

Article IX.—TOOTH CHARACTERS AND REVISION
OF THE NORTH AMERICAN SPECIES OF THE
GENUS *EQUUS*.

By J. W. GIDLEY.

PLATES XVIII-XXI AND 27 TEXT FIGURES.

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In the successive seasons of 1899 and 1900 the writer was sent by Professor Osborn to study more carefully the Paloduro (Goodnight) and Mt. Blanco beds of Texas, both of which Professor Cope had placed as typical American Pliocene. This study resulted in proving that the Paloduro beds are typical Loup-Fork or Miocene. The Blanco beds are rightly regarded as Pliocene but do not, as Cope supposed, contain any true remains of *Equus*. In the overlying true Lower Pleistocene or Sheridan Beds the writer found several skeletons which have already been described as *Equus scotti*, sp. nov. In connection with this work it appeared that the Pleistocene American Horses were greatly confused, and Professor Osborn detailed the writer to a thorough restudy and comparison of all the types, which have been carried on under his advice. The general results of this work are summarized at the close of this paper.

Fossil remains of the genus *Equus* (indigenous to North America) were reported as early as 1826 by Mitchell,¹ who referred to this genus some teeth and vertebræ found near the Never-sink Hills in New Jersey, without assigning them to a species. Since that time about twenty different species have been proposed by various authors, based on material found in different localities of the United States and Mexico.

Although the remains of this genus have been found widely

¹ Catalogue of Organic Remains, New York, 1826, pp. 7 and 8.

distributed, and very abundant in some sections, it was not until the discovery by the writer in the summer of 1899 of the excellent material upon which he founded the species *Equus scotti* that anything like a complete skull had ever been found in the United States; nor had the teeth and skeleton of a single individual ever been found certainly associated. The materials upon which the North American species were founded, and which formed the basis of the descriptions and discussions of Owen, Leidy, and Cope, were very fragmentary, for the most part consisting of disassociated teeth and bones, among which portions of maxillary bones containing several teeth were rare specimens; hence a number of the species proposed were founded on single disassociated teeth. Owing to this lack of good material and to an imperfect understanding of the characters presented in the teeth, errors have been frequent and several of the species of this genus, as they now stand, are practically indeterminate.

This is the conclusion reached by the writer after a careful study of the abundant *Equus* material from the Niobrara River (collected by the American Museum expeditions of 1893 and 1897¹), together with the skulls and associated partial skeletons from the Staked Plains of Texas, and of numerous specimens of the living species.

The object of the present paper is to present the results of this study and to attempt a revision of the species that have been proposed.

Before proceeding with the discussion, however, the writer wishes to extend his thanks to Prof. Henry F. Osborn for his valuable advice and aid in the systematic arrangement of this paper; to Mr. F. A. Lucas of the National Museum and Dr. C. R. Eastman of the Museum of Comparative Zoölogy, Cambridge, Mass., for making possible the examination of some type specimens and associated material; to Mr. Witmer Stone of the Academy of Sciences, Philadelphia, for assistance in examining the *Equus* material in the Academy that was used or identified by Dr. Joseph Leidy and Prof. E. D. Cope; and to Dr. W. D. Matthew and Dr. O. P. Hay of the American Museum, for valuable suggestions and assistance. The drawings for this paper

¹ This material consists of a large number of mostly disassociated bones, teeth, jaws, and skull fragments. There are a few complete and several nearly complete molar-premolar series in the lot.

were very carefully and accurately made by Mr. Bruce Horsfall. The photographs were taken by Mr. A. E. Anderson.

The nomenclature of the elements of the molar teeth employed in this paper is that introduced by Prof. Henry F. Osborn and is clearly indicated especially in Figs. 1 and 2a, pp. 94, 95.

I. PRINCIPLES OF TOOTH STRUCTURE. CHARACTERS DUE TO INDIVIDUAL VARIATION AND TO AGE OR DEGREE OF WEAR DISTINGUISHED FROM TRULY SPECIFIC CHARACTERS.

The following are the chief characters used in definition by Owen, Leidy, and Cope:

Tooth Characters.

1. Degree of complexity of enamel foldings (Owen, Leidy, and Cope).
2. Degree of incurvation of superior molars (Owen, Cope).
3. Degree of curvature of superior molar-premolar series (Owen).
4. Relation of the antero-posterior and transverse diameters of the triturating surfaces of the superior molars (Owen, Cope).
5. Ratio of antero-posterior diameter of protocone to antero-posterior diameter of whole triturating surface (Cope).
6. Comparative size (considered unimportant unless difference was considerable) (Owen, Leidy, Cope).
7. Presence or absence of cup in external lower incisor (Cope).
8. Relative size of third superior molar (Owen, Cope).
9. Crimped or ptychoid enamel of fossette (Cope).
10. Character of the separation of the lobes of the metaconid-metastylid columns (Cope).

Skull Characters Relative to the Teeth.

11. The position, in relation to the teeth, (a) of the anterior extension of the maxillary ridge, (b) of the anterior extension of the palatal notch, (c) of the post-palatal foramina; also (d) the amount of the posterior projection of the maxillary beyond m^3 (Cope).

More importance has been attached to most of these characters, apparently, than their merits warrant; evidently, therefore, the

only way of forming an estimate of their true value is to find out, in a large series of specimens, in what way and how much these characters may be affected in the individual and in different individuals of the same species.

The conditions which affect the tooth character of the Horse may be classed under two heads: (A) *Age* and (B) *Individual Variability*.¹

A.—TOOTH CHARACTERS AS ALTERED BY AGE OR DEGREE OF WEAR.

(I). *Effect of Wear on Complexity of Enamel Folding.*

When a molar or premolar tooth first comes into use, the face, as well as the sides of the crown, is completely covered with enamel (Fig. 2, *A*),

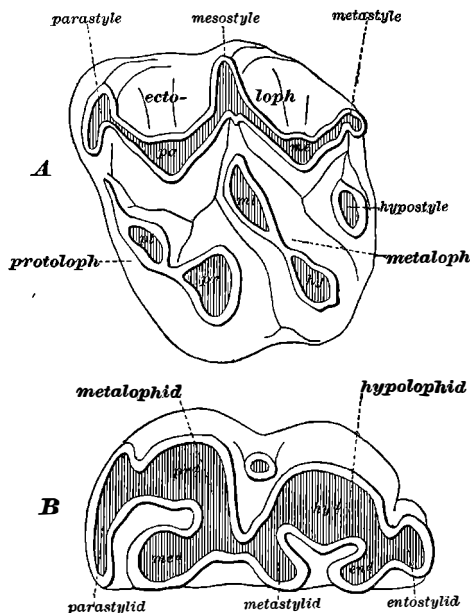


Fig. 1. Molars of Horses showing terminology. *A*, Upper molar, *Anchitherium*. *B*, Lower molar, *Merychippus*. (After Osborn.)

As the tooth is further worn away, these patches and irregular ridges broaden and rapidly lengthen until when about one-half to three-quarters of an inch of the crown

which folds in and out, and (though somewhat hidden by cement) presents the same general appearance as that seen in the much more primitive forms, *Anchitherium* and *Merychippus*. Soon the enamel on the tips of the cones and along the ectoloph wears through, and small patches and ridges of dentine completely surrounded by a border of enamel are exposed. (Fig. 2, *B*.)

¹ Sex seems to affect the tooth characters only in the canines, which are always prominent in the adult males, but absent or at best vestigial in the females; hence this factor is left out of the discussion.

has been worn away they have all become united by narrow isthmuses, and the fundamental tooth pattern of the horse is presented. (Fig. 2, C, D.) The five prominent points or cusps on the triturating surface of a newly erupted molar or premolar tooth are the paracone, metacone, protocone, protoconule, and a cusp apparently formed by the union of a ridge thrown out from the hypostyle meeting the metaloph at about its middle point. (Fig. 2, A.) The cusps forming the ectoloph are very early united, as is also the protocone with the protoconule. The next points of union are usually at the anterior and posterior walls of the tooth, where the protoloph unites with the parastyle, and where the hypostyle unites with the metastyle; usually then the antecrochet and crochet unite, and finally the metaloph extending across from the metaconule unites with the ectoloph directly opposite the mesostyle; this is because the metaloph is usually much depressed opposite

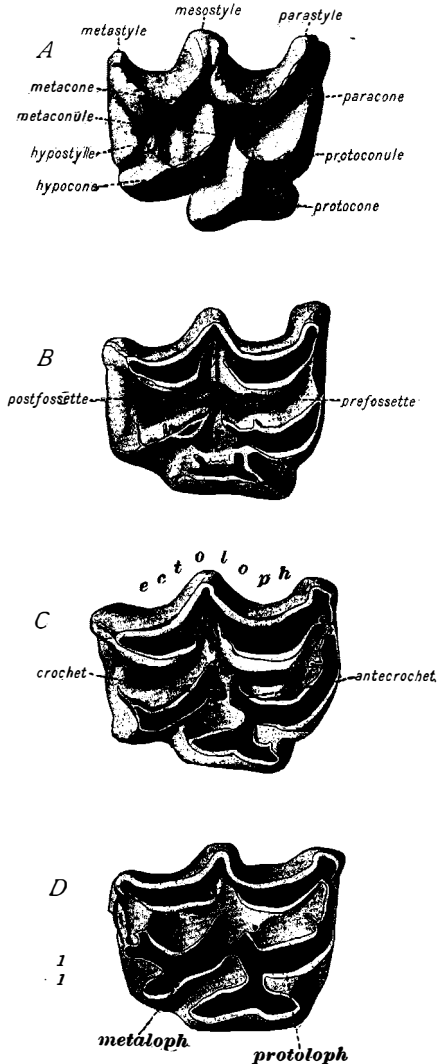


Fig. 2. Cusps, Crests, Styles, Crochets, and Fossettes in the molar teeth of the Horse (*E. complicatus*). A, un worn crown. B-D, successive stages of wear.

this is because the metaloph is usually much depressed opposite

the mesostyle, leaving the pre- and post-fossettes continuous after all other connections have been formed. Thus a continuous irregular wall of dentine is formed entirely around the tooth leaving a deep valley or inlet on the internal face of the crown and two large fossettes or lakes separated by the narrow transverse wall of the metaloph. The outside wall of dentine is bounded externally by a thin sheet of enamel, as are also the isolated fossettes. Just below the point where all these ridges and cusps are well united, appear the most elaborate enamel foldings, of the fossette borders, that are to be seen at any stage of wear.

