

Article XXXV.—REVISION OF THE MIOCENE AND PLIOCENE EQUIDÆ OF NORTH AMERICA.

BY JAMES WILLIAMS GIDLEY.

With an introductory Note by Henry Fairfield Osborn.

INTRODUCTORY NOTE.

The American Museum collection of Horses — from the Eocene to the Pleistocene inclusive — now numbers several thousand specimens, including nearly fifty types and about as many casts of types. It is desired gradually, as opportunity permits, to make this type collection absolutely complete either through originals or casts.

The first step towards a thorough understanding of the Equidæ is a systematic revision of all the generic and specific names which have been proposed, and of the characters of the valid genera and species, starting with an exact study and comparison of the type specimens. As planned this is being done by coöperation of the writer, of Mr. Walter Granger of the American Museum staff, and especially of Mr. J. W. Gidley, formerly of this Museum, now of the United States National Museum, and the author of the present paper, who has made a specialty of the horse from the Oligocene to the Pleistocene inclusive.

The list of these revisions, as completed or in progress, is as follows:

Pleistocene.

Tooth Characters and Revision of the North American Species of the Genus *Equus*. By J. W. Gidley. Bull. Am. Mus. Nat. Hist., Vol. XIV, 1901, pp. 91-141, pll. xvii-xxi, and 27 text figures.

Miocene and Pliocene.

Proper Generic Names of Miocene Horses. By J. W. Gidley. Bull. Amer. Mus. Nat. Hist., Vol. XX, 1904, pp. 191-194.

Revision of the Miocene and Pliocene Horses of North America. By J. W. Gidley. Bull. Amer. Mus. Nat. Hist., Vol. XXIII, 1907, pp. 865-932.

Oligocene of the White River.

New Oligocene Horses. By H. F. Osborn. Bull. Amer. Mus. Nat. Hist., Vol. XX, 1904, pp. 167-179, pll. iv and v, and 8 text figures.

Eocene.

North American Eocene Horses. (In Preparation.) By Walter Granger.

In order to spread the more exact knowledge of the American Horses — and to make our own collection more comprehensive — the Museum has made a series of casts of the skulls, teeth and feet, of typical specimens which are to be used in exchange for similar casts, or preferably original duplicates, from other Museums. As soon as the monograph on the Equidæ is completed the Museum will also be ready to exchange a large part of its original duplicate collection, but for the present it is desirable to retain all such specimens for the purpose of comparative study of growth changes and variations.— H. F. O.

INTRODUCTION.

This revision has necessitated not only a restudy and comparison of all the available types, representing upwards of fifty proposed species, but a systematic and exhaustive study of all other available horse material from the American Miocene and Pliocene deposits. The great amount of more complete and better collected specimens, obtained by the expeditions of later years, especially those of the American Museum made possible through the generosity of the late William C. Whitney, has been a large factor in clearing up many points regarding the determination and classification of species.

I wish here to acknowledge my indebtedness to Prof. Henry F. Osborn for placing this material in my hands for revision, and my especial appreciation of his valuable aid and that of Dr. W. D. Matthew in systematically laying out the work, and for their many helpful suggestions and kindly criticism.

At the beginning of this work it was found that, as in the case of the North American species of the genus *Equus*,¹ our knowledge of the Miocene and Pliocene horses has been obtained largely from material of a most fragmentary nature, in many instances consisting of single isolated teeth. In consequence there has been on the part of early writers a very limited understanding even of fundamental characters regarding the general tooth structure of horses. The effects of age-wear and the limits of individual variation have often not been taken sufficiently into account, and in many cases investigators have failed to distinguish between the deciduous and

¹ Tooth Characters and Revision of the North American Species of *Equus*. Bull. Amer. Mus. Nat. Hist., Vol. XVI, 1901, pp. 91-142.

permanent dentitions. These causes have frequently led to confusion in determining both genera and species, and has resulted in errors of classification.

One of the important results of this study has been to show the necessity of a partial rearrangement of the Equidæ as a whole. The species of the family may now be grouped provisionally under four distinct subfamilies, as defined below.

I. PROVISIONAL ARRANGEMENT OF THE NORTH AMERICAN EQUIDÆ.

Horses with Four Toes and Short-crowned Teeth. Eocene.

I. **Hyracotheriinae** Cope. Teeth brachyodont; molariform premolars not more than two; digit formula 4-3; rudimentary fifth digit on hind foot; 1st digit of fore foot not represented in known forms. Orbit not closed behind.

This subfamily includes all the known Eocene genera of horses.

Horses with Three Toes and Short-crowned Teeth. Oligocene, Miocene.

II. **Anchitheriinae** Leidy. Teeth brachyodont; molariform premolars three; digit formula 3-3; 5th digit on fore foot vestigial; 1st digit of fore foot not represented in known forms; lateral toes, so far as known, reaching the ground; orbit not closed behind.

A. *Inner cones (pr and hy) larger than median conules (pl and ml); protocone occupying more than one half the transverse diameter of the crown; prefossette continuous with inner median valley; no anterior median fold of metaloph (crochet).*

1. Metaloph not united with ectoloph; protoconule distinct, coniform; m_1 and p_4 largest of lower series. The points of greatest transverse width are the anterior half of m_1 and posterior half of p_4 *Mesohippus*.

2. Metaloph completely united with the ectoloph; protoconule distinct, coniform; p_3 and p_4 largest of lower series, subequal in transverse width.

Anchitherium.

3. Metaloph completely united with ectoloph; protoconule and metaconule nearly or quite lost in the continuous transverse lophs; m_1 and p_4 largest of the lower series, subequal in transverse width; metastylid undeveloped, or but slightly separated from the metaconid *Hypohippus*.

B. *Inner cones (pr and hy) larger than median conules (pl and ml); protocone occupying less than one half the transverse diameter of the crown; metaloph completely united with the ectoloph; protoconule distinct, coniform.*

4. Prefossette partially inclosed by a well defined anterior median fold (crochet) of the metaloph; p_4 and p_3 largest of the lower series, subequal in transverse width; metastylid separated more or less distinctly from the metaconid *Parahippus*.

5. Metaloph without anterior median fold; prefossette continuous with inner median valley; p_4 probably not larger than m_1 , as indicated by the comparatively large upper true molars *Archæohippus*.

C. Inner conules (pr and hy) smaller than median conules (pl and ml) protoconule semi-crescentic; partially or completely united with the metaloph; orbit completely inclosed; digits of fore foot all represented, but with 1st and 5th vestigial.

"C" includes hypothetical genera, not as yet discovered, more directly ancestral to the Protohippinæ.

Horses with Three Toes and Long-crowned Teeth. Miocene.

III. **Protohippinæ**¹ nom. nov. Teeth hypsodont; cement a functional part of the tooth crown, at least in the adult series; digit formula 3-3; lateral digits (2d and 4th) not reaching the ground so far as known; 1st and 5th digits of fore foot present but vestigial, being represented by nodules of bone in all known forms; orbit closed behind.

Additional characters are: protoconule and metaconule large, crescentic in outline and completely inclosing the pre- and post-fossettes respectively; protocone and hypocone smaller than median conules (pl and ml); metaconid and metastylid subequal and completely divided internally by a continuous groove.

A. Milk molars brachyodont to subhypsodont, with little or no cement; permanent molars short-hypsodont, height of crowns about equaling their anteroposterior diameters; cheek teeth heavily cemented, with cement a functional part of the crown.

1. Protocone free to completely united with protoconule; lachrymal fossæ shallow to well defined; malar fossæ well defined to wanting . . . *Merychippus*.

B. Milk and permanent molars hypsodont, well cemented; protocone completely united with protoconule; molar crowns not more than twice the length of their anteroposterior diameters; crowns of upper molars moderately curved; fossettes broad transversely, with open external loops and simple enamel foldings; inner wall of protoconule flat to concave; lateral toes much reduced, probably not functional.

2. Lachrymal fossa shallow, borders not sharply defined; malar fossa shallow or wanting *Protohippus*.

3. Lachrymal and malar fossæ large and partially confluent, with posterior borders sharply defined *Pliohippus*.

4. Characters like those of 3, except that the protocone and hypocone are partially to completely united. *Protohippus* or *Pliohippus*.

C. Both milk and permanent molars hypsodont and well cemented; protocone free from protoconule except at base; molar crowns more than twice the length of their anteroposterior diameters; crowns of upper molars comparatively straight; inner wall of protoconule flat to convex, giving a transversely compressed appearance to the prefossette.

5. Enamel foldings of fossette borders complex; protocone comparatively

¹**Protohippinæ** replaces *Hippotheriinae* Cope, which can no longer be employed since the genus name *Hippotherium* is antedated by *Hipparion*.

small, and more or less circular in cross-section; lachrymal fossa large and infolded into a well defined pit posteriorly; malar fossa shallow or wanting; lateral toes large *Hipparion*.

6. Enamel foldings of fossette borders comparatively simple; protocone comparatively large, and laterally compressed; lachrymal fossa shallow, borders not sharply defined; malar fossa shallow or wanting; lower border of mandibular rami deeply bowed; lateral toes much reduced. . . *Neohipparion*.

D. *So far as known, species diminutive as compared with those of 2, 3, 4, and 6 of B and C. Milk and permanent molars hypsodont, well cemented; molar crowns more than twice the length of their anteroposterior diameters; upper molar crowns comparatively straight; so far as known, lachrymal fossa comparatively small and shallow; malar fossa shallow or wanting; so far as known, lateral toes much reduced.*

2a. Protocone completely united with protoconule to summit; fossettes with simple enamel borders; lower borders of mandibular rami nearly straight.

Protohippus placidus.

6a. Protocone free or partially free from protoconule except at base; fossettes with moderately complex enamel borders; lower border of mandibular rami deeply bowed *Neohipparion gratum*.

Horses with One Toe and Long-crowned Teeth. Pliocene, Pleistocene and Recent.

IV. **Equinæ** Osborn. Tooth crowns hypsodont; cement a functional part of the teeth; digit formula 1-1; 1st and 5th digits wanting; 2d and 4th digits represented by "splints"; bicipital groove of humerus double; orbit closed behind.

A. *Limbs short; tooth crowns short hypsodont, upper molars deeply curved.*

1. Molar crowns less than twice the height of their anteroposterior diameters; upper molars with protocone small and cylindric, but united with protoconule to summit *Hippidion*.

B. *Limbs long; tooth crowns long; upper molars straight or but slightly curved.*

2. Molars more than twice the length of their anteroposterior diameter; upper molars with protocone large, laterally compressed and united with protoconule to summit *Equus*.

In tooth characters *Hippidion* has more the affinities of group B of the Protohippinae.

While phylogeny has by no means been ignored, the above grouping and definition of the subdivisions of the Equidæ are founded on a basis of structural affinities rather than on phylogenetic relations.

Thus, while the four subfamilies undoubtedly represent as many successive stages in the evolution of the horse, forms directly ancestral to the known genera of the later groups probably are not represented by known genera of the same or earlier groups. It is moreover evident, from a study of the abundant material at hand, that although the general lines of progressive development are clearly indicated and several distinct lines of subphyla

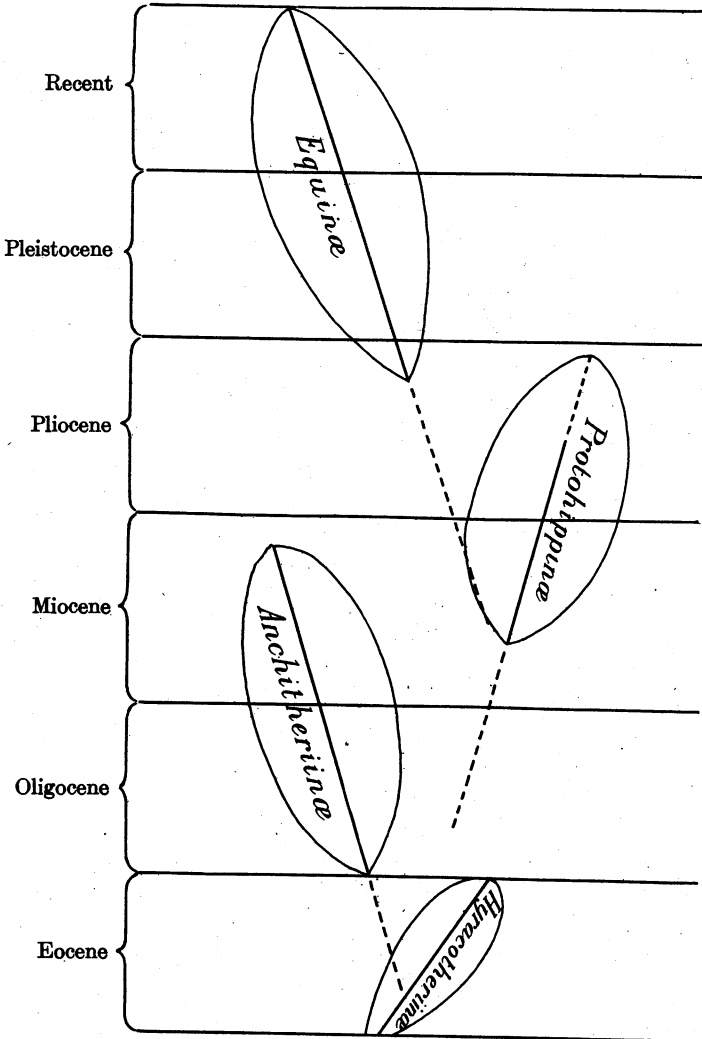
suggested, the direct lines of descent are by no means complete and the known genera cannot at present be arranged in any permanent phyletic series.

It is further indicated that the different genera of horses hitherto proposed may or may not represent groups of closely allied species, hence it is difficult in many instances to positively refer a species to its proper genus owing to the overlapping and apparent intermixing of characters to which generic values have been given.

It will be noted that the morphological distinctions between the two intermediate groups, the Anchitheriinae and Protohippinae of the above arrangement, are very clearly marked, indicating a considerable phyletic hiatus which is not bridged over by any species thus far discovered. This may be considered sufficient ground for dividing the great group into two distinct families, as has been done by Gill.¹ However, I prefer for the present to hold the above arrangement, filling in the gap with the hypothetical group defined under division C. of the Anchitheriinae.

¹ Arrangement of Families of Mammals, Theodore Gill, 1872, p. 104. Smithsonian Miscellaneous Collection, Vol. XI, 1874, p. 84.

The probable relations of the four subfamilies as above defined are suggested in the following diagram.



