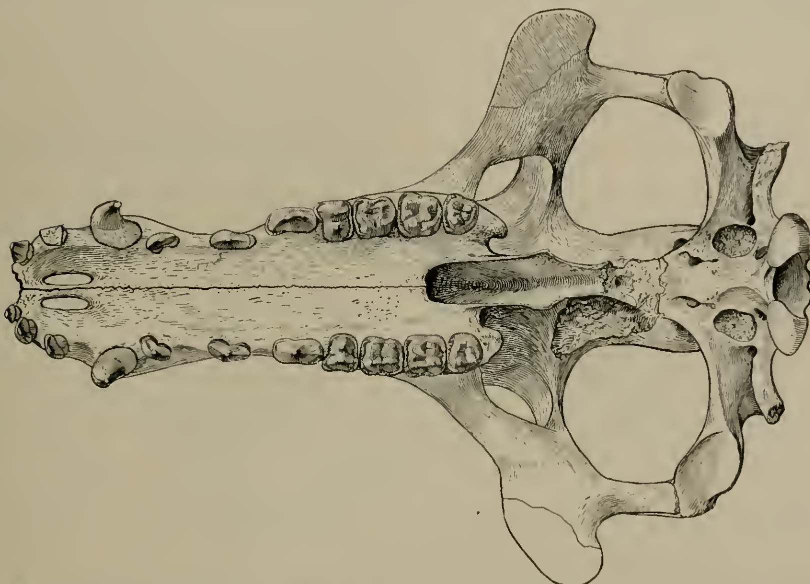

FIG. 6. Palatal View of Cranium of *Archæotherium mortoni* Leidy. ½ nat. size. (Carn. Mus. Cat. Vert. Foss. No. 1900.) The oblong area in front of the condyle represents the broken tympanic bullæ.

mortoni. This would seem to indicate that there is a considerable range of individual variation in the species *A. mortoni*.

Archæotherium mortoni subsp. **clavum** (Marsh).

Type: Skull.

Horizon: Lower Oligocene (Titanotherium beds).

Locality: Bad-lands of South Dakota.

Locality of Type: In Collection of Yale Museum, No. 2035.

The type of this subspecies is the skull of an animal the size of *Archæotherium mortoni*, and the characters which Professor Marsh has given do not clearly distinguish it from the latter species. Marsh states that the skull agrees in many respects with that of *A. crassum*, but is smaller, "the malar process is quite slender and tapering below [and] extending downward. . . . The dentition agrees in the main with that of *E.* [*A.*] *crassum*, the last lower molar in each having four cones only, and no heel." The malar arch and the dependent angle of the lower jaw, which Professor Marsh states, "will distinguish it from *A. mortoni*," are found to be present and more or less developed in all the specimens of this family found in America with these parts preserved.

In my notes on the type of *Archæotherium clavum* taken in the Yale Museum I find the following statements, which tend to show that Marsh's species should at least be given a subspecific rank:

"The general contour of the skull is much the same as that of *A. crassum*, the occiput is not overhanging, the anterior border of the orbit is opposite the middle portion of M^2, the antorbital foramen is large and placed over P^3. Premaxillaries produced forward giving plenty of room for the incisors, which are separated by

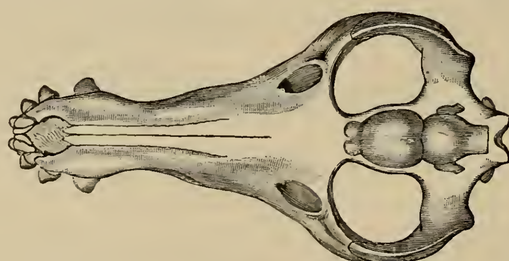

FIG. 7. Skull of *Archæotherium clavum* Marsh. About ½ nat. size. (After Marsh.)

diastemata except I^1 and I^2. The latter are, however, well separated at the apices. The orbit is placed slightly higher than in *A. crassum*. The dependent broad process of the jugal is not large, and, as Marsh stated, points directly downward and also slightly outward. The zygomatic process perhaps did not reach to the anterior border of the glenoid cavity. The condyles are well separated superiorly and inferiorly and the paroccipital process is rather short and truncated. The foramen magnum is large and subtriangular in outline. The chin has a considerable slope and is quite convex from side to side. The anterior knob-like protuberances are not large and are placed well back as in some species from the John Day formation. The posterior protuberance has the same relative size as in *A. crassum*. The anterior mental foramen is rather small and is placed low down on the mandible, opposite the anterior face of P_1. The posterior mental foramen is higher up upon the mandible and is opposite the posterior face of P_2.

"I^{1} relatively large, upper canines much elongated and pointed, M^{1} with well developed cingulum externally, M^{2} with cingulum faintly developed externally, and M^{3} with cingulum developed only on the antero-external angle. Lower canine rather short, which may be due to the fact that the specimen pertains to a rather young, though adult individual. Lower premolars high and sharply pointed; molars with high anterior tubercles. M_{3} with an unusually prominent posterior basal heel.[7] Cingulum only fairly indicated on the external faces of the inferior molars."

Archæotherium crassum (Marsh).

Type: Fragments of a skeleton.

Locality: Eastern Colorado.

Horizon: Lower Oligocene (Titanotherium beds).

Locality of Type: In Collection of Yale Museum, No. 12020.

In 1873 Professor Marsh founded this species on fragments of a skeleton (**58a**, p. 487). It was apparently the first time that the characteristic dependent process of the jugal of the American forms of the *Entelodontidæ* had been observed, and Marsh compared this process with those on the zygomatic arch in some Edentates and Marsupials. Marsh also pointed out that the radius and ulna of this species were separated or very loosely united.[8] Some idea of the foot structure of this species was also derived from this specimen. In a later paper (**63**, p. 408) Marsh more fully describes the type, together with additional material collected in Colorado, South Dakota, and Nebraska. On Plate VIII of this publication Marsh figures the skull and feet, which he regards as belonging to *A. crassum*, and states that the dependent process of the jugal "extends downward to the inferior margin of the lower jaw in front of the angle. This is the case when these processes are somewhat expanded transversely, as shown in figures 2 and 3, which represent the skull as it lay in the matrix" (see fig. 8). Marsh also calls attention to the small brains, the structure of the feet, and to the protuberances on the inferior border of the lower jaw, of which the anterior pair is slightly the heavier. In 1894 Marsh published the restoration of *A. crassum* (**64**, pp. 407–408, Pl. IX) and finally in 1897 published the same restoration (**65**, Pl. XXX) with the legend *Entelodon crassus*. In the text of the same volume, pp. 522–523, Marsh also referred to *Archæotherium* as *Entelodon*.[9] Through the courtesy of Professors Schuchert and Lull of Yale University the pres-

[7] The posterior position of the chin-process, the high anterior tubercles of the lower molars, and the prominent basal heel of M_{3} are among the more important characters of this subspecies.

[8] This is probably true of nearly all the species from the lower beds.

[9] This indicates that Marsh had already obtained some information which led to Miss Lucy P. Bush's publication of a later date in the American Journal of Science (Series IV, Vol. XVI, pp. 97–98, 1903).

ent writer was recently able to carefully study the type and the other material referred to *A. crassum* by Marsh. My observations are of some interest in this connection, as they serve to further characterize this species. I at once detected that the premaxillaries are long, as is usual in the species from the lower Oligocene, the preorbital foramen is above P – and is of large size, the orbit is rather low, and has the anterior border opposite the posterior part of $M^{\underline{2}}$. The downward projecting process of the jugal is directed rather more forward than backward and terminates in an enlarged and somewhat oval free end; the zygomatic process does not quite reach the anterior border of the glenoid cavity. $P_{\overline{3}}$ has a characteristically limited antero-posterior diameter. $P_{\overline{1}}$ and $P_{\overline{2}}$ are abruptly reduced as in *A. coarctatum* Cope, and the anterior tubercles of the molars are quite high, as in that species. The superior molars are yet buried in the matrix, so that nothing more can be said regarding their characters, than that they have apparently anterior and posterior cingula, as usual, but are externally almost smooth.

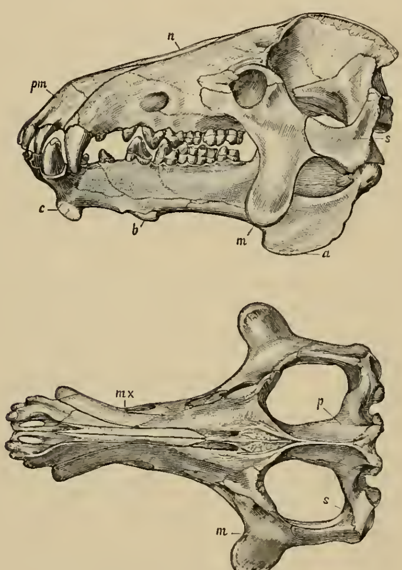

FIG. 8. Side and Upper View of Skull of *Archæotherium crassum* Marsh. ⅙ nat. size. (After Marsh.)

There are only a few fragments of vertebræ with the type. Portions of left arches of two dorsal vertebræ show perforations of large foramina at the base of, and immediately posterior to, the transverse processes, but in neither of the two arches are there any indications of vertical canals as in *Dinohyus*.

The limbs of the type specimen are very fragmentary; there is no scapula. The great trochanter of the humerus is very prominent and terminates superiorly above the head in an enlarged and truncated end, directed backward and with the process of the lesser tuberosity nearly enclosing the bicipital groove. The intertrochlear ridge is prominent and the external condyle is narrow. The internal epicondyle is relatively prominent. The calcaneal facet of the cuboid is broader than that for the astragalus. Mt. IV is complete and measures 155 mm in length. Mt. V was of relatively large size, judging from the facet for it on Mt. IV. The metapodial as a whole is rather delicate and the cross-section of the upper half of the shaft has a square appearance.

In the Carnegie Museum is a good portion of a skeleton with the vertebral column well represented, but without the skull or jaws (No. 1665, Carn. Mus. Cat. Vert. Foss.), collected by the writer in the *Titanotherium* beds on Sand Creek, Sioux County, Nebraska. This specimen has the sides of the walls of the neural arches perforated in a manner similar to that of the type of *A. crassum*. The specimen pertained to a somewhat larger individual than the type in the Yale Museum, but it is here referred to *Archæotherium crassum*. A skull and four cervical vertebræ (Carn. Mus. Cat. Vert. Foss. No. 142) which are referred to *A. crassum*, were collected by Mr. J. B. Hatcher in 1900, near the base of the Titanotherium beds on Lance Creek, Converse County, Wyoming. The skull of this specimen is much depressed by crushing, but is of interest because it supplies characters which show a considerable range of individual variation in this species. While the skull is of about the same proportionate size as that of *A. crassum* in the Yale Museum, it is seen that the dependent process of the jugal is of much smaller size and shorter, the superior border of the orbit is higher[10] or more nearly even with the transverse face of the frontals, the antorbital foramen is slightly further forward, and the cingula of the teeth are more strongly developed than in the specimen in the Yale Museum.

Archæotherium ingens (Leidy).

Types: Symphysis of lower jaws without teeth, the crown of an inferior molar, and several mutilated canine teeth.

Horizon: Oligocene (Upper Titanotherium beds?).

Locality: Nebraska (White River?).

Locality of Types: Unknown to the writer.[11]

The figures 8–11, which Professor Leidy gives on Pl. XXVII in "The Extinct Mammalian Fauna of Dakota and Nebraska," seem to agree with his original description of "*Entelodon ingens*" (**47**, pp. 164–165) and are undoubtedly to be regarded as the types of that species, although Leidy does not make this clear. The species was originally separated wholly on account of its greater size. On pages 192–194 (Ext. Mam. Fauna) Leidy gives a list with measurements of specimens, which he regarded as pertaining to *A. ingens*, but with no adequate description. To Professor W. B. Scott of Princeton University we are indebted for an admirable Memoir (**87**, pp. 273–324), the descriptions in which are based on a very nearly complete skeleton (Princeton Museum Collection No. 10885) collected in the upper Titanotherium beds of South Dakota by the late Mr. J. B. Hatcher and regarded by

[10] Even when the crushing of the skull is taken into proper consideration this character is especially noticeable.

[11] In the Proc. Acad. Nat. Sci. Philad., Vol. VIII, p. 165, 1856, Professor Leidy states that the specimens were collected by Dr. Hayden for the St. Louis Academy of Sciences.

Scott as "*Elotherium ingens.*" Scott states (**87**, p. 274) that the upper incisors "increase regularly in size from the first to the third, the latter being much the largest of the series; it has a conical or somewhat trihedral crown and resembles a canine

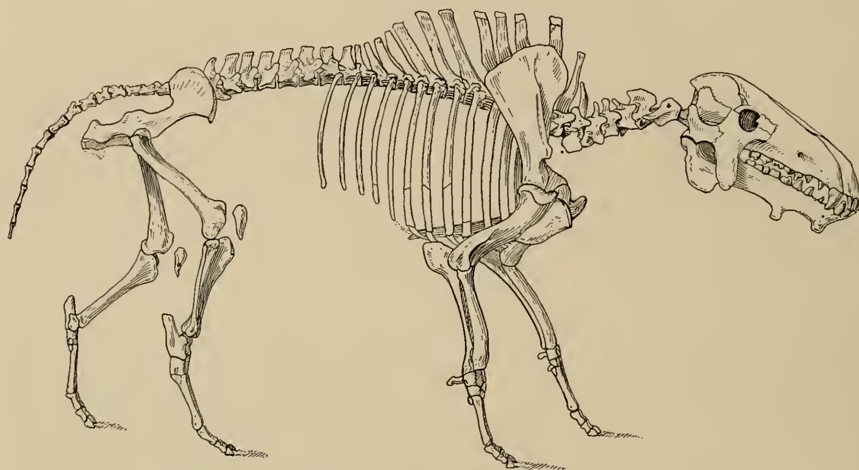

FIG. 9. Restoration of Skeleton of *A. ingens* Leidy. About $\frac{1}{18}$ nat. size. (After Scott.)

in shape and appearance. . . . The other incisors have spatulate crowns, with blunted tips, the attrition of use wearing down the apices as well as the posterior faces of these teeth. This description applies more particularly to the larger White River species, such as *E. ingens* and *E. imperator*; in *E. mortoni* the upper incisors are of more nearly equal size and more conical shape." In speaking of the upper premolars the same author states (*l. c.*, p. 275): "In the smaller species of the genus such as *E. mortoni*, $P\frac{3}{}$ and $P\frac{4}{}$ are placed close together, while in the larger forms these teeth are separated by a short space and the diastemata between the other premolars and between $P\frac{1}{}$ and the canine are relatively somewhat greater, the enlargement of these teeth hardly keeping pace with the elongation of the muzzle." The general contour of the skull in *E. ingens* is somewhat different from other species especially those from the lower beds. Thus, Scott (*l. c.*, p. 280) states: "In most American species the forehead rises very gradually and gently behind to the sagittal crest, but in *E. ingens* the rise is much more sudden and steep." The dependent process of the jugal "descends from beneath the orbit downward and outward to below the level of the ventral border of the mandible [and] forms a club-like thickening at the tip, which . . . is coarsely crenulate on the posterior border. . . . In *E. ingens*, from the Titanotherium beds, these openings [supraorbital foramina] are of good size, are placed quite near to the median line, and have well-marked vascular channels running forward from them." On the ventral border of the mandible the knob-like processes are well developed. In the type represented in Fig. 10, Pl. XXVII (Ext. Mam. Fauna of Dakota and Nebraska) these processes are shown to be of quite large size. In the dorsal vertebræ of the specimen, which Professor Scott referred to *E. ingens*, the canals perforating the walls of the neural arch for the spinal nerves are small and quite irregular in their position, indicating that they had a less important function than was the case in *Dinohyus* and *Sus*. The trapezium (tm. in fig. 10) is present in the manus of the splendidly preserved specimen in the Princeton Museum.

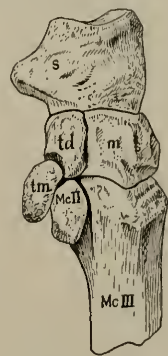

FIG. 10. Inside View of Carpus of *A. ingens* Leidy, showing Trapezium in Position. ½ nat. size. (Princeton Mus. Cat., No. 10885.)

Archæotherium coarctatum (Cope).

Type: A left mandibular ramus with molar-premolar series complete.

Horizon: Lower Oligocene, Titanotherium beds?

Locality: Cypress Hills, District of Assiniboia, Canada.

Locality of Type: Collection of the Geological Survey of Canada, Ottawa.[12]

The name *Entelodon mortoni* was used by Professor Cope in his first report of the presence of remains of the *Entelodontidæ* in Canada (**17a**, p. 163). Later he referred this material to "*Elotherium*" *coarctatum*, which again was changed by him in 1891 (**23**, p. 20) to "*Elotherium arctatum*." The type as figured on Plate XIV (**23**) clearly indicates this species as valid and the more important characters may be quoted from Professor Cope's description: "The species differs from *E. mortoni*, with which it agrees nearly in size, in having all the premolars in a series uninterrupted by diastemata except a very short one between Pm. III and IV [$P_{\overline{2}}$ and $P_{\overline{1}}$].[13a] The second premolar [$P_{\overline{3}}$] [13a] is the most elevated, and the third and fourth [$P_{\overline{2}}$ and $P_{\overline{1}}$][13a] are abruptly smaller. The fourth [$P_{\overline{1}}$] [13a] has one [13] compressed grooved root. . . . The posterior, or fifth tubercle is well developed, especially on the M. III [$M_{\overline{3}}$]." [13a] (See crown view in fig. 11.)

[12] Without catalog number.

[13] From the illustration it would appear that there were probably two roots on P_1, perhaps coalesced near the crown which is usual in many species from higher horizons.

[13a] The notation of the teeth enclosed in brackets [ ] is given by the writer, in order to facililate the understanding of Prof. Cope's description, in which he used the now obsolete method of numbering the teeth from the back of the jaw forward.

Professor Cope points out the "close-placed premolar teeth" and the elevation of the anterior tubercles[14] of the true molars as a more primitive character than is displayed by any of the American species so far known. To this may also be added the abrupt reduction of $P_{\overline{2}}$, which, though distinctly smaller than in *A. mortoni*, is, however, again repeated in *Dinohyus* from the Miocene. The latter has $P_{\overline{1}}$ and $P_{\overline{2}}$ of very nearly the same relative size as in *Archæotherium coarctatum*. The

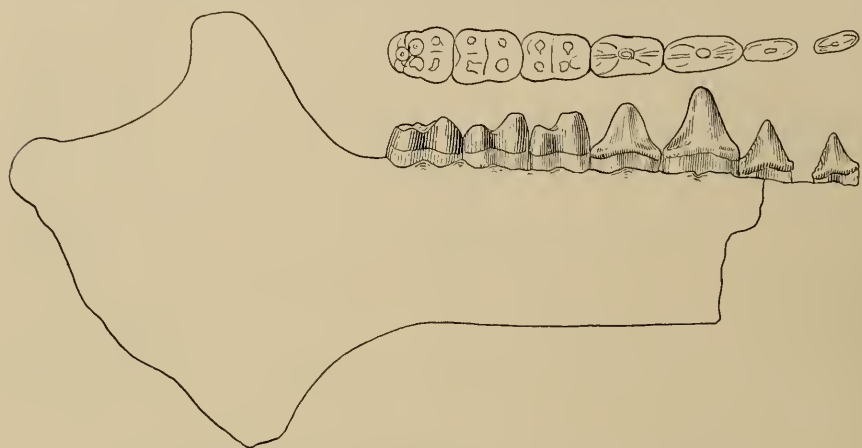

FIG. 11. Type of *Archæotherium coarctatum* Cope. About ½ nat. size. (After Cope.)

development of the posterior tubercles on $M_{\overline{3}}$ of the latter species seems to indicate a slight advance in modification toward the later forms, *Dinohyus* and *Ammodon*, while in the typical forms of *A. mortoni* these tubercles are less developed.

Subgenus PELONAX Cope.

Pelonax ramosum Cope.

Type: The greater part of a mandible.

Horizon: Upper Oligocene?

Locality: Eastern Colorado.

Locality of Type: The American Museum of Natural History. (Cope Collection, No. 6393.)

In the original description (**7**, p. 27) of the subgenus *Pelonax* Professor Cope enumerates strong specific characters, viz.: the "great size of the tubercles on the under side of the mandibular ramus, especially the anterior pair . . . the first and

[14] It should be carefully borne in mind that all the species known from the lower Oligocene beds have the anterior cusps of the molars higher in a greater or less degree.

second of the four premolars are separated by a diastema and have but a single[16] root . . . the tubercles of the molars are low . . . the last molar two-lobed and rather small," which should be regarded at least as of subgeneric value. Cope erected the genus *Pelonax* in 1874 (**6**, pp. 504–505) and said that it embraces species "nearly allied to *Elotherium*. It is more hippopotamoid than that genus [*Archæotherium*] in the possession of four[17] digits on all the feet and a rudimentary fifth on the pes." The statement regarding the digits of Cope's genus *Pelonax* is misleading,

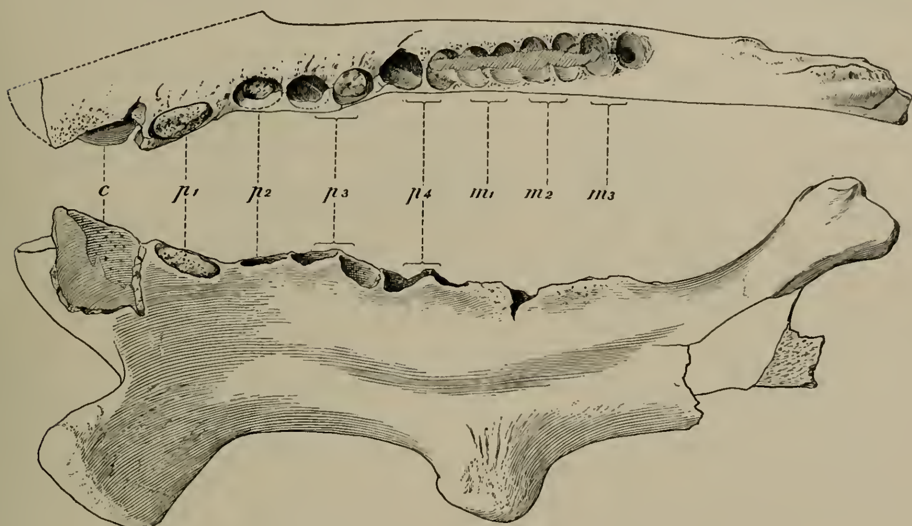

FIG. 12. Type of *Pelonax ramosum* Cope. Cope Collection, No. 6393. About ½ nat. size.

but the very large tuberosities on the chin and the single-rooted premolars, together with the characters enumerated above, are of considerable significance, and may be regarded as characterizing this subgenus. More material representing limbs and vertebræ associated with jaws and skulls from the type locality is of extreme importance in connection with the study of this subgenus.

Pelonax bathrodon (Marsh).

Type: $M_{\overline{3}}$ of right side.

Horizon: Upper Oligocene. Protoceras Sandstones?

[16] In a letter of reply from Dr. Matthew, of the American Museum of Natural History, New York, dated Feb. 26, 1908, I am assured that Cope's statement regarding the single-rooted premolars is correct.

[17] No true Entelodonts from the Oligocene of America or Europe have as yet been found with four digits on all the feet, as in hippopotamus.

Locality: Bad-lands of South Dakota.

Locality of Type: Collection of Yale Museum, No. 12030.

The tooth figured in 1893 by Professor Marsh (**63**, Pl. IX, fig. 4), and referred to the genus *Ammodon*, though inadequate as a type, fortunately shows characters which at once separate it from *Ammodon leidyanum*, not only specifically, but also generically (see fig. 13). In Marsh's original description in 1874 (**59**, p. 534), he gives the principal characters of $M_{\overline{3}}$ of his proposed species "*Elotherium*" *bathrodon*, which constitute the chief differences between that tooth of the latter species and the genus *Ammodon*. Marsh says: "This molar differs essentially from the same

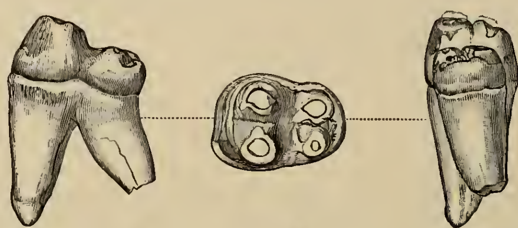

Fig. 13. Last Lower Molar of *P. bathrodon* Marsh. ½ nat. size. (After Marsh.)

tooth in the other known species of this genus [*Elotherium*], especially in having the anterior pair of tubercles much larger than the posterior pair, and elevated high above them."[18] On comparing Marsh's figures reproduced in this connection (fig. 13) it is at once seen that the tubercles are more distinctly separated by narrow longitudinal valleys, and that the cross-valley between the anterior and posterior tubercles is open and very broad, which is due to the small development of the posterior tubercles; a character common to the older American types of the family *Entelodontidæ*. In *Ammodon* and *Dinohyus* the development of the posterior tubercles (ento- and hypoconids) is relatively greater and the cross-valley is very much reduced in the antero-posterior direction. The distinct development of the fifth cone (hypoconid) in *Ammodon leidyanum* seems to have progressed in the same general ratio as that of the posterior tubercles.

In the Yale Museum is a specimen of an Entelodont, which was collected in 1890 by Mr. J. Brown and bears the catalogue number 10008. This specimen is a skull of a large individual apparently from the Protoceras sandstones of the Oligocene. The front and back of this skull is broken off so that its length cannot be ascertained. The size of the molars corresponds quite well with that of the tooth described by Marsh as the type of *Pelonax bathrodon*, and, from the fact that it was

[18] This elevated position of the anterior portion of the crown seems to be greater than in *Pelonax potens*.

found in the upper Oligocene, it would seem quite reasonable to suppose that it belongs to the same species.

The premolars of this skull are rather pointed, with wrinkled enamel, and with comparatively small antero-posterior diameter, approaching *Dinohyus* in these characters. P^4 has a small paracone and a very strong cingulum, which nearly surrounds the tooth; the external face is quite smooth, except the posterior and anterior angles. The molars have distinctly separated tubercles and rather broad or open cross-valleys. Opposite the cross-valley on the internal faces of M^1 and M^2 the heavy rounded cingula, or swellings, which are so prominent in *Dinohyus hollandi*, are indicated. The anterior tubercles of M^3 are well separated, while the posterior tubercles are fused and elevated posteriorly, so as to form a basin of the cross-valley; the tooth as a whole is relatively small when compared with *Dinohyus*.

The frontals are much less inflated than in the type of *Dinohyus*. Judging from the crushed condition of the skull, I am inclined to think that the anterior border of the orbit is opposite the posterior part of M^3, or perhaps somewhat further back. The anterior border of the posterior nares is opposite the posterior part of M^3. The dependent process of the jugal is very broad and extends well down.

A second specimen in the Yale Museum, which may be referred to *Pelonax bathrodon* (No. 10009), is a skull and lower jaws of a rather young individual. This has an unusual development of the posterior basal tubercles (hypoconulids) of the lower molars. The ento- and hypoconids of M_1 and M_2 are also relatively high in comparison with most Entelodonts from the Oligocene, while those of M_3 are low as in the type of *Pelonax bathrodon* and the cross-valley is also broad in the same manner.

MEASUREMENTS.

Skull No. 10008, Yale Museum.

	Mm.
Total length of the skull fragment about	540
Breadth of skull at M^2	144
Antero-posterior diameter of P^2	32
Transverse " " P^2	19
" " " P^3	28
Antero-posterior " " P^3	41.5
" " " P^4	31
Transverse " " P^4	34
" " " M^1	40
Antero-posterior " " M^1	38
" " " M^2	39.5
Transverse " " M^2	43
" " " M^3	37
Antero-posterior " " M^3	633

Pelonax potens (Marsh).

Type: Greater portion of left ramus and symphysis.

Horizon: Not indicated; most probably upper Oligocene.

Locality: Oligocene of Colorado.

Locality of Type: Collection of Yale Museum, No. 12042.

The most conspicuous feature of this type is the great development of the anterior dependent process of the inferior face of the lower jaw, which, as in *Pelonax ramosum*, gives to the chin an unusually short and rather broad appearance. The alveolus for $P_{\overline{1}}$ indicates that the roots were well[19] coalesced near the crown, a character usually found in types from the upper Oligocene, and which should be regarded as of subgeneric value. The antero-posterior diameter of $P_{\overline{3}}$ must have

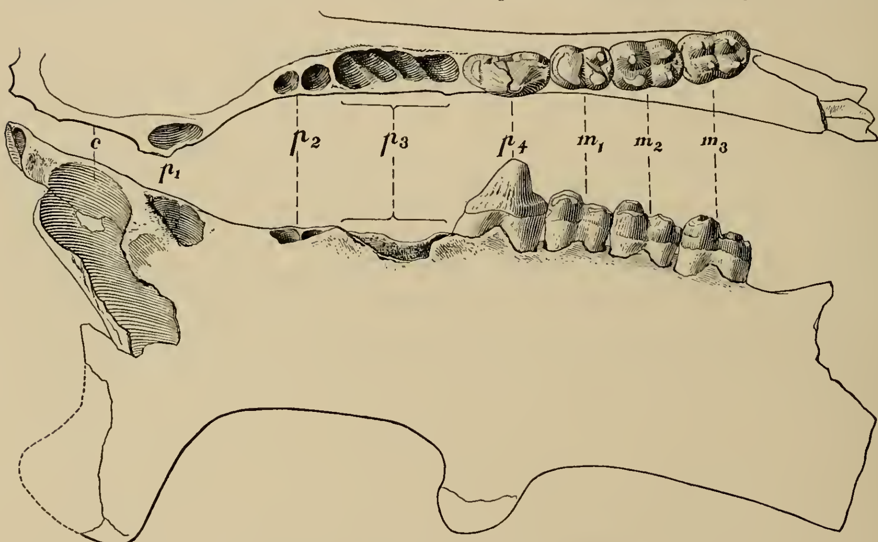

Fig. 14. Type of *P. potens* Marsh. About $\frac{1}{3}$ nat. size. (Yale Museum, No. 12042.)

been quite great, judging from the space which the alveolus occupies. The molars indicate a smaller individual than *Pelonax bathrodon*, as stated by Marsh (**63,** p. 410), but possessing the same characters as the latter, *i. e.*, the anterior tubercles of the molars are higher than the posterior, and the latter separated from the former by broad, transverse valleys. When more complete material from the Oligocene of Colorado is found, the validity of the type of *Pelonax potens* will be more satisfactorily established.

[19] In *Pelonax ramosum* $P_{\overline{1}}$ and $P_{\overline{2}}$ are apparently single-rooted.

Subgenus (?) BOÖCHŒRUS Cope.

Boöchœrus humerosus Cope.