From this point, which is usually about one-half to three-quarters of an inch below the face of the unworn crown, the triturating surface presents a gradually less complex pattern of enamel folding as the tooth crown is worn away, until in the very much worn tooth the simplest pattern of enamel folding is presented. Thus it may happen that a tooth will present the most elaborately complex enamel foldings when it is little worn, and become most simple in this respect when in old age the crown is worn very short, exhibiting all the intermediate stages in the course of wear. This principle is demonstrated in Fig. 3. *A* represents the little worn crown (No. 2726, Nebraska Coll.) of a fossil tooth of moderately complicated pattern. *A*¹, *A*², and *A*³ are three sections of the same tooth, and *A*⁴ indicates where each of these sections was cut. Note the difference in general of the fossettes and also the changes in the character of the outside enamel foldings.

(II). *Effects of Wear on the Proportions of the Teeth.*

1. The Teeth Taken Individually.

Unlike the degree of complexity of the enamel foldings, the corresponding diameters are affected differently by wear in different teeth of the molar-premolar series. The same general rule for the change in ratio of the antero-posterior to transverse diameter may be applied to the intermediate teeth p^3 to m^2 inclusive, but the most anterior and posterior teeth (p^2 and m^3) are affected differently, in this respect, from the intermediate teeth of the series and from each other as well.

a. Laws Governing the Changes of Diameters of the Tooth Crowns.

There seems to be no exception to the following laws for the changes of diameters of the tooth crowns as they are worn away by use.

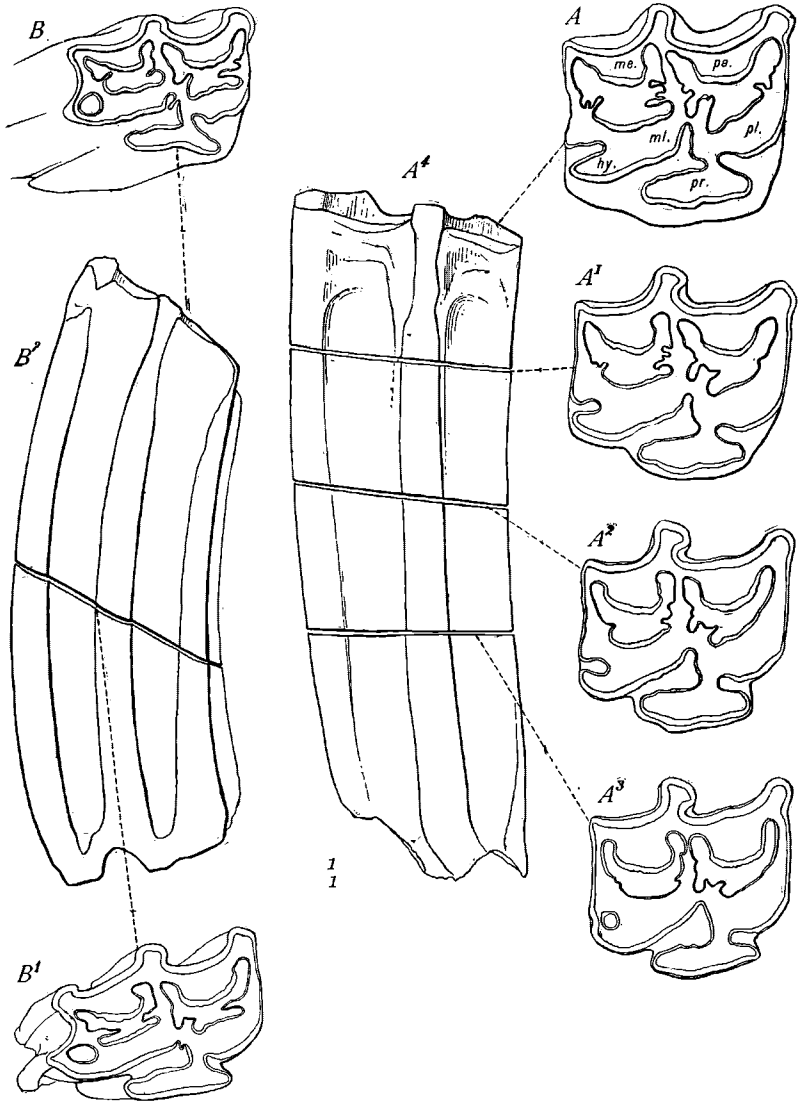


Fig. 3. Superior molars of *Equus complicatus*, sectioned to illustrate changes in dimensions and pattern at different stages of wear. *A*, trituration surface of m^1 . A^1 , A^2 , and A^3 , sections cut parallel to trituration surface. A^* shows where sections were cut; *B*, trituration surface of m^2 ; B^1 , section; B^2 shows where section was taken.

DESCRIPTION.	APPROXIMATE AGE.	CATALOGUE NUMBER.	DIAMETERS IN MM. ¹								
			p ²	p ³	p ⁴	m ¹	m ²	m ³			
Series 1.	Large draught Horse ♀	5 years	16274	Antero-posterior.....	40	32	30	30	30	29	
				Transverse.....	27	28.5	27.5	27	26.5	21.5	
				Antero-posterior, Protocone	11	14.5	15	13.5	15.5	16	
	" " " ♂	8 "	14131	Antero-post.....	36.5	29	28	25.5	25.5	29.5	
				Transverse.....	25.5	28	27	26.5	26	22	
				Antero-post., Protocone...	10.4	13.5	14	13	15	16	
	" " " ♂	15 + "	289	Antero-post.....	38.5	29.5	28.5	24	25	30	
				Transv.....	23	27.5	28	26	25.7	22.5	
				Antero-post., Protocone...	9.3	13	13	11.5	12.5	12.8	
	" " " ♂	12 + "	No number	Antero-post.....	40	30.5	30	27	27	29	
				Transv.....	28	30	28.5	28	26.5	23	
				Antero-post., Protocone ..	10	14	14	13	13.5	13	
Series 2.	Thoroughbred	♀	20 ± years	16277	Antero-post	36	26	25	21.5	21.5	30
					Transv	24	26.5	27	25	25	22.5
					Antero-post., Protocone ..	9	10	11	10	12.5	14.5
	" " " ♂	20 ± "	16275	Antero-post	33.5	25.5	25.5	22.5	23.5	26.5	
				Transv	23	26.3	26	25	25	23	
				Antero-post., Protocone ..	10	12	13.5	13.5	15	14	
	" " " ♀	6 "	Loaned by C. R. Knight	Antero-post	33.5	27.5	28	25	25.5	27.5	
				Transv	25	26.5	26.5	25.5	25	21.5	
				Antero-post., Protocone ..	8.5	13	13.5	13.5	13.5	15	
	Texas Pony	♂	7 "	No number	Antero-post.....	35	28	26	24	24.5	28.5
					Transv	23	25.5	25	25	24	21.5
					Antero-post., Protocone ..	8	10.5	10.7	10.5	10.5	11
Series 3.	Domestic Ass	♀	5 years	15675	Antero-post	33	26	25	22	23	23
					Transv	24.7	25	24	22.5	22.5	18.5
	Mexican Burro	♂	6 "	No number	Antero-post. Protocone ..	6.5	9.5	10.5	8.5	9.5	10.5
					Antero-post.....	31	24.5	23.5	21.5	21.5	22
					Transv	23	24.3	24	23.3	21.5	18
					Antero-post., Protocone ..	6.5	8.5	9	9	9	10.5

¹ In every case the transverse diameters were measured across from the exterior ridge of the mesostyle to the exterior wall of the posterior lobe of the protocone, exclusive of cement.

[Total length of three of the above skulls are as follows: No. 16274, 604 mm.; No. 14131, 573 mm.; Texas Pony, 515 mm.]

(1) The *antero-posterior* diameters of the grinding surfaces of all the intermediate teeth are greatest at the stage when the tooth has just fully come into use, that is, when about one-half of an inch, or less, of the crown has been worn away; from this point the antero-posterior diameter diminishes very rapidly for a short distance and then continues to diminish more gradually to the roots of the tooth.

(2) The antero-posterior diameter of the first premolar (p^2) remains about the same for the whole length of the crown, except that sometimes it narrows slightly near the roots.

(3) The antero-posterior diameter of the last molar (m^3), however, is relatively small at first, and increases continually as the tooth is worn away.

(4) When the teeth first come into use the *transverse diameters* of all the teeth of the series are quite narrow, owing principally to the rapid incurving of the ectoloph; this diameter increases very rapidly for about one-half to three-fourths of an inch, but from this point to the roots of the teeth the transverse diameters of p^3 to m^2 inclusive remain about the same, diminishing slightly near the roots; p^2 gradually diminishes while m^3 increases in transverse diameter as the crown wears away.

(5) The antero-posterior diameter of the protocone in all the teeth of the series remains the same for the whole length of the crown.

(6) The antero-posterior or long diameter of the incisors diminishes with age while the transverse diameter increases.

b. Effect of Wear on the Relative Measurements of Tooth Crowns.