Chronological Table of Proposed Genera and Species of Miocene Horses Reported from North America.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type
1	1854	<i>Hippodon speciosus</i> Leidy	Bijou Hill, S. D.	Not figured	Not located.
2	1856 (Feb.)	<i>Hipparion occidentale</i> Leidy	Little White River (Neb.) So. Dakota	Ext. Mam. Fauna Dak. & Neb., 1869, pl. xviii, figs. 1 to 5	Acad. Nat. Sci. Phila.
3	1856 (Dec.)	<i>Merychippus insignis</i> Leidy	Bijou Hill, S. D.	Ext. Mam. Fauna, Dak. & Neb., 1869, pl. xvii, figs. 3 and 4	Acad. Nat. Sci. Phila.
4	1856	<i>Hipparion (Hippodon) spe-</i> <i>ciosus</i> Leidy	Bijou Hill, S. D.	Not figured	Acad. Nat. Sci. Phila.
(1)	(Dec.)	<i>Anchitherium (Hypohippus)</i>	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, Dak. & Neb., pl. xxi, figs. 11, 12	No. 573, National Museum, Washington.
5	1858	<i>affinis</i> Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xxi fig. 7	No. 576, National Museum, Washington.
6	1858	<i>Anchitherium (Parahippus)</i> <i>cognatus</i> Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xvii, figs. 1, 2	No. 619, National Museum, Washington.
7	1858	<i>Equus (Protohippus) perditus</i> Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xvii, figs. 10, 11	No. 570 National Museum, Washington.
8	1858	<i>Merychippus mirabilis</i> Leidy	Fort Niobrara, Niobrara River, Nebraska	Holmes' Post-pli. Fossils, S. C., pl. xvi, fig. 33	Not located.
9	1860	<i>Hippotherium venustum</i> Leidy	Ashley River, So. Carolina	Not figured	Yale Museum.
10	1868	<i>Equus parvulus</i> Marsh (<i>Pro-</i> <i>tohippus parvulus</i> Marsh, 1874)	Antelope Springs, Nebraska		
11	1868	<i>Anchippus tezanus</i> Leidy	Washington Co., Texas	Ext. Mam. Fauna, pl. xxi, figs.	Acad. Nat. Sci. Phila.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type.
12	1869	<i>Protohippus placidus</i> Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xviii, fig. 40	Acad. Nat. Sci. Phila.
13	1869	<i>Hepparion affine</i> Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xviii, figs. 20-24	National Museum, Washington.
14	1869	<i>Hepparion gratum</i> Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xviii, fig. 25	National Museum, Washington.
15	1869	<i>Protohippus supremus</i> Leidy	Little White River, South Dakota	Ext. Mam. Fauna, pl. xxvii, fig. 4	Acad. Nat. Sci. Phila.
16	1874	<i>Hippotherium paniense</i> Cope	Pawnee Buttes, Colorado	Proc. Am. Phil. Soc., p. 458, figs. 13, 14	Amer. Mus. Nat. Hist.
17	1874	<i>Protohippus labrosus</i> Cope	Pawnee Buttes, Colorado	Not figured	
18	1874	<i>Protohippus sejunctus</i> Cope	Pawnee Buttes, Colorado	Not figured	Amer. Mus. Nat. Hist.
19	1874	<i>Pliohippus pernix</i> Marsh	Fort Niobrara, Niobrara River, Nebraska	Not figured	Yale Museum.
20	1874	<i>Pliohippus robustus</i> Marsh	Fort Niobrara, Niobrara River, Nebraska	Not figured	Yale Museum.
21	1874	<i>Protohippus avus</i> Marsh	Cottonwood Creek, Oregon	Not figured	Yale Museum.
22	1874	<i>Anchippus brevidens</i> Marsh	Cottonwood Creek, Oregon	Not figured	Yale Museum.
23	1875	<i>Hippotherium calamarium</i> Cope	Near San Ildefonso, New Mexico	U. S. Geol. Surv. west of 100th M., 1877, IV, pl. lxxv, fig. 1.	National Museum, Washington.
24	1878	<i>Stylonus severus</i> Cope	Cottonwood Creek, Oregon	Proc. Am. Phil. Soc., 1889, p. 458, fig. 24	Amer. Mus. Nat. Hist.
25	1880	<i>Hippidium spectans</i> Cope	Cottonwood Creek, Oregon	Am. Nat., 1887, p. 1072, fig. 41	Amer. Mus. Nat. Hist.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type
26	1882	<i>Hippotherium montezumae</i> Leidy	Hidalgo, Mexico	Proc. Acad. Nat. Sci., 1882, p. 291, fig.	National Museum, Wash- ton.
27	1882	<i>Hippotherium sinclarii</i> Wort- man	Cottonwood Creek, Oregon	Proc. Amer. Phil. Soc., 1886, p. 458, fig. 2	Amer. Mus. Nat. Hist.
28	1885	<i>Hippotherium peninsulatum</i> Cope	Vera Cruz, Mexico	Am. Nat., Vol. xix, pl. 28, fig. 5	Amer. Mus. Nat. Hist.
29	1885	<i>Protohippus castilli</i> Cope	Vera Cruz, Mexico	Am. Nat., Vol. xix, pl. 28, fig. 6	Not located.
30	1885	<i>Hippotherium ingenuum</i> Leidy	Archer, Fla.	Proc. Acad. Nat. Sci., 1885, p. 33	National Museum, Wash- ton.
31	1886	<i>Anchitherium ultimum</i> Cope	Cottonwood Creek, Oregon	Bull. Amer. Mus. Nat. Hist., 1905	Amer. Mus. Nat. Hist.
32	1887	<i>Hippotherium retidens</i> Cope	Vera Cruz, Mexico	Proc. Am. Phil. Soc., 1889, p. 458, fig. 3	Not known.
33	1887	<i>Hipparion plicatile</i> Leidy	Archer, Fla.	Proc. Acad. Nat. Sci., 1887, p. 310	National Museum, Wash- ton.
34	1889	<i>Hippotherium relicum</i> Cope	Oregon Desert	Proc. Am. Phil. Soc., 1889, p. 458, fig. 19	Amer. Mus. Nat. Hist.
35	1889	<i>Hippotherium retrusum</i> Cope	Philips Co., Kan.	Proc. Am. Phil. Soc., 1889, p. 458, figs. 7 and 8	Amer. Mus. Nat. Hist.
36	1889	<i>Protohippus</i> or <i>Hippidium</i> <i>profectus</i> Cope	Philips Co., Kan.	Proc. Am. Phil. Soc., 1889, p. 458, figs. 9 to 12	Amer. Mus. Nat. Hist.
37	1889	<i>Hippotherium sphenodus</i> Cope	Pawnee Buttes, Colorado	Proc. Am. Phil. Soc., 1889, p. 458, figs. 21, 22	Amer. Mus. Nat. Hist.
38	1889	<i>Hippotherium isonesum</i> Cope	Cottonwood Creek, Oregon	Proc. Am. Phil. Soc., 1889, p. 458, fig. 23	Amer. Mus. Nat. Hist.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type
39	1890	<i>Hippotherium princeps</i> Leidy	Peace Creek, Florida	Proc. Acad. Nat. Sci., p. 182, fig.	National Museum, Washington.
40	1892	<i>Plathippus gracilis</i> Marsh	Oregon	Not figured	Yale Museum.
41	1892	<i>Equus simplicidens</i> Cope	Mt. Blanco, Crosby Co., Tex.	Proc. Am. Phil. Soc., 1892, p. 124, fig. 1	University of Texas.
42	1892	<i>Protohippus pachyops</i> Cope	Donley Co., Tex.	Rep. Tex. Geol. Surv., 1893, pl. xi, fig. 1	University of Texas.
43	1893 (May)	<i>Protohippus fossulatus</i> Cope	Donley Co., Tex.	Rep. Tex. Geol. Surv., 1893, pls. v, vi, vii	University of Texas.
44	1893	<i>Protohippus lenticularis</i> Cope	Mulberry Cañon, Goodnight Texas	Rep. Tex. Geol. Surv., 1893, pl. xii, figs. 1, 2	University of Texas.
45	1893	<i>Hippidium interpolatum</i> Cope	Mulberry Cañon, Goodnight Texas	Rep. Tex. Geol. Surv., 1893, pl. xii, figs. 3, 4	University of Texas (?)
46	1893	<i>Equus eurystylus</i> Cope	Paloduro Cañon, Texas	Rep. Tex. Geol. Surv., 1893, pl. xx, fig. 6	University of Texas (?)
47	1893	<i>Equus cumminsii</i> Cope	Mt. Blanco, Texas	Rep. Tex. Geol. Surv., 1893, pl. xx, fig. 7	University of Texas (?)
48	1893	<i>Equus minutus</i> Cope	Mt. Blanco, Texas	Rep. Tex. Geol. Surv., 1893, pl. xx, fig. 8	University of Texas (?)
	1899	<i>Equus phlegon</i> Hay	(to replace <i>E. minutus</i> Cope, preoccupied)		
49	1893 (July)	<i>Desmatippus crenidens</i> Scott	Deep River, Montana	Trans. Am. Phil. Soc., 1893, pl. ii, figs. 9-14	Princeton University.
50	1893 (July)	<i>Anchitherium equinum</i> Scott	Deep River, Montana	Trans. Am. Phil. Soc., 1893, pl. iii, figs. 23-28	Princeton University.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type
52	1903	<i>Neohipparion whitleyi</i> Gidley	Little White River, S. D.	Not figured	Amer. Mus. Nat. Hist.
53	1906	<i>Prothippus sinus</i> Gidley	Little White River, S. D.	Not figured	Amer. Mus. Nat. Hist.
54	1906	<i>Neohipparion dolichops</i> Gidley	Little White River, S. D.	Bull. Amer. Mus. Nat. Hist. Vol. XXII, 1906, p. 149, fig. 14	Amer. Mus. Nat. Hist.
55	1906	<i>Neohipparion niobrarense</i> Gidley	Fort Niobrara, Nebraska	Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 152, fig. 18	Amer. Mus. Nat. Hist.
56 (31)	1906 (Dec.)	<i>Archaeohippus ultimus</i> (Cope) Gidley	Cottonwood Creek, Oregon	Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 357, figs.	Amer. Mus. Nat. Hist.
57	1907	<i>Merychippus campestris</i> sp. nov.	Cottonwood Creek, Oregon		Amer. Mus. Nat. Hist.
58	1907	<i>Hypohippus osborni</i> sp. nov.	Pawnee Buttes, N. E. Col- orado		Amer. Mus. Nat. Hist.
59	1907	<i>Parahippus pawnensis</i> sp. nov.	Pawnee Buttes, N. E. Col- orado		Amer. Mus. Nat. Hist.
60	1907	<i>Parahippus coloradensis</i> sp. nov.	Pawnee Buttes, N. E. Col- orado		Amer. Mus. Nat. Hist.

II. REVISION OF THE MIOCENE AND PLIOCENE EQUIDÆ.

The types and original descriptions are given in chronological order, and the notation corresponds to that of the chronological table.

1. *Hippodon speciosus* Leidy.

Hippodon speciosus LEIDY, Proc. Acad. Nat. Sci. Phila., 1854, p. 90.

Type: a lower molar. (Type specimen not located.)

Type locality, Bijou Hills, South Dakota ("Nebraska Territory").

Horizon: Middle or Upper Miocene.

Author's description (*op. cit.*). "An inferior molar of a solipedal animal, apparently intermediate to *Equus* and *Anchitherium*."

The definition given by Leidy is inadequate. Moreover the type being a lower molar would probably show no distinguishing characters, even if located. The genus and species are therefore indeterminate.

2. *Neohipparion occidentale* (Leidy).

Hipparion occidentale LEIDY, Proc. Acad. Nat. Sci. Phila., 1856, p. 59.

Hippotherium occidentale COPE, Proc. Amer. Phil. Soc., XXIII, 1886, p. 359.

Type: Four upper teeth, apparently of a single individual (rt. p², p³, and m², and 1. p³ (No. 3, Phila. Acad. Nat.Sci. coll.); No. 10794, cast, Am. Mus. Nat. Hist. coll.).

Type locality: Little White River, So. Dak. ("Nebraska Territory").

Horizon: Upper Miocene, Nebraska.

Author's description (*op. cit.*): "The internal isolated enamel column of the upper molars, on the worn crown, is elliptical and more than twice the length of the breadth. The central column of the same teeth are comparatively moderately folded."

*Measurements.*¹

Diameters of p ² : anteropost.....	31.5 mm.,	transv.....	23.5 mm.
" " p ³ : "	26.5 "	"	25 "
" " m ² : "	23 "	"	22 "
Anteroposterior diameter of protocones, p ² 8 mm., p ³ 10 mm., m ² 8 mm.			

To the description given by Leidy the following characters may be added:

¹ As the measurements given by Leidy, Cope and others were not always taken in a uniform way, some measurements including cement and others not including it, I have remeasured the type specimens where practicable. Transverse diameters are taken across the mesostyle and the posterior half of the protocone, exclusive of cement.

(1) The enamel foldings or plications of the fossette borders in the upper molariform teeth are comparatively complicated but not so elaborate as is usual in the European species of *Hipparion*. (2) The free protocone is relatively large, and flat-elliptical in cross section; (3) hypocone small, about one half the size of the protocone; (4) upper premolars relatively long anteroposteriorly; (5) molars, compared with the premolars, comparatively small; (6) tooth crowns long and but slightly curved.

The skull and foot characters of this species are not known.

3. *Merychippus insignis* Leidy.

Merychippus insignis LEIDY, Proc. Acad. Nat. Sci. Phila., Dec. 1856, p. 311; *ibid.*, May 1858, p. 27.

Protohippus insignis (Leidy) COPE, Bull. U. S. Geol. & Geog. Surv. Terr., Ser. 1, No. 1, 1884, p. 13.

Type: Two right upper milk molars, dp^2 and dp^3 , in a fragment of the maxillary (No. . . . Phila. Acad. Nat. Sci. coll.; No. 10770 cast, Am. Mus. Nat. Hist. coll.).

Type locality: Bijou Hills, South Dakota.

Horizon: Middle or Upper Miocene.

Author's description (op. cit.): "The teeth are inserted by distinct fangs; and the crowns strikingly resemble the true molars of ruminants. There are four demiconoidal lobes holding the relationship with one another as in the latter, especially as in the Deer. The outer lobes have almost the exact form as in the true molars of *Oreodon*. The inner lobes resemble those of ruminants but are complicated with accessory folds as in the horse. No cement fills up the interspaces of the lobes nor does it appear to have existed as a part of the structure of these teeth."

Measurements.

Diameters of dp^2 :	anteropost.....	22+	mm	.....	transv.	17.5	mm.
" "	dp^3:	"	.....	22	"	.....	19
							mm.

Although founded on teeth of the deciduous series, this genus is well characterized and the permanent molars are now well known from numerous specimens in the American Museum collections from the Pawnee Buttes, Colorado, locality. These specimens represent several species of horses especially distinguished by their brachyodont milk molars with little or no cement and short but truly hypsodont permanent teeth in which cement is a functional part of the tooth crown. In *Protohippus*, *Hipparion* and *Neohipparion* the milk molars are hypsodont in form and are heavily invested with cement which is a functional part of the tooth, while the permanent

series are longer crowned and more progressive in general than those of *Merychippus*; thus the genus is clearly distinct and was well founded, and may not be united with *Protohippus* as suggested by Cope.

The characters of the type species are less clearly indicated since it is known only from the type specimen. However it may be distinguished by (1) its moderately large size (see measurements); (2) the conical form of the protocone and hypocone; (3) the comparatively deep enamel foldings of the walls of the metaloph; and (4) the well marked ribs on the external walls of the paracone and metacone. These characters apply only to the milk molars.

4. *Hipparion (Hippodon) speciosum* Leidy.

Hipparion (Hippodon) speciosum LEIDY, Proc. Acad. Nat. Sci. Phila., 1856, p. 311.
Hippotherium speciosum Cope, non Leidy, Rept. U. S. Geog. Surv. W. of 100th Merid., 1877, p. 322, pl. lxxv, fig. 3.

Type: Same as *Hippodon speciosum*. *Paratypes*, *a*, an unworn upper molar of *Protohippus* sp.; *b*, an upper molar of *Neohipparion* sp.; *c*, an upper molar of *Neohipparion* sp. 2; *d*, a lower molar of uncertain reference. (These specimens are in the U. S. National Museum collection.)

Type locality: Bijou Hills, So. Dak.

Horizon: Middle or Upper Miocene.

Author's description (*op. cit.*): "Accompanying an inferior molar, there is an unworn upper molar and portions of three other upper molars, worn away in various degrees, which appear to be the teeth of *Hipparion*, and appear to belong to the same animal as the tooth referred to *Hippodon*."

In this description no distinctive characters were given by Leidy, and the specimens themselves only show characters sufficient to establish the fact that there are several species represented in this composite lot referable to two distinct genera. The teeth referred to this species by Cope (*op. cit.*) are smaller than those described by Leidy, and, moreover, are of the shorter crowned type, of the *Merychippus* group. The species, therefore, as proposed by Leidy remains indeterminable.

5. *Hypohippus affinis* Leidy.

Anchitherium (Hypohippus) affinis LEIDY, Proc. Acad. Nat. Sci. Phila., Mar. 1858, p. 26.

Hypohippus affinis LEIDY, Jour. Acad. Sci. Phila. (2), VII, 1869, p. 311.

Protohippus affinis COPE, Fourth Ann. Report Texas Geol. Surv., 1893, p. 20.

Type: Fourth upper milk molar, dp⁴, of left side (No. 573, U. S. National Museum coll., No. 10771, cast, Amer. Mus. Nat. Hist. coll.).

Type locality: Niobrara River near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description of genus and species (op. cit.): ".... the same form [of upper molar] as the corresponding teeth of *Anchitherium*, except that the outer surfaces of its external lobes present no trace of median rising. It indicates an animal larger than *A. aurelianense* and about the size of *Paleotherium crassum*."

Measurements.

Diameters of dp^4 : anteroposterior 27 mm., transverse 28 mm.

This genus, though based on a single upper milk molar, has, like *Merychippus*, since become well established through later discoveries of more complete material. The characters of the genus are especially well shown in the specimen described by Scott under the name of *Anchitherium equinum*, and several well preserved specimens in the American Museum, including a nearly complete skeleton. The genus may now be more definitely characterized as follows: (1) Both deciduous and permanent molariform teeth brachyodont in form, with little or no cement; (2) external walls of paracone and metacone concave and without external median ribs; (3) protocone and hypocone comparatively large and conical, with the protocone about one fourth larger than the hypocone; (4) protoconule and metaconule much reduced, or undeveloped, being nearly obscured in the continuous transverse lophs (protoloph and metaloph); (5) metaconid and metastylid of lower teeth undivided or but slightly divided by a shallow notch at their summit; (6) p_4 and m_1 are the largest of the lower series and of equal transverse width.

The upper molars of *Hypohippus* are especially distinguished from those of *Anchitherium aurelianense* by (1) the comparatively larger and more rounded protocone; (2) the more complete union of the metaloph with the ectoloph; (3) the more nearly continuous protoloph, with a less distinct protoconule; and (4) by the proportionately larger last upper molar, m^3 .

Hypohippus is distinguished from *Mesohippus* by the following important characters: (1) the more progressive development of all the lophs of the upper molars; (2) the completely inclosed posterior fossette; (3) the proportionally larger and more rounded protocone; and (4) the development in the latter of a deep lachrymal pit in the facial region of the skull.

The skeletal characters will be discussed under the description of a new species of this genus.

6. *Parahippus cognatus* Leidy.

Anchitherium (*Parahippus*) *cognatus* LEIDY, Proc. Acad. Nat. Sci. Phila., 1858, p. 26.

Parahippus cognatus LEIDY, Jour. Acad. Nat. Sci. Phila. (2), Vol. VII, 1869, p. 314.

Protohippus perditus (Leidy) COPE. Fourth Ann. Rept. Texas Geol. Surv., 1893, p. 20.

Type: Three upper milk molars of the left side (No. 567 U. S. National Museum coll.; No. 10772, cast, Amer. Mus. Nat. Hist. coll.)

Type locality: Niobrara River, near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*). "The Niobrara collection contains three isolated unworn crowns of upper molar teeth, which have the same form as the upper deciduous molars of *Anchitherium Bairdi* or *A. aurelianense*, except that the outer extremity of the prolongation of the postero-internal lobe branches into several short folds: these latter have the same arrangement as similar but more numerous folds in the same position in *Merychippus*."

Measurements.

Diameters of dp^2 :	anteropost.....	25 mm.,	transv.....	18 mm.
" "	dp^2 :	"	"	"
" "	dp^2 :	19	"	20
" "	dp^4 :	20	"	20

Again milk molars were taken to establish the type species of a genus, and like those of *Merychippus* and *Hypohippus*, were later regarded by Cope as representing the milk dentition of some species of *Protohippus*. That Cope was again in error is abundantly proven by a restudy of the types and of additional and better material representing both milk and adult teeth. The genus *Parahippus* as now understood may be more fully defined as follows: (1) Both milk and permanent molars brachyodont; (2) cement thin or wanting, not a functional part of the tooth; (3) inner cones (pr and hy) larger than the median conules (pl and ml) although (4) the protocone occupies less than half the transverse diameter of the crown; (5) protocone distinct, coneform; (6) pre-fossette partially inclosed by a well defined anterior median fold (crochet) of the metaloph; and (6) p_3 and p_4 largest of the lower series, subequal in transverse width. This definition is capable of including *Anchippus texanus* Leidy, *Anchippus brevidens* Marsh and *Desmatippus crenidens* Scott, all of which I regard as species of *Parahippus*.