Type: A portion of a skeleton without the skull or teeth.

Horizon: (Upper?) John Day Formation.

Locality: John Day River, Oregon.

Locality of Type: The American Museum of Natural History, Cope Collection, No. 7380.

The genus *Boöchœrus* was proposed by Cope and the type was fully described in 1879 (**10,** pp. 59–66). This John Day form has been regarded as belonging to *Archæotherium* by authors who have occasionally referred to it, and it is even now difficult to correctly place the remains generically, as there are unfortunately no remains of the skull or teeth with the type. The present arrangement must, therefore, be regarded as only provisional, pending the discovery of more material in the typical locality.

After restudying the type, and after comparing it with the splendid skeleton of *Dinohyus hollandi* from the Agate Spring Fossil Quarries, as well as with the Princeton specimen of *Archæotherium ingens* from the Titanotherium beds, which was described by Professor Scott, it appears that there are certain characters of generic value. When the skeleton of *Dæodon* is thoroughly known, *Boöchœrus* may possibly have to be referred to that genus.

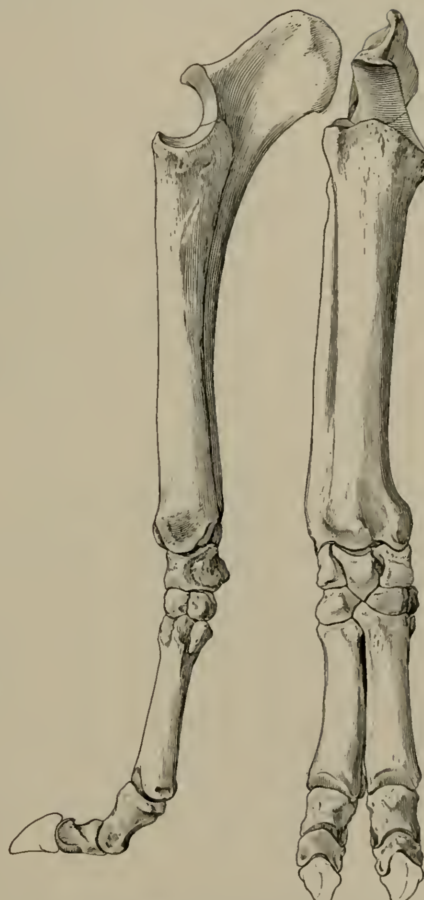

FIG. 15. Front and Inside View of Right Forefoot of *B. humerosus* Cope. About ⅙ nat. size. (Cope Collection, No. 7380.)

Principal characters of Boöchœrus humerosus: On comparing *Boöchœrus humerosus* with *Dinohyus hollandi* it is quite apparent that the humerus in the former is relatively long and the manus[20] broad

[20] Although *B. humerosus* is heavier than *D. hollandi*, the feet of the former are considerably shorter and broader than in the latter.

(**21**, p. 168) and short (see figs. 15 and 16). The absence of an articular facet for mt. III[21] on the lower tibial angle of the cuboid in the John Day form is also a noticeable feature. *Boöchœrus humerosus* differs from *Archæotherium ingens* by the absence of the trapezium and by the fact that the unciform and magnum do not

FIG. 16. Left Humerus of *B. humerosus* Cope. About ⅙ nat. size. (Cope Collection, No. 7380.)

FIG. 17. Right Hind Foot of *B. humerosus* Cope. (Cope Collection, No. 7380.) ⅙ nat. size.

touch one another dorsally when in position in the carpus.[22] From both *Dinohyus hollandi* and *Archæotherium ingens* the John Day subgenus differs by a relatively greater transverse diameter of the distal end of the femur.

Additional specimens from the John Day formation will undoubtedly give more complete information regarding this proposed genus. Cope states (**10**, p. 60) that the "remains indicate an animal of the size of the *Rhinoceros indicus*. The animal is characterized by the massive proportions of the humerus as compared with the femur, and by the short robust form of the metapodials."

[21] The head of mt. III in the type of *Boöchœrus* is restored on the fibular angle, but it was evidently the same as in *Archæotherium ingens*, judging from the absence of the facet on the lower tibial angle of the cuboid.

[22] Cope says (21, p. 171) that the lunar has penetrated so far as to almost divide the second row of carpals.

Genus DÆODON Cope.

A description of this genus was given by Professor Cope in a paper (**9**, p. 15) read before the American Philosophical Society, November 15, 1878, and published on December 3, of the same year. Owing to the very poor condition of the type, Cope

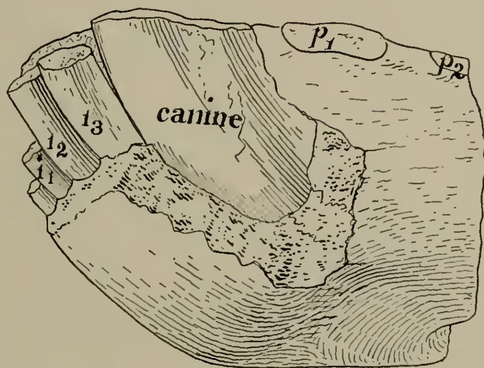

FIG. 18. Type of *Dæodon shoshonensis* Cope. About ½ nat. size. Cope Collection, No. 7387. Oblique View to show symphysis.

was unable to give any characters, except the absence of the osseous tuberosities on the anterior under borders of the lower jaws, which differ from those of the American Entelodonts generally. Cope placed *Dæodon* in the suborder Perissodactyla and associated it with *Titanotherium* and *Chalicotherium*. The genus has hitherto been regarded as belonging to the Perissodactyla and Zittel (**99**, p. 304) referred to it with a misprint under the name *Daledon* in connection with the synonymy of *Titanotherium*.

The fortunate discovery of additional material, which undoubtedly belongs to this genus, by the California University and published by Dr. W. J. Sinclair (**89**, pp. 132–134), furnishes much welcome light on the subject, and it now appears that *Dæodon* may confidently be removed from the Perissodactyla and placed in the family *Entelodontidæ*.

Principal Generic Characters of Dæodon: Chin without knob-like processes on the under border; posterior mandibular protuberance small and hollow; a gradual backward slope of the dependent angle of the lower jaw; jugal process with a moderate downward extension; fibula not[23] coössified with the tibia.

[23] In a letter from Dr. E. L. Furlong, of the California University, Berkeley, California, he assures me that "there is no fusion of the shaft of the fibula with the tibia."

Dæodon shoshonensis Cope.

Type: Symphysis of lower jaws.

Horizon: (Upper?) John Day Formation.

Locality: Bridge Creek, Wasco County, Oregon.

Locality of Type: The American Museum of Natural History (Cope Collection, No. 7387).

The principal characteristics of the type are the absence of the osseous bosses on the chin and the evenly rounded under surface of the symphysis. Only the roots of the teeth are preserved in the alveolar border of the type. These show that there were three incisors, a canine, and two premolars. The roots of the median pair of incisors are laterally compressed and indicate that they were small as in *Dinohyus hollandi*. $I_{\overline{2}}$ and $I_{\overline{3}}$ were evidently much increased in size, $P_{\overline{1}}$ is close to the canine and $P_{\overline{2}}$ is separated from $P_{\overline{1}}$ by a short diastema as in *Dinohyus*. That Professor Cope had compared the type of *Dæodon* with *Archæotherium* is evident from his statement (**9**, p. 15) that "the canine teeth are very robust, as in the species of *Elotherium*," but he associated *Dæodon* with *Chalicotherium* and *Titanotherium*, perhaps wholly on account of the absence of the large dependent processes of the chin. In this connection I may state that the symphysis of *Moropus* is much more procumbent and is of a decidedly more delicate structure than in the type of *Dæodon*. No Titanotheres have as yet been found in the John Day horizons, while Entelodonts of the same size are sometimes discovered.

Measurements of the Type Specimen of *Dæodon shoshonensis*.

	Mm.
Greatest antero-posterior diameter of symphysis [24]	164
" transverse " " " at $P_{\overline{1}}$	144
Vertical diameter of ramus at $P_{\overline{2}}$	100

Dæodon calkinsi (Sinclair).

Type: Skull, several vertebræ, and portions of fore and hind limbs.

Horizon: Upper part of the *Promerycochœrus* beds.

Locality: Bridge Creek, Wheeler County, Oregon.

Locality of Type: Paleontological Collection of University of California, No. 953.

From the description and figures of *Dæodon* (*Elotherium*) *calkinsi* (**89**, p. 134, Pl. XV) it is quite evident that the specimen pertains to the genus *Dæodon* described by Cope in 1878 (**7**, p. 15). Although the type of the latter represents an animal of considerably larger size, it agrees perfectly, so far as comparison can be made, with the species described by Sinclair. The character by which *D. calkinsi*

[24] The alveolar border is broken, which naturally reduces the antero-posterior diameter to some extent.

is specifically to be separated from *D. shoshonensis* is principally the smaller size, so far as can be determined by comparison of the two. Sinclair states that the type of *D. calkinsi* represents a very old individual and that many of the teeth are shed and

FIG. 19. Outline of Illustration of Skull of *Dæodon calkinsi* (Sinclair). (After Sinclair.)

the alveoli closed. "$P_{\overline{2}}$ . . . resembles the smaller premolars of the upper series. Anterior and posterior cingula are well developed on the lower molars. In $M_{\overline{3}}$ the hypoconulid is not differentiated from the posterior cingulum, which projects slightly, forming a very small heel. . . .

"The mandible is peculiar in the absence of the knob-like bosses on the chin The protuberances beneath $P_{\overline{1}}$ are small and deeply cupped. The dependent angle slopes gradually backward without the abrupt downward curvature characterizing *E. ingens*. . . .

"The chief point of specific value attaching to the cranium is in the shape and direction of the jugal processes. These processes are plate-like with a thickened median rib. The free edges, especially the anterior, are thin and sharp. The processes are short, not extending below the lower mandibular border. The orbits are posterior in position, their anterior borders lying above the posterior edge of M^3."

The unciform and tibia were kindly sent to the writer for purposes of study by Professor John C. Merriam of the University of California. It is at once noticeable that the lunar facet of the unciform is more elevated than in *Dinohyus* and that the small facet for the magnum on the proximo-radial angle is more nearly radially in position as in the Oligocene genus *Archæotherium.* The unciform and magnum apparently articulated dorsally as in the latter genus. There are otherwise no marked differences between these two bones in *Dæodon* and *Dinohyus.*

MEASUREMENTS OF UNCIFORM.

	Mm.
Greatest antero-posterior diameter	43
" transverse "	40
" vertical "	35

The tibia in general resembles that of the Oligocene type rather more strongly than the later Miocene form. The fibula was not coössified with the tibia, although a rough border on the fibular side of the tibia indicates that the two bones were in close proximity to each other. On the anterior termination of the intertrochlear ridge of the distal end of the tibia is a facet, which indicates that upon extreme forward flexure of the tibia this facet articulated with a corresponding facet in the large pit on the anterior face of the astragalus, as in *Dinohyus.* The general features of the tibia are otherwise quite similar to those in the Entelodonts generally. The proximal end of the tibia is wanting, as is also the external portion of the distal end, in the specimen here described.

MEASUREMENTS OF TIBIA.

	Mm.
Greatest length of the fragment	276
" transverse diameter of shaft, medially	40
" antero-posterior diameter of shaft, medially	32
" " " " " distal end	42

Genus DINOHYUS Peterson.

(Plates LV–LXI.)

In 1905 the writer sent from the field the original description of this genus to Dr. W. J. Holland, Director of the Carnegie Museum, who suggested the name *Dinochœrus;* the description was published in Science (**78**, pp. 211–212). Later *Dinochœrus* was found to be preoccupied, and a note of correction by the writer appeared the same year in Science (**79**, p. 719). The skull and lower jaws were published in 1907 (**81**, pp. 49–51, Pls. XVI–XVII) and the detailed description of the skeleton is found on pages 77 *et seq.* of this memoir.

Dinohyus hollandi Peterson.

Type: A nearly complete skeleton.

Horizon: Lower Miocene (Lower Harrison beds).

Locality: Agate Spring Fossil Quarries (Quarry No. 1), Sioux County, Nebraska.

Locality of Type: The Carnegie Museum (Catalogue of Vertebrate Fossils, No. 1594).

Principal Generic Characters of Dinohyus: Median incisor reduced and sometimes wanting. Transverse diameter of $P^{\underline{3}}$ nearly equal to the antero-posterior, $P_{\overline{4}}$ with large deuterocone; the crown subquadrate in outline and the tooth of relatively small size; a tendency to increase the antero-posterior diameter of $M^{\underline{3}}$, and the meta- and hypocones of relatively large size; lower molars with subequal height of posterior and anterior tubercles; the tubercles separated by narrow cross-valleys; the trigon lost; all the premolars spaced; dependent process of the jugal of proportionally small size and the posterior termination of the zygomatic process developed into a strong buttress at the anterior border of the glenoid cavity; small bony eminences on the chin and a strong knob-like process on the inferior border of the ramus opposite $P_{\overline{4}}$; a relatively gradual backward slope of the angle; relatively short alveolar border of the premaxillary and rather short chin; vertical and transverse canals of the dorsal vertebræ as in *Sus*; fibula coössified with the tibia; trapezium absent and mt. V sometimes absent.

Genus AMMODON Marsh.

Although Professor Cope (**5**, p. 704), Leidy (**50**, p. 388), and Marsh (**57**, p. 3), referred to the New Jersey specimen, there was no adequate description of the type until 1893, when the latter author gave a short description together with good illustrations (**63**, pp. 409–410).

Known Generic Characters of Ammodon: $P^{\underline{4}}$ of relatively large size; large hypoconulid on $M_{\overline{3}}$; anterior and posterior tubercles of lower molars subequal in height; the loss of the trigon; cross-valleys narrow; type representing an animal of large size.

Ammodon leidyanum Marsh.

Type: $P_{\overline{4}}$; Neotype: $M_{\overline{3}}$ of left[25] side.

Horizon: Middle Miocene?

Locality: Near Farmingdale, Monmouth County, New Jersey.

Locality of Type: Collection of Yale Museum, No. 12040.

From Marsh's description (**63**, pp. 409–410) and also from my observations upon the specimen it seems quite probable that $P_{\overline{4}}$ and $M_{\overline{3}}$ which Marsh described belong to the same individual. Working on this hypothesis it would seem that $P_{\overline{4}}$ is of greater proportionate diameter than in *Dinohyus hollandi*. The posterior heel of $P_{\overline{4}}$ in *Ammodon* is also larger than in *Dinohyus*, which is due to a heavy

[25] Professor Marsh mistook the left $M_{\overline{3}}$ for that of the right side, a mistake which might lead to confusion.

cingulum surrounding it in the former genus, but which is absent in *Dinohyus*. Furthermore, in the type of *Ammodon* the crown is somewhat higher and on the posterior face there are two mammilated ridges of considerable prominence

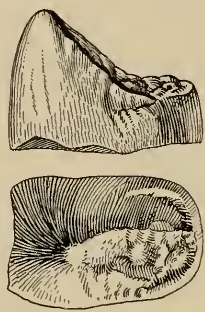

Fig. 20. Type of *Ammodon leidyanum* Marsh. Internal and Crown View of $P_{\overline{4}}$. $\frac{2}{3}$ nat. size. (Collection Yale Museum, No. 12040.)

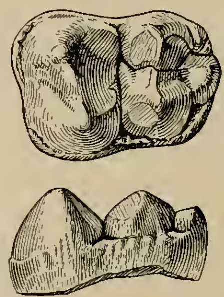

Fig. 21. External and Crown View of $M_{\overline{3}}$ of Neotype of *Ammodon leidyanum*. $\frac{2}{3}$ nat. size. (Collection Yale Museum, No. 12040.)

which take their origin, one at the postero-internal angle and the other at the antero-external angle of the heel, and continue to very near the apex of the crown (see fig. 20). In *Dinohyus hollandi* there is only a slightly uneven folding of the otherwise smooth enamel on the posterior face of the protoconid, and there are no decided ridges. $M_{\overline{3}}$ of *Ammodon leidyanum* is very similar to that in *Dinohyus hollandi*. In the former the posterior heel (hypoconulid) is of relatively greater development (see fig. 21) than in the latter, and the tooth has a continuous cingulum on the antero-external and antero-internal faces, while the corresponding tooth in *Dinohyus* has the cingula represented on the postero-external, and but very slightly on the external and internal angles of the anterior face. The teeth of *Ammodon leidyanum* are larger than those in *Dinohyus* and represent an even more modified type than the latter.

Fig. 22. External and Dorsal View of Fragment of Astragalus of *Ammodon?* $\frac{1}{2}$ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 1548.)

Unfortunately the type of *Ammodon* is rather inadequate and consequently the basis of comparison is very limited, but the characters enumerated above would seem to indicate that the geological horizon in which the New Jersey specimen was found, represents deposits as late, or perhaps later, than the lower Harrison beds of Nebraska, in which the type of *Dinohyus* was discovered.

In this connection it is of interest to note that a portion of an astragalus of an *Entelodont* of very large size was found in 1901 on the surface near the top of the upper Harrison beds in the upper Niobrara valley. This fragment (No. 1548, Carn. Mus. Cat. Vert. Foss.) although considerably worn by the elements, plainly indicates characters that are different from those in the corresponding bone of *Dinohyus*. Not only is the bone larger in size, but its sustentacular facet is proportionally of greater vertical convexity and the distal portion of the bone is produced anteriorly to a much greater extent than in *Dinohyus*. This peculiar feature of the astragalus under description would seem to indicate that the tarsus of this genus (*Ammodon ?*) had a somewhat different angle.

Species the Generic Location of Which is Doubtful.

Elotherium imperator Leidy.

Type: A canine, an incisor, and a portion of the crown of a premolar tooth.

Horizon: Middle John Day beds?

Locality: Bridge Creek, and John Day River, Oregon.

Locality of Type: National Museum, Washington, D. C.?[26]

The first specimens of Entelodonts, which Professor Leidy reported from the John Day Basin in 1873 (**53**, pp. 217, 320), are altogether indeterminable generically and specifically and consequently inadequate as types. "*Elotherium imperator*" should therefore be regarded only as an historical record of the first report of the existence of Entelodonts in the John Day formation.

Elotherium superbum Leidy.

Type: An incisor tooth.

Horizon: Miocene?

Locality: Douglass Flat, Calaveras County, California.

Locality of Type: Unknown to the writer.

The type of "*Elotherium superbum*" is altogether inadequate, and its geological horizon is apparently uncertain. The record (**49**, p. 175; **50**, p. 388) of this species should be regarded as only possessing value from the standpoint of history and geographical distribution.

[26] No catalog number at this writing has been given to the specimens.

The History of the Discovery of the Agate Spring Fossil Quarries, Where the Skeleton of Dinohyus Hollandi was Found.

While engaged in field work for the Carnegie Museum on the upper Niobrara River, locally known as Running Water, Sioux County, Nebraska, in 1904, the writer had often been invited by Mr. James H. Cook to visit his ranch, the Agate Spring Stock Farm, located on that stream, some twenty-five or thirty miles east of the Nebraska-Wyoming state line. One day in the latter part of July, I decided to break camp and go down the river in search of new localities for fossils and also to study the geological features of the neighborhood more fully. As Mr. Cook's ranch was on our way down the stream, it was decided to pay him a visit, and accordingly we stopped at his ranch. After a camp-ground had been pointed out to me,

Fig. 23. Ranch-House of Mr. James H. Cook, Agate Spring Stock Farm. (From a photograph by Mr. Albert Thomson.)

on top of a high butte immediately to the south of the farm buildings, and arrangements for wood, water, etc., had been made, the preliminary work of prospecting the neighborhood was at once under way. A day or two later Mr. Harold Cook, the eldest son of Mr. James H. Cook, accompanied the writer to a small elevation some four miles to the east of the farm buildings and immediately beyond the eastern limits of the land belonging to the ranch.[27] The talus of this low hill was discovered to be filled with fragments of bones, and was afterwards designated as quarry A (See fig. 24, A). On our return to the ranch I reported to Mr. James H. Cook

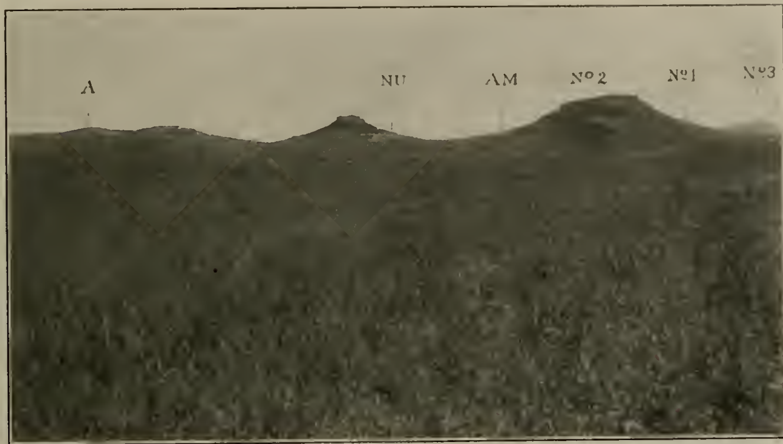

FIG. 24. View of the Buttes Showing the Location of the Different Quarries. Nos. 1-3, Quarries of the Carnegie Museum. AM, American Museum of Natural History. NU, University of Nebraska. A, Quarry A. (From a photograph by the writer.)

that the place which his son had shown me was of much interest and importance to me and that I wished to start the work of excavation on the prospect immediately. This was entirely satisfactory to Mr. Cook and his family. In fact there was evident satisfaction on the part of Mr. Cook that I had found something which I regarded as of interest and importance near his farm, and I was accorded every civility, which I could possibly desire. As I wished to be near my work, Mr. Cook invited me to camp in his "lower field." Accordingly our first camp was pitched on the south bank of the stream close to the hill and the operation of excavating in quarry A was begun during the last few days of July. We had worked three or four days in this quarry when I decided to visit the two buttes (since named Carnegie Hill and University Hill by Prof. E. H. Barbour) which lie about three hundred yards to the south of the place where we were working. One may easily imagine the thrilling excitement of a fossil-hunter when he finds the talus of the hillsides positively covered with complete bones and fragments of fossil remains.

It was with comparatively little effort that I was able to articulate portions of

[27] Mr. James H. Cook informed me that fall that the hills containing the fossils were on his ground (80, p. 487); this statement was found afterward to be founded upon an error, and Mr. Harold Cook has since (1908) filed on this government land.

the feet of *Diceratherium cooki* and *Moropus* using the disassociated bones picked up in great abundance in the talus. Here then was a veritable wonderland! I spent a considerable portion of the afternoon before I returned to where my assistants, Mr. T. F. Olcott and A. A. Dodd, were at work. The next day I again returned to the hills with wrapping paper, twine, and a sack in order to pack and bring down the bones which I had picked up the previous day; and also to more fully ascertain, if possible, the extent of these deposits. A few days later when I reported my additional find to Mr. Cook, I learned that I was perhaps not the original discoverer of the bones in these two hills, as he told me that he had seen bones there as long

FIG. 25. View of Carnegie Hill and University Hill, Showing Quarries No. 1 and No. 2 of the Carnegie Museum on Carnegie Hill, and Quarry of the University of Nebraska to the left. (From a photograph by the writer.)

ago as 1890, but always thought them to be of recent origin. In 1908 I was further convinced that the bones in these hills had been seen even earlier by Mr. Octave Harris,[28] a prominent ranchman of the neighborhood. To Mr. Cook is, however, due much credit, as these deposits of bones would perhaps not have been brought to the attention of paleontologists at this time, had he not invited me to his ranch.

In looking over the whole situation it was plain that the deposits required more time and assistance than I then had. Together with this fact I may mention that I had not been well all that spring; in fact I was obliged to leave the field on account of sickness about the middle of August. I wish to here acknowledge, with much appreciation, the kind and sympathetic treatment I received from Mr. Cook and his family during my week of sickness at his ranch. Before leaving for the east

[28] Mr. Harris extended much aid to our party during our last (1908) season's work in the quarry, and the interest which he took in our work is heartily appreciated and most gratefully acknowledged.

I assured Mr. Cook that I would be back the following spring to systematically take up the work in the hills, which decision he assured me was in accord with his wishes.

Early in the spring of 1905 the writer accompanied by Mr. T. F. Olcott resumed work in quarry No. 1 (see fig. 25). Mr. Cook impelled by curiosity had already started in the previous fall to excavate in quarry No. 1 (see Plan of Quarry, Pl. LIV, Cook Excavation), but after earnest entreaty by letter to await the coming of more expert help desisted from his work. Many piles of fragments were found on the edge of the opening which had been dug out by Mr. Cook. These fragments were carefully gathered and packed before the commencement of systematic excavations. The work being fairly started, Mr. Olcott was left in charge of the quarry, while I returned to Pittsburgh in order to attend to other duties in the museum. Thus was started one of the most important fossil quarries ever found in North America.

When I again returned to the field later in the season, Mr. Olcott was still engaged in the same hill, while Professor E. H. Barbour, of the Nebraska State University, had been invited by Mr. Cook to open a quarry in the adjoining hill, afterwards named by Professor Barbour "The University Hill." Much material had been uncovered in quarry No. 1 among which the most important were bones of *Moropus*, many individuals of *Diceratherium* and an unusually well preserved, and pretty nearly articulated skeleton of a gigantic Entelodont (see Pl. LIV, Plan of Quarry, Blocks Nos. 61, 86 in Sect. 4). The discovery of the latter was a surprise, nothing having hitherto been found representing this family in the lower Miocene of Nebraska. One hind limb and most of the parts of the skeleton anterior to the pelvis were recovered. The pelvis, the lumbar vertebræ, and perhaps also one hind limb[29] were unfortunately dug out by Mr. Cook and those assisting him and only portions of four vertebræ and the pubic symphysis of the pelvis were recovered from the fragments left on the edge of the quarry.

The skull was almost in contact with the atlas. The cervical and dorsal vertebræ were found in a successive series back of the skull, the dorsals being articulated by their zygapophyses (see Plate LIV, Sect. 4, Blocks 61, 72, 86). The greater number of the ribs and the sternum were found in close proximity in their relative positions, while one hind limb was found a short distance from the main portion of the skeleton. The fore feet were scattered. There is, then, no doubt that the following description of the skeleton is that of one individual.

In addition to this skeleton there were found, in Sections 16–21 in quarry No.

[29] The head of a femur, which may or may not pertain to this specimen, was found on the dump.

1, opened in 1908 by the writer, many other bones, fragments, and scattered teeth of *Dinohyus*. Some of these fragments were much worn by the elements before they were finally deposited, indicating that they were probably transported by a

FIG. 26. At Work at the North End of Quarry No. 1. (From a photograph by Professor Barbour.)

stream of water. When this additional material is used in this paper its catalog number is always mentioned in connection with the description.

Geological Notes.

The lower Miocene of western Nebraska and eastern Wyoming has been subdivided into four horizons. Successively overlying the Oligocene formation these horizons are: (1) the Gering beds; (2) the Monroe Creek beds; (3) the lower Harrison beds; (4) the upper Harrison beds. The latter horizon is capped at Spoon Butte and other high elevations on the divide between the Niobrara and Platte rivers, by a hard stratum of pinkish-gray sandstone (**81,** p. 23, fig. 1; **72f,** p. 73). This sandstone is from twenty-five to fifty feet (or about seven to fifteen meters) thick. No fossils have been found in this stratum on Spoon Butte by which its relative age can be determined. It is perhaps of considerably later origin than the Harrison beds, and may even be as late as the Pliocene. For convenience in this connection these beds may be called *The Spoon Butte beds.*[30]

It also appears, judging from the fauna of the upper Harrison beds, that this

[30] From a recent publication by Dr. Matthew (Science, N. S., Vol. XXIX, No. 735, p. 196, 1909) it would seem that these beds may be regarded as representing the Ogallala formation.

horizon of the Miocene exposed along the upper Niobrara, should be regarded as the base of the middle Miocene, or a horizon filling, in part at least, the hiatus between the lower and the middle Miocene. Places of non-conformity between the upper and lower Harrison beds are frequently found, the first of which observed by the writer in 1901 is situated immediately east of the Niobrara-Wyoming State line.

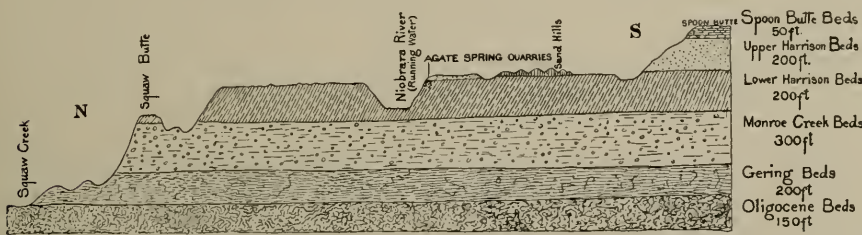

FIG. 27. Diagrammatic Section of the Miocene Beds in Western Nebraska and Eastern Wyoming.

This is in reality the type locality of the upper Harrison beds, which were called to J. B. Hatcher's attention by the writer in 1901. Hatcher, then Curator of Paleontology of the Carnegie Museum, decided these beds to be the "Nebraska beds" of Scott. Viewing these beds from the standpoint of certain portions of the fauna (**81**, p. 56) taken together with lithological characters, the sediment being usually of a darker color, it would seem that a natural division between the lower and middle Miocene may be established at the contact of these two horizons.

As has been stated elsewhere (**80**, p. 487; **81**, p. 41) the Agate Spring Fossil Quarries are located in the lower Harrison beds. The origin of the deposit in which the fossil bones of these quarries are found is most likely a stream deposit. In support of this view may be cited the fact that the parting plane underneath the layer carrying the bones is a few shades darker in color than that layer itself, and the

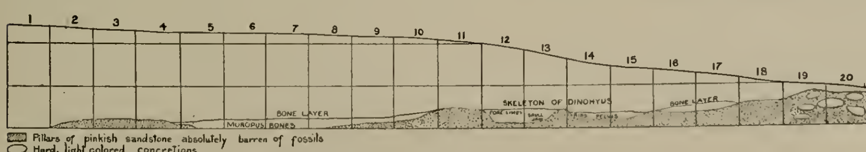

FIG. 28. Section of Face of Quarry of University of Nebraska at the End of the Season of 1908, showing channels in the stratum supporting the fossiliferous layers. The Nos. 1–20 indicate sections 5 ft. in length.

bones are often closely packed in irregular channels and pockets, which vary in thickness from two or three to eighteen or twenty inches (8 to 50 cm.). The surfaces of the bones are sometimes highly polished and worn, and there are numerous fragments of bones which are worn down to the shape of a pebble. These conditions could have been brought about in no other way than by the action of water in motion. There was here most likely a stream of considerable magnitude, instead of a lake, as was suggested by the writer (**80**, p. 49). The fossil-bearing bed has all the appearance of a stream the bottom of which was covered by quick-sands. In the quarry located on "University Hill" (see fig. 28) there are distinct evidences of narrow and rather shallow channels, which were separated by sandbars of greater or lesser dimensions. The bone-layer of this quarry is thus, irregularly separated, although confined to one general level throughout portions of the base of the hill.