(1.) *Ratio of the antero-posterior to the transverse diameter.*

It will be seen from the foregoing that owing to the very slight variation of the transverse diameters of the crowns of p^3 to m^2 inclusive, for almost their entire length, and to the great shortening of their antero-posterior diameters, the ratio of these diameters in these teeth is very different in old and in young individuals of the same species. Thus in the little worn condition of these teeth in a young horse, especially before the teeth have worn to that stage where the transverse diameter is greatest, the antero-posterior diameter is always greater than the transverse. As the crown wears away, the antero-posterior diameter diminishes and a

stage is reached where the two diameters are about equal, then, as the antero-posterior becomes still more shortened, the transverse exceeds it. In every series this variation in ratio seems always to be most advanced in m^1 and m^2 . This is evidently due not only to the order in which the teeth of the horse come into use, whereby the first to appear would at a given stage be most worn, but also, as is shown by an examination of Table I (p. 98), because the range of reduction of the antero-posterior diameters is greater in the molar than in the premolar teeth. M^1 is always the most advanced, as it comes into use before any of the others of the permanent set.¹

(2.) *Ratio of antero-posterior diameter of the protocone to the antero-posterior diameter of the crown.*

The antero-posterior diameter of the protocone, being, like the transverse diameter of the crown, practically unchanged through wear, also holds to the ever-changing antero-posterior diameter of the crown in the old and much worn tooth a very different relation from what it did when the tooth first came into use. Thus, it may happen that in a little worn tooth the antero-posterior diameter of the protocone is *much less than half* that of the entire crown, but may become *greater than half* this diameter when the tooth has become much worn in consequence of this shortening of the antero-posterior diameter of the crown.

2. On the molar-premolar series as a whole.

The shortening of the antero-posterior diameters of all the other teeth in the series, except p^2 , is not nearly compensated by the lengthening of this diameter in m^3 , hence it results that the series, as a whole, becomes much shortened and the teeth from behind crowd forward toward p^2 , which retains the same relative position in the skull, so that m^3 shows the greatest displacement and the discrepancy in length is all taken from the posterior end of the series. The gap which would otherwise be left in the maxillary bone behind m^3 becomes gradually filled in with a new growth of bone, as the teeth shift forward, leaving a flattened ridge which is continuous with the rugose prominence or ridge which

¹ The order of appearance or eruption of the permanent teeth of the large species from Texas (*E. scotti*) is the same as Owen has given for *E. caballus*, and is: first, m^1 , second, m^2 , third, p^2 , fourth, p^3 , fifth, p^4 , sixth, m^3 . This is probably the order in all other fossil species of this genus.

marks the posterior extension of the maxillary bone beyond m^2 ; hence the length of this posterior extension of the maxillary depends principally upon the age of the horse. In passing from the young to the old stage, there is also a marked change in the relative position, with respect to the molar teeth, of the anterior projection of the maxillary ridge, the post-palatal foramina, and the anterior projection of the post-palatal notch,—all appearing relatively more posterior in the old individual.

B.—INDIVIDUAL VARIABILITY.

a. *Degree of complexity of the enamel foldings of the teeth.*—The examination of a large number of specimens of *E. caballus*, many of them of about the same age, shows a great variability in this character aside from that caused by wear; this indicates that individual variability also has a very wide range, and no two specimens can be found, even of the same age and species, in which the enamel foldings of the corresponding teeth are exactly alike, and even corresponding teeth of the opposite sides of the same skull often show slight differences in the number and style of the

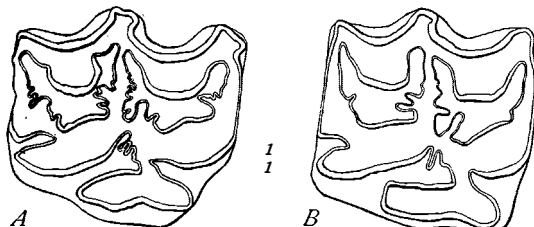


Fig. 4. Superior molars m^2 , *E. caballus*. *A* and *B* of different individuals of about the same age, showing variation in plication.

minor enamel folds. Fig. 4 (*A* and *B*) represents the corresponding teeth (m^2) of two very large draught horses of the same variety, with apparently only about a year's difference in age, the one represented by *A* being the younger. These teeth show considerable difference in the degree of complexity of the enamel folding, which may be due in part to their difference in age, but specimens can be found in individuals of the same age in which the difference is just as great. The corresponding tooth of the Texas pony (Pl. XIX, Fig. *D*) is much simpler than either of the above, yet the degree of wear of the teeth shows that this tooth was apparently intermediate in age between those of *A* and *B*, Fig. 4.

Although domestication may have made the range of individual variability greater in *E. caballus*, yet a careful examination of a large number of fossil teeth indicates that in the extinct species as well the range for this character was great.

b. *Effect of individual variability on dimensions of the teeth.*—It has been shown under the topic of age variations that the transverse diameters of all the superior molars and premolars, except p^2 and m^3 , the antero-posterior diameters of the protocones of all the teeth and the antero-posterior diameter of p^3 are measurements which change but slightly for much the greater length of the crown; hence, unless specimens of the same age are taken for comparison, it is in these measurements that one should look for evidences of individual variability. Careful measurements of the teeth of more than ten specimens of *E. caballus* have led to the following conclusions: (1) The transverse diameters of the corresponding teeth for p^3 to m^2 inclusive are remarkably constant, especially in skulls of nearly the same size; the greatest difference in a certain series of four skulls of large draught horses examined not exceeding 2.5 mm., and in another series of three skulls belonging to animals about the size of carriage horses being less than 1 mm. (See table of measurements, p. 98.)

The transverse diameters of m^2 of the large series vary only .8 mm., while in the small series all the transverse measurements for this tooth are the same. The greatest difference in the transverse diameter of m^2 , including both series of skulls, is only 1.5 mm., and adding a skull of the Texas pony to the list the extreme difference between the transverse diameter of m^2 of this whole lot of skulls, ranging in size from the large draught horse to the small Texas pony, is only 2.5 mm. It will be seen by reference to the table of measurements (p. 98) that the average variation of the corresponding transverse diameter for all these teeth is very small considering the great difference in size of the animals represented.

It seems reasonable that much greater variations of the comparatively constant characters of the teeth would be found in *E. caballus* than in the extinct species, since in this species domestication and breeding have caused such a very wide range in size and proportions of the individuals; hence, when, in two lots of fossil horse teeth, the difference between the transverse diameters of

corresponding teeth is on the average greater than that between the large and small varieties of *E. caballus*, it would seem that the teeth of the two lots could scarcely belong to the same species, and although the character of size, alone, could hardly be considered sufficient ground for establishing a species, yet where this difference exists, it seems reasonable to expect that when skulls which represent such two lots of teeth are known, other differences will be found which will clearly mark them as distinct species.

It has been shown that the antero-posterior diameter of the protocone is very little affected by wear; Table I (p. 98), makes it clear, however, that the range of individual variability of this diameter is very great, and cannot be depended upon as a distinguishing character even in corresponding teeth of individuals of the same size.

The Lower Teeth.

The characters of the lower teeth are, in general, affected in the same way as the upper, and seem to be of even less value in determining the species. A detailed discussion of the lower teeth will therefore be omitted, except in regard to a character given by Cope, that of the presence or absence of a cup in the external incisors. An examination of the large amount of material at

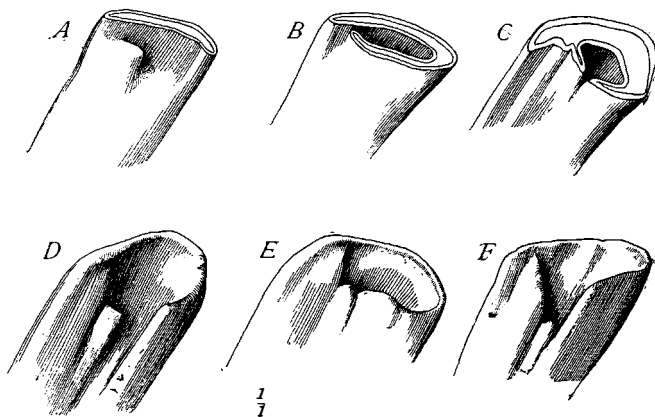


Fig. 5. External lower incisors showing development of cups. A, B, C. *E. caballus*; D, E, F, *E. scotti*.

hand shows: (1) that the fully developed cup is usually present in *E. caballus*, though not always, the writer having examined three specimens in which it is entirely wanting (Fig. 6, C); (2) in the two

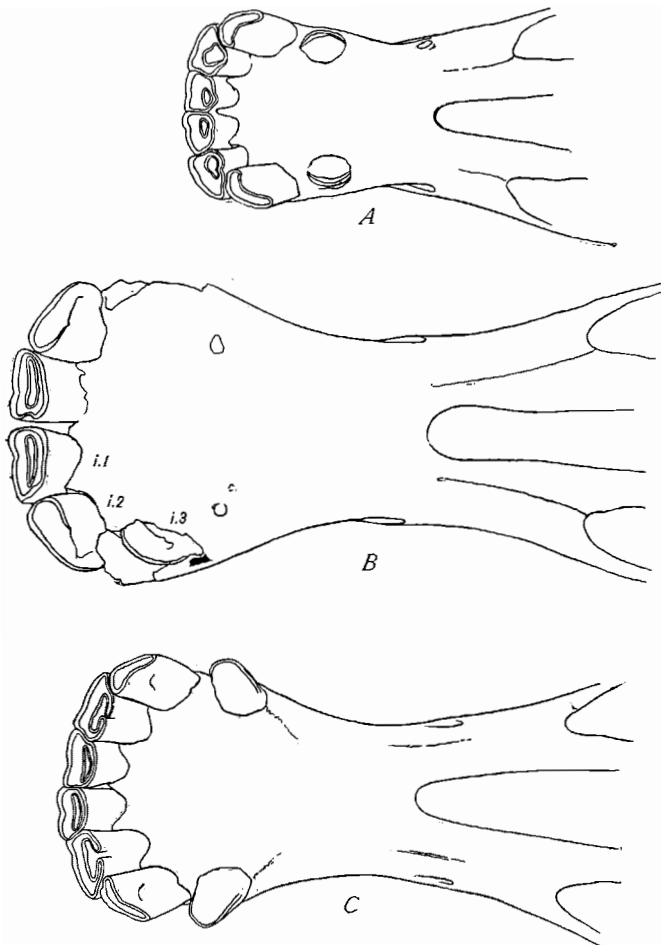


Fig. 6. Mandibular symphyses. A, *E. asinus*; B, *E. scotti*; C, *E. caballus*.

jaws of *E. asinus* in the Museum collection there is no indication of even a tendency toward cupping of the external incisors; and (3) the fossil species of *Equus* in which this character can be made out

show all the intermediate stages as well as both extremes of this character. A fact worthy of mention here is that in the American Museum material, the absence of a cup, or a very much interrupted inner wall, of the external incisor, is the rule in the species with a short muzzle, while in *Equus scotti*, which is a long-nosed type, the entire absence of a cup is much less frequent. Figure 5 shows a series of lower external incisors (*A, B, C,*) of *E. caballus* and another (*D, E, F*) of *E. scotti*, illustrating the variability of this character. The only other character of the lower teeth which Cope¹ seemed to consider important is the form of the groove or channel separating the two lobes of the metaconid-metastylid column, which he designates as (1) a "sharp entrantangular groove," (2) an "open gutter," (3) a "flat channel." An examination of a large number of lower teeth of *Equus* and of the Loup Fork genera of horses soon convinced the writer of the great variability and extreme unreliability of this character in specific determination. In the Loup Fork genera it seems to be the rule that when the separation of the lobes of the metaconid-metastylid column is well marked, the bottom of the groove is nearly always sharp, but when not well marked then the groove may be said to be a flat channel. It seems to be only a matter of individual variation as to which character is presented. In all the species of the genus *Equus* this separation is usually an open gutter.