The genus *Parahippus* is especially distinguished from *Merychippus insignis* and other species of the genus *Merychippus* by (1) the simple lophoid form and much smaller proportions of the median conules, pl and ml, together with the correspondingly large cone-like inner cusps, pr and hy,

which, though more reduced than in *Hypohippus*, still form a part of the internal boundaries of the pre- and post-fossettes respectively. In the milk as well as the permanent teeth of *Merychippus insignis*, the proportions of the inner cones and median conules are reversed, and the protocone and hypocone are entirely excluded from the fossettes by the large crescentic conules.

7. *Protohippus perditus* Leidy.

Equus (Protohippus) perditus LEIDY, Proc. Acad. Nat. Sci. Phila., 1858, p. 26.

Protohippus perditus LEIDY, Jour. Acad. Nat. Sci. Phila. (2), 1869, p. 275.

Merychippus perditus (Leidy) COPE, Amer. Nat., Vol. XXVI, 1892, p. 943.

Protohippus perditus Leidy, GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 136.

Type: A fragment of upper jaw containing the four posterior cheek teeth, p^4 to m^3 (No. 619, U. S. National Museum coll.; No. 10773, cast, Amer. Museum coll.). *Neotype*: A nearly complete skull (No. 10838, Amer. Museum coll.).

Type locality: Niobrara River near Fort Niobrara, Nebraska. Locality of neotype, Little White River, near Rosebud Indian Agency, So. Dakota.

Horizon: Upper Miocene, Nebraska beds. Same for neotype.

Author's description (op. cit.): "The portion of jaw is like the corresponding part in the recent Horse.... The enamel folds on the triturating surfaces are even less complex than in the recent Horse, and the antero-internal fold or column has the same form, direction and mode of construction as the postero-internal one."

Measurements.

Diameters of p^4 : anteropost.....	20	mm., transv.	22	mm.
" " m^1 : "	19.5	" "	21.5	"
" " m^2 : "	19.5	" "	21	"
" " m^3 : "	20	" "	17.5	"
Height of crown of p^4			36	"
Total length of series, p^4 to m^3			78.5	"

The type of this classical genus was founded on a fairly characteristic specimen of an adult individual, but Leidy's definition is far too general in character to be diagnostic. Cope redefined the genus, but he also made its limits too broad by including in it several species properly belonging to other genera.

The genus is now capable of a more definite and restricted definition as follows: (1) Milk molars as well as those of the permanent series hypsodont, with cement a functional part of the crown; (2) molar crowns of permanent series longer than those of *Merychippus* but not more than twice

the length of their anteroposterior diameters; (3) crowns of upper molars moderately curved; (4) fossettes of uppers molar broad and open transversely with well rounded external loops, (5) and simple enamel walls; (6) lateral toes greatly reduced and probably not functional, a character attained by most of the Miocene genera including some species of the Anchitheriinae group.

The neotype, described by the writer in a former volume of this Bulletin (*op. cit.*), makes possible a more extended description of *P. perditus*. The palate is only moderately arched, except immediately forward of the pre-molar series where it is especially high. The maxillaries are deeply constricted in this region, and the anterior palatal foramina are small, oval in outline and situated opposite the canines. The basisphenoid is short and broad, and is overlapped by the vomer.

The characters which especially distinguish the type species of this genus are: (1) Its moderately small size, which is less than that of the modern Donkey; (2) the laterally compressed and backwardly directed protocone and hypocone of the upper molars; (3) the shallow, not sharply defined, lachrymal fossa; and (4) the rudimental condition or entire absence of the malar fossa.

8. *Plihippus mirabilis* (Leidy).

Merychippus mirabilis LEIDY, Proc. Acad. Nat. Sci. Phila., 1858, p. 27.

Protohippus mirabilis (Leidy) COPE, Amer. Nat., Vol. XXVI, 1892, p. 943.

Type: A fragment of the right maxillary containing the posterior two milk molars, and the first true molar partially calcified. (No. 569, U. S. National Museum coll.)

Type locality: Niobrara River, near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska formation.

Author's description (*op. cit.*): "The temporary molars have the same form as the teeth from which the genus [*Merychippus*] was first characterized would have, in a more worn condition. They are invested with cementum, though in less quantity than is usual in the Horse, and it is more readily detached, which appears to have been the case in the two teeth from Bijou Hill. The crowns of the permanent teeth contained within the fragment of jaw under examination have the same form as the corresponding teeth of the recent Horse, with the modifications above noticed [in describing *Protohippus perditus*] characterizing the subgenus *Protohippus*."

Measurements.

Diameters of dp ³ :	anteropost.	24	mm.,	transv.	21	mm.
"	dp ⁴ :	"	26	"	"	21
"	m ¹ :	"	25	"	"	22

This species, originally referred to *Merychippus* by Leidy, has more the characters of the *Protohippus* group to which it was later assigned by Cope. The milk molars, though short-crowned, are of the true hypsodont type, and are invested with a considerable deposit of cement which is a functional part of the crown. This sufficiently distinguishes it from the species of *Merychippus*. It differs from the *Protohippus perditus* type in (1) its greater size; (2) the relatively broader transverse diameters of both the milk and permanent molars; (3) the comparatively smaller and more rounded protocone and hypocone; and (4) the presence of a deep malar fossa.

All these characters are common to the species of *Pliohippus* as redefined below. I therefore refer the present species to that genus.

9. *Hipparion venustum* Leidy.

Hipparion venustum LEIDY, Proc. Acad. Nat. Sci. Phila., 1853, p. 241 (name only).

Hippotherium venustum Leidy, Post-Pleiocene Fossils of South Carolina, 1860, p. 105 (first description).

Type: A left upper molar lacking the protocone, associated with a broken right upper molar in which the protocone is present.

Type locality: Ashley River, South Carolina.

Horizon: Pliocene.

Author's description (op. cit.): "Both specimens are from the upper jaw; and they are well characterized, not only by the isolation of the internal median enamel column, but also by the complex plication of the interior or central enamel columns. . . . The larger specimen is firm in texture. . . . In its present condition it is two inches in length; and possesses a moderate degree of internal and posterior curvature. . . . The smaller specimen is firm in texture, and brown in color. It is half worn down; tapers toward the root; and is little less than an inch in length. Its inner median enamel column is antero-posteriorly reniform."

Measurements (from Leidy's figures).

Diameters of No. 1, anteropost.	18 mm.,	transv.	16 mm.
" " No. 2, "	15.5 "	" "	13 "

These specimens described by Leidy are very incomplete and unsatisfactory as a type. But they represent one of the smallest though apparently very highly specialized species of the group to which they belong: The particular marks of specialization are the comparatively great height of the tooth crowns and the very complex plications of the enamel walls of the fossettes. In these characters and in the small well rounded protocone

this species differs from those of the typical *Neohipparion* and resembles the true *Hipparion* of the *H. gracilis* type.

10. ? *Parahippus parvulus* (Marsh).

Equus parvulus MARSH, Amer. Jour. Sci., 1868, p. 374.

Protohippus parvulus MARSH, Amer. Jour. Sci., 1874, p. 251.

Type: Fragments of skeleton, with an upper and a lower molar associated.

Type locality: Antelope Springs, Nebraska.

Horizon: ? Middle Miocene.

Author's description (for author's description see *op. cit.*, 1874, p. 251):

At the time Marsh first described this species, he had not noted any teeth associated with the type, hence his first description refers only to some foot bones which he regarded as belonging to a small species of *Equus*. On the examination of an associated upper molar, which he later discovered and described (*op. cit.*), he referred the species to the genus *Protohippus*, as it was then understood. It is evident, however, from Marsh's description that he had in mind the group of which *Merychippus insignis* is the type and which is now considered distinct from *Protohippus*.

Through Marsh's description, which I have verified by a reëxamination of the type specimen, this species is apparently well established, but there remains some doubt as to its generic reference. As noted by Marsh, the anterior fossette is not closed but is confluent with the inner median valley. This arrangement is unknown in *Protohippus* and the adult teeth of *Merychippus*. Moreover, there is no trace of any anterior fold or projection of the metaconule nor any tendency to a complete inclosing of the anterior fossette such as is observed in the milk teeth of *Merychippus insignis*. This together with the proportionally large protocone which exceeds the protoconule in size, seem to place it with the Anchitherinæ rather than with the Protohippinæ group. The fact that the molar under discussion is of the hypsodont or subhypsodont type and has a considerable investment of cement is contrary to this view. But both these latter characters indicate a stage of progression rather than any especial affinities, hence do not necessarily exclude the species from the former group and the specimen from Antelope Station, Nebraska, apparently represents an advanced type closely related, at least, to *Parahippus*. It may, therefore, provisionally be referred to that genus.

11. *Parahippus texanus* (Leidy).

Anchippus texanus LEIDY, Proc. Acad. Nat. Sci. Phila., 1868, p. 231.

Type: A portion of an upper molar, m^1 or m^2 , lacking the outer wall of the ectoloph.

Type locality: Washington Co., Texas.

Horizon: ? Upper Miocene. (Obtained from a well.)

Author's description (op. cit.): "The size of the tooth, as well as the general form and proportions, have been nearly as in the European *Anchitherium aurelianense*. Six lobes, as in the latter, enter into the constitution of the crown. The external lobes, imperfect, appear to have the same form as in *Anchitherium*. The inner lobes also have the same form but are proportionately less robust, while the median lobes are more so. The postero-median lobe pursues the same course as in *Anchitherium* and likewise, as in this, joins the outer lobes at their junction. From near the middle of its course it gives off a process directed towards the interval of the antero-internal and antero-median lobes and ceasing short of them. This process looks as if disposed to join the contiguous portion of the antero-median lobe, together with it to form a crescentoid lobe, embracing the antero-external one, as in the corresponding columns of equine teeth. No such arrangement exists in *Anchitherium*. A triangular tubercle, as in the latter genus, occupies the space at the back of the crown, and it appears as if its anterior angle had a disposition to join the contiguous portion of the postero-median lobe, to form with it a crescentoid lobe, in like manner as in the former case, to embrace the postero-external lobe."

Measurements.

The measurements of the type tooth are: anteroposterior diameter, 19 mm.; transverse diameter, 20+ mm.

Leidy's description sufficiently distinguishes *Anchippus texanus* from *Anchitherium* and, though not stated by him, the characters given distinguish it from *Meshippus* and *Hypohippus* as well. Leidy, however, did not compare it with *Parahippus cognatus*, and it is with this species that it seems most closely related. The type specimens agree in the complete union of the metaloph with the ectoloph, the development of a well defined crochet, and in the general form and proportions of the protocone and hypocone, while they differ only in a few points of minor detail of certainly not more than specific importance. The difference in proportion of crown diameters noted in comparing measurements is in this instance due entirely to the fact that one specimen is an adult molar while the other represents the milk dentition.

The additional material examined representing other species of this group does not apparently show any generic distinctions between *Anchippus* and *Parahippus*.

12. ***Protohippus placidus* Leidy.**

Protohippus placidus LEIDY, Jour. Acad. Nat. Sci. Phila., 1869, p. 277.

Type: A left upper premolar, p^2 (No. 621, U. S. National Museum coll.). *Neotypes*: several specimens from Big Spring Cañon, So. Dakota, the type locality (Nos. 10830, 10840, and others. Am. Mus. coll.).

Type locality: Niobrara River near Ft. Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (op. cit.): "A first upper molar tooth [p^2]... presents extreme simplicity in the arrangement of the enamel, compared with its condition generally in equine animals. The central lakes appear wide and gaping, as in the more posterior teeth of *Protohippus perditus*. No trace of a posterior valley or inflection of the crown exists."

Measurements.

Diameters of p^2 : anteropost.....18.5 mm., transv.....16 mm.

P. placidus, founded primarily on a single upper premolar, has become better known through material collected by recent American Museum expeditions, and has been redefined by the present writer.¹

It is apparently an abundant species in the Nebraska beds, and is represented by several well preserved specimens in the collection from Big Spring Cañon and the Little White River. As now understood the species, under the definition, belongs in the genus *Protohippus*, although in some respects its characters are more those of species referable to *Neohipparion*. The comparatively long-crowned teeth and nearly straight upper molars with their less rounded fossettes, resemble more in general the teeth of *Neohipparion gratum* (Leidy) than they do those of *Protohippus perditus*.

13. ***Neohipparion affine* (Leidy).**

Hipparion affine LEIDY, Jour. Acad. Nat. Sci. Phila., 1869, p. 286.

Type: Five upper molars of one individual, — left m^1 , m^2 , and p^4 , and right p^4 and p^3 . (No. 584, U. S. National Museum coll.)

Type locality: Niobrara River, near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (op. cit.): "Among the collection of equine teeth from the Niobrara River, there are a number of specimens larger than those referred to *Hipparion speciosum*, but having about the same size and proportions as those of *H. occidentale*, or of the existing Ass. They however

¹ Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, pp. 140 to 142.

differ from those of *H. occidentale* in the simplicity of arrangement of the enamel, which is not more folded than in the Horse. The internal enamel column is also not only proportionately very much wider than in *H. speciosum*, but also absolutely wider than in *H. occidentale*."

Measurements.

Diameters of p ³ :	anteropost.....	26	mm.,	transv.....	23	mm.
"	" p ⁴:	"	.....	25	"	"
"	" m ¹:	"	.....	24	"	"
"	" m ²:	"	.....	23.5	"	"
"	" m ² : at middle of crown	..21.5	"	"	.....	21.5
Height of crown of m ² (outside)	.....	58	"			"

This species is known only from the type, but is apparently distinct, as pointed out by Leidy, from *N. occidentale*, the species which it most nearly resembles.

14. *Neohipparion gratum* (Leidy).

Hipparion gratum LEIDY, Jour. Acad. Nat. Sci. Phila., 1869, p. 288.

Type: Right upper premolar, p², associated with two others, ?m² and m³. (No. 587, U. S. National Museum coll.).

Neotype: An anterior portion of a skull, containing the complete dentition of the left side (No. 10863, Amer. Mus. Nat. Hist.).

Horizon: Upper Miocene, Nebraska beds.

Author's description (op. cit.): "The first of the series . . . resembles the corresponding tooth of the first series ascribed to *Protohippus placidus* in size, form and proportions. The internal column appears on the triturating surface isolated, as in *Hipparion*, but it is a question whether at the same stage of attrition it would not have been associated with the antero-median column, as it appears in the tooth of *Protohippus placidus*. The central lakes are observed to be less gaping than the latter, and their surrounding enamel is rather more folded."

Measurements.

Diameters of p ² :	anteropost.....	21.5	mm.,	transv.....	17.5	mm.
Height of partially worn crown	.....	31	"			"

In size and general tooth characters, this species so closely resembles *Protohippus placidus* that Leidy was apparently in some doubt about its validity, while Cope later considered it synonymous with the latter. However, like *P. placidus*, *N. gratum* is now better known and has been well characterized through more complete material lately obtained by the American Museum field parties from the type locality in South Dakota and Nebraska.¹ From the neotype and other specimens referable to *H. gratum*,

¹ Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, pp. 145-147.

the species may now be more clearly defined as follows: (1) Protocone usually small, and elliptical in cross-section; (2) enamel borders of fossettes more deeply folded than in *P. placidus*; (3) anterior border of anterior fossette, at least in the premolars, infolded; (this fold does not appear in any specimen examined of species referable to *Protohippus*, but is apparently characteristic of species referable to *Hipparion* or *Neohipparion*); (4) both lachrymal and malar fossæ moderately deep, but limited in area; (5) anterior palatal foramina opening backward into long, narrow slits, as in the modern horses; (6) palate high arched, especially anteriorly; (7) nasals short-tipped, but very broad where they join the premaxillaries. The lower jaws are short and deep as in *P. placidus*, but with the following differences: (1) The symphysis is longer, while the length of jaw forward of the premolars is comparatively less than in *P. placidus*; (2) the angle of the jaw is proportionally smaller; and (3) the lower border of the ramus is much more curved or bowed.

15. *Plihippus supremus* (Leidy).

Protohippus supremus LEIDY, Jour. Acad. Nat. Sci. Phila., 1869, p. 328.

Protohippus mirabilis (Leidy) COPE, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 25.

Protohippus supremus (Leidy) GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 143.

Type: A left upper molar, m^1 , or m^2 . *Neotype*: A considerable portion of a skull containing milk molars (No. 10844, Amer. Mus. coll.).

Type locality: "South Fork of White River" (Little White River), S. Dakota.

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*): "Three isolated upper molars, larger than any of the above from the same locality [Little White River, S. Dakota]. In structure they bear a resemblance to those of *Protohippus perditus* more than to those of any of the other equine species indicated, but they are much larger, and probably belong to another species of the genus."

Measurements.

Diameters of m^1 , anteropost.....	24 mm.,	transv.....	25 mm.
Height of crown	48 "		

This species, founded on three unassociated upper molars, was regarded by Leidy as belonging to the genus *Protohippus*, and as differing from *P. perditus* only in size. However, through a better knowledge of the types and the examination of more complete material the species is now well established.

In the publication above cited, I redescribed this species under its original genus name *Protohippus*, but it apparently belongs more properly to *Pliohippus*, as that group is now distinguished from *Protohippus*, it being closely related apparently to *Merychippus mirabilis* Leidy, I therefore now assign it with that species to the genus *Pliohippus*.

The principal characters, as shown especially in the neotype, distinguishing this species from *P. mirabilis* are: (1) Its size which considerably exceeds that of *P. mirabilis*; (2) the more narrow proportions of the upper milk molars; (3) the greater complexity of the enamel foldings of the upper molars of both the milk and permanent series; and (4) the differences in form of the malar fossa, which has no dividing ridge and is comparatively smaller and shallower than in *P. mirabilis*. The basisphenoid is proportionally longer than in *Protohippus perditus* and is not overlapped by the vomer.

16. *Merychippus paniensis* (Cope).