It seems reasonable to suppose that in the immediate vicinity of the Agate Spring Fossil Quarries the ancient fauna of the region found a favorite crossing of this stream. The remains of the unfortunate animals which attempted to ford the river under unfavorable circumstances furnish the records which the collector is fortunate in securing, and which give a glimpse into the struggle for existence in those early times.

In this connection it is interesting to note certain topographical features in the vicinity of the Agate Spring Fossil Quarries. In this region the general direction of the Niobrara River is east and west. Very often the side cañons of this stream extend in a direction contrary to that which one would naturally expect. The draws and cañons on the north side extend diagonally southeastward and in a perfectly natural direction towards the main stream, while very often the cañons on the south side extend diagonally northwestward or up-stream, which is generally regarded as a feature of stream piracy. This anomalous feature was quite perplexing to me for some time, and it was not until I had studied the character of the sediment in connection with the topography that any tangible explanation was reached. It is a well-known fact, which has been observed by Darton, Hatcher, Peterson, and others, that in these Miocene beds are masses of pipey concretions of greater or less extent, which always have their long axes directed in a nearly northwest-and-southeast direction. The cañons to the north of the Niobrara would have no difficulty in cutting their way through to the river in a natural course, while those on the south side of the stream would sometimes have to accommodate themselves to the up-stream direction which is the course of the least resistance to the erosive elements. In this way there are developed sharp ridges and hogbacks, nearly always in the northwest and southeasterly direction on either side of the river. Chimney-rocks and pillars of numerous shapes are seen along the course of the Niobrara River for some forty miles in this general locality.

The entire Miocene section, and especially the lower Harrison beds, are apparently of considerably later age than the John Day formation in which Entelodonts have been discovered, judging from the fauna which has been published elsewhere (**81**, pp. 34–56). That some genera of the *Entelodontidæ* continued to the close of the lower Miocene is now well established; indeed it would perhaps not be surprising to find them represented in the middle and possibly in the upper Miocene. *Dinohyus*, which was discovered in the upper part of the lower Miocene beds (lower Harrison beds), was in all probability followed in the Miocene in New Jersey, by *Ammodon leidyanum*, which is without much doubt a later form.

Detailed Description of Dinohyus Hollandi Peterson.

The Superior Dentition.

(Plates LVII and LVIII.)

The median pair of incisors are lost in the type, but the alveolus of the right side is complete, and indicates a proportionally small tooth.[30a] I^2 is present and is much worn on the apex and the internal face; the tooth has a crowded position, and its antero-posterior diameter is greater than the transverse. I^3 is the largest of the incisors and is about twice the size of I^2; it has received much wear on the postero-lateral angle from contact with the inferior canine, and the apex is also much worn. The antero-posterior diameter of this tooth is, as in its predecessor, the greatest. All the incisors are more crowded than in the Oligocene forms generally. It is also noticeable that the transverse groove immediately above the enamel band, which Professor Scott refers to (**87**, p. 274), is very well developed in the type, and could not have been caused by the wear of the lower teeth.

Fig. 29. Oblique Side Views of Premaxillary Bone of *D. hollandi* Peterson. (Carn. Mus. Cat. Vert. Foss., No. 2145.)

As in other forms of the family, the canine tooth is very large, recurved, and has an enormous fang. In the present specimen the apex of the tooth has received considerable wear as has also the antero-internal face. There is a light cingulum on the posterior face, but externally the enamel is smooth.

The first, second, and third superior premolars in *Dinohyus* are in general quite similar in shape to the corresponding teeth in *Entelodon magnum* of Europe. They

[30a] A premaxillary bone (No. 2145, Carn. Mus. Cat. Vert. Foss.) in the collection from the Agate Spring Fossil Quarries, (Quar. No. 1, Sect. 19), which is here referred to *Dinohyus*, has only two alveoli, the median incisor having dropped out and the alveolus closed.

are, however, relatively small, $P^{\underline{4}}$ especially so, and the whole series is more spaced, while in the latter genus the second premolar forms a closed continuous series with the posterior teeth, and $P^{\underline{1}}$ only is widely separated by a diastema. In *Dinohyus* $P^{\underline{1}}$ and $P^{\underline{2}}$ are widely separated and $P^{\underline{2}}$ and $P^{\underline{3}}$ are separated only by a very short diastema. Back of $P^{\underline{3}}$ the dentition forms a continuous closed series.

$P^{\underline{1}}$ is of relatively large size with a simple crown, the apex of which is placed well forward the cingulum is quite heavy on the antero-internal angle and the

Fig. 30. Upper Right Canine of Type of *Dinohyus hollandi* Peterson. $\frac{3}{4}$ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 1594.)

heel slopes rapidly behind. $P^{\underline{2}}$ is of about the same size and shape as $P^{\underline{1}}$, except that the antero-internal cingulum is slightly more developed and extends further toward the external face of the tooth. The enamel of this tooth is less crinkled than that of $P^{\underline{1}}$. $P^{\underline{3}}$ has a relatively smaller antero-posterior and a greater transverse diameter than in the Oligocene forms. This transverse enlargement of the tooth causes a characteristic trihedral cross-section, which is very much less apparent in the forms from the Oligocene. The tooth is slightly larger than $P^{\underline{4}}$. The entire crown is practically taken up by the large protocone. The cingulum has developed into a narrow shelf on the antero-internal angle and continues in a much less conspicuous manner on the internal face, terminating in the heavy cingulum posteriorly. $P^{\underline{4}}$ has no cingulum externally, which is also true of all the other premolars, and its transverse is slightly greater than its antero-posterior diameter. The tooth has a proto- and a deuterocone. The latter is relatively more developed than in *Entelodon*. There is a heavy cingulum posteriorly and on the antero-external angle a prominent basal heel is developed, but there are no external or internal cingula.

The molars of *Dinohyus* are more specialized than those of *Archæotherium*, as is shown by the fact that the tubercles of the crowns are more depressed and consolidated, and the posterior portion of $M^{\underline{3}}$ is relatively more developed than in the Oligocene genus. The crown of $M^{\underline{1}}$ in the type specimen is much worn, so that it shows two large and irregular tracts with the bottom of the cross-valley extending beyond the triturating surface, especially on the inner portion of the tooth. There are heavy cingula anteriorly and posteriorly and a less developed cingulum externally, while internally the tooth is smooth. $M^{\underline{2}}$ is the largest of the series; the principal difference between it and the corresponding tooth in the Oligocene forms (especially those from the lower Oligocene) is revealed in the interruption of the internal exit of the cross-valley by a heavy rounded ridge (see Pl. LVIII, fig. 1) which was undoubtedly developed from the cingulum. The anterior border is entirely surrounded by a heavy cingulum, as is also the postero-external angle, while on the external face immediately back of the exit of the cross-valley there is very slight indication of a cingulum. The posterior portion of $M^{\underline{3}}$ is composed of (1) metacone, (2) hypocone, and (3) metaconule; the first is of much larger size than the second, and the third is very inconspicuous, in fact it is entirely absent on the corresponding molar of the right side of the type specimen. The cross-valley of $M^{\underline{3}}$ is interrupted in the same manner as is the case in the preceding tooth, and in addition this tooth has a mammillary cingulum which to some extent also closes up the external exit of the cross-valley. This cross-valley is not closed up in the specimens of *Archæotherium* known to me from the lower Oligocene. There is in the present type a heavy anterior cingulum on $M^{\underline{3}}$, but no posterior cingulum; the back part of the tooth having played a more important part in the make-up of the crown in this genus than is seen in older types.

The antero-external tubercle of the last upper molar in *Entelodon magnum* has reached a greater development than in *Archæotherium* and in this respect is more nearly like what is seen in *Dinohyus.* The posterior portion of this tooth in the latter genus is not unlike that of the European form, and shows a more advanced development than in *Archæotherium.* Altogether in *Archæotherium* the crowns of the molars are somewhat lower, the apices of the different points of the grinding surface are less united, and the teeth as a whole are less modified than in *Entelodon magnum* and *Dinohyus hollandi.*

MEASUREMENTS.

	Mm.
Length of alveolar border of maxillary and premaxillary	465
Distance from median incisor to M^1	330
Length of molar series	132
Antero-posterior diameter of I^2	28
Transverse " " I^2	24
" " " I^3	41
Antero-posterior " " I^3	35
" " " canine at base	50
Transverse " " " " "	53
Antero-posterior " " P^1	39
Transverse " " P^1	22
Antero-posterior " " P^2	38
Transverse " " P^2	22
Antero-posterior " " P^3	42
Transverse " " P^3	33
Antero-posterior " " P^4	37
Transverse " " P^4	40
Antero-posterior " " M^1	42
Transverse " " M^1	44
Antero-posterior " " M^2	45
Transverse " " M^2	48
Antero-posterior " " M^3	45
Transverse " " M^3	47

THE INFERIOR DENTITION.

(Plate LVIII.)

The incisors are much worn, but their outlines present more obtusely pointed crowns than in the older forms and the median pair is proportionately smaller, so that the gradual enlargement from $I_{\overline{1}}$ to $I_{\overline{3}}$ is in about the same proportion as in the superior series. The teeth are crowded and occupy a more nearly transverse position in the front of the jaws than is seen in the Oligocene forms generally. The crown of $I_{\overline{1}}$ is much worn; and its antero-posterior exceeds its transverse diameter, so that it is oval in cross-section. $I_{\overline{2}}$ is about twice the size of the median incisor and is also oval in cross-section, its antero-posterior being greater than its transverse diameter. There is a heavy cingulum on the posterior face which extends half way around the base of the lingual side. $I_{\overline{3}}$ is nearly twice as large as the tooth just described, but otherwise the two are quite similar. On the external faces of $I_{\overline{2}}$ and $I_{\overline{3}}$ are deep grooves across the faces, just below the enamel band, which were not caused by the wear of the upper teeth. Inasmuch as the canines of both sides have a similar and much greater worn area externally, which could not have been reached by any of the upper teeth, it further supports the contention of Professor W. B. Scott and C. F. Brackett, that these animals used the lower tusks in digging in the ground for roots (**87**, footnote, p. 275). They may also have been used for stripping off the foliage of shrubbery. There is a slightly developed cingulum on the posterior face of the canine, otherwise the enamel is quite smooth. The crown is higher and more pointed than that of the upper canine, but in general appearance and size it differs little from that tooth.[31]

$P_{\overline{1}}$ is separated from the canine by a short diastema; the tooth is implanted in the jaw by two strong fangs which coalesce for some distance below the crown. The latter is simple and is rather low when compared with that of *Archæotherium*. On the internal face the enamel is crinkled, but externally the tooth is quite smooth. Posteriorly there is a heavy cingulum and anteriorly there is a prominent oblique ridge, which originates at the antero-internal angle and continues outward and upward to the apex, constantly diminishing in prominence in its upward course. The apex of the crown in the type is considerably worn, but it is quite easy to ascertain its contour which was very much more obtuse than in *Archæotherium*. There is a considerable diastema between $P_{\overline{1}}$ and $P_{\overline{2}}$. The latter is also implanted with two roots which are, however, more divergent and do not coalesce below the crown as in $P_{\overline{1}}$. The crown of $P_{\overline{2}}$ is of about the same size as the crown of the preceding tooth, but its apex is less worn and there is a mammillated ridge on the anterior and posterior faces of the protoconid. There are prominent anterior and posterior cingula and the enamel on the internal face is thrown into light folds, while the buccal face of the tooth is smooth. $P_{\overline{3}}$ is, as usual, the largest in the series; it is not crowded in the alveolar border, but is separated from $P_{\overline{2}}$ by a very short diastema. The apex of the crown is next highest to that of the canine and in general form it is not unlike that of $P_{\overline{2}}$. $P_{\overline{4}}$ has a heavy heel which agrees in general with $P_{\overline{4}}$ in *Entelodon magnum*. Altogether $P_{\overline{4}}$ of the present genus presents a different outline from that of the corresponding tooth in the earlier genera, which fact is wholly due to the increased transverse diameter of the tooth posteriorly.

[31] The left lower canine is disproportionately short and stubby and was evidently broken off at the apex during the life of the animal.

The inferior premolars of *Entelodon* are relatively large, more regular in size, and $P_{\overline{3}}$ and $P_{\overline{4}}$ are entirely surrounded by cingula; while in *Dinohyus* the premolar teeth as a whole are smaller, $P_{\overline{3}}$ being conspicuously the larger of the series and $P_{\overline{3}}$ and $P_{\overline{4}}$ have the cingula less strongly developed.

The molar series in *Dinohyus* is very crowded and occupies less than one half of the antero-posterior diameter of the alveolar border. As in other allied genera, the molars are of relatively small size in comparison with the jaw and they increase

FIG. 31. Crown View of Inferior Dentition, Left Side. Type specimen of *Dinohyus hollandi* Peterson. $\frac{2}{5}$ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 1594.)

in size posteriorly. $M_{\overline{1}}$ is considerably worn in the type, so that the quadritubercular pattern is converted into two heavy transverse tracts having irregular outlines and with only a remnant of the cross-valley on the inner half of the tooth. On the antero-internal angle the cingulum is developed into a small basal tubercle. Opposite the cross-valley there are short and smoothly rounded cingula externally and internally. On the postero-external angle is a cingulum, which is continuous with a similar short cingulum on $M_{\overline{2}}$. The posterior face of the tooth is closely crowded against the anterior face of $M_{\overline{2}}$.

In the type the quadritubercular pattern of $M_{\overline{2}}$ is plainer than is the case in the tooth just described, but trituration has already caused the appearance of the solid cross-crests; the anterior being slightly more elevated than the posterior. Anteriorly there is a deep, narrow fissure, which is caused by projecting horns from the proto- and metaconids. On the external face the cingulum extends from the postero-external base of the protoconid and continues around the hypoconid, terminating in the posterior basal heel.[32] There is no cingulum on the external face of the protoconid, nor on the internal face of the inferior molars.

The proto- and metaconids of $M_{\overline{3}}$ are very little worn, so that the separation is still present, but it is reduced to a very narrow and shallow fissure on account of the

[32] In my preliminary notes on (*Dinochœrus*) *Dinohyus hollandi*, Science, Vol. XXII, p. 212. 1905, I made the statement that "There is no cingulum on the inferior molars," which is incorrect.

transverse development of the tubercles. The fissure which corresponds to that described on the anterior face of M_2 is present on $M_{\overline{3}}$ but is entirely closed in by the lateral horns of the proto- and metaconids. There are slight cingula on the antero-external angles and the external face of the hypoconid is surrounded by a heavy mammillated cingulum. Posteriorly there is a heavy basal ledge and a minute hypoconulid which is located at the base (posteriorly), between the hypo- and entoconids. One of the more significant characters of the lower dentition is seen in the relatively greater development of the hypo- and entoconids, which causes the narrowing of the cross-valley between the latter and the anterior tubercles.

There were found in quarry No. 1, the third lower molars of the right and the left rami (Vert. Foss., 1835; 2114), which differ from M_3 in the type of *Dinohyus*, by having the hypoconulid well developed. The cross-valley between the anterior and posterior tubercles is also interrupted externally by a heavy cingulum. The postero-external face of these teeth are otherwise quite smooth, while in *Dinohyus hollandi*, there is a continuous cingulum from the cross-valley to the posterior face of the hypoconid. These teeth may possibly represent another genus, but are inadequate as types.

The molars of *Entelodon* differ from those of *Dinohyus* in having the postero-internal cusp (entoconid), especially on $M_{\overline{2}}$ and $M_{\overline{3}}$ much less developed. The ledge produced by the cingulum on the posterior margin of the crown, which is so prominent in *Dinohyus*, is only very slightly represented in *Entelodon*. The cingula are also better represented on the molars of *Entelodon* than in those of the American genus. The most important feature of the lower dentition is seen in the greater development of the posterior portion of the crown of $M_{\overline{3}}$ in *Dinohyus* than in *Entelodon* which in the former is distinctly more specialized than in the latter genus. This same feature of $M_{\overline{3}}$ is also observed on comparing *Dinohyus* with *Archæotherium*.

MEASUREMENTS.

	Mm.
Length of inferior dentition	465
" from median incisor to $M_{\overline{1}}$	325
" of molar series	137
Antero-posterior diameter of $I_{\overline{1}}$	16
Transverse " " $I_{\overline{1}}$	12
Antero-posterior " " $I_{\overline{2}}$	25
Transverse " " $I_{\overline{2}}$	19
Antero-posterior " " $I_{\overline{3}}$ at the base of crown	34
Transverse " " $I_{\overline{3}}$ " " "	27
Antero-posterior " of canine " " "	48
Transverse " " " " "	45

Antero-posterior diameter of $P_{\overline{1}}$ at the base of crown	38
Transverse " " $P_{\overline{1}}$ " " "	21
Antero-posterior " " $P_{\overline{2}}$ " " "	40
Transverse " " $P_{\overline{2}}$ " " "	21
Antero-posterior " " $P_{\overline{3}}$ " " "	54
Transverse " " $P_{\overline{3}}$ " " "	28
Antero-posterior " " $P_{\overline{4}}$ " " "	45
Transverse " " $P_{\overline{4}}$ " " "	28
Antero-posterior " " $M_{\overline{1}}$ " " "	42
Transverse " " $M_{\overline{1}}$ " " "	34
Antero-posterior " " $M_{\overline{2}}$ " " "	47
Transverse " " $M_{\overline{2}}$ " " "	40
Antero-posterior " " $M_{\overline{3}}$ " " "	50
Transverse " " $M_{\overline{3}}$ " " "	39

The Milk Dentition.

(Plate LIX.)

In section 12, block 66 (see Plan of Quarry, Pl. LIV), were found the remains (No. 2137, Carn. Mus. Cat. Vert. Foss.) of the skull, and close by in another block, a portion of the lower jaw of a young individual, with the dentition partly in place. An incisor is represented only by the crown ; the tooth being too young for the formation of a fang. This incisor is pressed by the matrix close to the canine and has a simple conical crown slightly crinkled at the base and it is very thinly covered by enamel. The only noticeable difference between this tooth and more adult forms of the canine is its strongly serrated anterior and posterior ridges and the crinkled enamel. By excavating the alveolar border at the antero-internal angle of the deciduous canine the crown of the permanent canine was found.

The point of the crown of the permanent $P^{\underline{1}}$ appears in the circular alveolus immediately back of the canine. It is thus seen that the temporary $P^{\underline{1}}$ had a single fang and was crowded out quite early. Professor Scott has also (**87,** p. 276) pointed out a similar occurrence observed by him in a young specimen of *Archæotherium* which would tend to firmly establish the fact that there are four deciduous premolars in the upper jaw of at least two genera of this family. Deciduous $P^{\underline{2}}$ of the specimen under description is represented only by the alveolus, while the deciduous $P^{\underline{3}}$ is in position in the right maxillary and $P^{\underline{4}}$ again represented by alveoli. In the left jaw temporary $P^{\underline{4}}$ has been placed in position. Deciduous $P^{\underline{3}}$ of this specimen has two large cusps and two smaller tubercles. The anterior cusp (protocone) is a bluntly pointed pyramid which occupies the anterior half of the crown, while the postero-internal cusp (tetartocone) is smaller, and is confined to about one quarter of the tooth at its postero-internal portion. The two small cusps are nearly on a direct transverse line and immediately external to the tetartocone. Anteriorly and posteriorly there are very heavy cingula; externally and internally the cingulum is only moderately developed. The deciduous $P^{\underline{1}}$ was found quite close to its position and there is comparatively little, or no doubt, that this tooth belongs with this specimen. The tooth is molariform, as in the Oligocene genus (**87**, p. 287). It is strikingly similar to $M^{\underline{3}}$ of the permanent series, but has the antero-external portion of the cingulum developed into a more decided cusp.[33] Anteriorly there are three cusps on the crown: one internal, one external, and one directly anterior. The two former are of equal size, while the latter is quite small and occupies the anterior exit of the longitudinal valley. Posteriorly there are two subequal cusps which are separated from the anterior cusps by a deep cross-valley. The tooth is nearly surrounded by a cingulum.

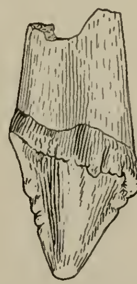

FIG. 32. Supposed Deciduous Upper First Premolar. Nat. size. (Carn. Mus. Cat. Vert. Foss., No. 2127.)

The chief feature of the maxillary bone is its comparatively short antero-posterior diameter. The premolar series is set closer together in the alveolar border than is the case in the adult; the preorbital foramen, however, seems to occupy the same relative position as in the latter. The palatine plate is quite thick, but its transverse diameter is small.

The milk dentition of the lower jaw is represented only by the last molar (No. 2137A, Carn. Mus. Cat. Vert. Foss.). The crown of this tooth is composed as usual of three transverse pairs of cusps and a small talon developed by the cingulum on the posterior face. The tooth is very long and narrow with broad transverse valleys separating each pair of tubercles, while the longitudinal valley is much less distinct. The crown is supported by two strong fangs which are bifurcated near their lower extremities. The posterior portion of a lower jaw (No. 2137A, Carn. Mus. Cat. Vert. Foss.) was found near the tooth described above and undoubtedly belongs to it. In this mandibular fragment the posterior alveolus for $dP_{\overline{1}}$ is still preserved, and into this the tooth referred to fits quite perfectly and is regarded by the writer as belonging to the same individual (see Pl. LIX, fig. 3). When the jaw is excavated from the inner side back of the last milk-molar there is seen the complete crown of $M_{\overline{1}}$, and only the anterior portion of $M_{\overline{2}}$. The crown of $M_{\overline{1}}$ is directed upward in the usual way, while that of $M_{\overline{2}}$ is directly inward, and would have to rotate outward and upward in order to erupt through the alveolar border in the usual manner. As is seen from the illustration (Pl. LIX, fig. 3) the two anterior

[33] Professor Scott evidently mistook the anterior part of the tooth he described for the posterior portion (*l. c.*, p. 276)

cusps of $M_{\overline{2}}$ are well united and apparently not developed independently, as in young titanotheres.[34] The posterior portion of $M_{\overline{1}}$ is not represented at all, as the tooth is too young.

The jaw fragment was somewhat worn by the elements before it was finally imbedded in the bone-bearing layer of the quarry. The coronoid process is, however, complete, and is low and broad antero-posteriorly. The condyle is on a horizontal line with the alveolar border and the angle is seen to project quite strongly downward below the ventral border of the jaw. The dental foramen is very large and is situated immediately in front of, and below, the condyle. The temporal fossa is high and very shallow.

An isolated upper tooth, which was found in the Agate Spring Fossil Quarries (Quarry No. 1) by Mr. Harold J. Cook and presented to the writer for publication, appears to be a deciduous upper premolar ($dP^{\underline{3}}$) of the right side (fig. 33). This tooth is surprisingly similar to an upper tooth of a carnivore (canid) and was so regarded by the writer for some time. Dr. W. D. Matthew kindly made a systematic comparison with the material in the large collection of the American Museum and suggested that it was perhaps a deciduous tooth of an Entelodont. The additional material secured in the Agate Spring Quarries during the season of 1908 enables us to correctly determine this tooth and it is here illustrated in order to assist the student. The chief peculiarity of this tooth is that instead of having three cusps on the posterior portion of the crown, as the tooth described above, it has only two, and in this respect agrees better with the tooth of *Archæotherium* described by Scott (**87**, p. 276). The portion of the posterior root which remains unbroken is abruptly pointed and short, having characters one would expect to find in a milk-tooth.

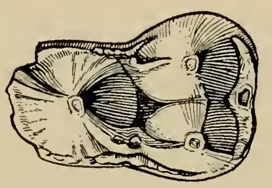

Fig. 33. Crown View of Deciduous P^3 Left Side, *Dinohyus hollandi*. Nat. size. (Harold Cook's Collection.)

Measurements.

	Mm.
Great diameter of the crown	43
Diameter across the paired tubercles	27

The Skull.

(Plates LV–LVIII.)

The orbits in the cranium of *Dinohyus* are so placed that the eye looked directly forward in an unusual manner (see Plates LVI, LX, and LXI). The eye is located

[34] Hatcher, Annals Carnegie Museum, Vol. 1, pp. 260–261, 1901.

well back in the skull, the face is very long, and the brain-case short. There is a well developed sagittal crest, and an overhanging occiput.[35] The descending broad and thin plate below the orbit is quite small when compared with some Oligocene species, and the zygomatic process of the jugal terminates in a heavy buttress, which forms the anterior border of the glenoid cavity. The comparatively gentle downward sweep of the angle of the lower jaw and the relatively small process on the ventral border of the chin are other features of importance.

The base of the skull has received considerable injury by crushing, and the sutures are entirely closed, but the character of the different bones are generally similar to, and agree quite closely with, the descriptions of those of the American Entelodonts given by Professors Leidy (**44**, pp. 57–67), Scott (**87**, pp. 278–287), and others. The basioccipital is short, slightly keeled ventrally, and has a rough area at its junction with the basisphenoid. The condylar foramen is of considerable size, and, as in *A. mortoni*, is placed some distance in front of the condyle. The exoccipital has a great transverse diameter at the base of the occiput and narrows rapidly superiorly. The condyles are well separated by broad notches superiorly and inferiorly, and their transverse diameters are a little less than three-fifths greater than the vertical, which agrees better with the American species than with *Entelodon magnum* of Europe. The foramen magnum is transversely oblong in a greater degree than is the case in the Princeton specimen, but this may in part be due to crushing. The paroccipital process is quite heavy, trihedral in cross-section, and terminates in a truncated and rugose free end; its position is similar to that in *Archæotherium mortoni* figured by Professor Scott (**87**, Pl. XVIII, fig. 2), but apparently relatively shorter.

The stylomastoid foramen and the pit for the tympano-hyal occupy apparently the same relative positions as in the Oligocene genus (see Pl. LVII), *i. e.*, anterior and external to the condylar foramen. The superior wing-like processes of the supra-occipital are crushed laterally, but I judge that in their normal condition they assume characters similar to the American forms generally. The basisphenoid, as in *Archæotherium ingens*, is narrow and not keeled ventrally. There is a canal in the median line, just at the point where the basisphenoid is concealed by the union of the palatines and pterygoids; this is also present in *A. mortoni* and has been figured by Scott (*l. c.*, Pl. XVIII, fig. 1). Whether or not there was a tympanic bulla in *Dinohyus* cannot be determined from the material at hand.[36] The pterygoids are much compressed laterally, but they extend well down and terminate in short and backwardly directed hamular processes. The foramen ovale is of considerable size and occupies

[35] This overhanging of the occiput in the type is due, to some extent, to crushing.

[36] In a well preserved skull of *Dinohyus hollandi* collected in the Agate Spring Quarries (University Hill Quarry) by Professor Barbour in 1908, there are no tympanic bullæ.

practically the same position as in the Oligocene genus, *i. e.*, just lateral to the ridge of the alisphenoid which leads to the pterygoids. The skull is distorted in this region, so that the peculiar conditions of the pterygoids, which Professor Scott describes (**87**, p. 283), cannot be ascertained from this specimen. The parietals extend well down on the side of the cranium and terminate superiorly in the high and sharp sagittal crest, which is rounded from before backward in a manner similar to what is observed in some other American forms. The sutural contact between the frontal, supraoccipital, and the squamosal is entirely obliterated. The frontals are very broad and much inflated over the orbits, terminating laterally in a heavy process, which meets its fellow of the jugal; the two are well coössified and form a heavy vertical bar, which completely encloses the orbit posteriorly. The orbit is of large size and faces forward and slightly outward. Immediately in front of the sagittal crest is a broad canal, which extends obliquely upward and backward, apparently piercing the cranial wall (see Pl. LVI). The exit of this canal leads into a depression on the frontals, which is of considerable depth and triangular in outline. This depression extends outward laterally by means of two large grooves, one on either side, running parallel with the temporal ridges, and by means of a broad anterior groove, which is continuous with the depressed median area of the frontals. On account of the enormous inflation of the frontals over the orbit and the great lateral extent of the postorbital process the eye was placed lower down and had a more direct forward look than in the older types of this family (see Pls. LV, LVI).

The zygomatic process of the squamosal has an enormous development, which seems to be relatively quite as great, if not greater, than is the case in the earlier forms. The lambdoidal crest descends steeply to a point immediately above the base of the paroccipital process; the border of the arch then rises again to form a broad, thin process similar to that in *Sus*, the peccary, and other ungulates. Anteriorly the zygomatic process forms the sutural contact with the jugal at the base of the orbital process. The temporal fossa thus has a tremendous transverse diameter, which is one of the chief characteristics of the cranium in this family. The glenoid cavity is well defined and its anterior border is provided with a strong buttress (the zygomatic process of the jugal referred to above), which seems to be a mark of evengreater specialization in this genus, than in the John Day forms, and has already been referred to in previous papers (**81**, pp. 49–51).

The jugal, as has been stated by Marsh, Scott, and others, constitutes one of the most extraordinary features of the skull in this family. Anteriorly the jugal extends but little on the side of the face, uniting by suture with the maxillary and the lachrymal. In its backward extension the upper margin forms the lower half of the border of the orbit, and the lower margin descends rapidly to form the dependent, broad, and laterally compressed process, which is in *Dinohyus* considerably smaller than is the case in many earlier species. This anomalous process is directed slightly outward as well as downward, and no doubt varies in shape in different species, if not in different individuals; at all events this appears to be true of the Oligocene forms.[37] Superiorly the jugal sends out a postorbital process, which is coössified with that of the frontal, as stated above and the posterior process is received by the zygomatic process of the squamosal (see Pl. LV).

The lachrymal covers a considerable portion of the side of the face and articulates anteriorly with the maxillary, superiorly with the frontal, not with the nasal, and inferiorly with the jugal. The bone supplies a portion of the anterior border of the orbit. The lachrymal tubercle is quiet prominent.

The long and slender nasals articulate superiorly with the spear-shaped processes of the frontals, and laterally with the maxillaries and the premaxillaries. At their junction with the frontals the median area of the nasals is very convex transversely and on the sides of the muzzle the nasals have a slight inward bend to accommodate them to the concave sweep of the muzzle in front of the orbits. More anteriorly the nasals are regularly convex from side to side and gradually decrease in width; their anterior ends are slightly damaged in the type, but it is seen that their free ends are slightly separated in the median line, and also that they projected slightly beyond the superior border of the premaxillaries.

The premaxillaries are more truncated anteriorly than in the known Oligocene forms. This causes the reduction of the median pair of incisors stated above, and the anterior border ascends slightly more rapidly than in the earlier forms. Superiorly the premaxillaries have a long contact with the nasals and posteriorly they are received by the oblique border of the maxillaries. The premaxillaries are of large size, but are relatively smaller than those in *Hippopotamus* and *Sus*. The incisive foramina are large and the palatine processes of the premaxillaries are only thin bony bridges, which are suturally connected in the median line, and extend back opposite the posterior portion of the canine.