SUMMARY.

An application of the foregoing principles of the variability of tooth characters to the specific definitions used by Owen, Leidy, and Cope shows the unreliability of most of the characters they have employed. Thus the degree of complexity of the enamel folding is seen to be greatly affected by both age and individual variability—a fact which must be correctly understood before this character can be of even subordinate value as a specific determinant; the other characters given by these authors have been shown to be so affected by either age or individual variability, or both, that no dependence whatever can be placed on any of them; and it has been also shown that size, especially the transverse diameter of the molars and premolars, although least

¹ Report Geol. Surv. Tex., 1893, p. 66.

account has been taken of it, is more constant in a species than any other tooth character hitherto used.

If the foregoing interpretation of the tooth characters of the genus *Equus* is correct, it seems evident that the synopses for a determination of the species given by Cope have very little value, and no dependence can be placed on them. For convenience of reference one of these synoptic tables is given below.¹

"I. Long diameter of anterior internal lobe of sup. molars not greater than one-third the long diameter of the crown.

" Borders of lakes crenate; internal anterior lobe notched on the inner side so as to be bilobate; crowns a little curved; large. *E. crepidens*.

"II. Long diameter of anterior internal lobe more than one-third and not more than one-half the antero-posterior diameter of the crown.

α Crowns more or less curved.

" Crowns wider than, or as wide as, long; enamel edges little folded.

E. curvidens.

α α Crowns straight or nearly so.

β Diastemata longer.

" Crowns nearly square, enamel not very complex; no facial fossa; maxillary bone produced much beyond m³ *E. caballus*.

β β Diastemata shorter.

γ No facial fossa.

" Crowns nearly square; enamel not very complex; maxillary bone little produced behind last molar; smaller.

E. hemionus; *E. burchelli*; *E. quagga*; *E. zebra*; and *E. asinus*.

" Crowns longer than wide on face; enamel little complicated; face and maxillary unknown; large. *E. occidentalis*.

" Crowns square; enamel more folded than in other species; face and maxillary unknown; large. *E. major*.

γ A facial fossa.

" Crowns nearly square; enamel less complex; maxillary short posteriorly; smaller. *E. andium*.

"III. Long diameter of anterior inner lobe more than half that of crown of molar teeth.

" Crowns square; enamel little complex (in Mexican specimens); diastemata and maxillary behind shorter; no facial fossa; large. *E. excelsus*.

" Crowns square; enamel little complex; smallest species. *E. barcenai*."

The synopsis written by Cope and published in the *Journal of the Acad. Nat. Sci., Phila., 1899, Vol. XI, part ii, p. 255*, seems likewise to have no standing.

CHRONOLOGICAL TABLE OF PROPOSED SPECIES REPORTED FROM THE UNITED STATES.

No.	NAME.	DATE AND PUBLICATION.	COLLECTION CLAIMING TYPE.	TYPE FIRST FIGURED.
1	<i>Equus</i> sp. Michel.....	Append. N. Y. div. Cuvier's Theo. Earth, 1826..	Not known.	Not figured.
2	" <i>curvidens</i> Owen...	Odontography, 1842, p. 575.....	Mus. Royal College Surgeons	Voyage H.M.S. Beagle, 1840, Pl. 32, fig. 13.
3	" <i>major</i> De Kay....	Nat. Hist. N. Y., Zool. I., 1842, p. 184.....	Not known.	Not figured.
4	" <i>americanus</i> Leidy.	Proc. Acad. Nat. Sci., Phila., 1847, p. 265.....	Cabinet Acad. Nat. Sci., Phila.....	Proc. Acad. Nat. Sci., 1847, Pl. 2, fig. 1.
5	" <i>fraternus</i> "	" " " " " 1858, p. 11.....	Am. Mus. Nat. Hist., Holmes Coll., No. 9200.....	Holmes's Post-Plio. S. C., 1860, Pl. 15, fig. 8.
6	" <i>complicatus</i> "	" " " " " 1858, p. 11.....	Same as <i>E. americanus</i>	Same as <i>E. americanus</i> .
7	" <i>excelsus</i> "	" " " " " 1858, p. 26.....	National Museum, Washington.....	Extinct Mam. Faun. D. & Neb., 1869, Pl. 21, fig. 31.
(8)	" (cf. <i>Protohippus</i>) <i>perditus</i> Leidy.....	" " " " " 1858, p. 26.....	(?) National Museum, Washington.....	Extinct Mam. Faun. D. & Neb., 1869, Pl. 17, fig. 1.
9	<i>Equus occidentalis</i> Leidy.	" " " " " 1865, p. 94.....	Mus. Comp. Zool., Cambridge, Mass.....	Fossil Vertebrates, 1873, Pl. 33, fig. 2.
10	" <i>pacificus</i> "	" " " " " 1868, p. 195.....	Not known.	Not figured.
(11)	" (cf. <i>Protohippus</i>) <i>parvulus</i> Marsh.....	Am. Jour. Sci., Vol. XLVI, 1868, p. 374.....	(?) Yale University.....	Not figured.
12	<i>Equus conversidens</i> Owen	Phil. Trans., London, 1869, pp. 563-564.....	Museum Nacional, Mexico.....	Phil. Trans., 1869, Pl. 61, fig. 1. Pl. 61, fig. 4.
13	" <i>tau</i> "	" 1869, p. 565.....	" " " "	Not figured.
14	" <i>cremidens</i> Cope...	Proc. Am. Phil. Soc., Vol. XXII, 1884, p. 12.....	" " " "	Not figured.
15	" <i>barcenai</i> "	" " " " " 1884, p. 15.....	" " " "	Not figured.
16	" <i>simplicidens</i> "	" " " " " Vol.——, 1892, p. 124.....	Texas Geol. Surv., Austin, Texas.....	Proc. Am. Phil. Soc. 1892, fig. 1, p. 124.
17	" <i>eurystylus</i> "	Report. Geol. Surv., Texas, 1893, pp. 43-45.....	Texas Geol. Surv., Austin, Texas.....	Geol. Surv. Tex., 1893, Pl. 20, fig. 6.
18	" <i>cumminsi</i> "	" " " " " 1893, p. 67.....	Texas Geol. Surv., Austin, Texas.....	" " " 1893, Pl. 20, fig. 7.
19	" <i>minutus</i> "	" " " " " 1893, pp. 67-68.....	Texas Geol. Surv., Austin, Texas.....	" " " 1893, Pl. 20, fig. 8.
20	" <i>semiplicatus</i> "	" " " " " 1893, p. 80.....	Texas Geol. Surv., Austin, Texas.....	" " " 1893, Pl. 23, fig. 2.
21	" <i>intermedius</i> "	Proc. Am. Phil. Soc., 1895, pp. 463-464.....	(?) Tulane University, New Orleans.....	Proc. Am. Phil. Soc. 1895, Pl. 9, fig. 8.
22	" <i>fraternus</i> <i>pectinatus</i> Cope.....	Journal Acad. Nat. Sci., Phil., 1899, pp. 252-259.	Acad. Nat. Sci., Philadelphia	Not figured.
23	<i>Equus phlegon</i> Hay.....	Am. Geologist, Vol. XXIV, 1899, p. 345.....	Same as <i>E. minutus</i>	Same as <i>E. minutus</i> .
24	" <i>eous</i> "	Science, Vol. IX, 1899, p. 593.....	Same as <i>E. intermedius</i>	Same as <i>E. intermedius</i> .
25	" <i>scotti</i> Gidley.....	Bull. Am. Mus. Nat. Hist., Vol. XIII, 1900, pp. 111-116.....	Am. Mu. Nat. Hist., No. 10606	Am. Bull. 1900, fig. 2, p. 113, fig. 3, p. 114.
26	" <i>giganteus</i> Gidley..	Bull. A. M. N. H., Vol. XIV, 1901, pp. 137, 138.	" " " " No. 8616	" " " 1901, fig. 27.

II.—REVISION AND DISCUSSION OF SPECIES.¹(2) *Equus curvidens* Owen.

Type Locality.—Punta Alta in Bahía Blanca, Argentina, S. A.

Horizon.—Found together with remains of *Megatherium*, *Megalonix*, etc.

Type.—Superior m²; little worn.

Author's description.—“A greater relative antero-posterior diameter than in the recent horse, but especially is it distinguished by the greater degree of incurvation of the upper molars.”

Measurements.

m ²	} Antero-posterior diameter.....	27 mm.
		{ Transverse “

This species must remain rather indeterminate until better material reveals its true distinguishing characters. Although Leidy at one time referred to it some *Equus* teeth found in the United States and, so far as defined above, some of the teeth in the American Museum collection might be placed in this species, the probability is that *E. curvidens* differs from any of the North American species, owing to its wide geographical separation from them.

(3) *Equus major* De Kay.

Type Localities.—Neversink Hills, N. J.; north bank of Susquehanna near Georgetown, D. C.; North Carolina.

Types.—Indeterminate, cited by author as follows: “Some teeth and vertebræ belonging to the genus *Equus*.”