Hippotherium paniense COPE, Bull. U. S. Geol. Surv. Terr. No. 1, Jan. 1874, p. 12.

Type: Right upper molar, m^1 , associated with a left upper m^3 . (No. 8260, Amer. Mus. coll.)

Type locality: Pawnee Buttes, N. E. Colorado.

Horizon: Middle Miocene, Pawnee Creek formation.

Author's description (*op. cit.*): "The latter [a right upper molar, m^1 above] is characterized by the generally greater simplicity of the enamel boundaries of the lakes as compared with the same portions of *H. speciosum*, with which it agrees in size. The only plications to be observed are the usual opposite ones entering the lakes from the middle of their adjacent boundaries, and a slight one at the inner angle of the same border of the anterior lake. The inner crescents are united, the posterior retaining its width posteriorly and giving off the posterior inner column from its anterior half. Both the internal columns are longitudinally oval and rather small, the anterior well separated."

Measurements.

Diameters of m^1 :	anteropost.....	18.5 mm.,	transv.....	20 mm.
"	" (associated) m^3 :	anteropost	20	" " " " 18.5 "
Height of crown, m^1 ,	outside.....	26	"	inside.....11.5 mm.
"	" " " m^3 ,	"	30	" " " " 16 "

This species is not well characterized, since it is known only from the type specimen and other isolated teeth, yet the short crowns, which when unworn are but little longer than their antero-posterior diameters, together with the more primitive proportions and form of the inner cones, p_2 hy,

than is observed in the Upper Miocene species mark this species as definitely referable to *Merychippus*, as that genus is now understood.

17. *Merychippus labrosus* (Cope).

Protohippus labrosus COPE, Bull. U. S. Geol. and Geog. Surv. Terr., No. 1, Jan. 1874, p. 13.

Type: A mandible and a portion of the right maxillary bone containing five molars.

Type locality: Pawnee Buttes, N. E. Colorado.

Horizon: Middle Miocene, Pawnee Creek beds.

Author's description (op. cit.): "Symphysis, flat, shallow; no diastema between their incisor and canine teeth; *P. labrosus*. . . *Protohippus labrosus* resembles the two species described by Leidy as *Merychippus*, in the short crowns and long roots of the molar teeth, with thickened external ridges separated by thin bands of cementum. It therefore differs from *Protohippus perditus* and *P. placidus*, resembling the first named in size."

*Measurements of type*¹ (after Cope).

Diameters of p ² :	anteropost.	22 mm.,	transv.	19 mm.
" " m ¹ :	"	18 "	"	22 "
Longitudinal diameter [height] of m ¹.	. . . . . 11 "			

Unfortunately the type of this species cannot at present be located and it was apparently not figured by Cope. The disposition of this species must rest therefore on Cope's definition and measurements. These are sufficient to place the species in the genus *Merychippus*, but farther than that it is at present of rather uncertain standing.

18. *Merychippus sejunctus* (Cope).

Protohippus sejunctus COPE, Bull. U. S. Geol. Surv. Terr., No. 1, Jan. 1874, p. 15.

Type: Complete skull and lower jaws with entire dentition, and parts of the skeleton associated. (No. 8291, Amer. Mus. coll.)

Type locality: Pawnee Buttes, N. E. Colorado.

Horizontal: Middle Miocene, Pawnee Creek beds.

Author's description (op. cit.): "The side of the cranium displays a considerable depression in front of the orbit, . . . The *P. sejunctus* is identical in measurements with the *P. labrosus*, and agrees with it in the simplicity of the enamel boundaries. It is also short-crowned, but the character is not

¹ For other measurements see Cope, Bull. U. S. Geol. Surv. Terr., No. 1, p. 14.

so marked as in the latter. It differs strikingly in the deep and convex symphysis, and, in the only specimen in which its alveolar border is preserved, in the hiatus separating the inferior canine from the incisors. It exhibits, also, the small and one-rooted first premolar of the *P. perditus*.

"The adjacent horns of the lakes of the molars are more produced outwardly than the remote ones, and the enamel borders have no plications. The sections of the inner columns are oval posteriorly and subround anteriorly.... The canines are separated by a considerable interval from the third incisors. The inferior molars are similar, in general, to those of *P. labrosus*."

Measurements of type (in part).

Diameters of p ² : anteropost.....	24	mm., transv.....	20	mm.
" " p ³ : "	18	" "	22	"
" " p ⁴ : "	19	" "	22	"
" " m ¹ : "	16.5	" "	21	"
" " m ² : "	18.5	" "	22	"
" " m ³ : "	20.5	" "	18.5	"
Total length of complete series less p ¹	175			"
Length of diastema between p ² and i ³ ,	54.5			"
Total length of skull taken on basal line,	325			"

This splendid type is a marked exception to those previously described and admits of a far more complete study and better definition of the species than is usual.

While Cope's description adequately separates the species from *Prothiippus perditus*, he did not sufficiently distinguish it from *P. labrosus* Cope. According to Cope's statement they are identical in measurements and agree in the general characters of the teeth, but they differ in the form of the lower jaw symphysis and the presence of a hiatus in *P. sejunctus* which does not exist in *P. labrosus* separating the inferior canine from the incisors. These characters are of but little value since they are influenced greatly by age and individual variation. However, since the type of *P. labrosus* cannot now be compared, *P. sejunctus* may be retained as a well established species.

The comparatively short crowns of the molars and the more generalized character of their cusps are features in common with species of *Merychippus*, making the present species more properly referable to that genus.

19. *Pliohippus pernix* Marsh.

Pliohippus pernix MARSH, Amer. Jour. Sci., Feb. 1874, p. 252.

Prothiippus (Pliohippus) pernix (Marsh) GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 144.

¹ For description of skeleton and other measurements see Cope: *op. cit.*

Type: A considerable portion of a skull and lower jaws, including nearly complete dentition, associated with foot bones and other parts of the skeleton.

Type locality: Niobrara River, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (op. cit.): "This genus closely resembles *Protohippus* Leidy in its dentition, but differs in the absence of lateral digits, which are only represented by slender splint bones. From the true *Equus*, the present genus, may be distinguished by the presence of a large antorbital fossa; by the functional first upper premolar; and by a different composition of the crowns of the upper molars."

Measurements of Type.¹

Diameters of p ² :	anteropost.....	31	mm.,	transv.....	22	mm.
"	" p ³:	"	.....	22.5	"	"
"	" p ⁴:	"	.....	22.5	"	"
"	" m ¹:	"	.....	20	"	"
"	" m ²:	"	.....	21	"	"
"	" m ³:	"	.....	25	"	"

Unfortunately the specimen representing the type species of this genus is that of an old individual with the teeth so much worn as to nearly obliterate their distinctive characters. However, their general features may be inferred with some degree of accuracy.

Marsh founded the genus primarily on the absence of complete lateral digits and the reduction of the metapodials, II and IV, to mere splints as in the genus *Equus*. The evidence for this advanced stage of development is only negative, however, since an examination of the type specimen shows that all the lateral metapodials represented are broken and the distal ends have not been preserved. They are much reduced distally, but not more so than in some specimens in the American Museum collection which still possess small but perfect lateral digits.

Other characters, however, especially those of the skull and teeth, seem to mark as distinct the group of horses of which *Phiohippus pernix* is typical. The type restudied presents the following characters: The skull in general appearance is like that of *Equus*, but is readily distinguished from that genus by (1) the shorter proportions of the muzzle, (2) the greater depth of the angle of the lower jaw (3) the proportionally shorter crowned and more curved molars, and (4) by characteristic facial pits or fossæ.

The group is apparently very nearly allied to *Protohippus* of the *P. perditus* type. But it may be distinguished from the typical *Protohippus* by the following characters: (1) The larger size, so far as known, of the species comprising the group; (2) the proportionally greater transverse diameters-

¹ For other measurements see Marsh, *op. cit.*

of the upper molariform teeth; (3) the presence of the deep malar pit which is apparently wanting in *Protohippus*; (4) the less constriction of the muzzle; and (5) the comparatively longer basisphenoid, which is not overlapped by the vomer.

As now understood *Pliohippus* Marsh may retain the rank of a full genus closely allied to *Protohippus*. The distinctions, however, are based on very different characters from those originally employed by Marsh.

20. *Pliohippus robustus* Marsh.

Pliohippus robustus MARSH, Amer. Jour. Sci. (3), Vol. VII, 1874, p. 253.

Type: Portions of skull and teeth, associated with foot and limb bones (No. 3008, Yale Museum coll.).

Type locality: Niobrara River, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*): "This species was nearly the same size as that last described [*P. pernix*], but the limbs were shorter and stouter. The first upper premolar is much larger, and the upper molars are longer, and much curved. The crowns of these teeth have a very similar arrangement of the enamel, but the folds are more complex."

Measurements of Type.¹

Diameters of p ² :	anteropost.....	29 mm.,	transv.....	22.5 mm.
" " p ³ :	"	26 "	"	24 "
" " m ² :	"	25 "	"	22 "
Height of crown, m ² (outside)	.....	62	"	

Aside from the difference in proportions of the limb bones, the characters given by Marsh to distinguish this species from *P. pernix* are of but little value, since they are in this instance for the most part indicative of age differences only. The type of *P. pernix* is of an old individual while that of *P. robustus* represents a young adult.

The comparative measurements of the limb and foot bones, and the difference in transverse diameters of the upper molars which are but slightly affected by wear, do indicate, however, a somewhat smaller size and more robust proportions for *P. robustus*, as pointed out by Marsh. The species may be further distinguished from *P. pernix* by the difference in form and character of the median terminal phalanges. In *P. robustus* the terminal phalanx is well rounded with the posterior external processes much reduced, as in the modern horse, but the plane of the proximal articular facet is

¹For other measurements see Marsh, *op. cit.*

directed more backward as in other species of Miocene horses. In *P. pernix* the ungual phalanx is more elongate and the posterior external processes are very prominently developed.

This species is not clearly distinguished from *P. supremus* (Leidy). It agrees with the latter in size and general characters so far as they are known, but there are not enough parts preserved in common to make that point clear.

21. ?*Parahippus avus* (Marsh).

Protohippus avus MARSH, Amer. Jour. Sci., Vol. VII, 1874, p. 253.

Type: Several associated teeth (No. — Yale Museum coll.).

Type locality: Cottonwood Creek, Oregon.

Horizon: Middle Miocene, probably Mascall beds.

Author's description (*op. cit.*): "The molar teeth have very short crowns, and are inserted by distinct fangs. The enamel is covered with a thick coat of cement. The molars are considerably worn, and the pattern of the enamel thus produced nearly resemble that in the corresponding teeth of *Anchitherium*, with which the present teeth agree, also, in form and arrangement. . . . The outer concavities of the external lobes are without any median elevation. The posterior inner cone is larger than the one in front. All the lower molars have an outer basal ridge." etc.

Measurements of type (after Marsh).

Space occupied by six upper molars,	110	mm.
Space occupied by three upper premolars,	57	"
Anteroposterior diameter of second upper premolar,	23	"
Transverse diameter,	22	"
Anteroposterior diameter of last upper molar,	17	"
Transverse diameter,	22	"
Extent of three lower premolars,	57.5	"
Anteroposterior diameter of first lower premolar,	20.5	"
Transverse diameter,	15	"
Anteroposterior diameter of first lower true molar,	18	"
Transverse diameter,	16	"

Marsh evidently recognized the *Anchitherium*-like characters of this species, although he placed it in the genus *Protohippus*. Without question it belongs to the *Anchitheriinae*, as especially indicated by the large inner cones and small median conules, but the proper generic reference under this group is at present somewhat uncertain.

22. **Parahippus brevidens** (Marsh).

Anchippus brevidens MARSH, Amer. Jour. Sci., Vol. VII, 1874, p. 254.

Type: Three upper true molars of a single individual, m^2 and m^3 of left side, and m^3 of right side (No. . . . Yale Museum coll.).

Type locality: Oregon, probably Cottonwood Creek.

Horizon: Miocene, ? Mascall beds.

Author's description (*op. cit.*): "These teeth agree in the general structure of their crowns with the type of *Anchippus texanus*, but the antero-median lobe is placed further forward, and hence its worn surface is not in the same line with that of the antero-internal lobe. The posterior crescentoid tubercle, also is isolated, and wears into an ear-shaped lobe, enclosing a pit with cement. The crowns of these molars are unusually short, even when unworn. They all have distinct fangs, and their enamel is covered with cement. The outer lobes have only a faint indication of a median ridge on their concave faces. The buttresses that enclose these faces are prominent."

Measurements (after Marsh).

Anteroposterior diameter of first upper true molar,	17.5 mm.
Transverse diameter,	22 "
Anteroposterior diameter of last upper molar,	17 "
Transverse diameter,	21.5 "
Height of unworn crown of last molar,	15 "

This species was founded on adult molars as stated by Marsh, and not on milk teeth as supposed by Cope.¹ The teeth are of the *Anchippus texanus* type, but differ from that species in (1) the considerable investment of cement; (2) the much greater angulation of the transverse lophs, especially the metaloph which is directed forward from the hypocone and at the crotchet turns at nearly a right angle to join the ectoloph; and (3) in the presence of a slight crenulation of the enamel walls of the metaloph, but this character is less marked than in *Desmatippus crenidens* Scott.

23. **Merychippus calamarius** (Cope).

Hippotherium calamarium COPE, Proc. Acad. Nat. Sci. Phila., Vol. XXVI, 1875, 259.

Type: Portion of the palate containing most of the teeth of both sides. (No. 2572, U. S. National Museum coll.)

Type locality: Pojuaque, north of Santa Fé, New Mexico.

Horizon: Middle Miocene; Santa Fé marls.

¹ Fourth Ann. Rept. Texas Geol. Surv., 1893, p. 23.

Author's description (op. cit.): "The species is allied to the *H. paniense* Cope, and differs from *H. occidentale*, *H. speciosum* and *H. gratum* of Leidy in the relative form and size of the interior dental column.... In the typical or New Mexican species the column is large, and its centre is anterior to the middle transverse line of the crown. In the present state of attrition,.... this column presents an angular projection towards the inner anterior crescent, betraying an approach to the union seen in *Protohippus*, which is in the fifth molar of the right side of the present horse, actually accomplished through the medium of a narrow isthmus.... The borders of the lakes are much plicate, the posterior border of the anterior lake having from four to six inflections.... The first premolar is quite small, and is two-rooted.... The palate is wide and well arched."

Measurements.

Diameters of p ² :	anteropost.....	25	mm.,	transv.....	21	mm.
"	" p ³:	"	.....	21.5	"	"
"	" p ⁴:	"	.....	21	"	"
"	" m ¹:	"	.....	20	"	"
"	" m ²:	"	.....	21	"	"
"	" m ³:	"	.....	20	"	"

This species was fairly well defined and its affinity to the *H. paniense* type of horse was recognized by Cope. But the characters given, which are in substance the shortness of the tooth crowns, the primitive form of the inner cones (*pr.* and *hy.*) of the upper molars, and the less specialized character of the teeth in general, are distinctive of *Merychippus* as that genus is now understood, hence it is more properly referable to *Merychippus* than to *Hipparion*.

24. *Merychippus severus* (Cope).

Stylonus severus COPE, Paleontolog. Bulletin, No. 30, p. 14, Dec. 3, 1878.

Hippotherium severum (Cope) WORTMAN, Kansas City Rev. Sci. and Ind., Vol. VI, 1882, p. 73.

Type: A right upper molar tooth, ?m² (No. 8180, Amer. Mus. coll.).

Type locality: Cottonwood Creek, Grant Co., Oregon.

Horizon: Miocene, ? Mascal beds.

Author's description (op. cit.): "*Stylonus* is allied to *Hippotherium* in details, including the isolation of the anterior internal enamel covered column.... It differs from it in the fact that the posterior internal column is isolated in the same manner as the anterior."

In a later publication,¹ under *Hippotherium severum*, Cope more fully

¹ Proc. Amer. Phil. Soc., Vol. XXVI, 1889, p. 457.

described the type specimen as follows: "Crown of superior molar moderately elongate and curved. Grinding face subquadrate. External ridges prominent. Section of anterior internal column oval, with an apex directed outwards at a short distance anterior to the single internal median loop. Posterior internal column also oval in section, distinct from posterior internal crescent, and without apiculate angle in specimen at present state of wear. Crescents narrow, separated by rather wide lakes entirely filled with cementum. Lake borders simple; anterior with a trace only of an anterior notch; posterior with a strong posterior notch. Opposite adjacent borders with one notch on the posterior and two on the anterior crescents, the latter inclosing a small loop in the usual position. External cement layer thin."

Measurements of type tooth.

Height of crown.....	28 mm. outside, 16 mm. inside.
Anteroposterior diameter.....	17.5 "
Transverse diameter.....	16.5 "

The type specimen is a tooth but slightly worn, hence the characters given by Cope indicate a small species of the *Merychippus* group, but with somewhat longer crowned teeth than the typical species of that genus. Since the knowledge of this species is confined to the characters of a single tooth, the type, it is at present of rather indefinite determination

25. *Plihippus spectans* (Cope).

Hippidium spectans COPE, Amer. Nat., Vol. XIV, 1880, p. 223.

Type: A left upper molar m^2 and an associated upper premolar, p^2 , (No. 8183, Amer. Mus. Coll.).

Type locality: Cottonwood Creek, Oregon.

Horizon: Upper Miocene, ? Rattlesnake formation.

Author's description (*op. cit.*): "The crowns of these teeth are very long and slightly curved, and the roots are short. The internal columns are relatively small and subequal in size, and are flattened in outline. A peculiarity of the species is seen in the great transverse width of the lakes which, at the middle, is equal to the anteroposterior diameter. The crescents, and especially the inner ones, are correspondingly narrow. The enamel borders are simple, there being only a few notches on the adjacent faces of the lakes. One loop projects from the inner enamel border, almost reaching the anterior inner column. Cement abundant."

Measurements of type teeth.