The maxillaries have a great antero-posterior diameter and the sides of the long and comparatively narrow muzzle are largely made up of these bones, although the lachrymal and the jugal cover a considerable space. The alveolar border forms an almost straight antero-posterior line until the canine is reached; at this point the maxillary has a rapid outward curve to accommodate the root for the large canine. The maxillo-premaxillary suture is somewhat short in comparison with that in older

[37] These processes are present in all of the American species, of which complete material, representing this portion of the skull, has been found.

forms. The infraorbital foramen is above the posterior part of P^3. The palatine plates are comparatively narrow transversely and have a considerable concavity in the same direction.

In the region of the palatines the skull is much crushed and the sutures are entirely obliterated, so that the outlines cannot be traced. The posterior nares are long and narrow, and extend anteriorly to opposite the anterior portion of M^3.

From Kowalevsky's illustrations (**38,** Plates XVI; XVII, fig. 5) it is evident that the base of the skull and the occiput in *Entelodon* is quite different from what is observed in the American forms. Judging from Kowalevsky's figures, the occipital condyle in the European form has a much greater vertical diameter in proportion to its transverse, the region of the paroccipital process extends further below the condyle, and the process itself is different in shape, being more compressed antero-posteriorly, expanded transversely, projecting well downward, and terminating in a rounded point. The base of the zygomatic process of the squamosal is in contact with the paroccipital process not unlike what is seen in *Sus* (See fig. 2 on page 45). The anterior face of the paroccipital process (see Kowalevsky, Pl. XVI), where we should expect to find the solidly fused region between the base of the paroccipital process and the postglenoid similar to that in the American Entelodonts, shows a remarkable similarity to what is seen in *Sus*, and it would not be surprising to find the external auditory meatus situated higher up on the cranium in *Entelodon* than is the case in the American species. In examining the posterior view of the skull of *Entelodon* (*l. c.*, Pl. XVII, fig. 5) it is at once observed that the summit of the supraoccipital is greatly expanded and again much contracted midway between the top and the condyles, and on either side of the median line is a long and narrow excavation, which is not present in the American forms. Another similarity to *Sus*, and also to some extent to *Hippopotamus*, is seen on the superior border of the foramen magnum, where the continuation of the supraoccipital sends down two blunt projections, which impart an irregular upper border to the foramen. This latter feature does not appear in the American forms.

The mandible is much elongated to conform with the extremely long muzzle. The horizontal ramus is, as in the Oligocene forms, nearly straight, and is characterized by considerable depth and thickness. The inferior border has one large knob-like tubercle in the middle region beneath $P_{\overline{4}}$ and $M_{\overline{1}}$, and only a trace of a tubercle opposite the posterior face of the symphysis. The angle is also extended below the horizontal line of the inferior border, but not to the extent seen in some earlier forms. These knob-like processes which are given off from the ventral border of the mandible are proportionally small, especially the anterior pair, when compared with some of the large species (*Pelonax ramosum*) from the upper Oligocene. In the latter form these knobs on the lower jaws are particularly long and heavy, indicating with other peculiarities a diverging line at that time. In *Dinohyus* the alveolar border has a rapid outward turn at the canine to accommodate the enormous root of that tooth. The chin is square and the symphysis shows no mark of division between the two rami. There are two mental foramina: the anterior, which is the larger, is situated below P^1; and the posterior below P_2. The ascending rami are low and rapidly flare outward in order to meet the widely separated glenoid cavities of the squamosals, which is a peculiarity most nearly approaching what is observed in *Hippopotamus*. The condyles are greatly convex antero-posteriorly and their transverse diameter is considerable; they are only very slightly elevated above the alveolar border. The coronoid process is low, but broad, and its free end terminates in an enlarged truncated rugosity. The temporal fossa is deep and extends across nearly the entire antero-posterior face of the ascending ramus, but does not reach very low; its inferior border is developed into a heavy ridge, which unites with the base of the condyle externally. The dental foramen is of rather small size and is a little posterior to the middle antero-posterior diameter of the sigmoid notch and on a level with the alveolar border.

The hyoidean arch of *Dinohyus hollandi* is represented by a number of fragments and three very nearly complete bones, the stylohyoid and both ceratohyals.

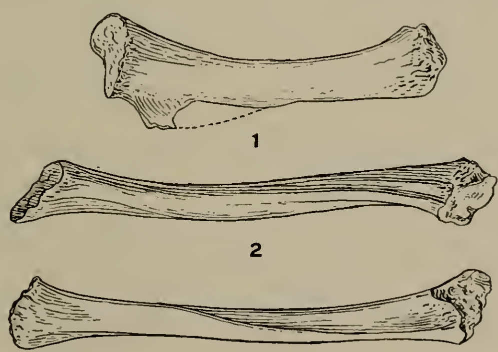

FIG. 34. (1) Inner View of Right Ceratohyal; (2) Inner View of Stylohyal; (3) External View of Stylohyal. Belonging to type of *D. hollandi* Peterson. Nat. Size. (Carn. Mus. Cat. Vert. Foss., No. 1594.)

The different bones appear to be of somewhat smaller proportions than in *Archæotherium ingens* described by Professor Scott. The shaft of the stylohyoid is a sinuous rod with prominent and spiral ridges (of which one extends the entire length of the shaft) and expanded upper and lower ends. The upper half of the shaft is trihedral in cross-section, while the lower half is subcylindrical. In *Archæotherium*, according to Scott (**87**, p. 286), the upper portion of the shaft is compressed laterally and has a more oval section lower down. The cerato-hyal is shorter than the stylohyoid in about the same proportion as in *Archæotherium.* The proximal end is expanded and cup-shaped, and immediately below the enlarged end the shaft becomes quite thin transversely, but broad antero-posteriorly. The lower half of the shaft is still more oval in section and terminates in an enlarged end for cartilaginous attachments. The bone as a whole is very like that in *Archæotherium.*

MEASUREMENTS.

	Mm.
Greatest length of skull	883
Distance from postorbital process of jugal to and including premaxillaries	528
" " " " " " " " " occipital condyle	305
Length of alveolar border of maxillary and premaxillary	465
Distance from median incisor to M^1	330
Greatest transverse diameter of condyles	165
Vertical diameter of condyle	56
Greatest transverse diameter of skull, approximately	580
Transverse diameter of muzzle in front of orbits, approximately	175
" " " " at P^2	132
Greatest length of mandible	725
Depth of mandible, inferior border of angle to and including condyle	200
" " " at M_3	120
" " " " P_2	100

VERTEBRAL COLUMN.

Atlas. — The atlas, on the whole, is very similar to that of the Oligocene genus. The more important differences are here given. The posterior exit of the vertebrarterial canal is shifted lower down on the posterior face of the transverse process than in *Archæotherium.* In the latter genus the position of this foramen is higher up, or, nearly on the superior face at the base of the transverse process.[38] In *Dinohyus* the facets for the axis are relatively higher and narrower, the cavities for the occipital condyles shallower, the neural canal narrower, and the neural spine somewhat more prominent than in *Archæotherium.* The transverse process does not project backward nearly as much as in the Princeton specimen, and consequently gives to the atlas of the latter a relatively greater total antero-posterior diameter.

Axis. — The axis of *Dinohyus* differs from that of *Archæotherium* in having the

[38] In a specimen (No. 1665) of the Carnegie Museum collection, from the *Titanotherium* beds, Sand Creek, Sioux Co., Nebraska, this foramen is placed lower down than in the Princeton specimen.

articular facets for the atlas more wedge-shaped; the facets are also of relatively less transverse and greater vertical [39] diameter, and the transverse process is heavier. This enlargement of the transverse process is especially noticeable at the superior

Fig. 35. Anterior and Superior Views of Atlas of *D. hollandi* Peterson. ¼ nat. size.

base over the posterior exit of the vertebrarterial canal where there is a blunt and rugose tubercle. The well defined ridge, which extends backward from the odontoid process along the floor of the neural canal in *Archæotherium*, is in *Dinohyus*

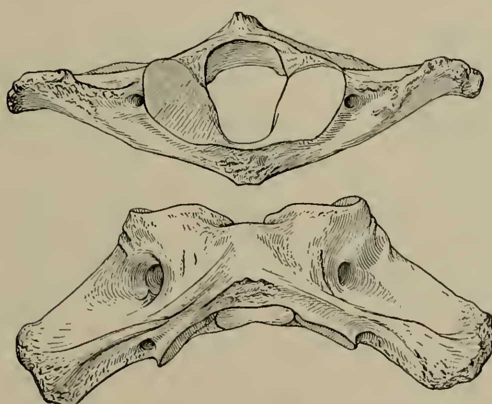

Fig. 36. Posterior and Inferior Views of Atlas of *D. hollandi* Peterson. ¼ nat. size.

converted into a broad rounded surface, which slopes backward and is interrupted by a rough ridge, which extends across the entire floor of the neural canal some

[39] The vertical diameter seems to have developed superiorly, as the ventral projection is of about the same proportion as in *Archæotherium*.

distance back of the odontoid process. Back of this ridge is a transverse excavation, 8 or 10 mm. in antero-posterior diameter, which is again succeeded by an elevated area along the posterior portion of the floor of the neural canal. As in

FIG. 37. Lateral, Posterior, and Anterior Views of Axis of *D. hollandi*. ¼ nat. size.

Archæotherium, the pedicles of the neural arches are not pierced by foramina for the passage of the second pair of spinal nerves. These canals are more lateral and are bridged over superiorly by heavy arms of the transverse processes which unite with the sides of the pedicles.

Third Cervical. — The third cervical vertebra differs from that in *Archæotherium* (**87**, p. 290) by having a proportionally much less developed neural spine, a sharper inferior keel, and the bony bridge, which bounds the vertebrarterial canal externally,

FIG. 38. Lateral View of Third Cervical of *D. hollandi* Peterson. ¼ nat. size.

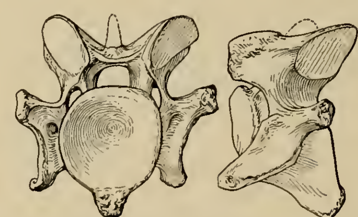

FIG. 39. Posterior and Lateral Views of Fourth Cervical of *D. hollandi* Peterson. ¼ nat. size.

narrower. As Professor Scott has stated (*l. c.*, p. 290) in connection with his study of *Archæotherium*, there are no foramina for the spinal nerve through the anterior portion of the pedicles as in *Sus*.

Fourth Cervical. — The neural spine of this vertebra is damaged, but I infer that, as in the preceding vertebra, it is relatively less developed than in the Oligocene genus. The inferior lamella has a slightly different shape, being more decidedly separated from the diapophysial process and is less developed than in *Archæotherium* (**87**, p. 290). In *Dinohyus* there are deep excavations on the inferior side of the base of the diapophyses, which are scarcely indicated in the Princeton specimen. The diapophyses are fully as well developed as in *Archæotherium,* and the inferior keel is sharper than in the latter genus.

Fifth Cervical. — As in the preceding vertebra, the neural spine is lost. The centrum is relatively much more opisthocœlous, and the inferior lamella is slightly less developed and less everted than in *Archæotherium.* The inferior keel is sharp

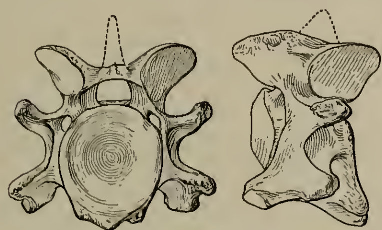

FIG 40. Posterior and Lateral Views of Fifth Cervical of *D. hollandi* Peterson. ¼ nat. size.

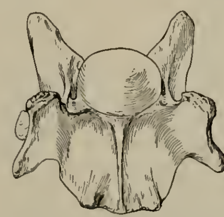

FIG. 41. Inferior View of Fifth Cervical of *D. hollandi* Peterson. ¼ nat. size.

and continues to the postero-inferior border of the centrum, where a blunt tubercle is located on either side of the median keel. In *Archæotherium* the keel is heavier and it terminates posteriorly in a heavy rugose mass, which indicates a relatively

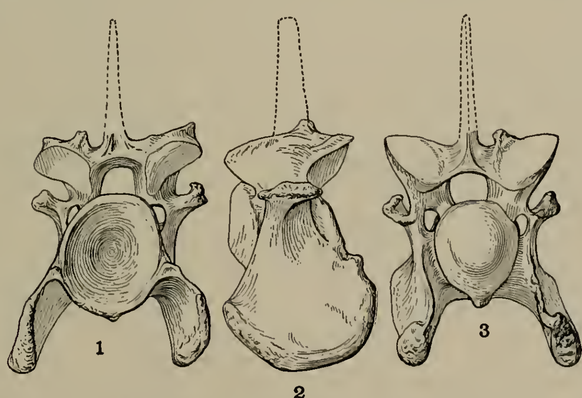

FIG. 42. Posterior (1), Lateral (2), and Anterior (3) Views of the Sixth Cervical of *D. hollandi* Peterson. ¼ nat. size.

heavier attachment for muscles than in the Miocene genus. In the latter genus the diapophyses present a more trihedral section and the ends are less expanded than in *Archæotherium.*

Sixth Cervical. — The base of the neural spine of the sixth cervical vertebra is present, and the size indicates a proportionally less developed process than is the case in the corresponding bone in *Archæotherium.* As in the preceding vertebra, the centrum is relatively more opisthocœlous than in the sixth cervical of the Princeton specimen. The inferior keel is also sharper and terminates in front in a swollen area. The anterior face of the centrum extends down over this area, which adds to the convexity of the centrum in a peculiar manner, quite unusual in most of the Artiodactyla, and is not unlike what is seen in the recent horse. The diapophyses are of about the same proportionate size as in *Archæotherium,* but the inferior lamellæ are relatively more developed, which is remarkable when one bears in mind that the neural spine is relatively less developed, while the neural arch has about the same proportions in both genera.

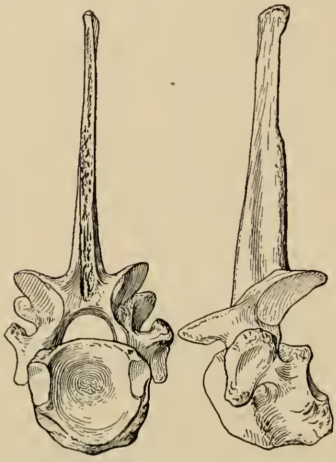

FIG. 43. Posterior and Lateral Views of the Seventh Cervical of *D. hollandi* Peterson. ¼ nat. size.

Seventh Cervical. — As in the preceding vertebræ the neural spine of the seventh cervical vertebra of *Dinohyus* is relatively smaller than in *Archæotherium.* The postzygapophysis is placed higher up than in *Archæotherium,* but is less concave and looks outward more decidedly than in the Oligocene genus. The pedicle is more rounded and the postero-inferior portion of the centrum is proportionally somewhat heavier, and has decided tubercles on either side of the median line, which are absent in *Archæotherium.* The transverse process has the same proportions as in the Princeton specimen, and, as in that specimen, is not perforated by the vertebrarterial canal.

FIG. 44. Inferior View of Seventh Cervical of *D. hollandi* Peterson. ¼ nat. size.

First Dorsal Vertebra. — In the type of *Dinohyus hollandi* there are fourteen dorsal vertebræ which were found in the quarry articulated with one another by their zygapophyses. The first dorsal vertebra is characterized by a long and very heavy neural spine greatly exceeding in length that of the seventh cervical. The neural spine has about the same relative size as in the Princeton specimen, but the postzygapophysis is more distinctly separated from the transverse process by a constricted area, and the centrum is more opisthocœlous. This vertebra is, except in these minor details, quite similar to the corresponding bone in *Archæotherium*.

Second Dorsal Vertebra.—The neural spine of the second dorsal vertebra is higher than that of the first, but not nearly so robust. In relative proportions the spine agrees quite well with that of *Archæotherium*. The vertebra as a whole

FIG. 45. Lateral and Posterior Views of First Dorsal of *D. hollandi* Peterson. ¼ nat. size.

FIG. 46. Lateral View of Second Dorsal of *D. hollandi* Peterson. ¼ nat. size.

FIG. 47. Lateral View of Third Dorsal of *D. hollandi* Peterson. ¼ nat. size.

differs in some important particulars from that of *Archæotherium*, viz.: the vertical diameter of the centrum is relatively greater, owing to the unusual development of the inferior keel; the anterior half of the keel is developed into a heavy and rugose tubercle, which projects well below the anterior face of the centrum; the prezygapophyses nearly meet in the median line, forming a narrow irregular emargination, while in *Archæotherium* they are more widely separated. The posterior face of the centrum is decidedly more concave than in the Oligocene genus. The general outline of the bone, except in the matter of its deeper centrum, is quite similar to that of the Princeton specimen.

Third Dorsal Vertebra.— The tip of the spine of the third dorsal is broken off, but it was evidently as high as that of its predecessor, and only slightly lighter.

FIG. 48. Lateral View of Fourth Dorsal of *D. hollandi* Peterson. ¼ nat. size.

FIG. 49. Lateral View of Fifth Dorsal of *D. hollandi* Peterson. ¼ nat. size.

One of the most important differences between the vertebral column of *Dinohyus* and that of *Archæotherium* is seen in the arrangement of the canals through the sides of the pedicles and the vertical canals through the superior portion of the neural arch, similar to that in *Sus* and *Bison americanus*. In Professor Scott's admirable memoir (**87**, p. 290) it is stated that the pedicles of the neural arch are not perforated by vertical canals as in *Sus*. While this is to a certain extent true, it is seen upon very close scrutiny of the specimen, that some of the dorsals have the vertical as well as the transverse canals present, although they are relatively smaller, are more irregular in their position, and could not have possessed the functional importance which they have in the Miocene genus. Back of the second dorsal in *Dinohyus hollandi* the arrangement of these canals is almost identical with that in *Sus*, the vertical canal being even relatively larger.

The costo-vertebral canals are very narrow but deep excavations, which lead directly into these large horizontal and vertical canals, forming an excellent protection for the spinal nerves. The keel of the centrum is fully as well developed as in the preceding vertebra. In *Archæotherium* the corresponding vertebra has a heavy and rugose area on the anterior half of the keel, but the ventral projection is not nearly so great.

Fourth Dorsal Vertebra. — In *Dinohyus* this vertebra is more nearly like that of the *Archæotherium* skeleton from Princeton than any of the preceding dorsals. The vertical diameter of the centra back of the second dorsal in *Archæotherium* rapidly increases, so that the centrum of the fourth has about the same proportionate diameter as in *Dinohyus*. The arrangement of the foramina through the walls of the neural canal, which are sometimes absent in *Archæotherium ingens*, is the chief character showing a difference between the vertebræ of the two animals.

Fifth Dorsal Vertebra. — The top of the neural spine of the fifth dorsal is complete, but unfortunately the contact is lost at the lower half of the spine. The length of the spine is estimated by a gradual slope from the second to the seventh dorsal vertebræ, which have complete neural spines. The general construction of this bone differs so little from that in *Archæotherium* that a description seems hardly necessary.[40]

Sixth and Seventh Dorsal Vertebræ. — With the exception of the broader and undoubtedly longer neural spine in the sixth dorsal vertebra, the seventh differs very little from it, and the two are so similar to the fifth dorsal that a separate description seems superfluous in this connection. With the exception of the perforations of the transverse processes, the deep median furrow near the base and rugose surfaces on the anterior faces of the neural spines, and the somewhat more sharply keeled centra, there are no differences from the corresponding vertebræ in *Archæotherium* described by Professor Scott.

Eighth Dorsal Vertebra. — This vertebra has no ventral keel on the centrum, it being quite smoothly rounded below, and consequently having a smaller vertical depth than the vertebræ anterior to it. The median furrow or groove on the anterior face of the neural spine extends well up and is still quite deep on the fragment we possess, proving that the spine itself must have attained a consider-

[40] In cleaning off the matrix for a closer examination of the transverse process of the fifth dorsal vertebra in *Archæotherium ingens*, which Professor Scott described, it is found that there is a small foramen on the upper face of the neural arch which is apparently connected with the horizontal canal as in *Sus*.

able length. The tubercular facet for the rib is of large size and concave in the antero-posterior direction. The transverse process is heavy, as is also the upper portion of the neural arch. The pedicle and transverse processes are perforated by the canals referred to above.

Ninth Dorsal Vertebra. — The ninth dorsal is represented only by a portion of the neural spine, half of the neural arch, and the upper third of the centrum of

FIG. 50. Lateral View of Sixth Dorsal of *D. hollandi* Peterson. ¼ nat. size.

FIG. 51. Lateral View of Seventh Dorsal of *D. hollandi* Peterson. ¼ nat. size.

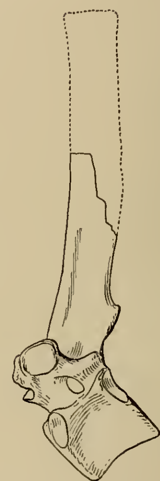

FIG. 52. Lateral View of Eighth Dorsal of *D. hollandi* Peterson. ¼ nat. size.

the left side. The capitular and tubercular facets are only slightly smaller than in the preceding vertebræ. The transverse process is of about the same size, but the perforations are somewhat smaller than in the eighth dorsal vertebra.

Tenth, Eleventh, and Twelfth Dorsal Vertebræ. — The tenth, eleventh, and twelfth dorsal vertebræ are represented only by fragments, but enough remains to supply essential characters. The centra are depressed and apparently have no ventral keels, and the neural spines still continue to have the median groove which extends from the base upward for some distance on the anterior face of the spines. On the tenth dorsal the rib-facets possess considerable size, but they rapidly diminish in the following vertebræ. The neural spines also show a rapid reduction, but the perforations of the pedicle and transverse processes continue to be of large size up to the thirteenth dorsal. There is only a slight suggestion of the metapophysis on the twelfth dorsal vertebra.

Thirteenth Dorsal Vertebra. — In the region of the thirteenth dorsal there is an important change in the dorsal series. The neural spine was still, no doubt, of the dorsal type, but short. The anterior zygapophysis is also of the dorsal type, while the postzygapophysis fits into a nearly typical lumbar articulation of the succeeding vertebra. The transverse process is quite heavy and has an almost flat surface for the tuberculum of the rib. The metapophysial area is divided into three small tubercles and the superior aspect of the transverse process is on the whole very rugose. The vertical perforation is very small and is placed near the anterior margin of the neural arch. The horizontal canal for the transmission of the spinal nerves, which perforates the wall of the neural arch between the posterior capitular and the tubercular facets is of large size. This vertebra appears to correspond most closely with the vertebra described by Professor Scott as the eleventh thoracic vertebra in *Archæotherium ingens* (**87**, p. 293).

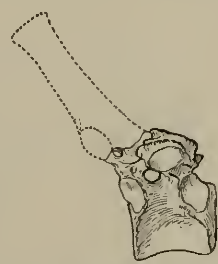

FIG. 53. Lateral View of Thirteenth Dorsal of *D. hollandi* Peterson. ¼ nat. size.

Fourteenth Dorsal Vertebra. — The fourteenth dorsal of *Dinohyus* agrees most closely with the one which Professor Scott regards as the twelfth of *Archæotherium ingens.* In *Dinohyus* this vertebra differs in many important characters from either the twelfth or thirteenth dorsals in the Princeton specimen in which the thirteenth is the last dorsal according to Scott. From both the twelfth and the thirteenth in the latter specimen the fourteenth thoracic vertebra in *Dinohyus* differs in having a very well developed transverse process, a large perforation through the sides of the neural arch back of the capitular facet for the last rib, and the absence of anapophyses. The superior portion of the neural spine is broken off, but its broad antero-posterior aspect indicates that in shape it closely resembled the lumbar vertebræ. The posterior zygapophysis is identical in form with that of the twelfth (thirteenth?)[41] in *Archæotherium.* As Scott has shown in his memoir, page 293, the cross-section of the zygapophyses of the lumbar vertebræ present an S-like outline which causes the development of large episphenial processes. The neural canal is transversely broad, but low. The centrum is well rounded and has no ventral keel or prominent rugosities for muscular attachments. The facet for the last rib is of large size, oval in

[41] The writer is of the opinion that *Archæotherium* from the Oligocene may have had fourteen thoracic (dorsal) vertebræ thus agreeing in its vertebral formula with *Dinohyus.*

outline, and placed in an oblique position. The metapophyses are prominent on this vertebra.

Lumbar Vertebræ. — There are only four lumbar vertebræ represented in the type specimen of *Dinohyus,* but from the fragments at hand it is very plainly shown that the last lumbar has been lost.[42] There are in the splendidly preserved speci-

Fig. 54. Anterior, Inferior, and Lateral Views of Fourteenth Dorsal of *D. hollandi* Peterson. ¼ nat. size.

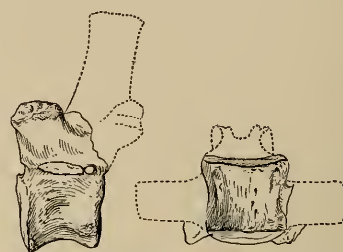

Fig. 55. Lateral and Inferior Views of First Lumbar of *D. hollandi* Peterson. ¼ nat. size.

men of *Archæotherium* in the Princeton collection, six lumbar vertebræ, which undoubtedly also must have been the number in the genus *Dinohyus.* This arrangement is thought to be correct in view of the evidence at hand from the Miocene and Oligocene genera and also from the fact that in *Sus scrofa* and the *Pecora* there are sometimes twenty thoraco-lumbar vertebræ: fourteen dorsals and six lumbars.

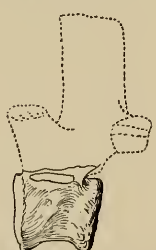

Fig. 56. Lateral View of Second Lumbar of *D. hollandi* Peterson. ¼ nat. size.

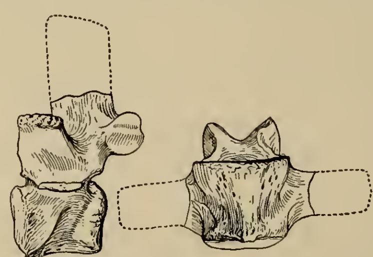

Fig. 57. Lateral and Inferior Views of Third Lumbar of *D. hollandi* Peterson. ¼ nat. size.

The centra of the four lumbar vertebræ preserved in the type are all present and in two instances portions of the arches and of the zygapophyses are also present. The neural spines and the transverse processes were unfortunately all lost in the proc-

[42] In the spring of 1905, the fragments of the lumbar vertebræ, the sacrum and a portion of the pubic symphysis of the pelvis was found by the writer on the edge of the quarry. These parts were dug out during the excavation in quarry No. 1, in the fall of 1904, by Mr. Cook and his assistants.

ess of collecting.[43] The neural spines are, however, restored from another specimen (No. 2193B) collected in the Agate Spring Quarries (Quarry No. 1) in 1908 and their shape (see Plates LX, LXI) is thought to be nearly correct. The centra in the anterior portion of the series are somewhat different from those in *Archæotherium*, having a transversely broader aspect ventrally and a very rugose surface on the sides. Posteriorly the centra become more depressed and the rugosities on the sides are divided into an anterior and a posterior area by a decidedly broad and shallow groove, extending obliquely from the posterior intervertebral notch to the ventral portion of the centrum, where it fades away, leaving a sharp ridge on the anterior margin of the exit of the groove. The neural arch of the first lumbar vertebra is pierced by a canal immediately posterior to the base of the transverse process. On the second lumbar is a similar canal on the right, while on the left side there is no canal present.

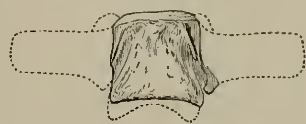

FIG. 58 Inferior View of Fifth Lumbar of *D. hollandi* Peterson. ½ nat. size.

In another specimen (No. 2126, Carn. Mus. Cat. Vert. Foss.) of *Dinohyus hollandi* is a last lumbar vertebra which approximates the proper size of the type specimen. This vertebra presents some interesting differences from the corresponding bone in the Princeton specimen. Of these differences the more important ones are: the proportionately lighter postzygapophyses and the much heavier transverse processes in *Dinohyus;* the enlarged transverse process of the last sacral vertebra in *Dinohyus*, which is due in a great measure to the heavy and rugose posterior border, somewhat after the analogy of some of the *Perissodactyla* (*Equus*). In the last lumbar

FIG. 59. Posterior, Lateral and Anterior Views of Sixth Lumbar of *D. hollandi* Peterson. ½ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 2126.)

vertebra of *Archæotherium ingens* the transverse process has in its posterior border near its base a small and rugose tubercle, which apparently had a tendency to meet

[43] A series of four posterior lumbar vertebræ (No. 2139B) was found in quarry No. 1 during the last (1908) season which furnishes some additional information. There were one and most probably two additional lumbar vertebræ in front of this series, judging from the absence of vertebræ with no perforations of the neural arches as in the first and second lumbars of the type and also from the characters of the fourteenth dorsal, which is present in this series.

a corresponding surface on the anterior face of the pleurapophysis of the first sacral vertebra and is somewhat similar to what is found in *Hippopotamus*. The transverse process of the last lumbar vertebra in *Archæotherium* is otherwise quite light, as is the case in all the preceding lumbar vertebræ. In the specimen under description the heavy posterior border of the transverse process of the vertebra does not come in contact with the anterior face of the pleurapophysis of the first sacral, but had a cartilaginous attachment with the ilium. The neural spine has a vertical position and its anterior and posterior borders gradually taper from the base of the spine to the summit. The latter is rounded, slightly enlarged, and rugose. The neural canal is broad, but low, and its floor is occupied in the median line by a heavy ridge, which extends antero-posteriorly the entire length of the superior face of the centrum. The centrum is depressed, but possesses a considerable transverse diameter; its posterior face is larger than its anterior. The prezygapophyses have prominent surfaces for the episphenial processes of the vertebra in advance of it, and these processes of the postzygapophyses are also quite prominent.