Author's description.—“They [the teeth and vertebræ] resemble those of the common domestic horse; but from their size, apparently belong to a larger animal.”

E. major is practically a *nomen nudum*, as no figures or measurements were ever given and it seems impossible now to locate the original specimens.

(4) *Equus americanus* Leidy.

Leidy first applied this term to three superior molar teeth (Fig. 7) from Natchez until he ascertained that it was preoccupied by Gervais for a South American type; he then substituted the term *E. complicatus*.

¹ For dates, location of types, etc., see Chronological Table, p. 107. The names of valid species are in heavy-faced type.

(6) *Equus complicatus* (Leidy).*E. americanus* Leidy (non Gervais).*Type Locality*.—Near Natchez, Mississippi.*Horizon*.—Tenaceous blue clay underlying a diluvial deposit.*Type*.—A second superior molar of the left side. *Cotypes*: Two third superior molars of the right side.*Author's description*.—"The enamel folds are one-fourth thicker than in the recent horse and the isolated enamel folds of the superior molars are much more plicated, resembling in this respect the *Equus plicidens*, Owen."*Measurements.*

m ²	{	Antero-posterior diameter = 1.2
		of an inch = 30 mm.
	{	Transverse diameter = 1.1
		of an inch = 27 mm.

When Leidy first described this species he gave it the name *E. americanus*, but, as explained above (4), he later substituted the name *E. complicatus*.¹ This name was employed by Leidy for some time,² but in his great Memoir of 1869 (Leidy, 1869, p. 264) he made *E. complicatus* a synonym of *E. major*, apparently without any justifiable reason, stating only that he suspected these two species to be the same. Thus, although *E. major* was employed continuously by Leidy and by Cope until 1899,³ the name really has no standing and *E. complicatus* should be retained.

The species *E. complicatus* itself is imperfectly characterized except



Fig. 7. Type of *Equus complicatus*. A, triturating surface; A¹, side view of crown. (After Leidy.)

¹ Proc. Acad. Nat. Sci. Phila., 1858, p. 11.

² Holmes's Post-Pleocene of So. Carolina, 1860.

³ On p. 259 of the Port Kennedy Cave Memoir (Cope, 99), Cope remarked that having looked into De Kay's account he finds no definite application of the term, *E. major*, can be made.

in point of size, and although many teeth from different localities have been referred to it, there is no assurance as to their reference.

Among the teeth subsequently referred by Leidy to *E. complicatus* were those on which Cope founded his species (21) *E. intermedius* (= *E. eous*, Hay) found at Petite Anse, La., not over 100 miles distant from the type locality of *E. complicatus*; they belonged to an old individual, and the differences are principally age characters; Leidy was probably correct therefore in his previous reference of these types to *E. complicatus*.

(5) *Equus fraternus* LEIDY.

Type Locality.—Near Charleston, S. C.

Horizon.—Phosphate Beds.

Type.—Superior p².

Author's description.—As has been pointed out by Cope,¹ when Leidy first named this species he gave no description by which it could be distinguished, simply stating that "its remains are undistinguishable from the corresponding parts of the recent horse, and are the representative of the *E. primigenius* of Europe, and may be distinguished by the name of *E. fraternus*." He afterward figured and described a number of teeth from near Charleston, S. C.,² referring some of them to this species and others to *E. complicatus*. From the teeth of this collection designated by Leidy as *E. fraternus*, Cope selected a tooth (No. 6, Pl. xv, H. P. S.) as the type of *E. fraternus*. Quoting from the publication referred to, he says: "The superior molar which is first described is figured on Pl. xv, Fig. 6, of that work (Holmes's Post-Pleocene Fossils of S. C.). Unfortunately the protocone of that tooth is largely broken off, but enough remains to show that it had the very small antero-posterior diameter characteristic of the Floridian teeth, and in other respects it agrees with them, except that it is larger than usual. . . . I therefore regard it as the type of the species as described by Leidy." As there are apparently two species represented by the figures designated by Leidy as *E. fraternus* it is important that the right tooth be selected as

¹ Proc. Am. Phil. Soc., Vol. XXXIV, 1895, p. 467.

² Holmes's Post-Pleocene of S. C., 1860, pp. 100 to 105, Pl. xv and xvi.

the type of this species; it is evident that Cope made a mistake in this selection, for the tooth to which he referred was not described at all by Leidy but simply mentioned and that not until after the teeth represented by figures 19-22, Pl. xvi, and figure 8, Pl. xv, had been described. The teeth represented by figures 19-22, Pl. xvi, are a composite lot of undistinguishable lower teeth regarded by Leidy as belonging to *E. complicatus* and *E. fraternus*. Since he mentioned figures 19 and 21 as exhibiting "a greater degree of plication in the enamel than is usual in any of the lower molars of the horse, whether recent or extinct," he evidently regarded these two teeth as belonging to *E. complicatus* and probably regarded the other two as belonging to *E. fraternus*. But as there seems to be really nothing in the teeth themselves by which they can be separated or distinguished, the choice of the type of *E. fraternus* seems necessarily to fall on the next described tooth which is represented by figure 8, Pl. xv, and described on page 102 of the above work.

This tooth, taken by the writer as the type of *E. fraternus* (see Figure 8, *A*, No. 9200, Coll. Am. Museum Nat. Hist.), seems to represent in general the teeth to which Leidy intended to apply this name, and seems to represent also this species, as understood by Cope, more nearly than the tooth selected by him as the type. Cope evidently was led to error in the description of his selection of the type by the poor representation of this tooth as originally figured by Leidy, for Figure 8, *B*, a careful drawing, taken from the tooth itself, shows that the protocone has not the "characteristically small antero-posterior diameter" which he attributed to the Florida specimens, but is rather large. As there seems to be nothing then to separate this tooth from *E. complicatus*, it should properly be referred to that species.

E. fraternus (thus clearly separated from the type used for it by Cope and based upon the first characteristic specimen mentioned by Leidy) then represents a rather small species of horse about intermediate in size between *E. complicatus* and *E. tau* as described and figured by Owen, with the enamel foldings inclined to be quite complicated in pattern, as is indicated by two other teeth, in the American Museum collection, probably belonging to this species (Nos. 9217 and 9203, Coll. Am. Museum, represented by figure 8, *C* and *D*). The side views of the crowns show that they

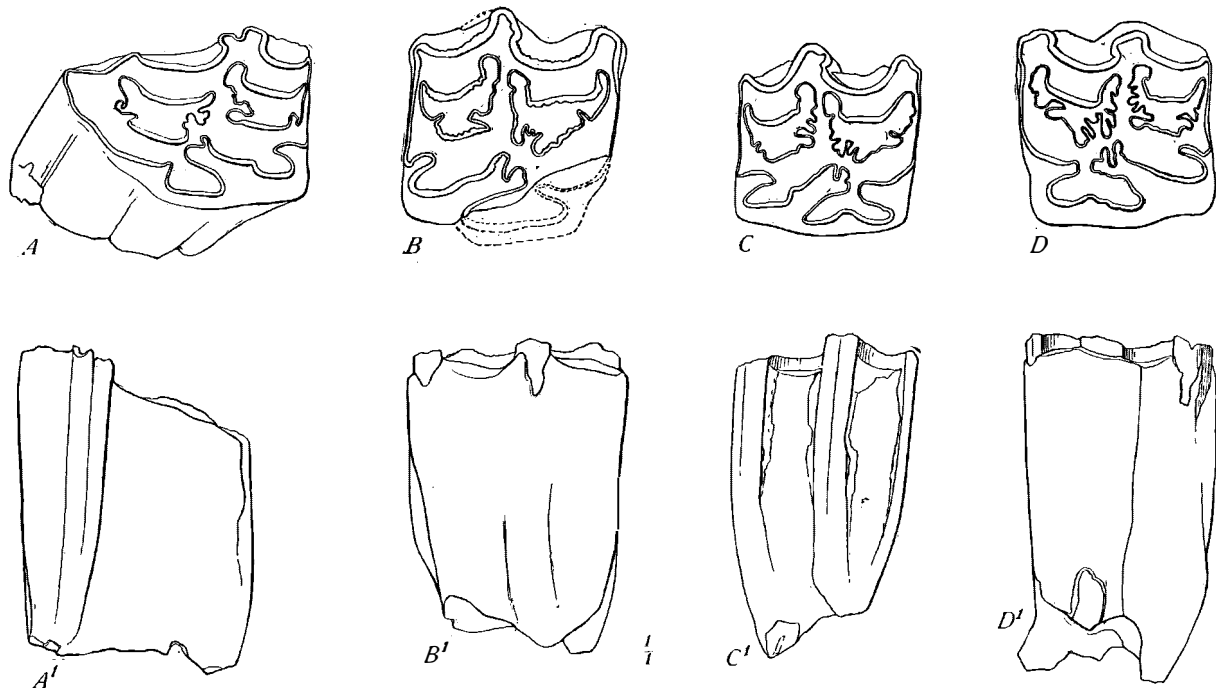


Fig. 8. Superior molars of *E. fraternus* and *E. complicatus*. *A*, crown view; *A*¹, external view of *p*², *E. fraternus*, type. (No. 9200, Coll. A. M. N. H.)
B, crown view; *B*¹, external view of *m*¹, *E. complicatus* ("type" Cope, *E. fraternus* Leidy, No. 9202, Coll. A. M. N. H.).
C, crown view; *C*¹, external view *m*¹, *E. fraternus*. (No. 9217, Coll. A. M. N. H.), Florida.
D, crown view; *D*¹, external view of *p*³, *E. fraternus* (No. 9203, Coll. A. M. N. H.), Charleston, S. C.

are well worn and hence near the stage when the simplest form of tooth pattern would be presented.

Measurements of type tooth.

p ²	{	Antero-posterior diameter.....	32 mm.
		Transverse ".....	23 "

Measurements of Nos. 9203 and 9217.

p ² (So. Carolina)	{	Antero-posterior diameter.....	25 mm.
		Transverse ".....	24 "
m ¹ (Florida)	{	Antero-posterior ".....	23.5 "
		Transverse ".....	24.5 "

(7) *Equus excelsus* Leidy.