Diameters of m ² , anteropost.....	26.5 mm., transv.....	26.5 mm.
“ “ “ “ (at base).....	24.5 “ “	29.5 “
“ “ p ²	35 “ “	25 “
Height of crown of m ² , outside.....		46 “
“ “ “ “ inside		26 “
“ “ “ “ p ² outside		26 “
“ “ “ “ “ inside		24 “

Compared with the South American genus *Hippidion*, to which Cope referred it, the type of this species shows the following important differences.

(1) The crowns of the upper molars are curved but to a less degree; (2) the fossettes are broader transversely; and (3) the enamel walls of the transverse lophs are less plicated and thicker making a heavier line in the cross-section pattern of the tooth crown. (4) The ribs, or styles, of the ectoloph (ps. and ms.) are less prominent.

In all these characters *H. spectans* Cope resembles the known species of *Pliohippus*, as at present defined. I therefore transfer it without question to this genus.

26. *Neohipparion montezumæ* (Leidy).

Hippotherium montezumæ LEIDY, Proc. Acad. Nat. Sci. Phila., Vol. XXXIV, 1882, p. 291.

Type: An upper premolar, p³ or p⁴, of the right side (No. 3304, U. S. Nat. Mus. coll.).

Type locality: Lacualtipan, Hidalgo, Mexico.

Horizon: ? Upper Miocene.

Author's description (op. cit.): "The specimens indicate a species about the size of *Hippotherium venustum* and *H. speciosum*, but the folding of the enamel on the triturating surface of the upper molar . . . is sufficiently different from the arrangement in the corresponding teeth of those species, to render it probable that the fossils belong to neither of them.

"In *H. venustum* the inner column of the superior molars, so far as known, is regularly cylindrical. In the tooth under inspection it is much wider than in the latter."

Measurements.

Anteroposterior diameter of type tooth, 19.5 mm.; transverse diameter, 17 mm.; height of crown, outside, 49 mm., inside, 45 mm.

The characters of this species are little known beyond what are shown in the type tooth, but the large, laterally compressed protocone and different character of the enamel plications, as pointed out by Leidy, seem sufficiently to differentiate it from *H. venustum*, while its small size and comparative

great length of crown apparently distinguishes it from any other species previously described. Its general characters are those of the *Neohipparion* species.

27. *Neohipparion sinclairi* (Wortman).

Hippotherium sinclari WORTMAN, Kans. City Rev. Sci. & Ind., Vol. VI, No. 2, 1882, p. 73.

Type: An upper premolar of the left side (No. 8178, Amer. Mus. coll.).

Type locality: Cottonwood Creek, Oregon.

Horizon: Upper Miocene, ? Rattlesnake formation.

Author's description (op. cit.): "Some species of *Hippotherium* exhibit an enlargement of the antero-internal lobes of the upper molars almost equal to that of *Equus* with a marked tendency to confluence. A new species from the Loup Fork beds of Oregon which may be called *Hippotherium sinclairi*, exhibits these characters of the superior molars in common with *H. occidentale*. It may be distinguished from the species, however, by its small size and the less marked concavity of the inner contour of the antero-internal lobe."

Measurements.

Diameters of type tooth: anteroposterior 20 mm., transverse . . . 19.5 mm.
Height of crown, 42 mm.

This species is known only from the type tooth, a single upper molar, which presents the characteristics of the genus *Neohipparion*. It is somewhat larger than *N. montezumæ*, and differs from that species in the relatively larger and differently formed protocone, and more simple enamel plications. The inner face of the protocone, in *N. sinclairi*, is slightly concave as in *N. affine*.

28. *Neohipparion montezumæ* (Leidy).

Hippotherium peninsulatum COPE, Amer. Nat., Vol. XIX, 1885, pl. xxxvi, fig. 5 (name and figure, no description).

Hippotherium peninsulatum COPE, Proc. Amer. Phil. Soc., Vol. XXII, 1885 (1886), p. 150, fig. 1.

Type: A right upper molar, m² (No. 8345 Amer. Mus. coll.).

Type locality: Tehuichila, Vera Cruz, Mexico.

Horizon: Miocene.

Author's description (op. cit.): "Crown of superior molar long, curved. Grinding face with anteroposterior diameter considerably exceeding the transverse. Internal column large, its section a narrow anteroposterior oval, with both borders convex. Internal enamel borders of internal cres-

cents with a prominent loop at junction, Opposite and adjacent enamel borders of the lakes, with several close and deep plications, which nearly cut off the adjacent horns The median and anterior external ribs of the crown are well developed, and there is but little cement on the grooves."

Measurements.

Diameters of type tooth, anteroposterior, 17.5 mm., transverse 15 mm.

Height of crown, 51.5 mm. outside, 40 mm. inside.

This species also is founded on a single upper tooth. In the characters of the comparatively long tooth crown, the size and form of the protocone, and the plications of the enamel fossette borders, it agrees very closely with *N. montezumæ* (Leidy). The tooth, a true molar, is somewhat smaller than the type of *N. montezumæ* which is a premolar. The difference in size therefore is not more than might exist between the molar and premolar teeth in the same individual. Moreover, the localities from which the specimens were obtained are not widely separated and the horizons are probably equivalent. It is therefore probable that the species are identical.

29. ***Protohippus castilli* Cope.**

Protohippus castilli COPE, Amer. Nat., Vol. XIX, 1885, p. 1208, pl. xxxvi, fig. 6;
Proc. Amer. Phil. Soc., Vol. XXIII, 1886, p. 150, fig. 2.

Type: An upper molar of the left side.

Type locality: Tehuichila, Vera Cruz, Mexico.

Horizon: Miocene.

Author's description (op. cit.): "This horse is represented by a superior molar tooth of a larger animal than the species last described [*H. peninsulatum*], and one only a little smaller than the zebra. . . . The crown of the tooth is of medium length and is strongly curved inwards. Its grinding surface is a little wider than long, and is worn into two transverse angles The lakes are strongly convex inwards and their horns are wide and obtuse. Their borders are simple, there being no folds on the remote sides, and on the adjacent borders only one on the posterior and two on the anterior, of no great depth. There is no loop at the junction of the inner edges of the internal crescents. External ribs of crown prominent."

Measurements (after Cope).

Length [height] of crown 40 mm.

Diameters of grinding face	{	anteroposterior 21 "
		transverse 23 "

The type tooth, which again is the sole known representative of the

species, has been temporarily mislaid, hence the validity of the species must, for the present, rest entirely on the description and figure given by Cope.

These indicate a true species of the genus *Protohippus*, very closely related to *P. perditus*.

30. *Hipparion ingenuum* (Leidy).

Hippotherium ingenuum LEIDY, Proc. Acad. Nat. Sci. Phila., Vol. XXXVII, 1885, p. 33, outline figure.

Type: Two upper molars of left side (No. 3306, U. S. Nat. Mus. coll.).

Type locality: Archer, Florida.

Horizon: ? Pliocene.

Author's description (op. cit.): "The tooth now under inspection is an upper molar, perhaps the fourth large one of the series. It indicates a small species, little more than half the size of the domestic horse, . . . The folding of the contiguous borders of the interior enamel islets of the worn triturating surface is less complex than in *H. venustum*, and the internal islet is elliptical instead of circular."

Measurements.

Diameters of m^2 , anteropost. 18.5 mm., transv. 16.5 mm.
Height of crown 43 mm. outside, 34 mm. inside.

But little is known of this species beyond what is shown in the type teeth. These indicate a species but little larger than *H. venustum* Leidy, and differing from it only in the characters pointed out by Leidy which are so slight as to be of but little value in separating them. The great differences in the size and form of the protocone, and the enamel plications separate both species very definitely from *H. montezumæ*.

31. *Archæohippus ultimus* (Cope).

Anchitherium ultimum COPE, Proc. Amer. Phil. Soc., Vol. XXIII, 1886, pp. 357, 358.

Archæohippus ultimus (Cope) GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XXII, Dec., 1906, pp. 385-388.

Type: An anterior portion of skull with nearly complete dentition (No. 8174, Am. Mus. coll.).

Type locality: Cottonwood Creek, Oregon.

Horizon: Middle Miocene, Mascall formation.

Author's description (op. cit.): "Unusual interest attaches to this horse since it is the latest representative in time of the genus to which it belongs.

It is from a horizon above the John Day Miocene, which contains several Loup Fork genera and species, as *Protolabis*, *Hippotherium* and *Dicotyles*. . . . The size is less than that of the *A. præstans* Cope and *A. equiceps* Cope (? *A. anceps* Marsh) of the John Day bed, and the dental series has the same length as that of the *A. longicriste* Cope, also of the John Day. . . . The premolars and molars have a well-marked external cingulum, and there is an internal cingulum round the base of the second premolar. The only other cingula are weak ones round the bases of the anterior lobes of the second and third true molars. . . . The diastema separating the canine from the first premolar is long. The latter has but one root and has a rather small crown.

"It is in the cranial characters that this species displays the greatest differences from the John Day species. In the first place there is a profound and large preorbital fossa, separated from the orbit by a vertical bow. The preorbital fossa in the John Day species is shallow, and not abruptly defined. In the next place the anterior border of the orbit is above the anterior border of the last molar tooth. In this it agrees only with the large *A. præstans*; in the *A. equiceps* and *A. longicriste*, the anterior border of the orbit is above the anterior part of the second superior molar. Thirdly, the infraorbital foramen is above the middle of the fourth premolar; it is over the posterior part of the third in the three John Day species. Finally, the nareal notch marks the anterior two-fifths of the diastema; it extends much further back in the John Day species."

Measurements (after Cope).

Length of diastema from I. 3 .....	.047
" " " " C. ....	.035
" " superior molar series .....	.079
" " true molars .....	.034
" " crown of p. m. l. (greatest) .....	.007
Diameters of crown of p. m. ii	{ anteroposterior ..... .0145
	{ transverse ..... .0145
" " " " m. i	{ anteroposterior ..... .011
	{ transverse ..... .015
" " " " m. iii	{ anteroposterior ..... .011
	{ transverse ..... .014

This species was fully described under the name *Anchitherium ultimum*¹ by Cope who recognized and pointed out many characters of advanced development over the Oligocene species. A wider knowledge of both the Oligocene and Miocene forms of horses not only confirms Cope's distinctive

¹ Cope used this genus name not because of any supposed affinities to the European genus *Anchitherium*, but because all American species of the *Mesohippus bardi* type were at that time referred to *Anchitherium*. Later writers placed *A. ultimum* with the others in Marsh's genus. *Mesohippus*.

characters, but emphasizes their importance. A restudy of these characters has resulted in placing the species under a new genus, *Archeohippus*. The principal characters distinguishing this genus as published in a recent paper (*op. cit.*) are as follows: The species is more advanced in general than any of the Oligocene horses and compares in degree of progression with the earlier forms of *Hypohippus* and *Parahippus*. From *Mesohippus* and *Miohippus* the genus is especially distinguished by (1) the complete union of the metaloph with the ectoloph in the upper molariform teeth; (2) the proportionally larger size of the protoconule; (3) the greater lengthening of the anterior portion of the skull, as shown in the comparatively longer muzzle; (4) the more backward position of the orbit; and (5) the great development of the lachrymal and malar fossæ.

It differs from *Parahippus* in (1) the absence or but slight development of a crochet on the metaloph; (2) the deeper notching of the external wall of the protoloph between the protocone and protoconule with a correspondingly less notching of the internal protoloph wall; (3) the comparatively more equal proportions of the molars to the premolars, and (4) the presence of a well developed internal basal cingulum.

Compared with *Hypohippus* (1) the protoconule is much larger than in that genus; (2) the molars in relation to the premolars are comparatively larger; (3) the muzzle is relatively longer; (4) the orbit is placed the width of a molar farther backward, and (5) the malar fossa, which is wanting in *Hypohippus*, is well developed, as is also the lachrymal fossa, with which it is nearly confluent, being separated only by a low rounded transverse ridge.

32. *Neohipparion rectidens* (Cope).

Hippotherium rectidens COPE, Proc. Amer. Phil. Soc., Vol. XXIII, 1886, p. 360.

Type: An upper? premolar of the right side.

Type locality: Tehuichila, Vera Cruz, Mexico.

Horizon: Probably upper Miocene.

Author's description (*op. cit.*): "The present animal presents very nearly the same enamel folds as the *H. peninsulatum* Cope, of the same locality, including the subquadrate central loop which is nearly cut off from the anterior lake. But the tooth differs in two essential points, and in some minor ones from that species. It is considerably larger, presenting .6 more area of the grinding surface. The shaft of the tooth, instead of being strongly curved, is straight."

Measurements.

Diameters of crown: anteropost.....	2 mm.,	transv.....	18.5 mm.
Height of crown.....			41 "

This species is known only from a single tooth. The wide and compressed isolated protocone, the deeply plicate enamel borders of the fossettes, and the long crown, seem to place it definitely in the genus *Neohipparion*; but its specific relations are at present somewhat indefinite. The characters pointed out by Cope, however, apparently distinguish it from any other described species.

33. *Hipparion plicatile* Leidy.

Hipparion plicatile LEIDY, Proc. Acad. Nat. Sci. Phila., 1887, p. 310.

Type: An upper molar of the right side (No. 3292, U. S. Nat. Mus. coll.).

Type locality: Levy Co., Florida. "Mixson's bone bed," 10 miles east of Archer, Florida.

Horizon: ? Pliocene.

Author's description (*op. cit.*). "A tooth from the same locality [Mixson's bone bed], indicates a species of *Hippotherium* different from *H. ingenuum*. . . . It is an upper of an animal approximating the Ass in size, and larger than *H. ingenuum*. The triturating surface . . . exhibits a complexly folded condition of the enamel, quite different from that of the latter."

Measurements.

Diameters of crown, anteropost. 20 mm., transv. 22 mm.
Height of crown (much worn) 30 "

The type is apparently a true molar with the crown at least half worn away by use, hence the elaborate plications are a distinctive feature. The protocone is small and well rounded like those of *H. venustum* and *H. ingenuum*, and in other respects the characters presented are similar. But the much greater size and the difference in character of the enamel foldings, distinguish it sufficiently from these species.

H. venustum, *H. ingenuum* and *H. plicatile*, all from the Atlantic coast and from deposits apparently of Pliocene age, form a group of horses differing in some seemingly important respects from any of the western American species of the Miocene period. They represent in general a slightly later phase of development, especially in the greater length of tooth crowns, the stronger development of the external styles, and the much more elaborate plications of the enamel borders of the fossettes.

In these respects, as well as the retention of a more primitive form of protocone, which is small and nearly circular in cross section as in some species of *Merychippus*, these species resemble closely the European *Hipparion* of the *H. gracilis* type. In foot structure, however, so nearly as can

be determined from the very fragmentary material available, they resemble more nearly the American Miocene forms. It seems not improbable therefore, that these species belong to an American branch of the *Hipparion* group of the Old World, rather than to the *Neohipparion* group more typical of this continent.

34. *Merychippus relictus* (Cope).

Hippotherium relictum COPE, Amer. Nat., Vol. XXIII, 1889, p. 254.

Type: An upper molar, ? m^1 , of the left side, associated with a second upper molar, m^3 , and two lower molars (No. 8673, Amer. Mus. coll.).

Type locality: Oregon Desert.

Horizon: Not known, but probably middle or lower Miocene.

Author's description (op. cit.): "Represented by two superior and three inferior teeth. The grinding surface is nearly square, and the crown is short, and moderately curved. The section of the internal style is a wide oval, and it presents no angle or point of approximation to the protoconic crescent, and conversely none to the posterior column. The latter has the usual connection with the hypoconic crescent, but projects as far inwards as the anterior area, and is well defined. The enamel borders are quite simple. The usual loop of the posterior inner border of the anterior is rudimental in an anterior true molar, and in the last molar it is small and subround. No isolated loop. A single short process of the border towards the internal column. Cementum abundant."

Measurements.

Diameters of m^1 :	anteropost.....	16	mm.,	transv.....	18	mm.
" " m^2 :	"	16.5	"	"	16.5	"
Height of crown of m^1 :	outside,	20	"	inside,	14	"
" " " m^2 :	"	16	"	"	12	"

This species, as indicated by the type, is about the size of *Merychippus severus* (Cope), and seems to differ from it only in minor details. The upper molars are relatively shorter crowned apparently, and have a somewhat greater transverse width, indicating a slightly larger form.

While its generic characters are clearly those of the *Merychippus* group, its specific relations are not well defined.

35. *Hippotherium retrusum* Cope.

Hippotherium retrusum COPE, Proc. Amer. Phil. Soc., Vol. XXVI, 1889, p. 446.

Type: Two upper molars (No. 8350, Amer. Mus. coll.).

Type locality: Phillips Co., Kansas.

Horizon: Upper Miocene.

Author's description (op. cit.): "The character by which the superior molars of the *Hippotherium retrusum* may be readily distinguished from those of all other species of the genus, is the extraordinary posterior extension of the anterior internal column, which brings it first into contact with the posterior internal column, and then on greater wear unites the two by an isthmus. In the first true molar the area of the column is in contact at its extremities with both the posterior column and the anterior inner crescent.... The complexity of the enamel border of the lake is of medium degree.... The crowns are robust, of medium length, and curved. That of the second true molar is rather longer than wide; the first true molar is about as wide as long."

Measurements.

Diameters of m ¹ anteropost.....	18 mm.,	transv.....	18.5 mm.
" " m ²: "	.....21 "	" "	.....17 "
Height of crown, m ¹.....	.....29	"	"
" " " m ².....	.....35	"	"

This species, known only from the two teeth of the type, is at present of rather uncertain reference. Cope placed it in the *Hipparion* group, but apparently on insufficient grounds. The union of the protocone with the hypocone as well as with the protoconule is frequently observed in species of *Protohippus* and *Pliohippus* where the tooth crown is worn to near its base, hence *H. retrusum* may represent a species of one of these genera which is highly specialized in this respect, the union occurring much nearer the summit of the unworn crown. Or the teeth described by Cope may be abnormal.

36. *Protohippus profectus* Cope.

Protohippus or *Hippidium profectus* COPE, Proc. Amer. Phil. Soc., Vol. XXVI, 1889, p. 447.