Sacrum.—The sacrum is composed of three well coössified vertebræ.[44] The centrum of the first sacral vertebra is quite large, but the succeeding two rapidly

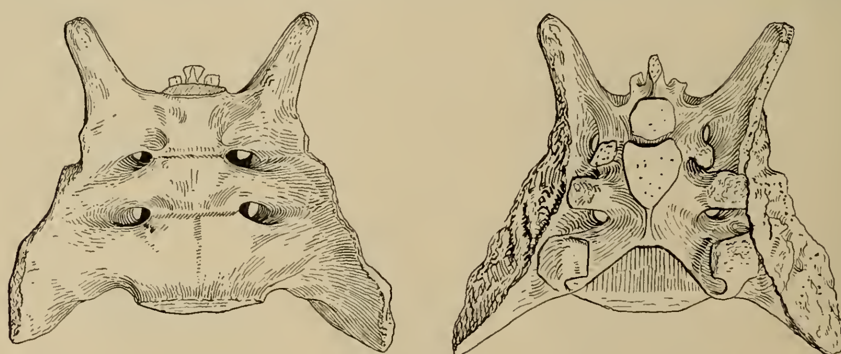

FIG. 60. Inferior and Superior Views of Sacrum of *D. hollandi* Peterson. $\frac{3}{8}$ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 2126.)

decrease in size, so that the posterior face of the centrum of the last vertebra has the transverse diameter less than one half of the anterior face of the first sacral. The pleurapophyses, which are very heavy on the first sacral, decrease in the posterior sacrals as rapidly as the centra. Unfortunately the neural spines are lost,

[44] In examining the sacrum of the Princeton specimen, *Archæotherium ingens*, No. 10885, it is seen that on its ventral face there are three distinct centra, which are very firmly coössified. Professor Scott (87, p. 294) mistook the two posterior centra of this sacrum for one only.

but their bases indicate that they were coössified so as to form one solid spine. The neural canal is of considerable size and its outline anteriorly is subtriangular; it diminishes rapidly backward agreeing in its diameter with all the other measurements of the sacrum. The chief differences revealed by the sacrum of *Dinohyus* when compared with that of *Archæotherium* are the relatively smaller antero-posterior and transverse diameters of the centrum, the actual measurements of length and breadth in the former being only very little greater than those of the latter genus, notwithstanding the smaller size of *Archæotherium*. The vertical diameter of the anterior face of the centrum more nearly corresponds to that of the Oligocene genus. The prezygapophyses have, as in *Archæotherium*, the additional articular surfaces for the episphenial processes of the last lumbar vertebra.

From material acquired in 1908 I am able to give complete illustrations (see figs. 60 – 62) and also to more fully describe parts of the sacrum, which are partially or wholly lost in the type specimen.

The reduced diameter, especially the antero-posterior, of the centra in the sacrum observed in the type specimen of *Dinohyus hollandi* is repeated in other individuals. In No. 2126 (Carn. Mus. Cat. Vert. Foss.) there is a complete sacrum (see figs. 60–62) and its measurements agree quite closely with those of the type.

FIG. 61. Anterior and Posterior Views of Sacrum of *D. hollandi* Peterson. ⅜ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 2126.)

Anteriorly the neural canal, which is triangular in outline, is of large size and rapidly decreases posteriorly. All the sacral foramina are of large size. The two anterior spinous processes are very heavy and quite solidly coössified, except at their extremities,[45] which are slightly separated and also greatly enlarged. The spine of the

[45] In a smaller though older specimen (No. 2139) the summit of the spines is solidly coössified and much expanded laterally.

last sacral vertebra is entirely free from those in front of it and all of its diameters, though of considerable size, are much reduced, when compared with the heavy spines of the first two vertebræ. The postzygapophyses are quite well developed and bear distinct articular facets for the prezygapophyses of the first caudal vertebræ. The posterior extension of the pleurapophyses exhibits a free area back of the iliac con-

FIG. 62. Lateral View of Sacrum of *D. hollandi* Peterson. $\frac{3}{8}$ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 2126.)

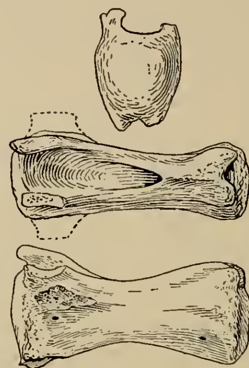

FIG. 63. Anterior, Superior and Inferior Views of Caudal from about the Middle of the Tail of *D. hollandi* Peterson. $\frac{2}{3}$ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 2135.)

FIG. 64. Superior and Lateral Views of Posterior Caudal of *D. hollandi* Peterson. $\frac{2}{3}$ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 1823.)

tact which is fully as large if not larger than is the case in *Archæotherium ingens* (see fig. 62).

Caudal Vertebræ. — The caudal vertebræ of the type of *Dinohyus* are not present. From several isolated bones found scattered throughout the bone-bearing layer of the quarry and also from a vertebra (No. 2135) found in the same horizon north of the Niobrara River, it is plain that the tail was of practically the same proportionate length as that of the Oligocene genus. Cuts of this bone and of one of the posterior bones of the tail found in quarry No. 1 are here given (figs. 63 and 64).

RIBS.

The ribs on both sides (especially the ones in the anterior portion of the thoracic cavity) are well represented in the type of *Dinohyus hollandi*. The first rib is somewhat sub-cylindrical proximally and broadens almost immediately below the head, while in *Archæotherium ingens* it continues rod-like to a greater distance distally and flares out more suddenly at the ventral end. In the anterior portion of the series the ribs are broad, with compressed sessile heads, and large tubercles, which are separated from the heads by deep cavities in the same manner as in *Archæotherium*. The fragments of the posterior ribs indicate that they were perhaps proportionately

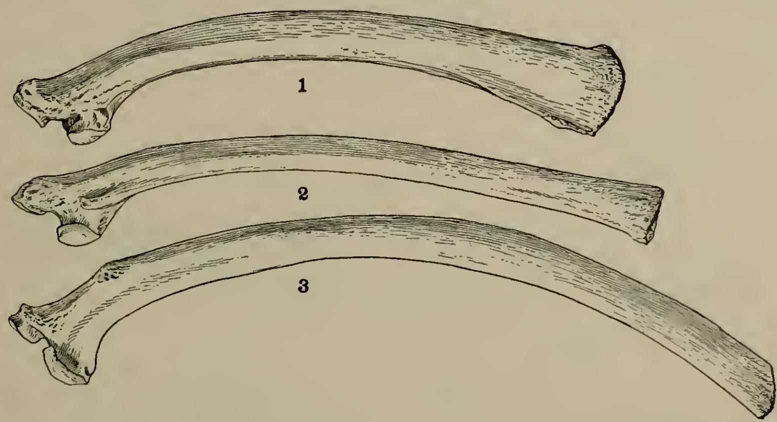

FIG. 65. (1) First Rib; (2) Second Rib; (3) Fifth Rib. From type of *D. hollandi* Peterson. ¼ nat. size.

broader than those in *Archæotherium*. In their relative lengths the ribs are not unlike those of the Oligocene genus, those behind being relatively perhaps somewhat longer.

STERNUM.

There are six sternebræ present in the type. The structure of the sternum is unique and can hardly be compared with that of the Suidæ. The presternum has an unusual vertical diameter, it is compressed transversely and the side view presents an irregular and curious outline.

The superior border of the presternum is slightly concave and terminates in front in a heavy and rugose tubercle; anteriorly the bone is strongly emarginate, producing the superior tubercle which has just been mentioned and an additional, larger, inferior tubercle (see No. 1 in fig. 66). Ventrally the bone again has an emarginate border which terminates posteriorly in a rapidly expanded, truncated, and very rugose process. The contact for the succeeding segment continues, from the truncated process mentioned, obliquely forward and upward and terminates in a slightly enlarged area which forms the contact for the second pair of ribs. The attachments for the first pair of ribs are situated on the lower half of the bone, nearer the anterior than the posterior border. In *Archæotherium ingens* the presternum has the same general outline as in *Dinohyus*, but the borders, especially the anterior, are less emarginate, which gives to the manubrium of the former genus a less striking appearance.

The first segment of the mesosternum has a curious structure. It is compressed laterally and its vertical is much greater than its antero-posterior diameter. The side view shows a Œ-shaped outline with the straight border behind. The segment is expanded on its borders, those behind being the heaviest. The antero-posterior

Fig. 66. (1) Lateral View of Sternum. (2) Inferior View of Sternum. Type of *D. hollandi* Peterson. ¼ nat. size.

diameter of the bone is slightly greater ventrally than dorsally. The bone differs greatly from that in *Archæotherium ingens* which has a relatively greater diameter vertically and a more angular outline laterally. The following two segments in the sternum of *Dinohyus* are coössified and their vertical diameter rapidly decreases, while their transverse diameter increases. The transverse diameter of the dorsal border is twice that of the ventral, and the posterior face of the fourth segment very suddenly expands laterally. The succeeding two segments of the mesosternum are broader than deep and the last segment is the broadest and shallowest. The dorsal face is considerably broader than the ventral and the last two segments are slightly concave both dorsally and ventrally. The posterior border of the last segment is injured by erosion, but the suture separating the following segment (xiphisternum) is plainly indicated (see fig. 66, No. 2). The sternum as a whole is not unlike that of *Archæotherium*, but it possesses a proportionally smaller antero-posterior diameter, which seems to indicate that the thorax of *Dinohyus* was relatively shorter.

Sternal Ribs. — There were four ossicles found with the sternum which are evidently the sternal ribs. They are much enlarged at one end and taper rapidly to the other (the attachment for the sternum) and have rugose faces for a heavy cartilaginous covering.

Measurements.

	Mm.
Atlas, greatest antero-posterior diameter	152
" " transverse "	337
" " vertical diameter including neural spine	127
transverse diameter of articulation for condyle	166
" " " " " " axis	144
Axis, greatest antero-posterior diameter	140
" " transverse "	145
" " vertical diameter including neural spine	160
" length of odontoid process	44
" transverse diameter of centrum posteriorly	78
" vertical " " " "	78
Third cervical, greatest antero-posterior diameter	110
" " transverse diameter	162
" " vertical "	148
" " transverse " of centrum posteriorly	80
" " vertical " " " " including ventral keel	96
Fourth cervical, greatest antero-posterior diameter	105
" " " transverse "	144
" " " vertical " approximately	145
" " transverse diameter of centrum posteriorly	80
" " vertical " " " " including ventral keel	98
Fifth cervical, greatest antero-posterior diameter	105
" " " transverse "	145
" " " vertical " approximately	160
" " transverse diameter of centrum, posteriorly	80
" " vertical " " " "	97
Sixth cervical, greatest antero-posterior diameter	110
" " " transverse " approximately	140
" " " vertical " "	260
" " transverse diameter of centrum posteriorly	76
" " vertical " " " "	88
Seventh cervical, greatest antero-posterior diameter	118
" " " transverse "	125
" " " vertical " including neural spine	318
" " antero-posterior diameter of centrum	86
" " transverse diameter of centrum, posteriorly	91
" " vertical " " " "	82
First dorsal, greatest vertical diameter	480
" " antero-posterior " of centrum	70
" " greatest transverse " " " posteriorly	93
" " vertical diameter of centrum, posteriorly	69
Second dorsal, greatest vertical diameter	512

	Mm.
Second dorsal, antero-posterior diameter of centrum, posteriorly	65
" " greatest transverse " " " "	89
" " vertical diameter of centrum, posteriorly	65
Seventh dorsal, greatest vertical diameter	365
" " antero-posterior " of centrum	67
" " greatest transverse " " " posteriorly	62
" " vertical diameter of centrum, posteriorly	67
First lumbar, antero-posterior diameter at the zygapophyses	90
" " " " " of centrum	65
" " transverse diameter at anterior zygapophyses	98
" " " " of centrum, posteriorly	68
" " vertical " " " "	54
Sacrum, greatest antero-posterior diameter, approximately	150
" antero-posterior diameter of centrum	105
" transverse diameter of centrum, anteriorly	66
" vertical " " " "	42
" transverse " " sacrum, posteriorly	31
" vertical " " " "	22
" greatest transverse diameter of sacrum	165

Ribs.

Greatest length of first rib	430
" " " second rib	467
" " " sixth rib	620
" " " eleventh rib	710
" " " last rib, approximately	540

Sternum.

Greatest antero-posterior diameter	505
" " " " of presternum	172
" vertical " " "	148
" transverse " " " anteriorly	35
" " " " " posteriorly	13
" antero-posterior " " first segment in mesosternum	60
" vertical " " " " " "	112
" transverse " " " " " "	40
Antero-posterior diameter of sixth sternebræ, approximately	90
Transverse " " " "	82
Vertical " " " " approximately	24
Greatest length of largest sternal rib	100
" transverse diameter at largest end of sternal rib	44

The Fore Limb.

The comparative lengths of the different elements of the limbs in *Dinohyus*, when compared with *Archæotherium*, in the judgment of the writer reveal characters of sufficient importance to warrant, when the many other differences are also taken into account, the generic separation of the two forms. From the very complete description of *Archæotherium ingens* by Professor Scott it is quite plain that the Oligocene genus was already capable of high speed, which appears to have been a requirement of these animals throughout the successive geological ages in which they existed. We naturally look for a reduction in the length of the humerus and femur accompanied by the retention or increase of the length of the lower portions of the limbs among the later survivors of the family. The limbs of *Dinohyus* which fortunately were found with the skeleton, show a greater advance than is found in *Archæotherium ingens*[46] in those characters which are necessary for speed and endurance.

FIG. 67. External View of Right Scapula of Type of *D. hollandi* Peterson. ¼ nat. size.

[46] The philosophy of the increase in length of the lower part of the limb in recent hoofed mammals has been discussed by Dr. Matthew in the Memoirs of the American Museum of Natural History, Vol. I, Part 7, p. 432 (1901).

Scapula. — The scapula of *Dinohyus* is relatively higher than that of the Princeton specimen from the Oligocene. Its neck also has a relatively greater transverse diameter. In other respects very little difference in the general make-up of this bone of the fore limb is shown in the two genera. The pre- and postscapular fossæ are divided by the spine in very nearly the same way in *Dinohyus* and *Archæotherium,* while according to Scott (**87**, p. 298), the John Day form, *Boöchœrus humerosus* Cope, has a much broader blade with the pre- and postscapular fossæ of nearly equal width.

MEASUREMENTS.

	Mm.
Scapula, greatest length	560
" " width	335
" transverse diameter of neck	93
" antero-posterior diameter of glenoid cavity	86
" transverse " " " "	67

Humerus. — The greater tuberosity of the humerus of *Dinohyus* was unfortunately lost in the process of collecting, so that its elevation above the head is only conjectural.[47] The bone is otherwise complete and its length is relatively less than that of *Boöchœrus humerosus* from the John Day formation, and considerably less than that of *Archæotherium.* Indeed the humerus of *Dinohyus* is even proportionately somewhat shorter than is the case in *Bos* and *Equus caballus,* while that of *Archæotherium* is relatively longer than in these two recent genera. The proximal end of the humerus in *Dinohyus* is, as in *Archæotherium,* of great antero-posterior diameter; its transverse diameter, though less than the antero-posterior, is also great, perhaps relatively greater than that in *Archæotherium.* The head is large and takes up a considerable portion of the proximal end. The greater tuberosity is very massive and evidently terminated above in a heavy blunt process, as in other representatives of the family. The lesser or internal tuberosity is unfortunately also damaged, but its anterior border indicates a strong margin which bounded the bicipital groove. The latter is broad and displays a large, smoothly convex tubercle, over which the tendon for the biceps muscle spread. The deltoid ridge is prominent and extends well down on the shaft. The distal end is much expanded, especially transversely, as the supinator ridge and the surfaces for the attachments of the ligaments are well developed. The internal epicondyle which is on the point of disappearance in *Archæotherium* is still smaller in *Dinohyus.* The intercondylar ridge, which is fully as prominent as in *Archæotherium,* is shifted even more outwardly than in that genus, and the trochlea has a more modernized appearance. The ridge which bounds the supratrochlear fossa externally is more prominent than in *Archæotherium;* the differ-

[47] From material recently (1908) acquired in the Agate Spring Fossil Quarries, it is very evident that the dotted lines in Fig. 68 are too high.

ence in the relative depth and size of the supratrochlear, and the anconeal fossæ in the two genera is small.

FIG. 68. External and Posterior Views of Humerus of Type of *D. hollandi* Peterson. ¼ nat. size. The dotted lines in the cut are too high.

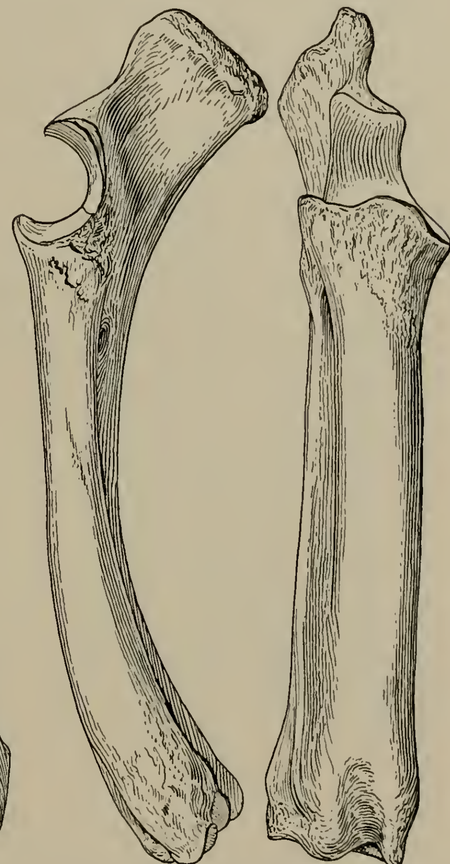

FIG. 69. Radial and Anterior Views of the Ulno-radius of Type of *D. hollandi* Peterson. ¼ nat. size.

MEASUREMENTS.

		Mm.
Humerus,	greatest length, approximately	480
"	head of humerus to and including distal end	444
"	middle of head " " " " "	425
"	antero-posterior diameter, proximal end, approximately	175
"	transverse " " " "	120
"	" " distal " "	120
"	antero-posterior " " " "	105

Radius and Ulna. — As has been intimated above, the ulna-radius in *Dinohyus* is proportionately longer than in *Archæotherium ingens*; it is also more curved or bowed forward; the olecranon process is more truncate; and the sulcus for the extensor tendon is less clearly defined. The humeral articulation of the radius differs only in minor details from what is seen in the Princeton specimen. The most noticeable of these minor differences are: the relatively narrower articular surface external to the intertrochlear groove, and a rugose pit, which interrupts the humeral articulation near the posterior margin. The transverse diameter of the shaft of the ulna-radius is shortest immediately below the head; from this point it rapidly increases distally, and the distal extremity has only a slightly greater diameter than the shaft of the compound bone. All traces of the suture between the radius and ulna are practically lost, except at the proximal and distal ends. The deeply channeled external face of the shaft shown in *Archæotherium ingens* is not so noticeable in *Dinohyus.* The ridge which separates the pyramidal and lunar facets is more developed, and the ridge separating the latter facet from that for the scaphoid is less developed than is the case in the Princeton specimen. In this way the peculiar condition found in *Archæotherium ingens* in which the ulna occupies the entire proximal face of the pyramidal and also effects a lateral contact with the lunar is even more emphasized in *Dinohyus hollandi.* The oblique direction of these ridges and the articulating surfaces to receive the carpus are practically nearly the same as in the Oligocene genus. Between the radius and ulna on the posterior face is a deep pit to accommodate the posterior hook-like process on the proximal end of the pyramidal when the manus is flexed backward. This pit is less developed in *Archæotherium.* The pisiform facet in *Dinohyus* as in *Archæotherium* is continuous with that of the pyramidal.

MEASUREMENTS.

	Mm.
Ulna-radius, greatest length	605
" head of radius to distal end	475
" length of olecranon process	157
" transverse diameter of head of radius	105
" " " " shaft immediately below head of radius	76
" greatest transverse diameter of distal end	117
" " antero-posterior diameter of distal end	83

THE MANUS.

Scaphoid. — The scaphoid is not present in the manus of the type specimen of *Dinohyus.* Judging, however, from the proximal articulation of the magnum and the corresponding articulation of the radius, which are quite broad, it is evident that the scaphoid in the Miocene genus had a relatively greater transverse diameter than in *Archæotherium* from the Oligocene.

In 1908 the Carnegie Museum field party was fortunate in finding (see plan of the quarry, Pl. LIV, Sect. 19, No. 47) a fore foot which was almost completely

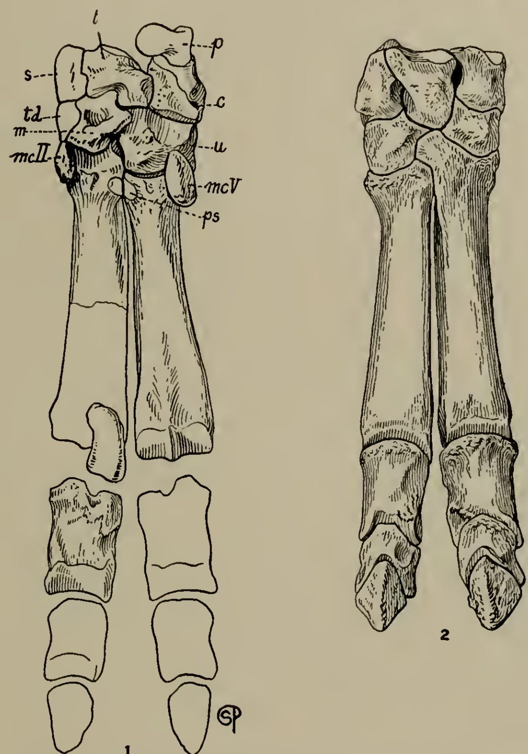

Fig. 70. Posterior (1) and Anterior (2) Views of the Right Fore Foot of Type of *D. hollandi* Peterson. ¼ nat. size. *ps*, facets for palmar sesamoid.

articulated. This specimen (No. 2136, Carn. Mus. Cat. Vert. Foss.) adds materially to our knowledge, inasmuch as the fore foot of the type specimen was found scattered, though in close proximity to the skeleton.

The scaphoid as a whole has a small transverse diameter, while antero-posteriorly it has the greatest diameter of all the carpal bones, which is due chiefly to the large palmar process. The more important characters in which this bone differs from that of *Archæotherium*, described by Professor Scott (**87**, pp. 302–303), are the relatively greater vertical diameter, the enlarged projection on the dorso-ulnar angle, which causes a slightly greater transverse diameter in this region, and also the absence of the third facet for the lunar on the ulnar face. The articular surface for the radius is divided into two parts, an antero-external and a postero-internal, as in *Archæotherium*. The postero-internal facet is saddle-shaped, concave antero-posteriorly, and constitutes the principal articulating surface of the proximal face. The antero-external facet is small, convex, continuous with the former facet, and descends steeply to conform with the anterior portion of the articular surface on the lunar On the ulnar face of the scaphoid there are two articulating facets for the lunar, one dorsal and one palmar, while in *Archæotherium* there are three. The dorsal facet is located on the prominent point which overhangs the ulnar surface of the radius and articulates posteriorly with the proximal radial face of the lunar by a broader surface than is the case in *Archæotherium*. The lunar facet, which is dorsal and distal in *Archæotherium*, is, as stated above, absent in *Dinohyus*. This facet though small is quite distinct in the former genus, while in *Dinohyus*, the further development of the prominent ridge on the proximal face of the magnum has so effectually separated the scaphoid and lunar in this region that the two bones perhaps very rarely, if ever, came into actual contact. The palmar facet for the lunar is of large size and occupies the entire lunar face of the palmar process of the scaphoid. Between the different facets the lunar face of the scaphoid is much excavated and extensively arched in the antero-posterior direction. The latter character is chiefly due to the excessive outward turn of the large palmar process. Distally the scaphoid has three facets: one posterior for the trapezoid, one anterior for the magnum, while on the ulnar angle there is a long narrow facet which also articulates with the high and antero-posteriorly directed ridge on the proximal face of the magnum. The articular surface for the trapezoid is concave antero-posteriorly and is continuous with the surfaces for the magnum. The two latter surfaces are irregularly convex and concave. Radially the bone is quite rugose and gently convex, while the anterior face is much more convex from side to side.

From Kowalevsky's illustration (**38**, Pl. XXVI, fig. 23) it would seem that the scaphoid of *Entelodon* has a smaller antero-posterior diameter, when compared with its vertical dimension, than is seen in the American forms. In *Anthracotherium* (see Kowalevsky, Paleontographica, Vol. XXII, p. 299; Pl. XI, fig. 38) the scaphoid has a remarkably close similarity to the scaphoid in the *Entelodontidæ*, as has been pointed out by Kowalevsky and Scott (**87**, p. 303). The scaphoid in *Sus* and *Hippopotamus* on the other hand is more unlike that in the *Entelodontidæ*, being broader, and of smaller antero-posterior diameter.

Lunar. — The lunar of *Dinohyus* is distinctly more modified than is the case in *Entelodon* and *Archæotherium*. In *Dinohyus* the vertical and antero-posterior diameters in relation to the transverse, are greater than in the Princeton specimen, a character naturally to be looked for in a later form. As in *Archæotherium*, the facet for the radius is divided into two parts, an anterior and a posterior; the former has a less abruptly rounded transverse ridge than in *Archæotherium*, and the latter has a relatively greater antero-posterior diameter and is deflected on the ulnar side to a greater degree. The dorsal face has a slightly different outline from that figured by Kowalevsky (**38**, Pl. XXVI, figs. 21–32), and also different from that which appears in the Princeton specimen. The principal difference in outline from that of the older forms is caused by the convex facet for the magnum on the radial face. In *Archæotherium* the facet is altogether the reverse, being concave instead of convex (see fig. 71). In *Dinohyus* it is seen that both the magnum and the unciform have yielded to the development and modification of the beak of the lunar so that the lateral contact of the two is entirely lost dorsally, and the lower end of the lunar is almost in touch with the proximal end of the third metacarpal (see fig. 70, 2). The beak which is more bluntly pointed than in *Archæotherium* is also apparently shifted farther toward the radial side than in the latter genus. The palmar face has a more oblique outline above; otherwise it is quite similar to that of the Oligocene genus. The ulnar side has two facets for the cuneiform, which are almost identical with those of *Archæotherium*. The dorso-proximal facet for the scaphoid is more clearly defined than in *Archæotherium* and the changed condition of the dorsal facet for the magnum, as stated above, gives to the radial face of the bone a more nearly vertical position than in the latter genus. The posterior portion of the facet for the magnum is recurved downward and developed into a hook on the posterior radial angle, which is relatively larger than in the Princeton specimen.

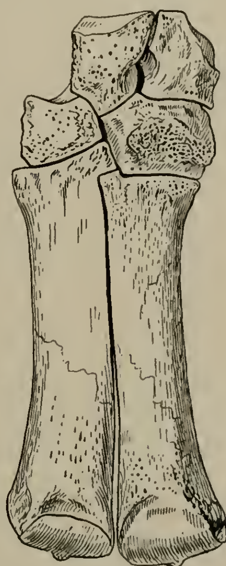

Fig. 71. Anterior View of Portion of Fore Foot of *Archæotherium crassum* Marsh. ½ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 1665.)

Measurements.

	Mm.
Lunar, greatest antero-posterior diameter	60
" " transverse " anteriorly	45
" " " " posteriorly	50
" " vertical " anteriorly	60
" " " " posteriorly	45

Pyramidal. — In *Dinohyus* the posterior ascending tubercle of the facet for the ulna is more prominent than in *Archæotherium*, which results in a greater concavity antero-posteriorly in the former. The facet for the ulna extends down on the bone in an unusual manner and hence it is proportionally greater than in *Archæotherium*, *Hippopotamus*, or *Sus*. The pisiform facet is more oblique than in the Oligocene form. Below this facet is a large and deeply excavated sulcus which extends parallel to the sharp ridge on which is located the above mentioned facet. The radial face has two facets for the lunar; the supero-anterior one is plane, subtriangular in outline, and inclined obliquely upward and outward; the postero-inferior facet is convex antero-posteriorly and concave supero-inferiorly and separated from the ulnar facet by a sharp ridge, while in *Archæotherium* the two facets are separated by a sulcus of considerable diameter. The distal articular facet is similar to that of the Princeton specimen in every respect.

MEASUREMENTS.

	Mm.
Pyramidal, greatest antero-posterior diameter	61
" " transverse " posteriorly	43
" " vertical " anteriorly	43
" " " " posteriorly	64

Pisiform. — There is no pisiform present with the type of *Dinohyus*. In another specimen (No. 2136, Carn. Mus. Cat. Vert. Foss.) the pisiform was found nearly in position and is here described in connection with the type specimen. There are only slight differences in the shape of the pisiform of *Dinohyus* and that of the older American types. The facet for the ulna extends slightly further back and is surrounded by a much heavier border so that the proximal face of the shaft has a deep excavation while in *Archæotherium* it is more evenly rounded. The facet for the pyramidal is larger than that for the ulna. From the attachment of the carpus the bone is strongly recurved backward and radially as in *Archæotherium* and the free end is enlarged into a thick knob. The bone, though comparatively small, is relatively of slightly larger size than that of the Oligocene genus.

The pisiform of *Entelodon*, as Scott (**87**, p. 304) has pointed out, is very different in its outline, though not altogether unlike that of the American forms. Scott suggests that the irregular shape of the pisiform which Kowalevsky (**38**, Pl. XXVI, fig. 27) figures "might be due to disease." It would, however, seem from the illustration that the facets also differ in having an irregular convexity while in the American forms they are obliquely concave. The pisiform of *Anthracotherium* is considerably larger and somewhat different in form, having a more decided shaft, a less club-shaped free end, and apparently differently shaped articular facets for the carpus and ulna (Palaeontographica, Vol. XXII, Pl. XI, fig. 58). In *Sus* the pisiform is shorter, thinner, and deeper, while in *Hippopotamus* it has a general similarity to the pisiform of the *Entelodontidæ*.

MEASUREMENTS.

		Mm.
Pisiform, greatest length		70
"	vertical diameter of proximal end	32
"	transverse " " " "	31
"	" " " distal "	32
"	vertical " " " "	30

Trapezium. — The trapezium of *Dinohyus* is no doubt entirely wanting, judging from its rudimentary condition in the Oligocene genus,[48] and its entire absence in the John Day form. Professor Cope states (**10**, pp. 62–63) that there is no trace of a facet for a trapezium on the trapezoid of *Boöchœrus humerosus*, which was verified by me on examination of the type specimen in the American Museum.[49]

Trapezoid. — Though absent in the type of *Dinohyus* this bone was found in position on the magnum of a fore foot, found in section 19 (see plan of quarry, Pl. LIV, No. 47) and is here described.

The transverse diameter of the trapezoid (No. 2136, Carn. Mus. Cat. Vert. Foss.) is only two millimeters greater than in *Archæotherium*, while the antero-posterior diameter is proportionately somewhat greater. The bone is consequently much compressed laterally and has a subquadrate outline, when viewed from its ulnar face. Radially the proximal face is more rounded before backward, by the articulating surface for the scaphoid, which gives this (radial) face a more irregular quadrate appearance. The transverse diameter of the bone is greatest proximally, and it gradually tapers distally, terminating in a border, which is rather narrow and rounded inferiorly. The facet for the scaphoid is obliquely convex antero-posteriorly and extends well back on the posterior face of the bone. The ulnar face bears three facets for the magnum, two of which are distal and one proximal. The proximal facet is well defined near the dorsal face and continues backward as a smooth rounded ridge on the proximo-ulnar angle. The two distal facets are a palmar and a dorsal, and may be regarded as practically one facet, as they are divided only by a very shallow, almost imperceptible, groove, while in *Archæotherium* there is a moderately large median swelling on the ulnar face which puts the two facets at a considerable angle with each other.