Type Locality.—Pawnee Loup Branch of the Platte River, Neb.

Type.—A fragment of the right side of an upper jaw, containing p⁴—m² inclusive.

Author's description.—“About the size of the largest variety of recent horse. . . . The teeth do not differ in constitution from those of the recent horse; and none of them present a greater degree of complication of the enamel folds on their triturating surface.”

Leidy gave no further identification of this species in his original description, but in his publication, ‘The Extinct Mammalia of Dakota and Nebraska,’ 1869, p. 266, he gave as an additional character, “the absence of the little infolding of the enamel at the bottom of the deep valley between the median and posterior columns of the upper molar teeth”; and he figured the type specimen on Pl. xxi, fig. 31, of that work.

Measurements of Teeth.

p ⁴	{	Antero-posterior diameter.....	28.5 mm.
		Transverse ".....	28.5 "
m ¹	{	Antero-posterior ".....	26.5 "
		Transverse ".....	28.5 "
m ²	{	Antero-posterior ".....	26.5 "
		Transverse ".....	27. "
m ³	{	Antero-posterior ".....	26. "
		Transverse ".....	19. "

This species, as it now stands, cannot be clearly defined. The type specimen is quite simple in tooth pattern, much more simple than is usual in the teeth of about the same size in the American Museum collection from the Niobrara River locality.

The teeth of the type specimen are little worn and hence the simplicity of the enamel folding is not due to age. A feature

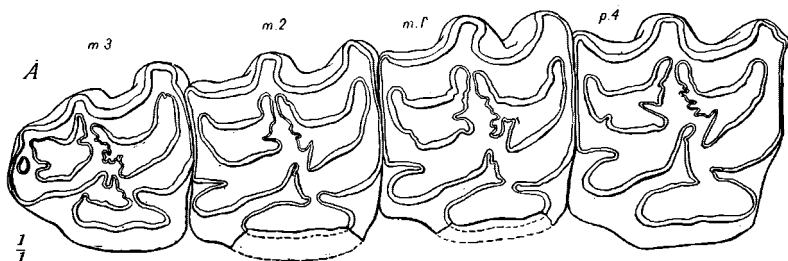
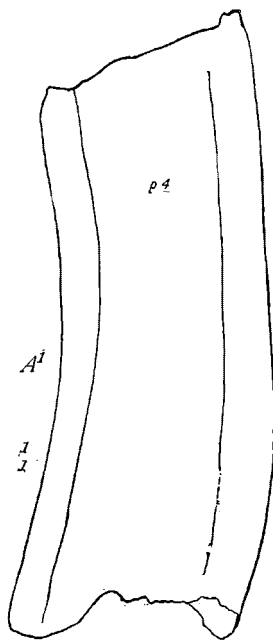


Fig. 9. *Equus excelsus* Leidy. Type. *A*, crown view of upper first, second, and third molars, and fourth premolar. *A*¹, anterior view of *p*⁴.

shown in this specimen which may distinguish it from the other species of its size is the extreme anterior position of the postpalatal foramen and the anterior extension of the palatal notch. These are placed about 15 mm. farther forward than in any of the Nebraska specimens of the same size in the American Museum collection, and indeed their position is more anterior than in even very young individuals of the domestic horse. However, to make this character a strong distinguishing feature, it would be desirable to obtain several other specimens from the same locality showing this same character.



(9) *Equus occidentalis* Leidy.

Type Locality.—Tuolumne Co., California.

Type.—Superior *p*².

Author's Description.—In describing the teeth from California Leidy said: "Two of them are second upper molars of different individuals. . . . These two upper molars, strongly resembling each other, differ from the more

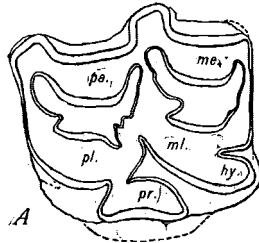
recent looking specimens, and from the corresponding teeth of the domestic horse, in the remarkable degree of simplicity of the enamel folding, as seen on the triturating surface."

Measurements given.

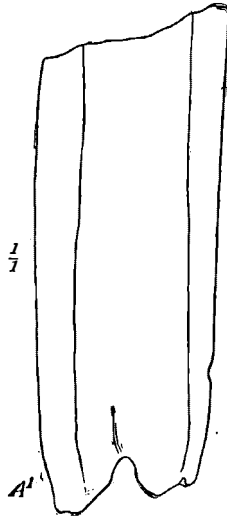
Second upper molar (? m ²)	{	Antero-posterior diameter	— 14 $\frac{3}{4}$ lines (31 mm.).
		Transverse	— 12 $\frac{1}{2}$ " (27 mm.).
" " " (? p ³ Type ¹)	{	Antero-posterior	" 15 $\frac{1}{4}$ " (32 mm.).
		Transverse	" 13 $\frac{1}{2}$ " (28.5 mm.).

This species is apparently undistinguishable from *E. excelsus*, as the type specimens agree in size and both are extremely simple in tooth pattern. However, the Nebraska specimen shows a tendency to a more complicated pattern of enamel folding and may be an extremely simple variation of a species possessing in general more complicated teeth (*E. complicatus*); while an examination of some teeth representing several individuals from the California locality, which have been identified by Leidy as *E. occidentalis*, shows a uniform simplicity of enamel folding. While this is by no means to be considered sufficient ground for retaining the species as separate, there is nothing on the other hand to prove them synonymous, and as they have been named from two widely different localities on opposite sides of the Rocky Mountain system, it is perhaps wisest to retain the two species as distinct for the present.

In 1869² Dr. Leidy united these two species on the ground of the absence in both, of the little enamel fold, near the bottom of the deep valley between the protocone and the hypocone. This,



A



A'

Fig. 10. *Equus occidentalis* Leidy. Type. Superior third premolar. A, crown view; A', external view.

¹ This tooth has been chosen as the type inasmuch as it was the one figured.

² Extinct Mammalian Fauna of Dak. and Neb., p. 267. When Leidy combined these two species he retained the name *E. occidentalis*, evidently through a mistake in the date of his first description of *E. excelsus*, which he gives as 1868, but which should be 1858.

however, would seem to be scarcely a sufficient reason for uniting them, as, in addition to this being a somewhat variable character, the type specimen of *E. excelsus* shows a deep notch in m^2 and a slight though well marked one in m^1 . (The notch in m^1 is not shown in Leidy's figure of the type.)

Professor Cope again separated these two species in 1884,¹ considering them distinct (as he explained in Rept. Geolog. Surv. Texas, 1893), on the untenable ground of the smaller size of the protocone in *E. occidentalis*. Moreover the specimens upon which Cope evidently relied for his characters of *E. occidentalis* were taken from an entirely different locality and undoubtedly belong to a species different from either of the two species under discussion.

(10) *Equus pacificus* Leidy.

Type Locality.—Martinez, Contra Costa Co., California.

Type.—Superior p^2 .

Author's description.—"The triturating surface in its arrangement of the enamel presents nothing strikingly different from that of the corresponding tooth of the recent horse. As in this there is an inflection of the enamel at the bottom of the principal internal valley, and in this respect and the less simplicity of folding of the enamel islets of the triturating surface differs from *Equus excelsus* of the Niobrara and of California. The tooth probably represents an extinct species, upwards of eighteen hands high. Its measurements are as follows:

Length along the outer median column to the origin of the fangs, 26 lines (56 mm.). Breadth of triturating surface fore and aft, $16\frac{1}{2}$ lines (35 mm.). Thickness independent of cementum, 15 lines (32 mm.)."

Without giving any reason for doing so, Leidy included this species in his list of synonyms of *E. occidentalis* given in 'Fossil Vertebrates,' 1873, p. 322.

It seems altogether likely, however, since *E. pacificus* is so much larger, as is indicated by the tooth measurements, and is more complicated in enamel folding, that it is distinct from *E. occidentalis*. This view is strengthened greatly by an examination of the *Equus* teeth from the Silver Lake, Oregon, locality, which were described by Cope and referred to the species *E. occidentalis*,¹ but which agree exactly, both in size and description, with *E. pacificus* as given by Leidy and are certainly distinct from the specimens described and referred by him to the former species.

¹ Proc. Am. Phil. Soc., Vol. XXII, 1884, p. 11.

If these Silver Lake specimens can be regarded as representative of *E. pacificus* as described by Leidy, this species can now be

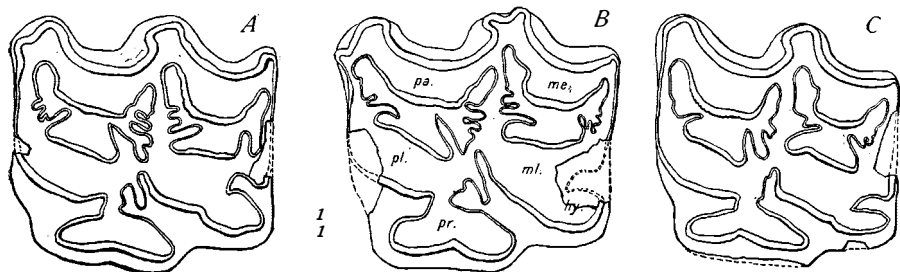


FIG. 11. *Equus pacificus*. A, superior fourth premolar, p^4 (No. 8602, Coll. A. M. N. H.); B, superior third premolar, p^3 (No. 8601, Coll. A. M. N. H.); C, superior second molar, m^2 (No. 8603, Coll. A. M. N. H.)

pretty clearly defined. Figure 11, A, B, C (Nos. 8601, 8602, and 8603, Coll. Am. Museum Nat. Hist.), are representative teeth of the Oregon collection. Their measurements are as follows:

(No. 8601) p^3	}	Antero-posterior diameter.....	35 mm.
		Transverse	34 "
(No. 8602) p^4	}	Antero-posterior	34.5 "
		Transverse	32.5 "
(No. 8603) m^2	}	Antero-posterior	32.5 "
		Transverse	31 "

The collection above referred to was briefly but not accurately described by Cope. Careful measurements of the bones in this collection show that the astragalus and other bones of the feet that can be identified as fully adult are not smaller than in *E. caballus*, as stated by Cope, but compare in size with the large draught horse. Also he is probably mistaken in the statement that "the inferior canine issues in direct contact with the last incisor, without the diastema seen in the horse." None of the mandibular symphyses in this collection are well enough preserved to show the unbroken alveolar borders and only show that these two teeth were close together or in contact deep down in the jaw. This is often the case in *E. caballus*, but the much greater curvature of the canine brings it to the surface usually some little distance behind the last incisor, leaving a short diastema.