Type: Four fragmentary upper cheek teeth (Amer. Mus. coll.).

Type locality: Phillips Co., Kansas.

Horizon: Upper Miocene.

Author's description (op. cit.): "The anterior inner column presents in the second individual [the type of *P. profectus*] the same flattened form as in the first above described [*H. retrusum*], but is connected with the anterior crescent by a narrow isthmus, and not in two of the three teeth at least, where the part is preserved, with the posterior crescent. The animal may possibly belong to a species distinct from the *H. retrusum*, and perhaps to

a species of *Protohippus* or *Hippidium*. If so, it differs from the known species of those genera in the posterior position and flatness of the anterior column It approaches nearer to *Equus* than any known species of those genera."

Measurements.

Diameters of p ² :	anteropost.....	45 mm.,	transv.....	23 mm.
"	" m ² :	"	"	"
"	"	24 "	"	20 "
Height of crown p ²	.....	19	"	"
"	" " m ²	.....	36	"

This species, like *H. retrusum*, is of doubtful reference, and was not well characterized by Cope. Its greater size separates it sufficiently from *H. retrusum*, although its characters so far as they can be made out seem to class it in the same group.

37. *Merychippus sphenodus* (Cope).

Hippotherium speciosum (Leidy) COPE, Ann. Rep. U. S. G. G. S. Terr., 1873 (1874), p. 522; not of Leidy.

Hippotherium sphenodus COPE, Proc. Am. Phil. Soc., Vol. XXVI, 1889, pp. 449, 450.

Cotypes: Two upper premolars (No. 8281, Amer. Mus. coll.).

Type locality: Pawnee Buttes, Colorado.

Horizon: Middle Miocene, Pawnee Creek beds.

Author's description (op. cit.): "Their characters are somewhat similar to those of *H. speciosum* in the plications of the enamel, but the form of the internal columns is entirely distinct, referring the species to the group of the *H. calamarium*. The latter species is, however, distinguished by the very short wide form of the anterior teeth, especially of the second premolar."

Measurements.

Diameters of p ² :	anteropost.....	25 mm.	transv.....	19.5 mm.
"	" p ² :	"	"	"
"	"	21 "	"	18. "

This species was founded on single premolars of two individuals. They differ as much, in minor details, between themselves as from *M. calamarium* (Cope), the species with which Cope grouped them. The general characters of the teeth, including the short hypsodont crowns place them in the *Merychippus* group. They apparently agree more nearly with *M. calamarium* than any of the other species described, but with the material at hand their exact distinction or relationship cannot be certainly determined.

38. ***Merychippus isonesus* (Cope).***Hippotherium seversum* COPE, Proc. Amer. Phil. Soc., 1886, p. 359.*Hippotherium isonesum* COPE, Proc. Amer. Phil. Soc. Vol. XXVI, 1889, p. 451.

Type: A nearly complete skull and lower jaws associated with a large part of skeleton (No. 8175, Amer. Mus. coll.).

Type locality: Cottonwood Creek, Oregon.

Horizon: Middle Miocene, Mascall beds.

Author's description: (For Author's description of species, which is long and detailed, see Cope, *op. cit.*)

Measurements of type.

Diameters of p ² :	anteropost.....	22	mm., transv.....	16 mm.
" " p ³ :	"	19	" "	18 "
" " p ⁴ :	"	18.5	" "	18 "
" " m ¹ :	"	19	" "	19 "
" " m ² :	"	19	" "	17 "
Height of crown of p ²	.....	23	"	"

(For other measurements see Cope's description, *op. cit.*)

This type has been fully described by Cope, but its distinctions have not been clearly brought out. The short molar crowns with their less specialized characters place the species in the genus *Merychippus*. As at present understood, therefore, *M. isonesus* (Cope) may be briefly redefined as follows: The upper molars are comparatively short crowned and of the true *Merychippus* type. The inner cones, pr and hy, are subequal in size, small and well rounded in outline, and free at their summits in an unworn tooth. The hypocone soon joins the metaconule, or posterior crescent, but the protocone remains distinct as in *Hipparion* and *Neohipparion*. The protocone has a rib, or projection, extending towards the protoconule, or anterior crescent.

In all of these characters and in the general appearance of the comparatively simple enamel foldings or plications of the enamel walls of the fossettes, these teeth very much resemble the type of *M. seversum* (Cope), but their larger size and comparatively shorter crowns sufficiently distinguish them from that species.

Other characters of importance are the comparatively short muzzle, and the large size and form of the facial pit which is single but occupies the position of both the lachrymal and malar fossæ in *Pliohippus* and some species of *Neohipparion*.

This fossa is larger and deeper than in *Protohippus perditus* or any other species of *Merychippus* in which this character is known. It differs

especially from *Phiohippus* in the absence of any dividing ridge between the lachrymal and malar fossæ.

39. *Neohipparion princeps* (Leidy).

Hippotherium princeps LEIDY, Proc. Acad. Nat. Sci. Phila., 1890, p. 182.

Equus major LUCAS, Trans. Wagner Free Inst. Sci., Vol. IV, 1896, p. 49.

Type: An upper premolar, p^3 or p^4 , of the right side. (No. 3299, U. S. National Museum coll.)

Type locality: Peace Creek, Florida.

Horizon: Probably Pleiocene or early Pleistocene.

Author's description (*op. cit.*): "The size of the tooth indicates the species to have been as large as the ordinary domestic Horse and therefore the largest species of the genus yet discovered. . . . The tooth, a second or third upper molar, is three inches long in its outer curvature and the worn tritulating surface, represented in the accompanying woodcut, measures 15 lines fore and aft and 14 lines transversely. The arrangement of the enamel most nearly approximates the condition observed in *H. occidentale* from our western tertiary formation. The inner column, of uniform breadth the entire length of the crown, measures half an inch fore and aft, and in section is horizontally reniform. The species was a third larger than the *H. gracile*, the largest European form."

Measurements.

Diameter of tooth crown, anteropost.	31 mm.,	transv.	27 mm.
Height of crown.	75 "		

The insufficient material renders it impossible at present to make an entirely satisfactory disposition of the species, but the evidence at hand inclines me to regard it as belonging to the *Neohipparion* group.

Mr. F. A. Lucas (*op. cit.*) has regarded the type specimen as an abnormal or reverted tooth of *Equus major* (*complicatus*), but this supposition seems scarcely warranted in view of the fact that, except for size, the general characters presented are those of *Neohipparion* rather than *Equus*. The protocone is broad anteroposteriorly, compressed transversely, presenting a concave inner face, while it is completely isolated. The hypostyle groove is deep and extends nearly to the base of the crown. The enamel borders of the fossettes are very plicate and deeply folded, and the external ribs, or styles, are more strongly developed than is usual in species of *Equus*. All these characters are *Neohipparion* or *Hipparion* like, but the large size and form of the protocone suggests *Neohipparion* rather than the latter genus.

It seems more probable, therefore, that *H. princeps* represents a very

large and highly specialized species, and perhaps one of the last of the *Neohipparion* group which may have survived almost or quite to the Pleistocene age, being a contemporary of some of the earlier species of *Equus* with whose remains the type tooth was found associated.

40. *Pliohippus gracilis* Marsh.

Pliohippus gracilis MARSH, Amer. Journ. Sci., Vol. XLIII, 1892, p. 347.

Type: An incomplete hind foot.

Type locality: Oregon Desert.

Horizon: Probably Middle Miocene.

Author's description (op. cit.): "The frequent reappearance of the second digit as an extra toe in the modern horse would seem to indicate that this feature was functional in a late ancestor, but no fossil equine with two toes has yet been found." [Foot note.] "A small species of *Pliohippus* from the Pliocene of Oregon may be an exception. An incomplete hind foot in the Yale Museum shows the second metatarsal as a splint bone, the third very long and slender, and the fourth so well developed that it probably supported phalanges. This may be also a case of reversion. The species is new, and may be called *Pliohippus gracilis*."

This species was not well defined by Marsh, nor does the type show any especially distinctive features. The character given, that of the great inequality of the lateral metatarsals, is frequently observed in species of widely different genera of Miocene horses — hence it is not determinative. The species is therefore indefinitely known at present.

44. *Pliohippus simplicidens* (Cope).

Equus simplicidens COPE, Proc. Am. Phil. Soc., Vol. XXX, 1892, p. 124.

Pliohippus simplicidens (Cope) GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XIV, 1901, p. 124.

Type: An upper molar or premolar of the left side, associated with three other upper molars of different individuals.

Type locality: Mount Blanco, Crosby Co., Texas.

Horizon: Pliocene, Blanco formation.

Author's description (op. cit.): "The size of the teeth is about that of the *E. occidentalis* and *E. caballus*. The internal column is of moderate antero-posterior extent, its posterior border marking the anterior third of the posterior lake. Its long diameter is considerably less than half that of the crown. A peculiarity found in two of the superior molars, but not in

two others, is that the median dentinal connection between the external and median crescents is interrupted by the continuity of the enamel plates bordering the lakes from the one to the other. This arrangement is frequently seen in the large pm. 3, in the species of *Equus*, but does not occur in the other premolars and molars. It is a reversion to the condition seen in *Anchitherium*. A principal character of the species is seen in the extreme simplicity of the enamel borders of the lakes. They are without inflection, except the usual loop on the posterior inner border of the anterior lake, and this is simple and widely open at the base. At the point of junction of the median crescents (meta- and paraconules), the usual loop of the internal enamel border is seen. The external median rib is narrowed and not flattened; the anterior rib is more flattened, especially at the present grinding face."

Measurements (from Cope's figure).

Diameters of crown, anteropost.....	32 mm.,	transv.....	26 mm.
Height of crown.....	60 "		

While the type tooth is not available for examination, Cope's published figures indicate that it is a true molar of a young adult individual, hence but slightly worn by use. If true, the character of the interrupted metaloph, mentioned by Cope, has no particular significance.

The principal characters shown in the type as well as the other teeth from the same locality, referable to this species, point to a more primitive phase than any true species of *Equus*. In the simplicity of the enamel foldings, the small size and form of the protocone, and the less reduced proportions of the hypocone, as well as the tendency to a sharp entrant-angular groove between the metaconid and metastylid columns in the lower teeth, the Blanco species resembles more the known species of *Pliohippus*, from the upper Miocene beds, than those of the true *Equus*.

For these reasons I have, in a former publication (*op. cit.*) transferred the species to the genus *Pliohippus*. However, the lack of sufficient material leaves the species of somewhat uncertain reference.

42. *Protohippus pachyops* Cope.

Protohippus pachyops COPE, Fourth Ann. Rept. Geol. Surv. of Texas, May, 1893, p. 26.

Type: Skull and lower jaws lacking muzzle and posterior portion of cranium.

Type locality: Donley Co., Texas.

Horizon: Upper Miocene, Clarendon formation.

Author's description (op. cit.): "The malar-maxillary ridge is obtusely rounded, and there is no preorbital fossa. There is an oval maxillo-nasal fossa, which is strongly pronounced. The infraorbital foramen issues above the middle of the first true molar. The maxillary bone projects about half the diameter of the last molar tooth posteriorly to it, but this dimension may increase a little, as the animal is not fully grown. The anterior orbital border marks a point above the middle of the last superior molar. The last superior molar is just protruding from the alveolus. The first and second molars are worn. Their crowns have a greater anteroposterior than transverse diameter, and the section of the protocone is greater longitudinally than transversely, although its junction with the paraconule is complete. The enamel of the lake borders is simple, except that that of the posterior wall of the anterior lake presents the usual loops well defined. The superior molars have the crowns long and well curved transversely. In the inferior molars the anterior and posterior lobes of the metaconid have but little anteroposterior extent, and the paraconid and hypostylid are well developed. The column of the last inferior molar, which forms the heel, is quite small."

Measurements (after Cope).

Length of maxillary bone to anterior border of P. m. i.....	127 mm.
Length of ditto from orbit to preorbital foramen.....	64 "
Anteroposterior diameter of true molars.....	84 "
Diameter of crown of M. i.....	{ anteroposterior..... 28 "
	{ transverse..... 25 "
Length of crown of inferior true molars.....	88 "
Length of crown of last inferior molar.....	30 "
Diameters of M. i.....	{ anteroposterior..... 31 "
	{ transverse..... 13 "
Depth of ramus at front of M. i.....	46 "
Depth of ramus at posterior end of M. iii.....	67 "

Cope's description of the type is sufficiently accurate and detailed, but his conclusions were based on a misconception of the age of the specimen. The portion of skull was regarded by Cope as representing a young adult animal with the last true molar just protruding from the alveolus. But a more careful examination of the type shows it to be that of a colt still retaining the milk molars, with the first true molar just coming into use and the second just protruding from the alveolus, the third not yet having made its appearance.

This is of especial interest and importance since Cope described and figured a skull, with teeth of a wholly different character, as representing the milk dentition of this species. But the type specimen shows them to be very similar, except for proportions and relative length of crown, to those

of the permanent series. As restudied, the characters of this species are observed to be in general those of the genus *Protohippus*, but differing in several important details, as pointed out by Cope, from any of the foregoing species.

The affinities of the young skull, wrongly referred to this species by Cope, are unmistakable. The brachyodont form of the crowns, which are without functional cement; the large subequal and well rounded protocones and hypocones; and the simple, almost uninterrupted, transverse lophs in which the median conules are so small as to be scarcely observable are characters which make its reference to the genus *Hypohippus* unquestionable. Cope remarked its close resemblance to the type of *Hypohippus affinis* Leidy, with which it also agrees very nearly in size.

The proportions of the teeth and height of their crown are almost exactly those of the tooth representing *H. affinis*, and the specimen may with little doubt be referred to that species.

43. *Protohippus fossulatus* Cope.

Protohippus fossulatus COPE, Fourth Ann. Rept. Geol. Surv. of Texas, 1883, p. 30.

Type: Portion of cranium.

Type locality: Donley Co., Texas.

Horizon: Upper Miocene, Clarendon formation.

Author's description (*op. cit.*): "The dimensions of this species are superior to those of any other members of the genus excepting the *P. pachyops* and *P. mirabilis*. It equals the former and is a little exceeded by the latter. The characters of the lateral facial fossæ are peculiar, and as they are exactly alike on both sides of the skull, I believe them to be normal. There is no fossa immediately in front of the orbit, but there is a narrow and deep maxillonasal fossa, whose posterior extremity approaches nearer to the superior part of the orbit than any other. Beneath it, and immediately above the penultimate molar tooth, is a small but well pronounced fossa, which is about as large as would be produced by an oblique impression of the end of the thumb in putty. Immediately anterior to the infraorbital foramen is a wider and shallower fossa. Anterior to this is a fossa directed obliquely downward and forward, as a continuation of the nasomaxillary; and below and in front of this one is a deep concavity of the alveolar border." (For further description see Cope, *op. cit.*)

Measurements (after Cope, in part).

Diameters of m ¹ :	anteropost.....	20 mm.,	transv.....	25 mm.
" " m ³ :	"	27 "	"	24 "
Total length of molar-premolar series.....				145 "
" " " molar series.....				69 "

This species was fully described and fairly well characterized by Cope.

Although comparing in size with the northern Miocene species, which I have regarded as belonging to *Pliohippus*, *P. pernix*, *P. robustus*, *P. mirabilis*, and *P. supremus*, the general skull characters presented are more nearly those of *Prohippus perditus* as that species is now understood. The maxillonasal, or lachrymal, fossa described by Cope is in form and position strikingly similar to that shown in a young skull of *P. perditus* from the upper Miocene beds of South Dakota (No. 10838, Am. Mus. coll.) but it is somewhat deeper and more sharply defined than in the latter. The Texas specimen also shows a deep depression of the skull, not mentioned by Cope, in the median line directly between the orbits, as in the *P. perditus* skull, but it is not divided as in the latter specimen.

Other characters common to both species are, the unusual broadening of the nasals anteriorly, the comparative shortness of the muzzle, and its deep constriction immediately in front of the premolars.

The larger size, the presence of an insipient maxillary fossa, and the greater depth of the lachrymal fossa, sufficiently distinguish the Texas species from *P. perditus*, while suggesting a somewhat more advanced form.

44. ? **Hipparion lenticularis** (Cope).

Protohippus lenticularis COPE, Fourth Ann. Rept. Geol. Surv. of Texas, 1893, p. 41.

Type: Two superior molars.

Type locality: Mulberry Canyon, near Goodnight, Texas.

Horizon: Upper Miocene, ("Goodnight beds.") = Clarendon formation.

Author's description (op. cit.): "Two superior molar teeth represent this horse in the collection from Goodnight's. They indicate a species of the size of the *Hippotherium speciosum*, and present several peculiarities. The most conspicuous is seen in the form of the protocone, which is long separate from the paraconule. It has an absolutely lenticular section, presenting acute angles anteriorly and posteriorly, and convex surface internally and externally. In this respect it differs from all the species of *Hippotherium* and *Protohippus* known to me. The column is fused towards the base with the paraconule, so that an old animal belongs to the genus *Protohippus*, as in the case with the *Protohippus placidus*, described on a preceding page. As both the teeth of *P. lenticularis* are only partially worn, the pattern of their grinding faces is that of the genus *Hippotherium*.

"The enamel borders of the lakes are moderately complex, the anterior having the posterior loop nearly isolated, and a trace only of other irregularities, while there are two deep notches of adjacent borders of the

posterior lake. The remote borders of the lakes have each a mere trace of a notch. There is one deep loop of the internal border, which extends to the protocone in one tooth and nearly to it in the other. It is rarely so pronounced in the three-toed horses, and when large is frequently double.

"The crown is curved transversely but not anteroposteriorly."

Measurements (after Cope).

Diameters of No. 1, anteropost. . . . 21 mm., transv. . . . 19 mm., height, 48 mm.
 " " " 2, " . . . — " " . . . 18 " " " 44 "

This species, founded on two isolated upper molars, was described and named under *Protohippus* by Cope. But his reasons for placing it in this genus are insufficient. According to Cope's statement the protocone does not join the protoconule ("paraconule") except near its base, a condition which may frequently be observed in old individuals of the true *Hipparion* or *Neohipparion*. In other respects the characters presented are those of the latter genera rather than of *Protohippus*.