[48] There is, in the Princeton specimen described by Professor Scott, a trapezium with a well formed facet for the trapezoid, and the bone, though laterally compressed, is of considerable size antero-posteriorly and extends well down over Mc. II, but does not articulate with the latter. (See fig. 10 on page 55.)

[49] In my note book I find the following statement regarding the trapezium of *Boöchœrus*: "The trapezoid has a small pit radially which may have lodged a trapezium, but there is no distinct facet."

Between the proximal and distal facets the surface of the bone is very slightly excavated while the corresponding face on the magnum is very deeply excavated, forming a large sinus. Radially there is but one small facet: that for the rudimentary Mc. II (see fig. 72). This facet is situated near the dorsal face and has a radial position, while that in *Archæotherium* described by Professor Scott (**87**, p. 305) is directly on the distal face. There is no facet for the trapezium, while in *Archæotherium* the facet is quite plain and the trapezium is present.

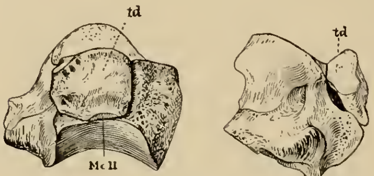

FIG. 72. Radial and Palmar Views of Magnum with Trapezoid in Position. ½ nat. size. (Carn. Mus. Cat. Vert. Foss., No. 2136.)

In the European genus *Entelodon* the trapezoid is not known, which is also true of *Anthracotherium*.

The trapezoid in *Sus* and also in *Hippopotamus* is relatively large; it has more functional importance in the make-up of the carpus, and can hardly be compared with the rudimentary form, which the bone possesses in the *Entelodontidæ*.

MEASUREMENTS.

		Mm.
Trapezoid, antero-posterior	diameter	28
" transverse	"	12
" vertical	"	25

Magnum. — Proximally there are two oblique facets on the magnum: an antero-radial for the scaphoid; and a postero-ulnar for the lunar. The former facet is concave from side to side and convexo-concave from before backward. The latter facet is convex antero-posteriorly and concave on the postero-ulnar angle presenting a sinuous surface, which terminates behind in a beak-like process on the proximo-ulnar angle of the palmar process. In *Archæotherium* the palmar process is placed more distally and has not an upward recurved beak, as in the present genus. The facet for the scaphoid is relatively broader and more concave on the ulnar angle than in the Princeton specimen. The facet for the lunar has a proportionally smaller transverse diameter than in *Archæotherium* and the dorsal contact with the lunar is entirely lateral and concave supero-inferiorly, while in *Archæotherium* it is convex in order to receive the concave facet of the lunar, as stated above. The ulnar side has two deeply excavated areas; one of large size in front, and one smaller, back of a broad obliquely located ridge, which terminates above in the lateral facet for the unciform. This ridge is much less developed in *Archæotherium.* The groove for the trapezoid seen in the latter genus is less clearly defined in its vertical portion in *Dinohyus,* while in the antero-posterior direction it is broadly developed. This is due to the fact that the extension of the superior border articulates with the scaphoid, while the inferior border articulates with Mc. III in *Dinohyus*. The articulation for the trapezoid is also relatively smaller and reduced to two facets, a small superior and a larger inferior, while in *Archæotherium* there are three facets, one superior and two inferior. The palmar process is compressed laterally, but attains a considerable vertical diameter, reaching the lunar above and articulating with it by a beak-like process referred to above. The position of the palmar process is oblique and the shape is thus very different from what appears in the Princeton specimen, described by Professor Scott (**87**, p. 306), which has a more rounded palmar process. The head of the magnum rises more abruptly toward the palmar side in *Dinohyus* than in the Oligocene genus, which Scott used for his comparison with the European form. In the latter Scott says "the head of the magnum rises less abruptly toward the palmar side." In *Hippopotamus* the palmar hook is even more prominent, but is placed more transversely and is extended more downward than in *Dinohyus*. Distally there is in the latter genus only one articulation, that for the third metacarpal. It is concave antero-posteriorly and convex laterally. The antero-posterior diameter of the facet is proportionally greater than in *Archæotherium ingens*.

The magnum of *Entelodon* figured by Kowalevsky (**38**, Pl. XXVI, figs. 21, 23, 29–32) is, as Scott has stated (**87**, 306), generally similar to that in the American genera, but there are a number of minor differences. The facet for the scaphoid in the European genus is less horizontal; the facet for the lunar is more oval in form and is not continued outward on the palmar hook; the articulation for the trapezoid is relatively larger and is in a different position, *i. e.*, near the dorsal face and also at the palmo-distal angle of the bone. The palmar process is relatively as large as in *Dinohyus*, but different in shape, being more rounded. The sulcus, which on the distal ulnar face separates the lunar facet, is very much smaller than in *Dinohyus*.

MEASUREMENTS.

	Mm.
Magnum, greatest antero-posterior diameter	70
" " transverse " posteriorly	47
" " " " anteriorly	43
" " vertical "	58
" " " " anteriorly	31

Unciform. — The greatest antero-posterior and transverse diameters of the unciform are very nearly equal. The bone as a whole is massive, and is, as in *Boöchærus humerosus*, the second largest bone of the carpus. Its anterior face is rugose and unevenly convex transversely. Posteriorly there is a palmar hook not unlike that of *Hippopotamus*, though somewhat less produced downwards. At the base of this palmar process on the ulnar side there is a facet for Mc. V, which meets the facet for the pyramidal at right angles. In *Archæotherium ingens* these two facets are separated by a considerable surface, which is concave vertically and convex transversely. The radial side is occupied by a large facet for Mc. III, which is strongly inclined radially. Back of this facet is a large excavated area, which extends over the remainder of the radial face of the bone. The small oblique facet for the magnum on the radial angle of the unciform in *Archæotherium* is almost entirely proximal in *Dinohyus*, and passes imperceptibly into the lunar facet. Proximally the lunar and pyramidal articulations are divided by a prominent ridge, which extends antero-posteriorly, the pyramidal facet being the larger of the two. The distal face is occupied almost entirely by the large facet for the fourth metacarpal, which on the radial angle presents an abrupt continuation of the facet for Mc. III as in *Archæotherium*. There is no dorsal articular surface for the magnum on the radial face, as in older forms[50] of this family, and these two bones (unciform and magnum) when in position in the carpus appear well separated (see fig. 70).

Professor Scott has already pointed out that "the unciform of Kowalevsky's specimen does not differ in any significant way from that of the American species" (**87**, p. 306). In *Hippopotamus* and *Sus* the unciform is larger, which is due to the tetradactylous condition of the feet in these genera.

Measurements.

	Mm.
Unciform, greatest antero-posterior diameter	64
" " transverse "	54
" " vertical "	47

Metacarpal II. — The second metacarpal is not present in the type of *Dinohyus*, but a deep vertical groove on the lateral face and a minute articular facet on the proximal angle of the third metacarpal indicate the presence of this bone. In my notes on *Boöchœrus humerosus* in the American Museum, I find it stated that Metacarpal II has two facets proximally: one small one for the trapezoid and a larger one for the facet on the radial face of Mc. III. The reduction of these two elements (trapezoid and Mc. II) in the manus of the Nebraskan Miocene form is in all probability carried to a greater degree than in the John Day form. The second metacarpals of the fore feet are present in the Princeton specimen, which Professor

[50] In the type of *Boöchœrus humerosus* the unciform and magnum are separated, but not to the same extent as in *Dinohyus;* the beak of the lunar in the latter genus extends lower down than in the former. This fact is not well illustrated in fig. 15 on page 61 where the lunar appears too low.

Scott described (*l. c.*, p. 307). They are small nodular bones with well defined facets for Mc. III, the magnum, and the trapezoid, but with no facet for the trapezium.

Metacarpal III. — Unfortunately the third metacarpal is represented only by the proximal and distal ends, as the contact of the shaft was lost in collecting the material. The head is much expanded transversely, especially on the ulnar side, which has a heavy cubital process articulating with Mc. IV and the unciform in an interlocking manner. Besides the dorsal articulation for Mc. IV, there is also a palmar articulation on the ulnar side, which is located on the very prominent palmar process. Continuous with the latter facet, and separated from it only by a sharply defined ridge, is a facet evidently for a palmar sesamoid.[51] Proximally the bone is taken up by the large facet for the magnum, which is convex antero-posteriorly and concave laterally. On the dorso-ulnar angle is a smaller and obliquely placed facet for the unciform referred to above. The radial side is excavated quite deeply and has two facets, one dorsal and one palmar, for the rudimentary Mc. II; the dorsal facet is quite large and is wedge-shaped in outline with the apex downward; the palmar facet consists only of a minute rounded ridge on the radial angle of the articular surface of the magnum. The shaft of the bone is quite broad transversely and compressed antero-posteriorly. When held in a vertical position the distal trochlea is well shown on the anterior face of the bone, less so behind. The metapodial keel is confined only to the plantar portion and is proportionately less developed than in the Oligocene genus. In general appearance there are no very marked differences of the metacarpals from those of the known earlier forms; though in the present genus they are relatively of slightly greater length, and have rugosities on the inner sides. The comparative length of the metapodials with the upper arm-bones is a significant feature in *Dinohyus*.

Professor Scott states that the third metacarpal in Kowalevsky's specimen (**87**, p. 307) "does not differ in any important way from that of the American species, though the magnum facet is somewhat more concave transversely and the shaft is rather more slender." Kowalevsky, however, points out (**38**, p. 444, Pl. XXVI, fig. 23) that there are three facets on the radial face of Mc. III, of which the two lower undoubtedly articulated with the rudimentary Mc. II, while the upper one articulated with the trapezoid. In all the specimens of the American forms, which I have examined and in which these parts were present, I have not been able to find more than two facets, those for Mc. II, on the radial face of Mc. III. From this fact it is quite evident that the trapezoid in *Entelodon* had not suffered the reduction, which is seen

[51] In specimen No. 2136 (Carn. Mus. Cat. Vert. Foss.) this palmar process was found very nearly in position (see fig. 70, ps.).

in the American forms, and had a somewhat similar though less prominent contact with Mc. III, as in *Sus*. In *Anthracotherium*, the general similarity of Mc. III (Palæontographica, Vol. XXII, p. 308, Pl. XIII, fig. 80) to that of the *Entelodontidæ* is quite striking, as Scott has pointed out, but it "is relatively heavier; at the proximal end the tubercle for the insertion of the extensor carpi radialis muscle is more conspicuous, and the palmar projection of the head more prominent." To this might also be added that the facet for the trapezoid is apparently indicated, which is naturally to be expected in a tetradactyl form, although Kowalevsky does not mention it.

MEASUREMENTS.

	Type No. 1594. Mm.	No. 2136. Mm.
Metacarpal III, greatest length		240
" " antero-posterior diameter, proximal end	57	58
" " transverse " " "	57	65
" " antero-posterior " distal end	45	46
" " transverse " " "	54	55

Metacarpal IV. — The fourth metacarpal is complete in the type, and, as in the earlier forms of this family, smaller than the third. There are two articulating surfaces on the proximal face, one for the unciform and the other for Mc. III. The former is large and nearly triangular in outline; the latter has a wedge-shaped outline with the apex directed posteriorly. On the radial side are two facets, one dorsal and the other palmar; the two articulate with Mc. III. On the radio-palmar angle is a third facet of small size, which supports a palmar sesamoid (see fig. 70). On the ulnar side there is a prominent process, which has a round articular surface for Mc. V. The shaft has the greatest constriction immediately below the head and gradually becomes wider distally. There is no essential difference in the distal trochlea from that of Mc. III.

MEASUREMENTS.

	Type No. 1594. Mm.	No. 2136. Mm.
Metacarpal IV, greatest length	215	220
" " antero-posterior diameter, proximal end	58	56
" " transverse " " "	62	63
" " antero-posterior diameter, distal end	44	45
" " transverse " " "	55	57

Metacarpal V. — The fifth metacarpal is a rudimentary almond-shaped sesamoid which is of about the same proportionate size as that in *Archæotherium*.[52] Proximally there are two distinct articular surfaces: a superior one for the unciform, and an inferior one for Mc. IV.

[52] The fifth metacarpal in *Boöchærus humerosus* from the John Day formation is apparently of greater size and also longer than in *Dinohyus*.

MEASUREMENTS.

	Mm.
Metacarpal V, greatest length	40
" " transverse diameter	25

Phalanges. — The proximal and second phalanges are broad and depressed. The proximal phalanx has a shallow groove for the metapodial keel, confined to the plantar portion of the proximal articulation. Distally there is a smooth articular surface for the second phalanx, which is convex antero-posteriorly and concave transversely. The articulation is carried around upon the plantar surface of the bone, but does not extend very high up on the dorsal face. The plantar face has prominent rugosities for attachments not unlike what is seen in the recent camels. The second phalanx is even more suggestive of the camel though relatively much shorter and less depressed. It is unusually broad on the plantar face, but slopes rapidly dorsally. The proximal end has a smooth surface, which is deeply concave supero-inferiorly and gently convex laterally, to receive the correspondingly smooth surface of the distal end of the proximal phalanx. The distal trochlea is flexed in a much greater degree, especially dorsally, than that of the proximal phalanx. The bone is quite asymmetrical, having the internal border shorter than the external and also very rugose and heavy, while the external border shows no unusual characters.

The ungual phalanges of the fore foot are not present in the type, but fortunately they are represented in the fore foot of specimen No. 2136 (Carn. Mus. Cat. Vert. Foss.). This bone is unusually short and quite high. Anteriorly the ungual phalanx is much truncated and the bone as a whole has a curious nodular shape. The plantar surface is quite broad and convex in all directions except posteriorly. The sides slope rapidly to form a rounded and prominent dorsal ridge; this ridge terminates on the postero-dorsal angle in a broad, rather large and truncated tubercle for ligamentary attachments. Proximally there are two articulating facets for the phalanx of the second row, an external and an internal, and these are imperfectly divided by an oblique ridge.

The phalanges of *Entelodon,* which Kowalevsky figures (**38**, Pl. XXVII, fig. 38), are quite similar in shape to those in the American forms, except that the proximal phalanx according to this author is relatively longer in *Entelodon.* By comparative measurements it seems that the three[53] phalanges of a digit in *Enteledon* are together perhaps longer than those in the American genera of this family; in *Sus* the phalanges are of a different shape, the proximal being thicker in proportion to its length, with a deeply grooved proximal trochlea for the keel of the distal end of the metapodial, while the ungual is longer, broader, and more pointed. In the Ameri-

[53] The ungual phalanx of *Entelodon* is not known and is here only estimated.

can forms of the *Entelodontidæ* on the other hand the three phalanges together are far from being as long as the metapodial. In *Hippopotamus* the ungual is reduced and has a nodular form, as in the Entelodonts, while the proximal and median phalanges are broad and very heavy.

MEASUREMENTS.

		Mm.
Greatest	length of a first phalanx	78
"	transverse diameter of a first phalanx, proximally	54
"	antero-posterior diameter of a first phalanx, proximally	44
"	transverse " " " " distally	48
"	antero-posterior " " " " "	38
"	length of a second phalanx	58
"	transverse diameter of a second phalanx, posteriorly	41
"	antero-posterior diameter of a second phalanx, posteriorly	35
"	" " " " " distally	38
"	transverse " " " " "	43

THE HIND LIMB.

Pelvis. — The only part of the pelvis of the type which is preserved is the posterior portion of the pubic symphysis. This fragment agrees, except in its larger size, with the corresponding portion of *Archæotherium ingens* from the Oligocene.

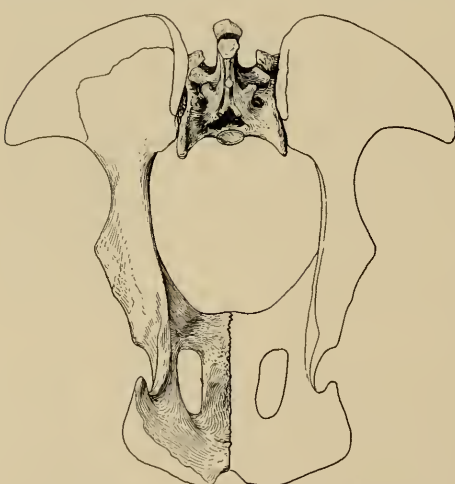

FIG. 73. Superior View of Pelvis of *D. hollandi* Peterson. 1/6 nat. size. (Carn. Mus. Cat. Vert. Foss., No. 2126.)

In one individual of *Dinohyus* (No. 2126, Carn. Mus. Cat. Vert. Foss.), secured in 1908 in Quarry No. 1, Sec. 17 (see plan of quarry, Pl. LIV) there is found a nearly complete half of a pelvis, not fully adolescent, but which apparently agrees quite well in size with the type. A second specimen (No. 2139, Carn. Mus. Cat. Vert. Foss.) of smaller size found in section 19 (No. 33) has the pelvis practically complete. The former specimen will be used in this description as a paratype, while the latter, which may represent another species, is used only to more fully elucidate the description.

It is at once observed that the pelvis of *Dinohyus* is relatively shorter though slightly deeper than that of *Archæotherium ingens* from the lower Oligocene formation. The shortening of the pelvis is principally confined to the region back of the acetabulum. The ilium has nearly the same relative length as in the Oligocene genus, and its anterior plate is suddenly expanded into a strongly everted antero-inferior portion. The dorsal surface of the ilium is basin-like, the entire crest having a slightly everted border. Ventrally it is strongly convex and the greater portion of its surface is taken up with the attachment for the sacrum. The latter is so placed that when articulated with the vertebral column the pelvis has a more vertical position than in *Archæotherium*. The shaft of the ilium is relatively shorter than in *Archæotherium*, but has the same general trihedral out-

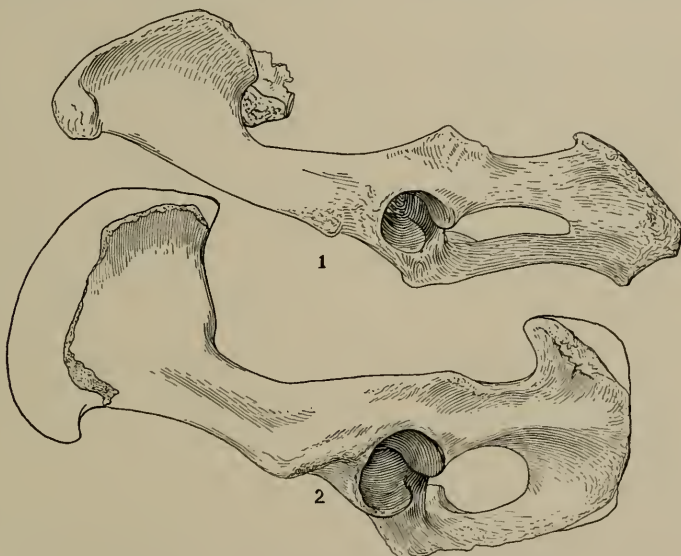

FIG. 74. (1) Lateral View of Pelvis of *Archæotherium ingens* Leidy (Princeton Museum, No. 10885). (2) Lateral View of Pelvis of *Dinohyus hollandi* Peterson (Carn. Mus. Cat. Vert. Foss., No. 2126). ⅜ nat. size.

lines, while its ilio-pectineal tubercle on the inferior border is heavier than in the latter genus. The great sacro-sciatic notch has a heavy rounded border on its anterior margin, while further back the border becomes sharper, though not to the same degree as in *Archæotherium*. The ventral or anterior border of the ilium has a sharper border than the notch above and is arched to a greater degree than in *Archæotherium*, which is chiefly due to the larger development of the ilio-pectineal eminence in the Miocene genus. In *Hippopotamus* the ilium is not very like that of the *Entelodontidæ*, the peduncle being shorter and much heavier, the ilio-pectineal eminence wanting (except a slight enlargement at the extreme anterior border of the acetabulum), and the anterior portion flares out into a heavy fan-shaped plate with little or no eversion such as is found in *Archæotherium* and *Dinohyus.*

The ischium, as has already been said, is much shorter in *Dinohyus*, and its vertical diameter posteriorly is somewhat greater than in the Princeton specimen. The depressed area for ligamentary attachments takes up a considerable space of the acetabulum and the cotyloid notch is wide, though quite shallow. The dorsal border, or spine, of the ischium is not nearly so prominent as in *Archæotherium*, and the lesser sacro-sciatic notch is quite short, with a heavy rounded border, which gradually decreases in its backward trend. Posteriorly this notch is suddenly recurved, due to the anterior extension of the prominent tuberosity of the ischium.

The vertical diameter of the ischium from the point of the tuberosity to the symphysial border, is relatively somewhat greater in *Dinohyus* than in *Archæotherium*, and this results in giving the former genus a slightly deeper pelvic cavity. In *Hippopotamus* the body of the ischium back of the acetabulum is longer and more nearly circular in outline than is known in the Entelodonts, and posteriorly it flares out to form a heavy tuberosity as in the latter family, but the symphysis of the ischium is rather delicately developed. Another important difference is seen in the small area of the acetabulum taken up by the ligamentary attachments and the small deep cotyloid notch in *Hippopotamus.*

The pubis, though short, is relatively slightly longer than in *Archæotherium.* In the region of the spine the pubis is very heavy and there is a large symphysial surface which meets that of its fellow, making the symphysis unusually heavy. Further back the ramus of the pubis is thinner and unites with the ischium to form the lower border of the obturator foramen. The latter is of large size, but is, as might be expected, less elongated in the antero-posterior direction than in *Archæotherium.* In neither *Sus* nor *Hippopotamus* is there any marked similarity to the Entelodonts in the region of the pelvis, though there is more general resemblance, as Professor Scott has stated (**87**, p. 310), between the latter genus and the Entelodonts than there is in the former.

Measurements of Pelvis.

	Mm.
Greatest length, approximately	490
Length from middle of acetabulum to end of ischium	195
" " " " " " crest of ilium, approximately	300
Greatest vertical diameter of ischium	192

Femur. — The femur is complete, except the great trochanter which was lost in the process of collecting. The femur is long and slender, but proportionately heavier, and also considerably shorter, than in the Princeton specimen. The head is well rounded; it is set on a distinct neck, and the depression for the ligamentum teres is rather small and shallow. The lesser trochanter is quite large, and projects, as in the Oligocene genus, almost entirely backward.[54] Between the greater and lesser trochanters is a ridge extending obliquely across the posterior face of the shaft which is more prominent in the present genus than in *Archæotherium*. Immediately in front and superior to the lesser trochanter is a prominent and very rugose ridge, which runs parallel with the shaft and is separated from it by a deep groove. The middle region of the shaft is proportionally less constricted than in *Archæotherium* and the linea aspera is more developed than in the latter genus, a character which agrees better with what we know of *Boöchœrus* through Cope (**10**, p. 65). The large and rugose groove above the external condyle, for the plantaris muscle, terminates above in a heavy and very rugose tubercle; immediately above the internal condyle on the posterior angle there is a prominent ridge for muscular attachment. The shaft of the femur as a whole is more arched than in the Princeton specimen. The rotular trochlea is short, not very deep, but broad, and slightly oblique. The condyles are rather small, the external being the larger of the two, and placed more directly fore-and-aft than the internal. The intercondylar fossa is deep, oblique, and wider in front than behind.

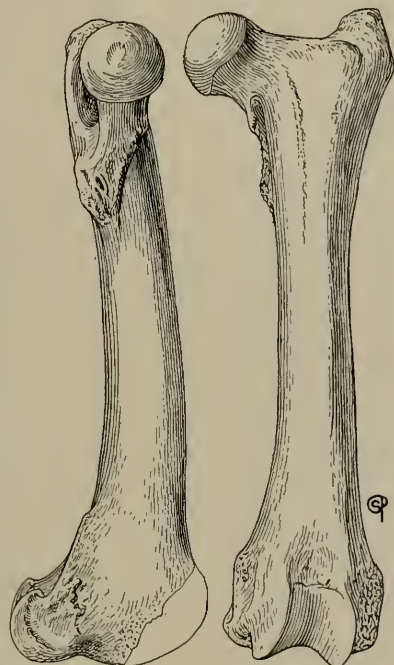

FIG. 75. Internal and Anterior Views of Femur of Type of *D. hollandi* Peterson. ¼ nat. size.

One of the more important differences between *Dinohyus* and *Boöchœrus humerosus* is revealed in the comparative diameter of the distal end of the femur. In *Dinohyus* the femur has the antero-posterior diameter proportionately greater than in *Archæotherium ingens*, and in this respect *Dinohyus* more nearly resembles *Hippopotamus*, while, in *Boöchœrus humerosus* the diameter of the distal end is more nearly

[54] Cope states (Bull. U. S. Geol. Surv., Vol. V, p. 65, 1880) that the lesser "trochanter is large and projects well inwards."

equal transversely and antero-posteriorly, like what may be observed in *Sus* and the peccaries. Unfortunately no complete femur of *Boöchœrus humerosus* has been as yet discovered and we are therefore unable to compare it with the corresponding bone of earlier and later forms.

MEASUREMENTS OF FEMUR.

		Mm.
Greatest length		470
" transverse diameter of proximal end, approximately		155
Antero-posterior diameter of head		63
Transverse " " "		63
Greatest antero-posterior diameter of distal end, approximately		144
" transverse " " " "		120
Diameter of shaft at middle	transverse	53
	antero-posterior	56

Patella. — The patella which was found with the type and undoubtedly belongs to the same individual, is quite different from those found with the Princeton specimen. The diameters are relatively smaller in the vertical and antero-posterior directions, while transversely they are greater than in *Archæotherium.* The general outline of the bone is sub-oval, with a short, blunt process below and an angle greater internally than externally. It is evenly convex in front. The articular facet for the rotular trochlea of the femur is evenly rounded without a separating ridge, which agrees perfectly with the condition of the groove of the femur. The patella of *Dinohyus* is further characterized by having a considerable rugose area on the postero-internal angle which is separated from the main articulation by a very narrow,

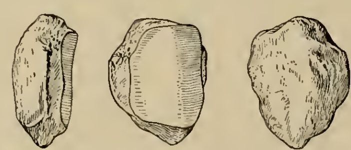

FIG. 76. Lateral, Posterior, and Anterior Views of Patella of Type of *D. hollandi* Peterson. ½ nat. size.

but well marked groove. In *Archæotherium* instead of this rugose area there is a small recurved tubercle, which adds to the transverse diameter of the femoral articulation of the patella. The patella of *Boöchœrus humerosus* is relatively larger than that of *Dinohyus hollandi* and in this respect more nearly resembles that of *Archæotherium ingens;* the general shape is also more nearly like that in the latter genus, though there are some differences, for instance in *Boöchœrus* the patella is more massive, with a rapid contraction in the lower portion to form a process distally, while in *A. ingens* the patella is of the greatest antero-posterior diameter proximally and gradually diminishes to a transversely broad and antero-posteriorly compressed process.

MEASUREMENTS OF THE PATELLA.

	Mm.
Vertical diameter	100
Tranverse "	68
Antero-posterior diameter	40

Tibia. — One of the more noteworthy characters of *Dinohyus* is seen in the coössification of the tibia and fibula. In the Princeton specimen from the Oligocene the fibula, though much reduced, is entirely free, while in *Dinohyus* it is firmly coössified. The internal condyle extends somewhat more over the shaft than in *Archæotherium,* which results in a relatively greater expansion. The two condyles are separated by a prominent spine which rises more abruptly than in the older forms. The cnemial keel is prominent and extends very nearly to the middle of the shaft before it disappears. On the internal face of the cnemial crest the shaft is quite flat, while externally there is a large fossa for the flexor tendon, which is bounded superiorly by the expanded head and the deep tendinal groove, laterally by the high cnemial keel and the rounded external border; distally the fossa gradually becomes shallower and finally fades away on the shaft below the cnemial keel. Posteriorly there is another prominent fossa for the tibialis posticus, which is bounded above by the overhanging borders of the popliteal notch, and laterally by the internal and external borders of the bone. Distally the fossa fades away and the surface of the shaft is almost flat, while internally, externally, and anteriorly, there are greater convexities imparting to the bone a sub-oval cross-section. More distally the shaft becomes nearly quadrate.

FIG. 77. Anterior View of Tibia-fibula of Type of *D. hollandi* Peterson. ½ nat. size.

The transverse expansion of the distal end is not great and the antero-posterior diameter is only very moderate. The trochlea is unequally divided by a prominent ridge extending antero-posteriorly; the external portion is the larger, and more elevated than the internal, which causes a considerable obliquity of the trochlea. This character is more nearly like what may be observed in the *Merycoidodonts* (*Oreodonts*) than any of the recent *Suidæ.* The bifid termination at the anterior margin of the intercondylar ridge in *Archæotherium* is absent in *Dinohyus,* and instead there are two facets on the extreme antero-inferior end, which touch corresponding facets in the median portion of the neck of the astragalus when the tibia is flexed forward. A similar arrangement is also seen on the intercondylar ridge of the tibia in *Dæodon calkinsi* from the John Day formation. The articulating surface of the inter-condylar ridge is proportionately more interrupted than in the Oligocene genus, as the irregular-shaped sulcus continues to the posterior border, at which point it entirely separates the articulations of the trochlea. The internal malleolus is rather small; it is compressed transversely, does not extend much below the distal end of the fibula, and it covers only one-half of the antero-posterior diameter of the trochlea.

The proximal end of the fibula is well coössified with the head of the tibia. Immediately below the head the shaft is separated from the tibia for a distance of 100 mm.; below this point the fibula, as stated above, is entirely fused with the tibia leaving little or no trace of a suture between the two bones, except at the distal end. The distal end is much expanded antero-posteriorly and rather compressed transversely. On the anterior half of the external face is a prominent vertical ridge which forms the anterior border of the tendinal groove and extends upward for a distance of 60 mm. where the ridge becomes rapidly contracted and disappears on the side of the fibular face. Distally the fibula extends well down below the trochlea and furnishes a symmetrical appearance to the outline of the distal end of the tibia-fibula.

Kowalevsky in his memoir figures a tibia and a portion of a fibula which was found with *Entelodon magnum* (**37**, Pl. XXVII, fig. 33).

These illustrations, together with the casts of the specimens now in the Carnegie Museum, present characters quite similar to those of the corresponding bones in the older American forms. The proximal end of the tibia of *Entelodon* is possibly somewhat more expanded, but this may be due in great measure to crushing, as the bone has apparently received some injury laterally. The fibula, which is quite delicate, is represented by a portion of the shaft lying closely appressed to the shaft of the tibia as figured by Kowalevsky. This bone appears to have been turned end about; the lower portion, as seen in the specimen, apparently agrees better with the proximal than distal end of the American forms.

MEASUREMENTS OF TIBIA.