It may be added to the description already given by Cope, (1) that the teeth are actually and proportionally much larger, while the bones of the skeleton about equal in size the larger varieties

of *E. caballus*; (2) the occipital region seems to be narrower transversely, and the muzzle, judging from the front portions of lower jaws in the collection, seems to be proportionally shorter.

(12) ***Equus conversidens* Owen.**

Type Locality.—Valley of Mexico.

Type.—A portion of the upper jaw of the right side containing the full molar-premolar series.

Author's description.—In describing the specimens to which he gave the name *E. conversidens*, Owen considered the following to be the distinguishing characters: They correspond closely in "size, curvature, and pattern of the grinding-surface of the upper molar teeth, with *Equus curvidens*. . . . There is "a curved convergence of the two series of upper grinders towards the fore part of the palate to a degree exceeding that in other Equines. . . . The last molar, m^2 , is relatively smaller than in any old-world Equines. The first premolar, p^2 , resembles in the minor production of the anterior lobe that tooth in *Equus asinus*, *Equus quagga*, and differs in this respect from *E. caballus*. The grinding-surface, however, retains, as in *Equus* aff. *caballo*, Ld., and in *E. curvidens*, the general conformity of character of enamel-folding so remarkable in all the modern and in the European Pleistocene Equine species hitherto described. . . . But the most distinctive character of the upper grinders of *E. conversidens* is their disposition in the jaw, denoted by the *nomen triviale* of the extinct Mexican horse; and to the character of the curvature of the molar series of alveoli may be inferentially added a concomitant modification of the shape of the upper jaw itself, involving that of the lower one."

Measurements.

p^2	}	Antero-posterior diameter	30 mm.
		Transverse	25 "
p^1	}	Antero-posterior	25 "
		Transverse	25 "
m^1	}	Antero-posterior	22 "
		Transverse	21 "
m^2	}	Antero-posterior	19 "
		Transverse	18 "

The principal character upon which Owen based this species is undoubtedly an unnatural feature, not, however, due to distortion, as suggested by Cope,¹ but rather to a placing together of upper jaws of opposite sides of two different individuals. The writer was led to this conclusion by a careful comparison of the corresponding teeth of the opposite sides as shown in Owen's figure of his type specimen. (See Plate XXI, which is a reproduction from

¹ Proc. Am. Phil. Soc., 1884, p. 13.

the original plate, Phil. Trans., pl. lxi, fig. 1.) An examination of this figure shows that not a single tooth in the one series corresponds at all closely with its opposite in the other series. Not only are the comparative measurements different, but the enamel foldings are so radically different in the corresponding teeth of the two series as to make it very certain that the specimen is a composite of two individuals.

A comparison of the two series in any skull of any species of *Equus* will show the reasonableness of this conclusion. These differences, however, are entirely within the range of individual variability and of changes due to age. The relatively shorter antero-posterior diameters of the teeth (especially of m^1 and m^2), the relatively less length of the entire series and the relatively greater posterior extension of the maxillary beyond m^3 , all indicate that the series of the left side is of an older individual than that of the right.

Although the principal character assigned to this species by Owen must be disregarded, there remain still enough other characters to define it fairly well. Two of the characters pointed out by Owen, which are shown in both series of his type specimen, seem worthy of consideration, namely, the comparatively small size of m^3 and of the anterior lobe of p^2 . Evidently the comparatively small size of m^3 is not due to a little-worn condition of these teeth, as the comparatively small antero-posterior diameters of the other molars, especially in the series of the left side, indicate that it, at least, is of an old individual with all the teeth much worn. Cope seems to suggest, in his article above referred to, that Owen might have taken this character from an imperfectly proportioned photograph of the specimen, for he remarks: "This appearance could be produced by the oblique angle of the aperture of the camera in photographing, due to its too anterior position."¹ This view, however, seems scarcely worthy of consideration, as the other teeth seem to be not at all disproportioned, and had so great a distortion of m^3 been produced m^2 at least would have been affected to a perceptible degree also. Moreover it is evident, from reading Owen's descriptions of the species *E. tau* and *E. conversidens*, that, although, as he states, his descriptions

¹ Proc. Acad. Sci. Phila., 1884, Vol. XXII, p. 13.

were based on a series of specimens, casts, and photographs sent to him by the Engineer of Mines, Mexico, he must have had either the cast or the specimens themselves, upon which he founded the species *E. conversidens*, and from which he took his characters and measurements; for he mentions at the beginning of his description (see p. 118) that, among other features, the curvature of the molar teeth corresponds closely with *E. curvidens*, and this character could not possibly be made out from a photograph showing only the crown view.

Thus, then, the two characters above mentioned, together with its smaller size and geographical location, seem to determine this species fairly well.

(13) *Equus tau* Owen.

Synonym, *Equus barcenæi* Cope.

Type Locality.—Valley of Mexico.

Type.—A superior molar-premolar series lacking p^2 .

Author's description.—"They [the teeth] are as much smaller than the corresponding teeth of *Equus conversidens* as are those of the *Asinus fossilis* from the Oreston Cavern (History of British Fossil Mammals, p. 396, figs. 157, 158) compared with the teeth of *Equus placidens* from the same cavern, and they indicate a species about the size of the common Ass.

"As compared with any of the smaller existing kinds of Equines the antero-posterior diameter of the grinding-surface of the crown, especially in the premolars, is in excess; and in this character *Equus tau* also differs from *Equus conversidens*, as it does in the greater relative size, especially antero-posterior breadth, of the last molar m^3 : *E. tau* further differs in the greater flattening, from without inward, of the inner lobe of most of the molars."

Unfortunately Owen did not give any measurements with this description, but if his figure of the type specimen is sufficiently accurate to be relied upon, as seems quite probable from the exactness of his other figures, the measurements may be given as follows:

p^3	{ Antero-posterior diameter	22.5 mm.
	{ Transverse	"	19 "
p^4	{ Antero-posterior	"	23 "
	{ Transverse	"	20 "
m^1	{ Antero-posterior	"	21 "
	{ Transverse	"	19.5 "
m^2	{ Antero-posterior	"	21.5 "
	{ Transverse	"	18 "
m^3	{ Antero-posterior	"	22 "
	{ Transverse	"	15.5 "

This species is much the smallest of any described from America. Owen considered it about the size of the common Ass, but it is much smaller than that species, *E. conversidens* and *E. asinus* being much more nearly of a size (see Table I, p. 98).

In his paper on 'The Extinct Mammalia of the Valley of Mexico' ¹ Cope united *E. conversidens* with *E. tau*, retaining the latter name. Why he did so, he does not explain, except that he says, "I could detect no specific differences between the seven or eight specimens I examined." As Cope expressed considerable doubt as to the identity of the type specimens, especially of *E. tau*, it seems quite probable that the true type of this species was never in his hands, and his description of *E. tau* was probably based upon specimens that properly belonged to *E. conversidens*.

There is a superior molar tooth, m^2 (No. 9211), in the collection of the American Museum from Peace River, Florida, which is much too small to be referred to any species reported from the United States. A second tooth from Lookout Mountain, Tennessee, recently presented to the American Museum by Mr. E. S. Hallock, agrees almost exactly in size and character with the Florida tooth. These two teeth represent a very small horse once inhabiting the south-eastern part of the United States, which in point of size did not differ materially from *E. tau* of the Mexican Valley. Hence as there are no characters

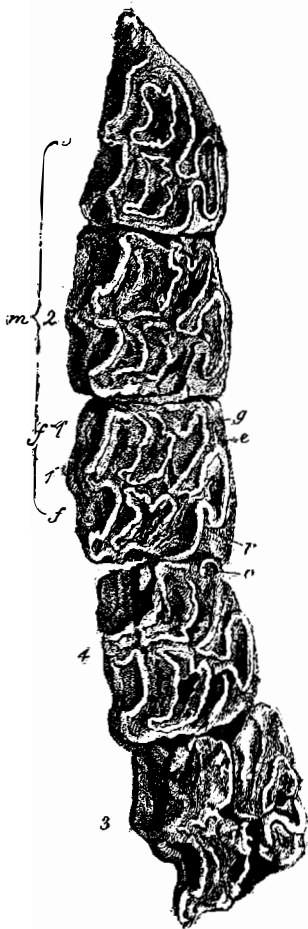


Fig. 12. *Equus tau* Owen. Type. Upper molar-premolar series, lacking second premolar, p^2 . (After Owen.)

¹ Proc. Am. Phil. Soc., Vol. XXII, 1884, pp. 12, 13.

in the teeth above mentioned to distinguish them from *E. tau* they should provisionally be referred to this species, although the two localities are so widely separated. Future discoveries may prove that the teeth from the southeastern United States belong to a distinct species.

(14) *Equus crenidens* Cope.

Type Locality.—Tequixquiác, Valley of Mexico.

Type.—Fragment of upper jaw containing the premolars of one side.

Author's description.—"This species is primarily distinguished by the close and strong wrinkling of the enamel border of the lakes of the superior molar teeth. This wrinkling, or vertical plication, reminds one of what is seen in the *Elephas indicus*. This wrinkling is not found in the enamel edges which border the interior crescents on the inner side, nor in those bordering the internal lobes or columns. The borders of the lakes are not folded in the complex loops seen in *Equus major* Dek., but have the plainer looping seen in *Equus tau* Ow. The grinding faces are nearly square. . . . The crimping of the enamel of the lakes distinguishes this species from the others of the genus."