The protocone is small and well rounded, and in this respect is more like the European *Hipparion* than any species described from this country, except Leidy's three species from Florida and South Carolina as mentioned above (page 914). The character of the lenticulate form of the protocone, pointed out by Cope as distinctive of the species, is apparently due entirely to the little worn condition of the tooth crown. Unlike the Atlantic coast species the enamel foldings are comparatively simple and the fossettes are in character more like species of *Neohipparion*. It is therefore with some doubt that I place this species in the genus *Hipparion*.

In 1899 I obtained a second specimen, apparently of this species, from the Clarendon beds of Donley Co., Texas. This very much more complete specimen, consisting of the anterior portion of a skull with full dentition (No. 10584, Am. Mus. coll.) makes possible a better comparison and characterization of the species. The corresponding teeth are nearly identical in size and characters with those on which the species was founded, hence they need no further description except that the protocones of the less worn teeth are lenticulate in form while the others have the usual rounded outline. The special features of importance are seen in the skull characters. The palate is high-arched, the muzzle is comparatively long and slender, and the cranium, as compared with *Protohippus perditus*, has a considerable vertical depth.

The species is especially *Hipparion*-like in the characters of the facial region. The malar ridge is high and angular, and there is no malar fossa or depression but the lachrymal fossa is especially well developed. Though smaller in area than in the typical *Hipparion gracilis*, it is sharply defined,

and deeply pocketed posteriorly. In its facial characters *H. lenticularis* differs from all other American Miocene horses, so far as known.

45. *Pliohippus interpolatus* (Cope).

Hippidium interpolatum COPE, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 42.

Type: Two upper molars.

Type locality: Mulberry Cañon, near Goodnight, Texas.

Horizon: Upper Miocene, ("Goodnight beds.") = Clarendon formation.

Author's description (*op. cit.*): "The form and area of the grinding surfaces are similar to those of the corresponding molars of the domesticated horse (*Equus caballus*). They may be distinguished from the corresponding teeth of the species of *Protohippus* by the small size of the protocone and hypocone. The former reached posteriorly to the line of the anterior border of the posterior lake, but does not overlap it, as is the case with the species of three-toed horses generally. Its junction with the paraconule is strongly constricted. The internal enamel border between the protocone and hypocone is inflected to a point beyond the line of the internal border of the anterior lake, and in front of its apex it sends inward a deep narrow loop. The lakes are relatively large, and the borders are quite simple. The anterior border of the anterior lake is simple; the posterior border has an inflection but no loop. The exterior border of the posterior lake has one inflection, and its posterior border a slight emargination. Owing to the transverse width of the lakes, their horns are little produced. The crowns are curved transversely, but scarcely anteroposteriorly. Cementum abundant."

Measurements (after Cope).

Diameters of m ¹ :	anteropost.....	28 mm.,	transv.....	27 mm.
"	" m ² :	"	"	"
		29 "	"	29.5 "
Height of crown of m ²:	.....	65	"	"

This species is somewhat poorly characterized since it is known only from two molars, the type teeth. They are of a young adult individual, hence the fossettes are not so wide transversely as they undoubtedly would be with a greater degree of wear. In other respects, especially in the simplicity of the enamel walls, the small rounded protocone, and the degree of curvature of the tooth crown, they are like the northern species of *Pliohippus* more than those of the South American *Hippidion*. They agree in size with *P. speciosus* Cope.

46. ? *Hipparion eurystylus* (Cope).

Equus eurystylus COPE, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 43.

Hipparion eurystylus (Cope) GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XIV, 1901, p. 125.

Type: A broken lower molar. *Paratypes*: Several lower molars and premolars.

Type locality: Paloduro Cañon, Crosby Co., Texas. *Locality of Paratypes*: Mulberry Cañon, near Goodnight, Texas.

Horizon: Upper Miocene, ("Goodnight beds.") = Clarendon formation.

Author's description (op. cit.): "This small but remarkable true horse was first brought to my notice by a broken inferior molar from the Palodura Cañon, where it was found by Mr. Cummins. The horizon of this locality was unknown to me, but the discovery of four additional lower molars at Goodnight's by Mr. Cummins fixes it. It is the most characteristic species of the epoch which intervened between the Loup Fork and Blanco.

"The species belongs with the *E. minutus*, Cope, to a section of the genus characterized by the relatively great width of the metaconid-metastylid column of the inferior molars, and its close appression to the protoconid and hypoconid, and hence by the relatively narrow molar crown; and also by the small size....

"Other specimens examined since the above description was written throw much additional light on its characters. These are four inferior molars, all from Goodnight's, and all apparently from as many individuals. From these it seems that the external faces of the protoconid and hypoconid are flat and not convex as is usual in this genus. Also that the hypoconid throws outwards an acuminate or acute loop just before joining the protoconid, which loop is the summit of an acute ridge of the middle of the external face of the crown." (For further description see Cope, *op. cit.*)

Measurements (after Cope).

Diameters No. 2.....	{	longitudinal.....	55
		anteroposterior.....	24
		transverse.....	10
Diameters No. 5.....	{	longitudinal.....	40
		anteroposterior.....	22
		transverse.....	12

The type tooth is so fragmentary as to show no particularly distinctive features, therefore, following Cope, the principal characters of the species may be taken from the paratypes. A restudy of these teeth makes it very clear that Cope was not warranted in referring them to the genus *Equus*

The characters throughout are especially those of the *Hipparion* or *Neohipparion* group. The little fold of enamel observed at the antero-external angle of the protoconid, and the appression of the metaconid metastylid column to the protoconid and hypoconid, are characteristic features of the Miocene genera of the *Protohippinæ*. The little anterior fold of the enamel wall is commonly observed in species of this group while it is never present in species of true *Equus*.

The tendency toward flat external faces of the protoconid and hypoconid, and the external median keel, mentioned by Cope, as well as the great height of crown, are characters which suggest *Hipparion* or *Neohipparion* rather than *Protohippus* or *Pliohippus*.

The teeth representing this species are from the same horizon and from practically the same locality as those of *H. lenticularis*. Moreover they agree in size, that is, in anteroposterior diameter, with the corresponding upper teeth of this species, hence it seems quite possible that the two species are identical. But since the lower dentition of *H. lenticularis* and the upper dentition of *H. eurystylus* are not certainly known, this point may not be determined at present.

47. *Protohippus cumminsii* (Cope).

Equus cumminsii COPE, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 67.

Protohippus cumminsii (Cope) GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XIV, 1901, p. 126.

Type: An upper molar of the left side associated with two other upper molars.

Type locality: Mount Blanco, Crosby County, Texas.

Horizon: Pliocene, Blanco formation.

Author's description (*op. cit.*): "They represent an animal of considerably smaller size than the latter, measuring with the *E. tau* and *E. simplicatus*. Their enamel borders are entirely simple, as in *E. simplicidens* and are hence different from those of the *E. semiplicatus*. It differs from both the *E. simplicidens* and the *E. tau* in the prominent convexity of the internal wall of the paracone and metacone, from which it results that the external border of each lake is deeply concave, and the horns appear to be strongly produced. The protocone has a very short anteroposterior diameter, in which it resembles the *E. simplicidens*, *E. crenidens* and *E. stenonis*, and differs radically from the *E. tau* and the other species of the Equus beds. It is not bilobate or grooved on the internal face....

"The subcylindric character of the paracone and metacone approach what exists in Hippidium and some species of the three-toed horses."

Measurements (after Cope).

Diameters of crown, anteropost.....	24 mm.,	transv.....	24 mm.
Height of crown.....	33 "		

This species is represented by only three upper molars from Mount Blanco, Texas.

Although compared principally with species of *Equus*, both the description and figures given by Cope apparently show a much closer relationship with the three-toed horses of the Miocene. The small size and form of the protocone seems to identify this species with the Upper Miocene genera, and the simple, widely open fossettes and concave form of the external walls of the protocone and metacone appear to mark its especial affinities to *Protohippus* or *Pliohippus*. The greater depth of the notch anterior to the protocone, suggests a somewhat more advanced form than any species of *Protohippus* from the Miocene horizon.

48. *Protohippus phlegon* (Hay).

Equus minutus COPE, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 67.

Equus phlegon HAY (to replace *E. minutus* Cope, preoccupied), Bull. 159, U. S. Geol. Surv., 1901, p.

Protohippus phlegon (Hay) GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XIV, 1901, p.

Type: A lower molar, ? m₂, of the right side.

Type locality: Mount Blanco, Crosby Co., Texas.

Horizon: Pliocene, Blanco formation.

Author's description (*op. cit.*): "The inferior molar is narrowly hypsodont, and has apparently had but a thin cementum investment. This appears probable, from the fact that it is as thin where protected from weathering as where exposed to it, *i. e.*, in the groove between the external columns. The inner side of the crown shows marked peculiarities. The metaconid and metastylid are appressed to the hypoconid and protoconid, and are spread widely apart so as to be connected by a narrow antero-posterior isthmus, and separated on the internal face of the crown by a wide channel which has a greater anteroposterior diameter than the metaconid and metastylid respectively near the apex of the crown, and an equal width at the base of the crown. The hypostylid is also appressed to the hypoconid and has a recurved posterointernal angle, which forms an acute ridge bounding the internal face of the crown posteriorly. This incloses with the metastylid a flat open gutter as wide as the metastylid. A sharp ridge marks the internal face of the anterior border, but it is closely appressed to the metaconid, which it does not equal in elevation."

Measurements (after Cope).

Length of crown preserved.....	37 mm.
Anteroposterior diameter at middle.....	16.5 "
Transverse diameter at metastylid.....	8 "
Transverse diameter in front of metastylid.....	6 "

This species was based on a single lower molar and is known only from this tooth and a series of lower molars (No. 10626, Am. Mus. coll.) from the same locality, which I have referred to the species in the publication above cited. The species therefore is not well characterized. While showing in general a more advanced stage than the species of the upper Miocene, the characters, like those of *E. cumminsii* Cope, are apparently more those of *Protohippus* or *Neohipparion* than of *Equus*. The close appression of the metaconid-metastylid column to the protoconid and hypoconid, and the well rounded outer walls of the protoconid and hypoconid are characters in which it resembles the Miocene species, while the greater backward extension of the metastylid, and the reduction of the anterior-external enamel fold of the protoconid to a mere rudiment are intermediate characters leading toward the true *Equus* type. If an upper molar seen by the writer, but unfortunately lost in the field, could be identified with this species it would indicate its affinity to the *Neohipparion* or *Hipparion* group rather than to *Protohippus*, for, as I distinctly remember, the crown of this tooth presented a small rounded protocone, well separated from the protoconid.

A careful restudy of this species leads me to conclude that at present it may be regarded as a somewhat intermediate type of rather uncertain reference.

49. *Parahippus crenidens* (Scott).

Desmatippus crenidens SCOTT, Amer. Nat., Vol. XXVII, July, 1893, p. 661.

Parahippus crenidens (Scott) GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XX, 1904, p. 192.

Type: Dentition of both the upper and lower jaws, lacking the incisors, canines, first lower premolar and last upper premolar; the mandible; portions of the radius and ulna, femur, manus and pes, and fragments of other bones.

Type locality: Deep River valley, Montana.

Horizon: Middle Miocene, Deep River formation.

Author's description (op. cit.): "*Desmatippus* gen. nov.—Molars and premolars short crowned, the valleys more or less filled with a thin deposit of cement. In the upper series the posterior transverse crest is connected with the outer walls and sends forward a process which extends nearly to the anterior conule. Inner cusps of lower teeth expanded so as to narrow

entrances to the valleys. Median inner cusps (a, a' of Rütimeyer) much more distinctly separated than in the older genera.

"D. crenidens sp. nov.—Posterior transverse crests of upper cheek teeth sinuous; limbs elongate and slender; size moderate.

"This interesting new equine very satisfactorily fills the gap between *Miohippus* and *Protohippus*. The type specimen was found by I. Benet in the upper strata of the Deep River." (For detailed description see Scott, Trans. Amer. Phil. Soc., Vol. XVIII, 1896, p. 84.)

Measurements.

Diameters of p ¹ :	anteropost.....	15	mm.,	transv.....	10	mm.
"	" p—:	"	.....	22	"	"
"	" p ³:	"	.....	18	"	"
"	" p ⁴:	"	.....	18.5	"	"
"	" m ¹:	"	.....	17.5	"	"
"	" m ²:	"	.....	16	"	"

(For measurements of foot bones see Scott, Trans. Am. Phil. Soc., Vol. XVIII, 1896, p. 89.)

At the time this species was described by Scott and made the type of a new genus, *Desmatippus*, the characters of *Merychippus* were not well understood, and the genera *Parahippus*, *Anchippus*, and *Hypohippus* were not well known, the latter three genera being regarded by Cope and others as representing milk dentitions of species of *Protohippus* or *Hipparion*. As now known, with the exception of *Anchippus* which I regard at present as equivalent to *Parahippus*, these are all well defined and clearly distinct genera. The definition of *Desmatippus* given by Scott exactly fits that of *Parahippus* Leidy as that genus is now understood. And since a comparison of types and the study of other material amply confirm the likeness of characters, I have, in a former publication (*op. cit.*) transferred *D. crenidens* Scott to that genus.

The species agrees very nearly in size with *P. brevidens* (Marsh) but is apparently distinguished from that species by a less marked angulation of the metaloph, and the somewhat shorter proportionate height of the principal cones. Scott considered that *P. crenidens* stands 'morphologically' exactly intermediate between *Miohippus* and *Protohippus*. But a better knowledge of the tooth structure of these earlier forms of horses obtained from far more abundant material does not seem at all to confirm this opinion. While teeth of the *Desmatippus* (*Parahippus*) type represent a much more advanced stage than *Miohippus* or *Mesohippus* as seen in the tendency to a greater height of crown, the complete union of the metaloph with the ectoloph, the development of a more or less well defined spur (crochet) on the anterior wall of the metaloph, and in the lower teeth of a more complete

division of the median inner cusps (med. and msd.) they are still, in general structure, essentially *Anchitheriinae*-like in character, while they differ widely in some essential features from the *Merychippus* or *Protohippus* form of tooth. The chief points of difference between the two groups, apparently not bridged over by any known form, are these: (1) In the upper cheek teeth of the *Anchitheriinae* group the inner cones, pr and hy, are larger than the median conules (pl and ml), presenting by far the greater grinding area. (2) The median conules, especially the protoconule, if developed, are more or less conical in outline, not having assumed the crescentic form observed in *Merychippus*. In the *Protohippinae* the proportions of the inner cones and median conules are exactly reversed, and the greatly enlarged conules have fully assumed the crescentic form essential to the complete inclosing of the cement lakes, or fossettes, while they form the principal functional part of the inner portion of the crown.

50. *Hypohippus equinus* (Scott).

Anchitherium equinum SCOTT, Amer. Nat., Vol. XXVII, July, 1893, p. 661.

Type: Fragmentary skull and jaws with nearly complete dentition, and parts of the skeleton.

Type locality: Deep River valley, Montana.

Horizon: Middle Miocene, Deep River formation.

Author's description (*op. cit.*): "Size equal to that of *A. aurelianense*, but with teeth relatively larger; lower incisors without enamel pits; humerus with bicipital tubercle and double bicipital groove.

"This is the first American species of *Anchitherium* in the restricted sense in which that name is here employed. It was found by Mr. Benet in the upper beds." (For detailed description see Scott, Trans. Am. Philos. Soc., Vol. XVIII, 1896, p. 94.)

Measurements.

Diameters of p ¹ :	anteropost.	.....	15.5 mm.,	transv.	.....	11 mm.	
"	p ²:	"	.....	25 "	"	.....	25 "
"	p ³:	"	.....	22.5 "	"	.....	28 "
"	p ⁴:	"	.....	23 "	"	.....	30 "
"	m ¹:	"	.....	23 "	"	.....	29.5 "
"	m ²:	"	.....	21.5 "	"	.....	29 "
"	m ³:	"	.....	19 "	"	.....	25 "

This species has been well defined but its characters are without question those of *Hypohippus* as that genus is now understood, and it is quite distinct from the European *Anchitherium*, the genus in which it was placed by Scott.

51. *Neohipparion whitneyi* Gidley.

Neohipparion whitneyi GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XIX, 1903, p. 467.

Type: A complete skeleton of an adult individual (No. 9815, Amer. Mus. coll.). *Paratypes*: Partial skeletons of five associated individuals, some of which are of young animals with milk dentition.

Type locality: Little White River, near the Rosebud Indian Agency, South Dakota.

Horizon: Upper Miocene, Nebraska formation.

Author's description (op. cit.): *Generic characters*.¹ Protocone free except at base, as in *Hipparion*. Protocone comparatively large and usually much expanded anteroposteriorly. Enamel foldings simple as compared with *Hipparion*, but usually more complex than in *Protohippus* or *Pliohippus*. So far as known the facial fossæ are never pocketed, nor are their borders sharply defined. The median external basal column present in the lower milk molars as in *Hipparion*, but shorter and much more expanded anteroposteriorly. Digits, in general, more slender than in *H. gracilis*, and the lateral digits much more reduced.

Specific characters. Size about equal to *Neohipparion occidentale*, but enamel foldings much more simple, even more simple than in *N. affine*. *N. whitneyi* further differs from *N. affine* in the much stronger development of the styles of the ectoloph. Protocone relatively large and very much elongated in cross-section anteroposteriorly. Inner or lingual, wall of the protocone flat and slightly depressed, as is usual in *Equus caballus*. Metapodials very long and slender. Lateral digits greatly reduced, their terminal phalanges not extending to the distal end of the first phalanx of the median digit. (For more detailed description see Gidley, *op. cit.*)

Measurements (in part).