	Mm.
Greatest length	450
" antero-posterior diameter of proximal end, approximately	115
" transverse " " " "	126
" " " " distal "	97
" antero-posterior " " " "	65

THE HIND FOOT.

As in other representatives of the *Entelodontidæ*, the pes, as well as the manus of *Dinohyus*, is didactyl. The total absence of the facet on the cuboid [55] for mt. V in the type of *Dinohyus hollandi* is interesting and of some importance in connection with other modifications of the genus. Professor Scott states (**87**, p. 318) that in *Archæotherium ingens* from the Oligocene of America the fifth metatarsal is present. From Kowalevsky's statement and figures it is also very evident that *Entelodon magnum* of Europe had a fifth metatarsal (**38**, p. 449, Pl. XXVII, fig. 35). Unfortunately the cuboid and mt. IV of the type of *Boöchærus humerosus* from the John Day formation, are badly preserved in the region where the facet for mt. V would be found, so that its presence or absence is only a matter of speculation. Through the courtesy of Professors Schuchert and Lull the writer had the opportunity of studying the material representing Entelodonts which was collected for Professor Marsh from the John Day region as long ago as 1875. In this collection is a portion of a skeleton of an Entelodont from the green sandstone (probably the middle beds) which is somewhat smaller than *Boöchærus* described by Cope. The general features of the remains seem to indicate a more primitive type having a closer resemblance to *Archæotherium ingens* from the Oligocene than the new genus *Dinohyus.* On the cuboid of this specimen from the John Day formation the facet for mt. V is plainly indicated.

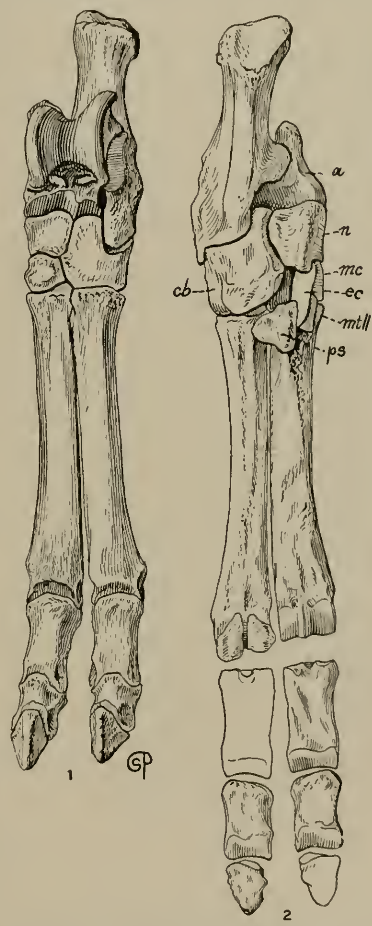

FIG. 78. Dorsal and Palmar Views of Left Pes of Type of *D. hollandi* Peterson. *ps*, palmar sesamoid. ¼ nat. size.

Astragalus. — In correspondence with the oblique trochlea of the tibia the proximal

[55] A cuboid (No. 1926) referred to this genus, which was found in quarry No. 2 (Agate Spring Fossil Quarries), is somewhat heavier than that in the type. The two specimens, which represent two individuals, are almost identical in their general characters, except that in No. 1926 there is present a minute articular surface for mt. V, which would seem to indicate individual or specific differences.

trochlea of the astragalus displays considerable asymmetry. The external condyle is much higher and more produced dorsally than the internal condyle, but the articular surface does not extend so far distally on the anterior face as that on the internal condyle, which nearly meets the articulation for the navicular. The pit on the dorsal face, which separates the distal and proximal articulations, is large, comparatively shallow, and in the bottom are located two facets, which articulate with corresponding facets on the anterior termination of the intertrochlear ridge of the tibia when the latter is flexed forward. In *Archæotherium* this pit is deeper and has no facets. The trochlear articulation of the external and internal condyles of *Dinohyus* are entirely separated by a broad sulcus, which takes up the deepest part of the trochlea and is directly opposite the corresponding sulcus on the intertrochlear ridge of the tibia when the two bones are in position. The distal trochlea is oblique and unequally divided into two facets, the navicular facet being larger than the cuboidal. The latter facet is proportionally of a less transverse diameter than that in the Princeton specimen, which indicates a tendency toward the narrowing up of the tarsus. The distal trochlea as a whole is more deeply concave on the median line, the ridge separating the two facets being more prominent than in the Oligocene genus. The sustentacular facet is relatively limited in the vertical direction and also somewhat narrower superiorly when compared with that in *Archæotherium*. There are three calcaneal facets externally; one is situated on the extreme distal angle of the bone, while the other two are superior to the deep cavity which takes up a large area of the external face.

The appearance of the astragalus figured by Kowalevsky (**38**, Pl. XXVII, fig. 34) is not unlike that of the American genera, although the pit on the dorsal face, which separates the proximal and distal articulations, is apparently somewhat smaller in proportion than in these.

Measurements of Astragalus.

	Mm.
Greatest length	106
" transverse diameter	68
" " " of proximal trochlea	58
" " " " distal "	59
" antero-posterior diameter of astragalus	55

Calcaneum. — As in *Archæotherium* the calcaneum has a long tuber, which is deeply channeled externally and terminates posteriorly in an enlarged and truncated end, but differs from that of *Archæotherium* in having an open flat surface for the tendo-achillis instead of a decided groove. The fibular facet is divided by an oblique ridge into a superior and an antero-inferior portion. The two facets are confluent, but at right angles, and are quite similar to those in *Sus* and *Hippopotamus*. The unusual dorso-plantar extent of the distal facet for the astragalus in *Archæotherium*, which was pointed out by Scott, is in *Dinohyus* fully as great. The latter facet is confluent with the lateral facets for the cuboid, and only separated from the distal facet for the same bone by a rounded angle, which is confined to the anterior half of the distal facet. The distal facet for the cuboid is divided into two parts: an anterior, which is plane; and a posterior, which is obliquely concave antero-posteriorly, and is carried high up upon the tibial face to accommodate the corresponding facet of the prominent plantar hook of the cuboid. Above the cuboid and distal astragalar facets there is on the fibular face a deep excavation, which is bounded superiorly by the fibular and sustentacular facets and posteriorly by the heavy border of the tuberosity. The sustentacular facet is quite large and is slightly convex transversely and concave in the dorso-palmar direction.

MEASUREMENTS OF CALCANEUM.

	Mm.
Greatest length	188
Length of tuber	100
Greatest antero-posterior diameter at fibular facet	82
" transverse diameter at sustentacular facet	60

Navicular. — The proportions of the navicular are different from those in the Oligocene genus, which fact is due to the relatively smaller transverse and greater antero-posterior diameters in *Dinohyus*. The articulation for the astragalus is divided by a broad rounded ridge, which is evenly convex from side to side, deeply concave antero-posteriorly, and terminates in elevated and rounded borders dorsally and palmarly. The fibular portion of the astragalar facet is rapidly deflexed externally and terminates abruptly at the fibular angle, while the tibial portion is gently concave transversely and greatly concave antero-posteriorly. The fibular face has three facets for the cuboid, two dorsal and one palmar, as in *Archæotherium*. There is apparently a tendency toward coössification between the navicular and cuboid, as the articulating facets are reduced and the surfaces very rugose throughout. The dorsal face is plane except the rugose and sharp fibular angle which abuts against the cuboid. On the anterior portion of the tibial face the bone is convex vertically, and more so posteriorly. This convex portion is suddenly succeeded by a prominent and rugose area for muscular attachments.

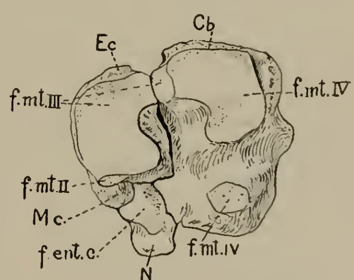

FIG. 79. Distal View of Tarsus of Left Pes of Type of *D. hollandi* Peterson. ½ nat. size. *f* = facet. *Ec* = ecto-cuneiform. *Mc* = mesocuneiform.

The plantar hook is quite prominent and extends well below the distal facets, while in *Archæotherium* it is much reduced, and is, as Professor Scott states, "hardly more than a roughened ridge." The anterior portion of the distal face is taken up by the facet for the ectocuneiform. The latter facet is divided into two areas by fibular and tibial sulci leaving a narrow isthmus midway between the two. The small facet for the mesocuneiform, on the tibial angle in *Archæotherium*, is entirely absent in *Dinohyus*. Another interesting difference in *Dinohyus* is seen in the very much less prominent tubercle on which the facet for the entocuneiform is located; the facet being almost on the same level with that for the ectocuneiform, and saddle-shaped, with the posterior margin deflected on the base of the plantar hook.

The navicular of *Entelodon magnum* (**38**, Pl. XXVII, figs. 34 and 37) is relatively shorter antero-posteriorly, and has a less developed palmar hook than in *Dinohyus*. In *Sus* the navicular is quite different, being broad and articulating distally with the three cuneiforms, as is also the case in *Hippopotamus*. In the latter genus, however, the navicular has no palmar hook, and the articulating surface between the navicular and cuboid is situated near the palmar face.

Measurements of Navicular.

	Mm.
Greatest anteror-posterior diameter	73
" transverse "	41
" vertical " anteriorly	33
" " " posteriorly	55

Entocuneiform.— Unfortunately the entocuneiform is lost in the type. Judging, however, from the space on the navicular, and cuneiform when in position, this bone was of considerable height, rather compressed transversely and antero-posteriorly, and in general apparently somewhat different from that in *Archæotherium*.

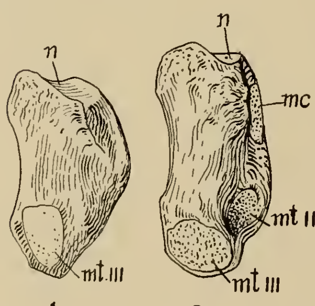

Fig. 80. (1) External View of Right Entocuneiform of *A. ingens* Leidy (Princeton Museum, No. 10885). (2) Same View of Corresponding Bone in *D. hollandi* Peterson (Carn. Mus. Cat. Vert. Foss., No. 2139a).

An entocuneiform of *Dinohyus* (No. 2139a, Carn. Mus. Cat. Vert. Foss.) which was found in quarry No. 1, section 20 (See plan of quarry, Pl. LIV), is of an animal of approximately the same size as the type specimen. The bone differs somewhat from the corresponding bone in *Archæotherium*, being dorsally less produced and more developed in the palmar direction; it is not pointed distally, and its navicular articulation is less oblique. It is further to be observed that there are two facets, one near the proximal end for the mesocuneiform (fig. 80, mc.), and another small one near the distal end for Mt. II. These are not present in *Archæotherium ingens* (the Princeton specimen). The distal fibular angle of the bone under description is entirely taken up by a large facet, which is slightly convex in all directions, and articulates with a corresponding facet on the palmar process of Mt. III. The bone as a whole has a great vertical diameter, while antero-posteriorly and transversely it is rather compressed, especially in the latter diameter.

Scott (**78,** p. 316) has already stated that the entocuneiform has not yet been found in connection with *Anthracotherium* or with *Entelodon.* In *Sus* the entocuneiform is larger distally than proximally, the palmar tubercle is very prominent and the bone as a whole is altogether different from that in *Archæotherium* or *Dinohyus,* having a large and very prominent articular facet for Mt. II. In *Hippopotamus* the entocuneiform is also heavier, and broader than in the latter genera.

Mesocuneiform. — The mesocuneiform is entirely ankylosed with the ectocuneiform, but its outline, especially on the palmar and tibial angle, is clearly defined (Fig. 79, Mc.). There is, however, no articular facet on the proximal end for the navicular as in *Archæotherium* and there is no facet for Mt. II, but on the proximal fibular angle is a facet for the entocuneiform.

Ectocuneiform. — The ectocuneiform is of considerable size and Q-shaped in general outline viewed distally or proximally. The entire proximal face is occupied by the facet for the navicular, and the distal face is taken up by the facet for Mt. III. On the palmar tibial angle of the distal face is a very minute articular surface for Mt. II. The fibular face is very rugose back of the facet for the cuboid, which is located near the dorsal face and occupies the entire vertical diameter of the bone ; there is no facet for the cuboid on the proximo-palmar angle, as in *Archæotherium.* In this respect the ectocuneiform of *Dinohyus* is more like that in some peccaries, while in *Hippopotamus* the ectocuneiform articulates with the cuboid only by the large palmar-fibular facet. The antero-posterior diameter of the facet on the distal face for Mt. III is proportionately greater than in *Archæotherium,* and, as in that genus, the facet is in its dorsal portion obliquely convex from side to side, and near the plantar region obliquely concave antero-posteriorly. The fibular border of the facet is deeply emarginated by a sulcus.

Measurements of Ectocuneiform.

	Mm.
Greatest antero-posterior diameter including mesocuneiform	52
" transverse diameter	32
" vertical "	28

The general outline of the ectocuneiform of *Entelodon magnum* (**38,** Pl. XXVII, figs. 34, 35, 37) is quite similar to that of *Dinohyus*, but the distal articulation is interrupted on the fibular angle and it is plainly seen from the figure that Mt. III, did not come in contact with the cuboid as in *Dinohyus*.

Cuboid. — The cuboid is relatively large and reveals some interesting and important differences from that of the earlier types. The articular facets for the calcaneum and astragalus occupy the proximal end in nearly equal proportions, the former facet being slightly wider,[56] which is directly the opposite of what is the case in *Archæotherium ingens*, where the astragalar facet is the larger of the two. The cuboid of the type of *Boöchœrus humerosus* more nearly approaches that of *Dinohyus* so far as the two specimens can be compared. The astragalar facet of the present genus is plane transversely, deeply concave antero-posteriorly, and the articular surface is confined to the anterior and posterior parts, with an interrupted median area twelve millimeters long. A deep pit is located on the fibular side of this interrupted sinus, which separates the calcaneal and astragalar facets at this point. The calcaneal facet is less interrupted than that in *Archæotherium*, as described by Scott, and continues obliquely from in front upward and backward, terminating near the summit on the postero-tibial angle of the ascending palmar hook. The tibial border of the dorsal face is heavy and very rugose; the fibular angle is also prominent and abruptly convex antero-posteriorly. The tibial face is rugose and in addition the dorsal facet for the navicular has developed a projecting ledge[57] so that together with the palmar facet, which also occupies a similar though much larger ledge, the cuboid and navicular bones are very strongly interlocked. Below the navicular facet near the dorsal angle is a small facet with square outlines, which articulates with the ectocuneiform. The latter bone was undoubtedly connected posteriorly by cartilage only, as the corresponding surfaces on the two bones are very rugose with no distinct facets, such as are found in *Archæotherium ingens*. Immediately below the facet for the ectocuneiform there is a third facet on the tibial angle.[58] This facet articulates in a prominent and quite important manner with a process of Mt. III which extends above the head of Mt. IV similar to, though less prominent than, that in the manus (figs. 70, 78). These articulations are not present in the peccary, *Sus*, *Hippopotamus*, or *Entelodon magnum*, but on Mt. III in *Archæotherium* there is a very slight indication

[56] On page 448 (38) Kowalevsky says that the cuboid of *Entelodon magnum* has a narrower facet for the astragalus than for the calcaneum, which is also well shown in his illustrations (Pl. XXVIII).

[57] In *Boöchœrus humerosus* this projecting ledge is more developed than in the Princeton specimen from the Oligocene, but is not so prominent as in *Dinohyus*.

[58] In the type of *Boöchœrus humerosus* this facet is not present on the cuboid, but in a smaller individual from the green sandstone (middle beds) of the John Day formation (Yale Museum No. 12765; Collector, L. S. Davis, 1875) this facet is fairly well developed on the cuboid.

of a facet on the fibular angle of the head, which is quite prophetic of the conditions found in *Dinohyus*. The anterior portion of the distal face is taken up by the facet for Mt. IV, that for Mt. V being entirely absent in the type. The palmar face is greatly excavated above the hook; the latter is very prominent and covers the entire lower portion of the palmar face. Distally there is on the tibial angle a facet of considerable size for the palmar process of Mt. IV.

The vertical diameter of the cuboid is relatively less than in the Princeton specimen, which in this respect as well as in the deeper tendinal sulcus on the fibular side of the Carnegie Museum specimen, seems to agree more nearly with *Entelodon magnum* (**38**, pp. 448–449, Pl. XXXVII, figs. 34, 35, and 36). In the latter species the facet on the palmar hook for the palmar process of Mt. IV is absent, and the facet for Mt. V on the fibular-distal angle is present, just the reverse of what appears in *Dinohyus*, in which there is no facet for Mt. V, and there is a facet present on the palmar hook for Mt. IV.

MEASUREMENTS OF CUBOID.

	Mm.
Greatest antero-posterior diameter	70
" transverse "	50
" vertical " anteriorly	55
" " " posteriorly	71

Metatarsal II. — The second metatarsal is reduced to a very small oblong nodule about half the size of Mt. II in the Princeton specimen. The nodule is held in place chiefly by the distal end of the entocuneiform, for which it has an articulating facet of considerable size on the palmar face. On the proximal tibial angle is a small facet for the ectocuneiform.

MEASUREMENTS OF SECOND METATARSAL.

	Mm.
Greatest length	22
" transverse diameter	13
" antero-posterior diameter	7

Metatarsal III. — The third metatarsal is larger and slenderer than Mc. III, but the articular facets for Mt. IV on the third metatarsal are surprisingly similar to the corresponding facets for Mc. IV. Thus the fibular angle of the head rises to a prominent tubercle which overlaps the head of Mt. IV and articulates with the cuboid in much the same manner in which Mc. III articulates with the unciform. This character of the pes seems to be a modification perhaps brought about since Oligocene times, as the genus *Archæotherium* has only a very faint suggestion of a facet for the cuboid, and has the fibular angle of the head of Mt. III only very slightly higher than the tibial angle.[59] The proximal facet for the ectocuneiform is slightly concave transversely in the dorsal region, and convex antero-posteriorly in the palmar region to conform with the facets of the ectocuneiform already described. On the postero-fibular angle of the head is a very minute facet which articulates with Mt. II. Below this facet is a rugose shallow channel, which receives the second metatarsal. The palmar process is strongly developed, and, as in *Archæotherium*, bears three facets; the one on the tibial side is for the entocuneiform, the one on the fibular side is for Mt. IV, and the one on the palmar end is for a large sesamoid. The facet for Mt. IV, which is near the dorsal face is larger and more pronounced in *Dinohyus* than in the Princeton specimen. The shaft is quite flat, long, and slender on the palmar and fibular faces, round on the tibial and dorsal faces, and is similar to that of *Archæotherium*, except for its greater rugosity on the fibular face, which is a marked character, showing a tendency toward the coössification of the two functional digits in *Dinohyus*. The large tubercle which is developed on the fibular border of the dorsal face just above the trochlea in *Archæotherium*, is in *Dinohyus* developed into a swollen area which occupies the entire dorsal face of the shaft, causing a deep depression distally. This depression is the superior boundary of the distal trochlea. The latter is, as in *Archæotherium*, rather low and narrow. The carina, which is confined principally to the plantar side, is plainly indicated on the dorsal face by a faint ridge, which continues to the extreme proximal border of the articulation. On either side of the carina is a shallow depression, which causes a slight lateral convexity in the tibial and fibular portions of the trochlea.

MEASUREMENTS OF THIRD METATARSAL.

	Mm.
Greatest length	240
" antero-posterior diameter of head	55
" transverse " "	40
Antero-posterior diameter of shaft medially	30
Transverse " " "	30
" " " trochlea	40
Antero-posterior " " "	45

Metatarsal IV. — The fourth metatarsal is of very nearly the same length and thickness as the third. The head does not rise as high as that of the third, but the palmar process is, as in *Archæotherium*, longer than that of the third metatarsal. Dorsally the articular facet for the cuboid is slightly concave in all directions and rises into an antero-posterior convexity in the palmar region. There is a large facet for the cuboid on the end of the palmar process; the tibial face of the process is

[59] Some species of the John Day formation more nearly approach *Dinohyus* in the matter of the articular facets of the cuboid and Mt. III.

occupied by the facet for Mt. III; and immediately behind and at almost right angles is a third facet, which corresponds to that on Mt. III and which supports a palmar sesamoid. There is no evidence of a facet for Mt. V on the fibular angle of the head. Dorsally the shaft is quite flat on its dorsal, tibial, and fibular faces, while the palmar face is unevenly rounded. Towards the distal end the shaft is more cylindrical, the palmar face being by far the flattest. Distally the bone is similar, including the trochlea, to that of the third metatarsal.

MEASUREMENTS OF FOURTH METATARSAL.

	Mm.
Greatest length	237
" antero-posterior diameter of head	59
" transverse " "	41
" " " shaft medially	28
Antero-posterior " " " "	32
" " " trochlea	33
Transverse " " "	37

Metatarsal V. — Judging from the total absence of facets for the fifth metatarsal on the cuboid and Mt. IV it would seem that this element is entirely wanting in *Dinohyus*. There is, however, a minute scale-like eminence on the fibular angle on Mt. IV, which may, or may not, represent the fifth metatarsal.

A water-worn fragment of a fourth metatarsal which I refer to *Dinohyus* (No. 1927, Carn. Mus. Cat. Vert. Foss.) was found in the Agate Spring Fossil Quarry, No. 1, where the type of *Dinohyus* was found. On the postero-fibular angle of the facet for the cuboid of this metatarsal the articulation is flexed downward in such a manner as to suggest the presence of a small fifth metatarsal in this individual.

Palmar Sesamoid. — The palmar sesamoid is a large bone, triangular in outline, compressed antero-posteriorly, and much expanded, especially in the tibial and distal directions. The palmar surface is rugose and on the dorsal face near the fibular angle are two facets for the third and fourth metatarsals described above. There are facets on the palmar processes of the metatarsals in *Archæotherium* which indicate the presence of similar sesamoids.

MEASUREMENTS OF PALMAR SESAMOID.

	Mm.
Greatest vertical diameter	38
" transverse "	32
" antero-posterior diameter	12

Phalanges. — The proximal and median phalanges are proportionately longer and narrower than those of the manus; otherwise they are similarly depressed antero-posteriorly and expanded transversely. The articulation for the metatarsal on the proximal phalanx is divided into two parts by a faint groove, which extends across the face and terminates in the deep plantar notch. On either side of the latter are facets on the extreme plantar angle of the proximal end which abuts against the sesamoids. The distal trochlea is, as in the manus, simply convex antero-posteriorly and concave transversely. The median phalanx is quite similar to that in the manus. The ungual phalanx is short, high, and somewhat compressed. They suggest strongly those of the recent camels though proportionally larger.

Measurements of Phalanges.

Proximal phalanx.

	Mm.
Greatest length	78
" transverse diameter of proximal end	42
" antero-posterior " " " "	35
" transverse " " distal "	37
" antero-posterior " " " "	23

Median phalanx.

	Mm.
Greatest length	57
" transverse diameter of proximal end	36
" antero-posterior " " " "	35
" transverse " " distal "	34
" antero-posterior " " " "	30

Ungual phalanx.

	Mm.
Greatest length	39
" vertical diameter, approximately	30
" transverse "	27

Sesamoids. — The sesamoids, though of considerable size, are much smaller than those of the manus. They are heaviest anteriorly and taper to an obtuse hook posteriorly. The dorso-proximal angle carries an articular surface which abuts against a corresponding surface on the proximo-plantar angle of the first phalanx described above.

Restoration of Dinohyus Hollandi.

(Plates LX, LXI.)

The most conspicuous features of the skeleton of *Dinohyus hollandi* are the disproportionately large skull, the long muzzle, the heavy neck, the high withers, and the elongated limbs. Many other characters are impossible to fully appreciate without seeing the skeleton mounted in full relief. The thorax has nearly the same proportions as in *Bos taurus*, but the lumbar region is shorter. In *Sus* the lumbar region is relatively longer than in *Dinohyus*, and the latter genus is, in this respect, more analogous to the *Hippopotamus*. The sternum is of enormous size and there are osseous sternal ribs present. The fore limbs are powerful and the skeleton in this region is not unlike that of *Bison americanus*. In the region of the fifth, sixth, and seventh cervicals the neck was of enormous vertical diameter.

There are only four lumbar vertebræ present derived from the type and a fragment of the pubis represents all that was found of the pelvis. These parts were found in a pile of fragments left on the edge of the quarry by Mr. Cook who started to excavate in the fall of 1904. The pelvic material, which was found in quarry No. 1 in 1908, is used in this restoration and its anatomical features are thought to be practically correct. The right femur and certain bones of the manus were also found in quarry No. 1 and are here used for the purpose of accuracy. The right cuboid, the entocuneiform and Mt. IV are derived from other individuals. The caudal region is restored throughout.

The skeleton was mounted by Mr. Serafino Agostini of the paleontological staff, to whom much credit is due for the skill he has displayed in his work.

In 1894 Professor Marsh published (**64**, pp. 407–408, Pl. IX) a restoration which is based on rather incomplete material and as a consequence a number of errors occur, some of which were pointed out by Professor Scott in his memoir on "*Elotherium*" (**87**, pp. 320–321). In *Dinohyus hollandi* there are unquestionably fourteen dorsal vertebræ, which were found in a continuous series. The character of the anterior sacral vertebra in comparison with the lumbars present in the type of *Dinohyus hollandi* seems to indicate that there must be two vertebræ missing. Two vertebræ have therefore been inserted (l. 3 and l. 6) which appears justifiable. Furthermore, it is quite evident from Professor Scott's publication (**87**), as well as from my own observations on the same material, that there are six lumbar vertebræ in *Archæotherium ingens*. It would then seem that Marsh (l. c.) was correct as regards the number of presacral vertebræ of his restoration, but made a mistake in the division of the dorso-lumbar series, while Scott's restoration (fig. 9) shows only thirteen dorsal vertebræ. In examining the Princeton specimen it occurred to me that the spines in the posterior dorsal region are too abruptly shortened and that there was probably an additional dorsal vertebra.

In comparing the articulated skeleton of *Dinohyus* with that of *Archæotherium ingens* (see fig. 9) it is at once seen that the former has a relatively larger head, shorter and heavier body, higher withers, and a shorter pelvis. Furthermore, the sagittal crest is higher posteriorly, which indicates a greater vertical diameter of the neck immediately back of the skull. Thus, it is seen that the Miocene genus had a relatively heavier neck than its Oligocene predecessor.

Measurements of the Restored Skeleton.

	Cm.
Length from premaxillary of skull to the posterior end of ischium	288
Length of cervical region	51
" " dorsal "	91
" " lumbar "	38
" " sacral " approximately	12
" " sternum	52
Height at 2d dorsal vertebra	177
" at superior border of ilium	140
" " end of ischium	113

A model in full relief of *Dinohyus hollandi*, a photograph of which is given on Plate LXII, has been made by Mr. Theodore A. Mills under the direction of the writer. An examination shows that this figure is at variance with the painting prepared by Mr. Charles R. Knight under the direction of Professor Henry Fairfield Osborn (**72a**, p. 713). *Archæotherium* is represented in that figure as having long stiff bristles on a very broad neck, with the ears as in the *Suinæ*, and as having heavy pendant wattles hanging from the bony tubercles of the inferior margins of the mandibles. Although the bristles and the broad neck shown in Knight's illustration may be correct, there is reason to believe that the ears were placed lower down and were more drooping, judging from the position of the external auditory meatus, which in the true pigs is directed upward and slightly outward, while in those American genera of the Entelodontidæ, in which this part is known, the auditory meatus is directed nearly horizontally outward and has a prominent overhanging border on the upper side formed by the squamosal. In the restoration by Mr. Mills the dependent processes on the inferior border of the mandibular rami of *Dinohyus* are represented as supporting muscles, it being believed by the writer that these processes, at least in the genus *Dinohyus*, existed for the attachment of muscles in order to give required strength to this portion of the head. The model, of which the figure is given, is of course to a certain extent conjectural, but is believed by the writer to very fairly represent the animal as it was in life, and he takes occasion to compliment Mr. Mills upon the skill which he has shown in carrying out the suggestions made to him.

Conclusion.

While the osteology of at least two genera of this interesting family is now quite completely before us, I make no attempt to present a succession of species, as it seems to me that we have not yet the necessary material in order to satisfactorily study the more detailed questions of the phylogeny of this group. Aymard and Pomel with the extremely limited material representing this family at their command, were constrained to place it among the living swine, where it has since, with only one or two exceptions (*Subursi* of de Blainville and *Arctodon* of Leidy), generally been placed by different writers. That the family is a "collateral branch" of the Suidæ, which "branched off in early Eocene time" as Marsh says (**64,** p. 406), is from all the evidence at hand unquestionable. "Schlosser has referred the genus [*Elotherium*] to the bunodont division of the family *Anthracotheriidæ*, which family he derives from an Eocene stock common to the *Anthracotheriidæ*, the *Anaplotheriidæ*, the *Hippopotamidæ*, and the *Suidæ*" (**87,** p. 322). Scott says (*l. c.*): "The genus [*Elotherium*] is so far specialized that it implies a long ancestry, not a member of which is, as yet, certainly known, although there are certain Eocene genera, which throw some light upon the problem." Stehlin in his discussion of the dental structure of the *Entelodontidæ* (**90,** pp. 121–123) concludes in a footnote (p. 123) by saying: "jedenfalls liegt die Vorgeschichte der Elotherien noch sehr im Dunkeln." It is apparent that, although we are well acquainted with the general anatomical features of this family, we can for the present at best only speculate in a general way as to the early history of the group. From the work of Schlosser it is plain that he regards the early Tertiary of the Old World as the home of the ancestral line of the *Entelodontidæ*, which may possibly prove to be true, unless "we may suppose," as Matthew has stated in connection with his study of the genus *Ancodon*,[60] "that from a diffusion center in Northern Asia early stages in the evolution of [this] phylum [also] reached Europe," and that the American form reached North America at the beginning of the Oligocene.

As for the known forms in the early American Tertiary there is not one which can properly be regarded as truly ancestral to the family. *Achænodon* of the Bridger, and *A. uintense* of the Uinta are already too far advanced in the modification of their dentition, having but three premolars, while the limbs of *A. uintense* would seem to have retained a more primitive condition, having "four [? functional] digits in the pes" (**72,** p. 105). The suggestive resemblances of the known characters of *Achænodon* found in the Bridger formation, and *A. uintense* of the Uinta, should, I think, be regarded only as pointing to a remote relationship; indeed it would seem that no great violence is done in referring these general resemblances to parallelism, which was no doubt a greater factor in moulding characters than is sometimes realized. The primitive bunodont teeth, the characteristic glenoid cavity of the skull, the expanded zygomatic arches, and the elongated muzzle of these earlier Tertiary forms are not to be dismissed so easily, as they are certainly most suggestive of the *Entelodontidæ*. But, as has been suggested by others (**87,** p. 322) there is no more

[60] Bull. Am. Muesum of Natural History, Vol. XXVI, p. 4, 1909.

reason why we should not expect a parallelism here as well as, for instance, in the odontoid process of the axis, the selenodont molars, the reduction of the lateral digits, and many other features, which have been independently acquired by several distinct lines.

In regard to the ancestry of the *Entelodontidæ* Dr. Herluf Winge (**92a,** p. 134) seems to have reached a somewhat similar conclusion to that of Schlosser. From a study of the dental, cranial, and other skeletal characters of the *Entelodontidæ*, Winge (*l. c.*, p. 141) seems also to think that they perhaps were less in the habit of rooting in the earth than their ancestors and that, instead of the usual plant-food of the Ungulates, which they perhaps entirely excluded, they accustomed themselves to mixed, or flesh-food. In fact Winge (*l. c.*, p. 141) states that the incisors, canines, and premolars served as grasping-tools and weapons similar to those of carnivores ; and (*l. c.*, p. 142) that it is also not altogether unlikely that they lived in a similar manner to that of dogs, preying on live animals, or, when they discovered carcasses, fruits, etc., that they fed on them. That these animals actually seized live animals as their food, as Dr. Winge seems inclined to believe, may well be doubted, while that they fed on carrion and fruits, as well as on plants, is not altogether unlikely.

Lydekker has very suggestively said (**53a,** p. 78) that the "food of the higher selenodont pigs consisted in great part of leaves and grass (which require finer trituration . . .) while their bunodont allies feed, as we know, more generally on roots and tubers, and occasionally on animal matter. Hence it is probable that the muzzles of most of the selenodonts were less elongated than in the true pigs, which require to turn up the soil to obtain nutriment." It has been, I think, quite conclusively shown, by Scott (**87,** p. 278), and also in the description of the dentition of *Dinohyus* in the present paper, that the wear of the lower canines and incisors could not have been caused, in this animal, except by the habit of digging up roots.

The dental structure of *Tetraconodon*, from the Siwalik hills of India, precludes its introduction into the family *Entelodontidæ* and it has quite correctly been placed in a distinct family by Lydekker (**53a,** p. 78). This genus is apparently quite far removed from the *Entelodontidæ* as is *Achænodon* of the American Eocene.

The phyletic and geologic position of the family *Entelodontidæ* may then be expressed in a general way as follows :

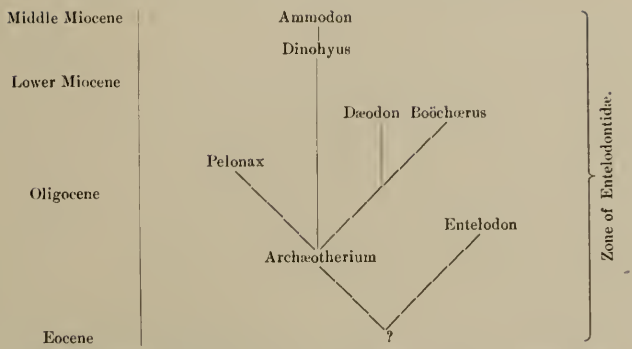

DIAGRAM EXPRESSING THE PHYLETIC AND GEOLOGIC POSITION OF *Entelodontidæ.*

As Pomel (**74,** p. 1085), Leidy (**50,** p. 174), Marsh (**64,** p. 408), Kowalevsky (**38,** p. 450), Scott (**87,** p. 322), Schlosser (**83,** p. 80), and others have shown us, this family has in the pigs and *Hippopotamus* its nearest [61] representatives of the recent forms, while the direct ancestors are yet to be found. In the meanwhile we have seen that during the relatively short geological time in which we are able to trace the family in Europe and America there are certain anatomical differences, indicating lines of divergence. These lines probably point to habits due to the varied environments during the life-history of the group.

We have, for example, in the European genus *Entelodon*, a form with enlarged premolars indicating a diverging step from *Archæotherium.* It has further been pointed out that the base of the skull of *Entelodon* is very greatly different from that of the American forms; and also that the trigon of the lower molars is entirely absent, while in *Archæotherium* it is quite plain in young, but fully adult specimens. *Pelonax ramosum* of the upper Oligocene has tremendously heavy chin-processes, a very prominent angle, and single-rooted first and second lower premolars. *Dæodon* of the John Day formation has no chin-processes at all and has a light angle of the lower jaw; while in the Miocene of Nebraska we have in *Dinohyus* a form with very small chin-processes, and a gentle sweep of the downward projection of the angle approaching what is seen in *Dæodon.* The median upper incisors of *Dinohyus* are distinctly reduced and are in fact sometimes wanting, having been perhaps shed quite early and the alveoli closed up.

In confining ourselves to these characters of the mandible alone and leaving out *Entelodon* whose generic position can hardly be doubted, it would seem that there is a variation of importance, when we consider the fact that all the specimens

[61] The relationship to these recent forms is a very remote one.

found with these parts present in the Oligocene formation have the chin processes present. This character then cannot be regarded as only of sexual importance so far as the Oligocene forms, which are most abundantly found, are concerned. It then remains to be seen whether certain forms like *Archæotherium clavum* with the relatively small and posteriorly placed chin-processes led up to such forms as *Dæodon* or if we will yet find in the lower Oligocene a form minus these protuberances. The discovery of such a form would indicate that the various lines even to quite small details of differences were already well established in older Tertiary time. While the variation in the canine teeth, the dependent processes of the lower jaw, and the jugal of the skull in the different species of the lower Oligocene, may seem comparatively small, they are nevertheless of some importance when it is shown that certain other parts, as for instance the vertebral column, are quite varied. In *Archæotherium ingens* from the lower Oligocene, the neural arches of the dorsal vertebræ are imperfectly pierced by canals, while in *Archæotherium crassum* from the same horizon, the horizontal canals are apparently present as in *Bos taurus*. In *Dinohyus* from the Miocene we know that the neural arches of the dorsals are not only perforated by horizontal canals, but by vertical canals as well; a character which is identical with what is found in *Sus*.

While the geographical distribution of this family in Asia is at present only a matter of speculation, it is clear that Europe and especially North America were occupied by it. Thus we have seen that while their remains are comparatively abundant on the flanks of the Rocky Mountains, evidence of their existence is not altogether wanting in California and New Jersey ("*E. superbum*," *Ammodon leidyanum*). From the lower Oligocene upward, and before the close of the Miocene, then, they occupied certain areas of the North American continent from the Pacific to the Atlantic coasts. Judging from their anatomy, their undoubtedly omnivorous dental structure, their elongated limbs, and their distribution, it is highly probable that these animals were capable of combating adverse conditions when occasion required change. While we know that the representatives of this family continued in America to a later geological age than was recently believed and that there were distinct genera and species during the known existence of the group from the lower Oligocene to the middle Miocene, there is yet much to be ascertained and we are far from having solved the whole history of this interesting branch of the suborder *Artiodactyla*. When a more extensive survey of Asia, especially its northern part, is made, and its Tertiary fauna becomes better known, we probably will be supplied with much valuable information on obscure points in connection with the study of the vertebrate paleontology of the Tertiary formations of the continents of the northern hemisphere.

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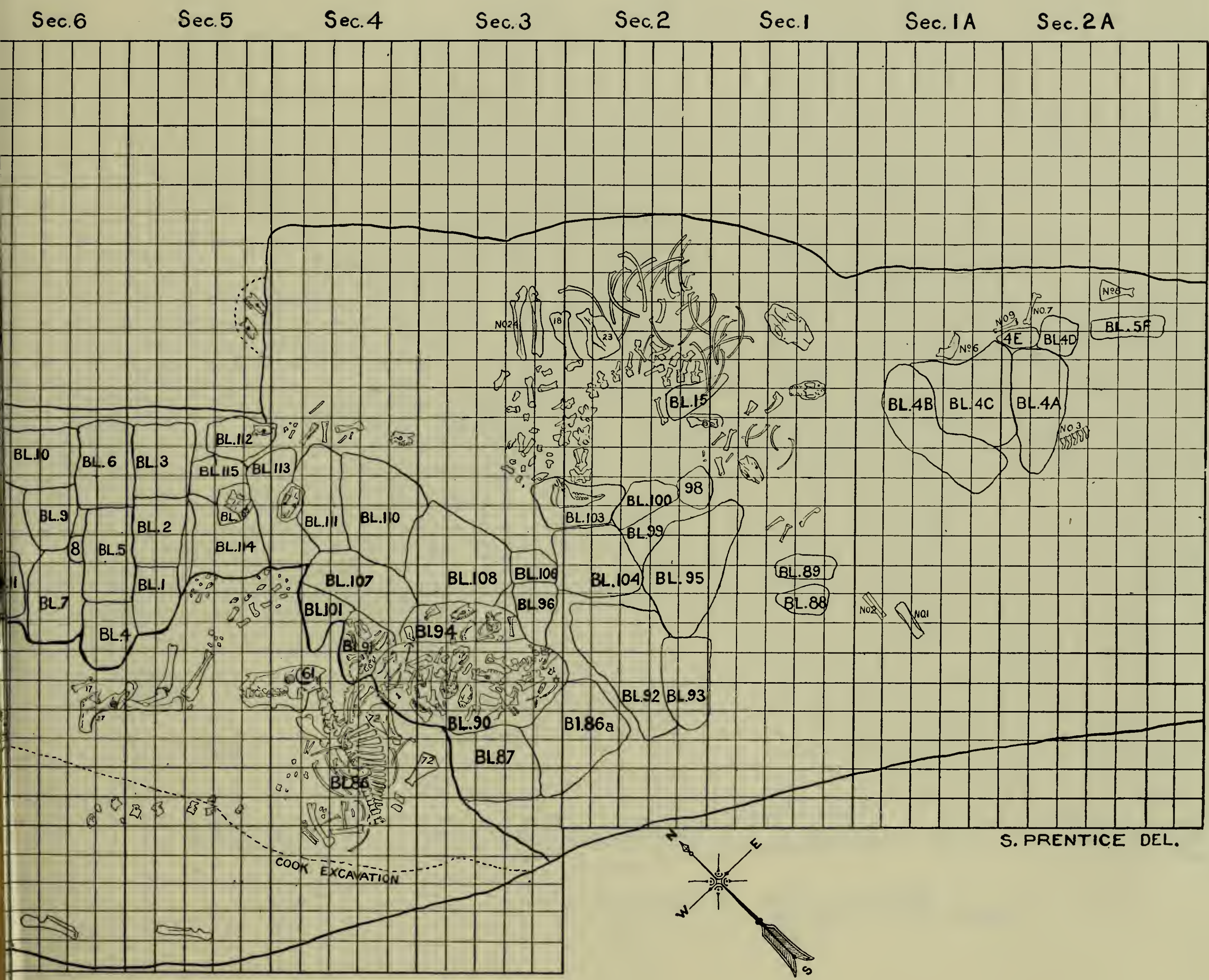
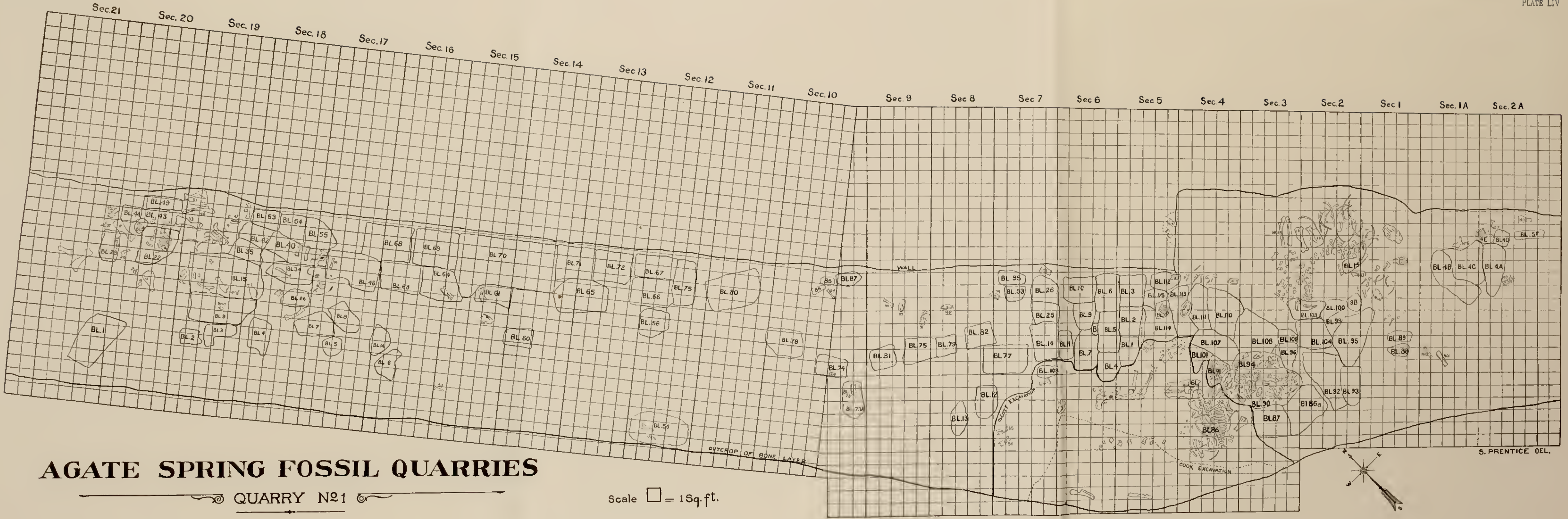
EXPLANATION OF PLATE LIV.

Agate Spring Fossil Quarries. Plan of Quarry No. 1. Bl. = " Block " and associated with numbers indicates relative size of blocks taken out of the quarry. Sections 2A, to 21, indicate relative position of each block and specimen as they were taken out.

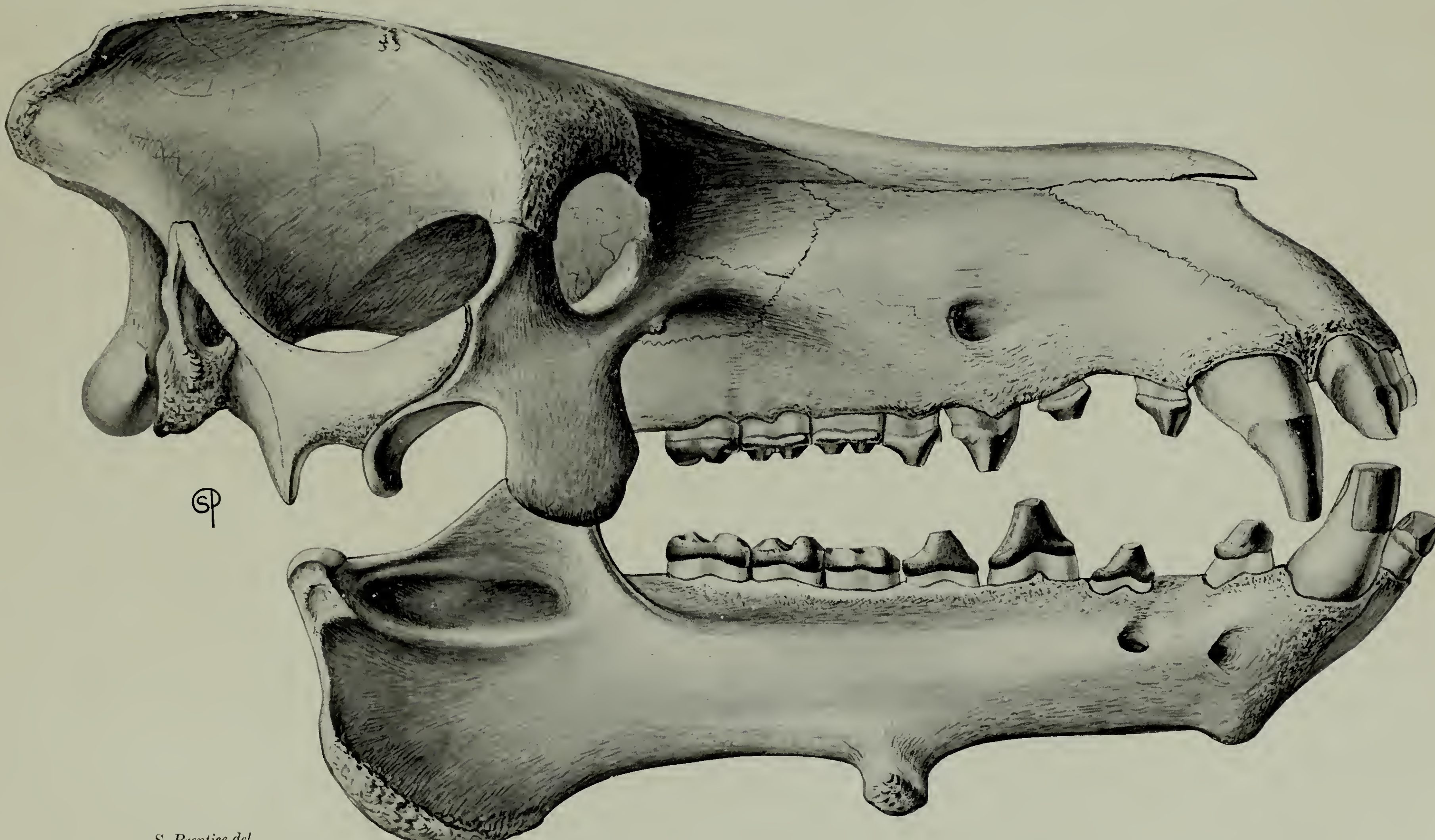


S. PRENTICE DEL.



AGATE SPRING FOSSIL QUARRIES

QUARRY No. 1



S. Prentice del.

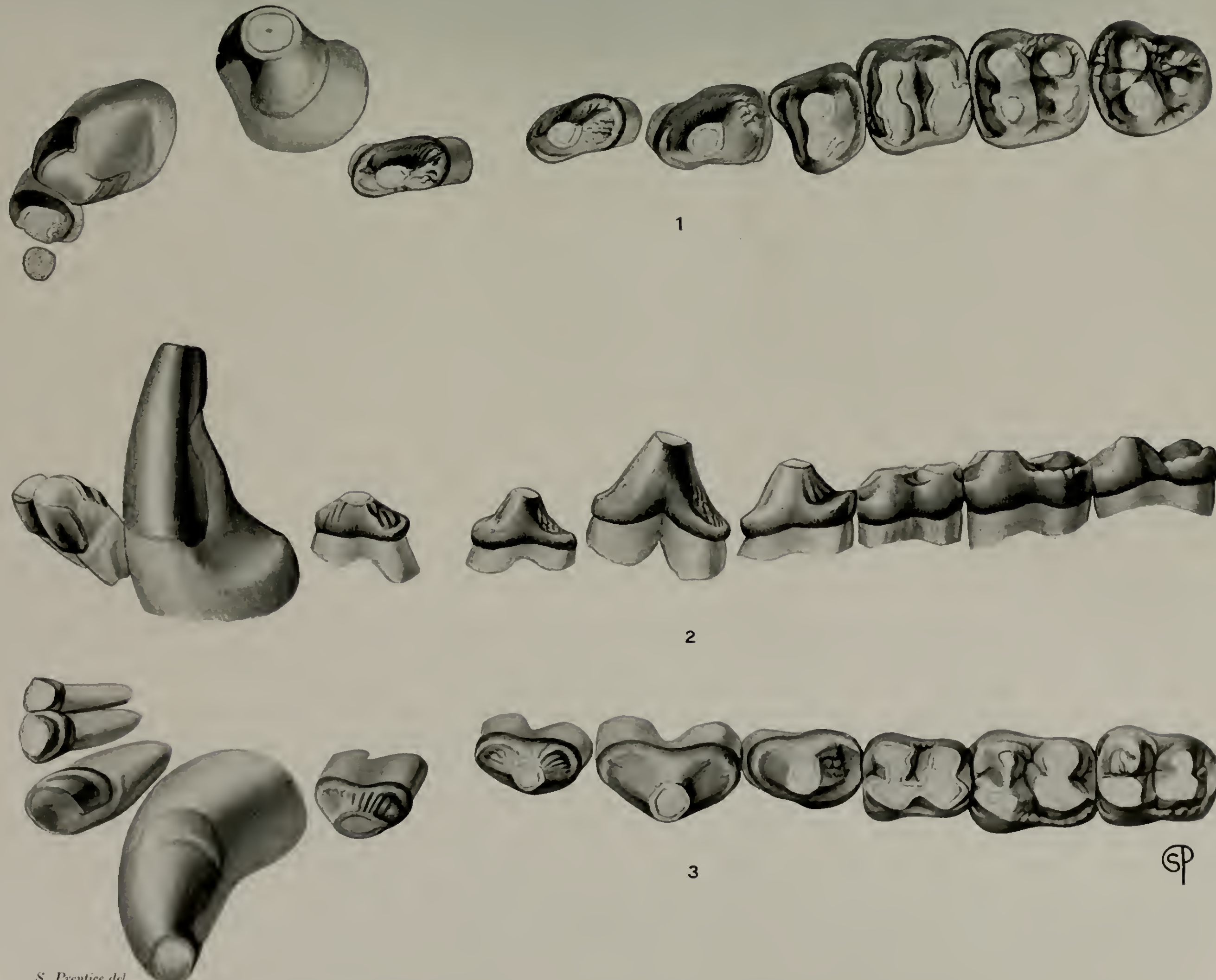
View of Right Side of Skull of *Dinohyus hollandi*, Peterson. $\frac{7}{25}$ Nat. Size. (Carn. Mus. Cat. Vert. Foss. No 1594.)

S. Prentice del

SUPERIOR VIEW OF CRANIUM OF *Dinohyus hollandi* PETERSON. $\frac{7}{25}$ NAT. SIZE.

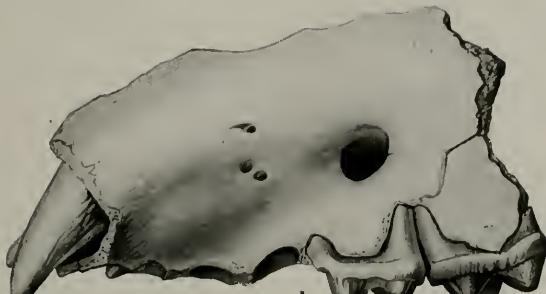
S. Prentice del.

PALATAL VIEW OF CRANIUM OF *Dinohyus hollandi* PETERSON. $\frac{7}{25}$ NAT. SIZE.



S. Prentice del.

DENTITION OF *Dinohyus hollandi* PETERSON. ½ NAT. SIZE. 1. CROWN VIEW OF UPPER DENTITION OF LEFT SIDE. 2. SIDE VIEW OF LOWER DENTITION OF LEFT SIDE. 3. CROWN VIEW OF LOWER DENTITION OF LEFT SIDE.

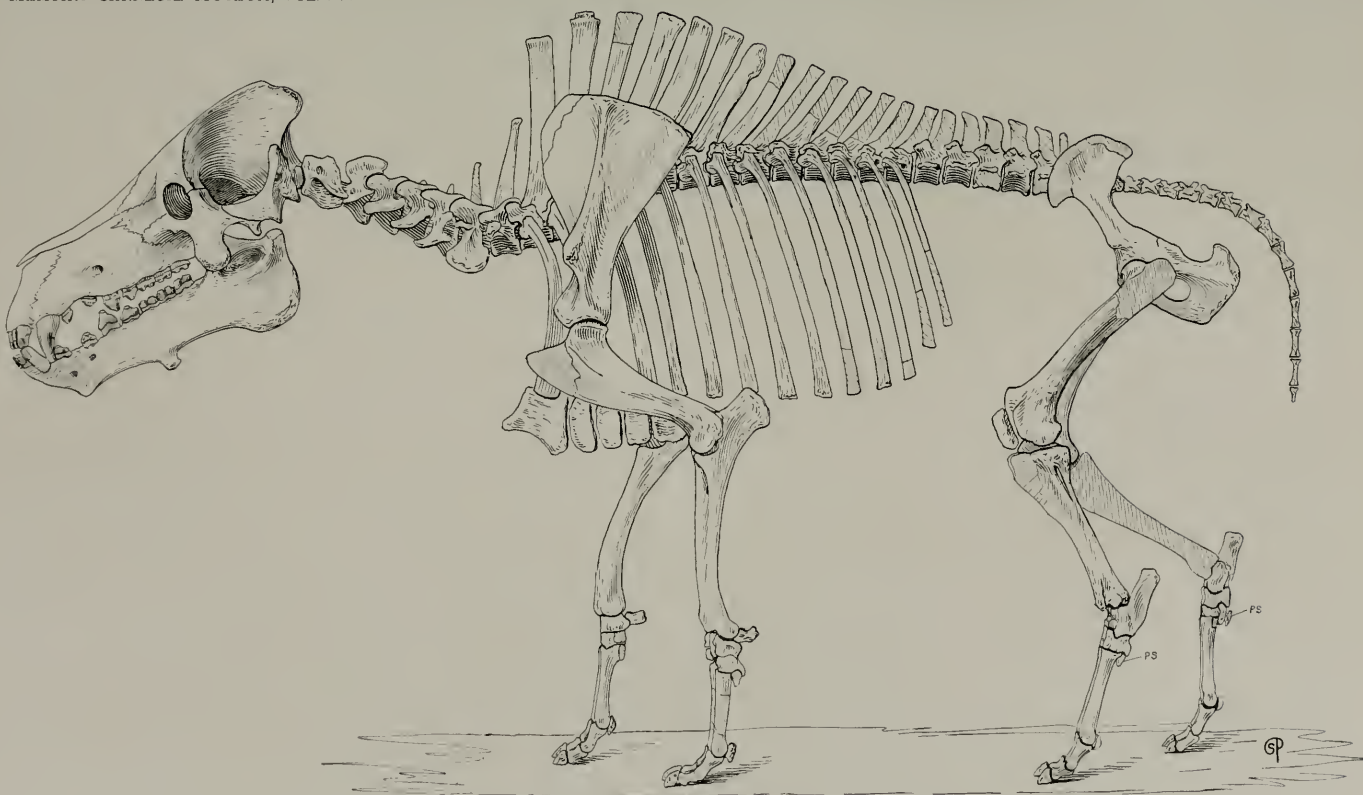


1

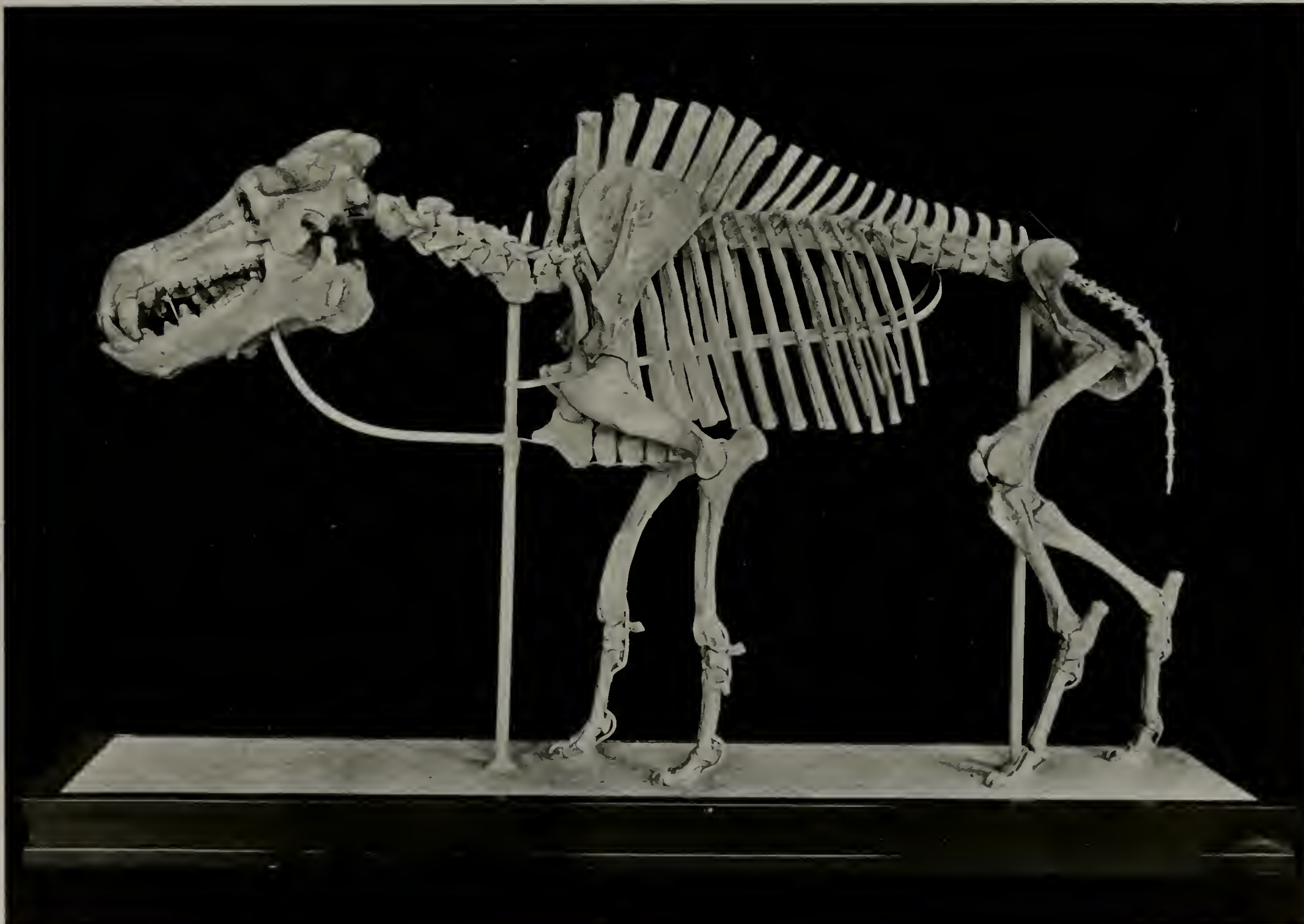
2

S. Prentice del. 3

DECIDUOUS DENTITION OF *Dinohyus hollandi* PETERSON WITH PERMANENT DENTITION COMING INTO VIEW. ½ NAT. SIZE. FIGS. 1–2. NO. 2137; FIG. 3, NO. 2137A, CARN. MUS. CAT. VERTEBRATE FOSSILS.



MOUNTED SKELETON OF *Dinohyus hollandi* PETERSON. $\frac{1}{13}$ NAT. SIZE.
(*ps*, Palmar sesamoid.)



Photographic Reproduction of the Mounted Skeleton of *Dinohyus hollandi* Peterson. About $\frac{1}{15}$ Nat. Size.

RESTORATION IN RELIEF OF *Dinohyus hollandi* PETERSON. ABOUT $\frac{1}{12}$ NAT. SIZE. MODELLED BY THEODORE A. MILLS UNDER THE DIRECTION OF O A. PETERSON.