Diameters of p ¹ :	anteropost.	9.5 mm.,	transv.	7 mm.
" " p ² :	"	29.5 "	"	23.5 "
" " p ³ :	"	25 "	"	25 "
" " p ⁴ :	"	25 "	"	25.5 "
" " m ¹ :	"	22 "	"	23 "
" " m ² :	"	24 "	"	23 "
" " m ³ :	"			
Total length of series				152 "
Width across external incisors				55 "

¹This definition has been revised and made broader to include more accurately all the species referred to the genus.

Milk dentition (upper).

Diameters of dp ² :	anteropost.....	31.5 mm.,	transv.....	21.5 mm.
" " dp ³ :	"	26 "	"	21 "
" " dp ⁴ :	"	29 "	"	20 "

This species was selected as the type of a new genus (*op. cit.*) closely allied to, but apparently distinct from, the European *Hipparion*. The genus includes practically all the North American species of upper Miocene horses, described by Leidy and Cope under the synonymous names *Hipparion* and *Hippotherium*. The specimen on which the species was founded being so unusually complete and well preserved constitutes a remarkably good type for comparison.

52. *Protohippus simus* *Gidley*.

Protohippus simus GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 139.

Type: Anterior portion of adult skull with nearly complete dentition (No. 9820, Amer. Mus. coll.). *Paratype*: A portion of upper jaw containing all the large cheek teeth, except m¹, (No. 10871 Amer. Mus. coll.).

Type locality: Little White River, near the Rosebud Indian Agency, South Dakota.

Horizon: Upper Miocene, Nebraska formation.

Author's description (*op. cit.*): "These specimens represent an animal very distinct from species of the *P. mirabilis* and *P. supremus* type, but apparently more closely allied to *P. perditus*, though somewhat larger and differing from that species in the following characters:

"In the upper teeth the protocones show a more progressive stage in their fuller development anteriorly, thus forming a deeper infolding of the enamel between them and the protoconules. In other respects the teeth do not differ greatly from those of *P. perditus* except that the cement lakes are narrower transversely.

"The chief points of difference are in the skull characters. The muzzle is short but much broader than in *P. perditus*. The incisive border is but little curved. This, together with its great breadth, gives the muzzle a rather truncate appearance.

"The palate is broader and less arched than in *P. perditus*, especially forward of the premolars, where it is relatively very flat. The anterior palatine foramina are elliptical in outline and are placed in about the same relative position as in *P. perditus*.

"The malar fossa is wanting, as in *P. perditus*, but the lachrymal fossa is broader, much shallower, and less sharply defined than in that species.

"Compared with *N. whitneyi* it is distinguished by (1) its smaller size and (2) by the greater number of folds in the enamel walls of the metaloph in the upper teeth, (3) the more open fossettes, and (4) the more rounded forms of the protocones. The small portion of skull preserved in the type does not admit of many comparisons, but a distinctive feature is shown in

the extreme forward position of the infraorbital foramen, which is placed directly above the space between p^2 and p^3 . The masseter ridge extends but little farther forward than in *N. whitneyi*.

"The lower jaw is much longer and more slender than in *N. whitneyi*, or any other known Miocene species of horse. The muzzle portion is proportionally longer than the average of a dozen specimens of *Equus caballus* examined.

"The lower border of the ramus is bowed as in *N. whitneyi* and *N. gratum*.

"*Measurements of Type (No. 10865).*

Diameters of p^2 :	anteropost.....	30	mm.,	transv.....	22	mm.
"	" p^3:	"	.....	23	"	"
"	" p^4:	"	.....	23.5	"	"
"	" m^1:	"	.....	20	"	"
"	" m^2:	"	.....	20	"	"
					23.5	"
					23+	"
					22	"
					21.5	"

54. ***Neohipparion niobrarense* Gidley.**

Neohipparion niobrarense GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 151.

Type: Anterior portion of skull with lower jaws, both containing complete dentition (No. 10828, Amer. Mus. coll.).

Type locality: Near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska formation.

Author's description (op. cit.): "The type of this species represents an animal but little larger than *N. gratum* and differing from it in the following characters:

"(1) The skull, especially in the nasal and premaxillary region, is longer and narrower; (2) the palate is narrow and more arched; (3) the anterior palatine foramina are more open but do not extend as far backward as in *N. gratum*; the posterior palatal notch apparently extends as far forward as the middle of m^1 ; (4) the malar fossa is wanting; (5) the lachrymal fossa is larger, extends farther backward, and has a rather sharply defined posterior border. (6) the symphysis of the lower jaw is longer and narrower than in *N. gratum* but is not so extreme in proportions as in *N. dolichops*; and (7) the ramus is bowed as in *N. gratum* but has a less vertical depth.

"Measurements of Type (No. 10828).

Diameters of p ¹ :	anteropost.....	11	mm.,	transv.....	7	mm.
"	p ²:	"	.....	22	"	.....19.5 "
"	p ³:	"	.....	16.8	"	.....21.8 "
"	p ⁴:	"	.....	17	"	.....21.5 "
"	m ¹:	"	.....	16.5	"	.....20.5 "
"	m ²:	"	.....	16.4	"	.....20 "
"	m ³:	"	.....	21	"	.....19 "

Skull.

Total length of molar-premolar series including p ¹	117	mm.
Total length of molar-dental series, m ³ to i ¹	185	"
Length of diastema between p ¹ and i ³	53	"
Width of palate between first molars.....	38	"
Width of palate between second premolars.....	27.5	"
Width of palate in front of first premolars.....	21	"
Width of incisive border.....	28	"
Height of skull above m ¹	86	"
Distance from orbit to anterior narial notch.....	115	"

Lower Jaw.

Total length of jaw.....	265	"
Length of complete dental series m ₃ to i ₁	185	"
Length of molar-premolar series.....	110	"
Length of diastema between p ₂ and i ₃	52	"
Width of symphysis at narrowest point.....	21	"
Width across incisive border.....	34	"
Depth of jaw at m ₁	53	"
Height of condyles above bottom of jaw.....	140	"

"The type specimen is of a very old individual with the tooth characters practically obliterated by wear. The skull and jaw characters, therefore, form the basis of its generic reference.

"In a lot of upper teeth in the United States National Museum, referred by Leidy to his "*Hipparion speciosum*," there are several specimens which agree in size with the teeth of *N. niobrarensis*. These specimens are clearly of the Neohipparion pattern and are possibly referable to this species."

***Merychippus campestris* sp. nov.**

Type: Upper molar — premolar series of the left side associated with the lower jaws fragments of skull, vertebræ, and portion of fore and hind limbs and feet. (No. 9069, Amer. Mus. coll.)

Type locality: Pawnee Buttes, Colorado.

Horizon: Middle Miocene, Pawnee Creek formation.

Species character: In the American Museum collection of fossils from Pawnee Buttes, Colorado, there is a specimen, consisting of upper teeth

associated with the lower jaws, fragments of skull, vertebræ, and portions of the fore and hind limbs and feet, apparently all of one individual. This specimen represents an undescribed species of horse representing apparently a *Pliohippus* phase of the *Merychippus* group. The milk dentition is not known, but the tooth crowns are apparently as short as in many of the species in which the milk teeth are known to be of the brachyodont type, and the specimen comes from a lower horizon than any known species of *Pliohippus*, with the possible exception of *Pliohippus spectans* (Cope) from Cottonwood Creek, Oregon. The characters presented are more primitive throughout than those of other described species of *Pliohippus*.

The upper molars though somewhat smaller have much the same general appearance as *Pliohippus spectans*, but differ from that species in the following particulars: (1) The molars are shorter crowned; (2) the external cones (*pa* and *ma*) are thicker transversely, making a less transverse width for the fossettes; and (3) the protocones are smaller and more rounded, being nearly circular in outline as in the South American *Hippidion*. Like *P. spectans*, the horns of the fossettes end in broadly open louns and their enamel borders are very simple throughout.

The lower jaws are comparatively long and slender; the symphysis is shallow but heavy. There is a considerable diastema between the canine and the first incisor. The lower borders of the rami are considerably bowed, but the jaws have the appearance of having been deformed by some disease of the bone in life which affected especially the region of the ramus containing the molariform teeth, hence there is some doubt as to this being the normal form.

There are apparently no special characters shown in the portions of skull preserved, except that the space between the postglenoid process and the mastoid process is somewhat greater than in horses of the *Neohipparion whitneyi* type, the postglenoid process is more robust, and the mastoid bone extends outward and overlaps the exoccipital to a greater degree. In these characters it more nearly resembles *Equus caballus*.

The atlas is more progressive in general character than that of *N. whitneyi* of the Upper Miocene or any species of horses from the middle Miocene in which the atlas is known. The transverse processes are well expanded and the anterior external notch is partially inclosed, suggesting a strong tendency to the condition of an inclosed foramen which has been attained by *Equus* and *Hippidion*.

Metacarpal III is moderately short and heavy (see measurements) and the lateral metacarpals, mII and mIV, are very much reduced. The shaft of the ulna is much reduced and fused with the radius for the greater part of its length.

Measurements.

Diameters p ¹ : anteropost.....	13	mm., transv.....	7.5 mm.
“ p ² : “	29	“ “	22 “
“ p ³ : “	23	“ “	25 “
“ p ⁴ : “	23	“ “	25.5 “
“ m ¹ : “	20.5	“ “	24 “
“ m ² : “	21.5	“ “	25 “
“ m ³ : “	21.5	“ “	21.5 “
Total length of molar premolar series.....	144.5		“
Total width of occiput of skull.....	80		“
“ “ “ “	55.5		“
Width of condyles.....	300		“
Length of jaw forward of premolars.....	87		“
Diastema between premolar 2 and canine.....	35		“
Depth of symphysis.....	30		“
Width of symphysis at narrowest point.....	31		“
Depth of ramus at p ₄	44		“
“ “ angle immediately behind m ₃	78		“
Length of radius.....	225		“
Width of radius at distal end.....	44		“
Length of metacarpal III.....	175		“
Transverse diameter, proximal end.....	28.5		“
Anteroposterior diameter, proximal end.....	24		“
Transverse diameter at middle of shaft.....	21		“
“ “ “ distal end shaft.....	25		“
Length of femur.....	244		“
“ “ tibia, exclusive of spine.....	275		“
Transverse width of tibia, proximal end.....	60		“

58. *Hypohippus osborni* sp. nov.

Type: A nearly complete skeleton (No. 9407, Amer. Mus. coll.). Found by Barnum Brown, Amer. Mus. Expedition of 1901.

Paratype: A palate with complete dentition, associated with lower jaws and other parts of the skeleton (No. 9395, Amer. Mus. coll.).

Type locality: Pawnee Buttes, northeastern Colorado.

Horizon: Middle Miocene, Pawnee Creek beds.

Species characters: As indicated by the teeth, this species is intermediate in size and progressive development between *H. affinis*, the type of the genus, and *H. equinus* (Scott), the latter being the smallest and least specialized. Compared with *H. equinus* the principal differences are, (1) cheek teeth relatively longer crowned; (2) outer walls of upper cheek teeth more deeply curved; (3) protocone and hypocone more compressed anteroposteriorly; and (4) the incisors are relatively wider.

It does not seem necessary here to describe in detail the different ele-

ments of the type skeleton since, except for their somewhat larger size, they so nearly resemble those of the *H. equinus* specimen so fully described and compared by Scott.¹ However, a few skull characters and points of skeleton proportions, not so clearly shown in the less complete type of *H. equinus*, seem of sufficient importance to merit note.

In general the skull and teeth have retained many of the more primitive characters seen in *Mesohippus* while the lines of specialization have been, as pointed out by Scott, away from rather than toward the line of descent leading to the modern forms of horses. Thus the median conules (ml and pl) have diminished in size while the tooth crown has but slightly or not at all increased in height. The skull and jaws also have become somewhat more elongate but have decreased rather than increased in vertical depth. Other characters of the skull worthy of note are presented in the great enlargement of the lachrymal fossa which forms a deep pocket in the side of the face, and in the broad expansion of the nasals, especially in their anterior portion.

The unusually complete skeleton on which the genus *Neohipparion* (*N. whitneyi*) was found affords an opportunity for an interesting comparison of two wholly different types of horses.

In general proportions *H. osborni* is longer necked, longer bodied and shorter limbed than *N. whitneyi*. The relatively smaller head with its brachyodont uncemented teeth, its less vertical depth, its more anteriorly placed orbits which are not inclosed behind, presents a totally different appearance from that of *N. whitneyi* which is very much nearer the typical modern horse. A comparison of the feet also shows some marked differences. In *H. osborni* the lateral toes are relatively no more reduced than in *Mesohippus* and are functional, this together with the long, flattened, terminal phalanx of the median digit presents to the ground a comparatively large foot area. In *N. whitneyi* the toes are long and slender, the lateral ones being so greatly reduced as to render the foot practically monodactyl.

Measurements of Teeth.

Diameters of p ¹ , anteropost.....	18	mm., transv.....	11.5 mm.
“ “ p ² , “	27.3	“ “	26. “
“ “ p ³ , “	25.7	“ “	28.7 “
“ “ p ⁴ , “	27.	“ “	29.9 “
“ “ m ¹ , “	27.2	“ “	31. “
“ “ m ² , “	23.3	“ “	31.5 “
“ “ m ³ , “	21.	“ “	27.8 “
Total length of series (p ¹ to m ³).....	151 mm.		
“ “ “ molar series (m ¹ to m ³).....	69		
Width of incisive border across external incisors,.....	44		

¹ Trans. Amer. Phil. Soc., Vol. XVIII, 1896, pp. 94-122.

Skull Measurements.

Total length of skull, incisors to condyles.....	371.
“ “ “ palate.....	164.
Width of palate between first molars.....	54.
Length of diastema between upper canine and i ³	10.
“ “ “ “ “ “ “ p ¹	28.
Width of skull across zygoma.....	160.3
“ “ condyles.....	60.4

59. *Parahippus pawniensis* sp. nov.

Type: The upper and lower cheek teeth of one side, and fragments of the skeleton, including parts of the feet. (No. 9085, Amer. Mus. coll.).

Found by Handel T. Martin, Amer. Mus. Expedition of 1898.

Type locality: Pawnee Buttes Creek, northeastern Colorado.

Horizon: Middle Miocene, Pawnee Creek beds.

Species characters: (1) Cheek teeth shorter crowned than in any other species hitherto described; (2) The metaloph in the upper teeth is comparatively straight, with enamel walls simple except for the median anterior fold, or crotchet; (3) crotchet slightly united with the protoconule at its base; (4) external walls of paracone and metacone relatively flat, as in *P. crenidens*, with only a faint indication of the median rib; (5) crowns of upper cheek teeth proportionately narrower than in *P. crenidens*; (6) the meta-stylid in the lower teeth less prominent and less distinctly separated from the metaconid than in the other known species of this genus.

This type apparently represents one of the least specialized species of the genus.

Measurements.

Diameters of p ¹ , anteropost.....	mm., transv.....	19. mm.
“ “ p ³ , “.....	17.9 “ “.....	19.8 “
“ “ p ⁴ , “.....	17.2 “ “.....	20.1 “
“ “ m ¹ , “.....	17.8 “ “.....	20. “
“ “ m ² , “.....	16.5 “ “.....	18.7 “
“ “ m ³ , “.....	15. “ “.....	17. “
Total length of series p ² -m ³ (approximate).....	92. mm.	
Total length of molar series (m ¹ -m ³).....	46.2 “	

60. *Parapippus coloradensis* sp. nov.

Type: A single upper molar, m³ (No. 9040, Amer. Mus. coll.).

Paratypes: two fragments of lower jaws containing teeth (Nos. 9412 and 8282, Amer. Mus. coll.).

Type locality: Pawnee Creek, northeastern Colorado.

Horizon: Middle Miocene, Pawnee Creek beds.

Species characters: (1) Larger than *P. pawniensis*, about equaling *P. crenidens* in size; (2) tooth crown comparatively high; (3) outer walls of the paracone and metacone strongly ribbed, (4) metaloph with crotchet well developed, the type tooth presenting two additional enamel folds; (5) the metastylid of the lower teeth well developed and separated from the metaconid by a well marked groove reaching nearly to the base of the crown. (6) On the external walls of the lower teeth the enamel is very rough, almost wrinkled in appearance.

The characters presented in these teeth indicate a species of *Parahippus* somewhat more advanced in development than *P. crenidens*, and decidedly more specialized than *P. pawniensis*.

Measurements.

Diameters of m^3 (type), anteropost.....	16	mm., transv.....	20.5 mm
" " p_4 (No. 9412) "	21.5	" "	17.5 "
" " m_2 " "	20.	" "	15.5 "
Height of crown of m^3			14.5 mm.
" " " " p_4			15.5 "
Total length of lower series, less p_1			128. "

SUMMARY AND CONCLUSIONS.

In the foregoing revision the lines of comparison and study have been confined principally to characters of the teeth and skull, for the reason that by far the greater number of species of horses have been founded on tooth and skull material not associated with other parts of the skeleton. The expeditions of the last few years however are constantly increasing the collections and adding quantities of more complete material, including many specimens in which teeth and bones of the feet are associated. This class of material will greatly aid in working out more fully than has been done the characters of foot development of horses, and should result in throwing added light on the phyletic relations of the extremely varied groups which seem to have reached their culmination, as regards numbers of genera and species, in the Miocene period.

The principal results attained by this study are, first, a better understanding and interpretation of the principal characters shown in the numerous and varied types representing the American Miocene Horses; second, the reestablishment and better definition of several of the genera and species proposed by Leidy, the validity of which was questioned by Cope; and third, a reclassification of the entire family of the Equidæ.

As at present understood, the fact seems to be fairly well established that there is a considerable phyletic hiatus between the groups of the Equidæ

as above subdivided, which are as yet not bridged over by intermediate forms. Such a hiatus seems especially marked between the Anchitheriinae and the Protohippinae, while these groups greatly overlap each other in time. So far as indicated by any known species the Anchitheriinae could not well have stood in direct ancestral line to the latter group or to the Equinae. There seems also to be almost as decided a gap between the Anchitheriinae and the known species of the older group, the Hyracotheriinae. The Equinae may well have been derived from some species of the *Protohippus* division of the Protohippinae.