Measurements given.

p ²	{	Antero-posterior diameter.....	43	mm.
		Transverse "	30.5	"
p ²	{	Antero-posterior "	33.5	"
		Transverse "	34	"
p ⁴	{	Antero-posterior "	31	"
		Transverse "	35	"

Although a minute description and measurements have been given, this species appears to be indeterminate. As seems usually to have been his custom, Cope has given the transverse measurements of the teeth, including the cement, hence they are not of much value except in as far as they show that the type of *E. crenidens* is of a large horse, apparently about the size of *E. pacificus* or the somewhat smaller *E. scotti*. The crimping of the enamel which Cope seemed to consider the distinguishing character is probably not more than an exaggeration of the same character often indicated in the premolars of *E. caballus*. That Cope himself did not place great reliance on this character is evidenced by the fact that he afterward described and figured a large tooth from southwestern Texas,¹ referring it to this species, which shows no uncommon tendency to any such wrinkling. This tooth, however, from its enormous size evidently belongs to

¹ Am. Nat., 1885, p. 1208, fig. 4 (No. 8616, Am. Museum Nat. Hist., Cope Coll.).

a species much larger than the Mexican specimen which Cope called *E. crenidens*, or even the large *E. pacificus*.

(15) *Equus barcenæi* Cope.

Type Locality.—Valley of Mexico.

Type.—Two superior molars.

Author's description.—"This horse is distinguished from all the others here mentioned or described by its small size. In the characters of its superior molars it is like the *Equus excelsus*. The anterior internal column is flat, and its antero-posterior diameter is five-eighths that of the crown of the tooth. The prism is straight. The lakes have the margin but little looped; the posterior notch of the anterior lake is trebled or triplex. The grinding face of the crown of the third superior molar is a little longer than the others."

Measurements.

Diameters of molar No. 1.	{	Antero-posterior.....	21.5 mm.
		Transverse	23 "
Diameters of molar No. 2.	{	Antero-posterior.....	22 "
		Transverse	22 "

In 1893¹ Cope made this species a synonym of *E. tau*. It is difficult to make out whether, in doing so, he referred to *E. tau* Cope (not of Owen),² which has been shown to be the equivalent of *E. conversidens*, or whether he now regarded *E. tau* in the light of the original description given by Owen. It seems probable, however, that the latter view is the correct one, as in this connection he referred to Owen's description of *E. tau* and not to his own. Taking into account the fact that the transverse diameters of the teeth of *E. barcenæi* given by Cope probably include the cement, there seems to be no distinction between this species and *E. tau* Owen, and therefore it may be considered, as Cope has already placed it, a synonym of this species.

(16) *Plihippus simplicidens* Cope.

Equus simplicidens Cope.

Type Locality.—Mt. Blanco, Texas.

Horizon.—Blanco Beds (Upper Pliocene).

Type.—Superior molar.

Author's description.—"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

¹ Report Geol. Surv. Texas, 1893, p. 74.

² Proc. Am. Phil. Soc., 1884, p. 12.

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 dental 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."

Measurements not given.

This species was founded upon exceedingly doubtful characters, all the characters given in the above description being apparently due to the little-worn condition of the tooth. (See Fig. 2, C, D, and discussed p. 95.) However, the validity of the species is somewhat strengthened by Cope's description and figures of additional specimens from the same locality,¹ and from the fact that it seems to be the only large horse so far discovered in this geological horizon.

It seems exceedingly doubtful, however, whether this species can be properly placed in the genus *Equus*. Cope did not point out or suggest any characters that mark it as belonging to this genus, nor are there any such characters shown in any of his figures. On the contrary, there are in his descriptions and figures, and also in three teeth collected by the writer from the same locality (No. 10624, Am. Mus. Nat. Hist. Collec.) and probably belonging to the same species, several indications of primitive characters

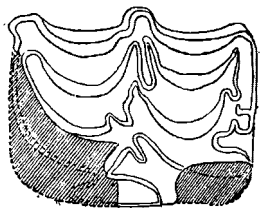


Fig. 13. *Pliohippus simplicidens*. Type. (*Equus simplicidens* Cope). Superior premolar. (After Cope.)

linking this species much more closely with *Pliohippus*, as this genus is understood, than with *Equus*. The character of the very small protocone and the tendency to a sharp entrant-angular groove between the metaconid and metastylid columns, a distinguishing character given by Cope¹ for the lower teeth, are both like the Loup Fork genera and unlike any of the Pleistocene or recent species of *Equus*. Besides these characters the American Museum specimens show other characters which seem

¹ Report Geol. Surv. Texas, 1893, p. 66.

to indicate the close relationship of this species to the more primitive genera of the Loup Fork. The little outward folding of the enamel at the antero-external border of the protoconid, so generally observed in all the Loup Fork genera, is plainly indicated in the two lower teeth by a well-marked groove. This peculiar fold of enamel, which is entirely wanting in the genus *Equus*, seems to be a primitive character and apparently was derived, in the evolution of the tooth, from the anterior cingulum of the more primitive brachydont tooth in passing to the hypsodont form. Although these teeth are of an old individual and are pretty well worn, they have the appearance of being of a very short-crowned pattern.

This species is about the size of *Pliohippus mirabilis* Leidy.

(17) *Hipparion eurystylus* (Cope).

Equus eurystylus Cope.

Type Locality.—Paloduro Cañon, Texas.

Horizon.—(?) Goodnight Beds.

Type.—Lower molar.

Author's description.—"This species belongs with *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." (For further description see Report Geological Survey of Texas, 1893, pp. 44, 45.)

Measurements given.

Specimen No. 2 (Cope)	{	Longitudinal diameter.....	55 mm.
		Antero-posterior "	24 "
		Transverse "	10 "
Specimen No. 5 (Cope)	{	Longitudinal "	40 "
		Antero-posterior "	22 "
		Transverse "	12 "

None of the characters given in Cope's very minute description of this species, or shown in his figures, prove any relationship to the genus *Equus*; but they all seemingly show its positive identity with or at least its very close relationship to the three-toed horses of the Loup Fork.

An examination of the horse teeth from the true Loup Fork Beds (in the American Museum collections) indicates that the

character of "the relatively great width of the metaconid-metastylid column of the inferior molars" is only a feature of individual variability, as this column is very variable in size. The characters that seem to point most strongly to the association of this species with the genus *Hipparion* are as follows: (1) The appression of the metaconid-metastylid column to the protoconid and

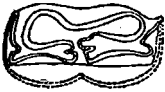


Fig. 14. *Hipparion eurystylus*. Type of *Equus eurystylus* Cope. Superior premolar. (After Cope.)



Fig. 15. *Hipparion eurystylus* (*Equus eurystylus* Cope). Lower molar. (After Cope.)

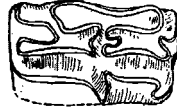


Fig. 16. *Hipparion eurystylus* (*Equus eurystylus* Cope). Lower premolar. (After Cope.)

hypoconid, which seems to be characteristic of *Protohippus* and *Hipparion* and not of *Equus*; (2) the presence of a well-defined enamel keel or loop in the anterior border of the protoconid; (3) the greater extension of the transverse ridge of enamel thrown out from the parastylid, which extends beyond the middle and usually to the outer edge of the metaconid, and marks the antero-internal corner of the tooth in *E. eurystylus* and all the three-toed horses; and which in *E. caballus* and the fossil species of *Equus* seems seldom to extend beyond the middle of the metaconid and often only as far as its inner margin:

(1) The tendency toward flat external faces of the protoconid and hypoconid, and (2) toward the formation of the external median keel, mentioned by Cope, together with its size, seem definitely to place this species in the genus *Hipparion*. (Compare Cope's figures of *E. eurystylus* with Leidy's figures given in 'Extinct Mammalia of Dakota and Nebraska,' Pl. xix, figures 4, 6, 10, 31, 34, 37, and 40.) The specific distinctions apparently cannot be made out.

(18) *Protohippus cumminsii* (Cope).

Equus cumminsii Cope.

Type Locality.—Mt. Blanco, Texas.

Horizon.—Blanco Beds.

Type.—Superior molar.

Author's description.—"The enamel borders are entirely simple. . . . It differs from the *E. simplicidens* and *E. tau* in the prominent concavity of the

internal wall of the paracone and metacone, from which it results that the exterior border of each of the lakes is deeply concave, and the horns appear to be strongly produced. The protocone has a very short antero-posterior 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 given.

The measurements of the best-preserved crown are: length, 33 mm.; transverse diameter, 24 mm.; antero-posterior, 24 mm.

This species was founded on three superior molars, two of which were figured by Cope. (See Figure 17.) Both the description and the figures show some characters that seem to mark its close relation with the three-toed horses, and like those given by Cope for the distinction of his *E. eurystylus* and *E. simplicidens* they show no characters that indicate any connection with the genus *Equus*. The very small size and form of the protocone seems especially to identify this species with the Loup Fork genera, and its extreme simplicity of enamel folding of the tooth crown seems to place it in the genus *Protohippus*.

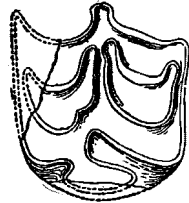


Fig. 17. Type of *Protohippus cumminsi* (*Equus cumminsi* Cope). Superior molar. (After Cope.)

(19) **Protohippus phlegon** (Hay).

Equus phlegon Hay.

Synonym, *Equus minutus* Cope.

Type Locality.—Mount Blanco, Texas.

Horizon.—Blanco Beds.

Type.—An inferior molar—(?) m₂.

Author's description.—"The inferior molar is narrowly hypsodont, and has apparently had but a thin cementum investment. . . . 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 antero-posterior 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 (entoconid) is also appressed to the hypoconid and has a recurved postero-internal angle, which

forms an acute ridge bounding the internal face of the crown posteriorly. This encloses 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 given.

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

This tooth shows the same characters pointed out in Cope's *E. eurystylus* to distinguish it from the genus *Equus* except that the little fold of enamel at the anterior border of the protoconid is



Fig. 18. Type of *Protohippus phlegon* (*Equus minutus* Cope). Lower molar. (After Cope.)



Fig. 19. Lower molar of *Protohippus* sp. (Loup Fork).

wanting. A comparison of Cope's figure (reproduced in Figure 18, and Figure 19 which represents a corresponding lower molar of *Protohippus*, No. 10579, Coll. Am. Mus.,) shows the very close relationship of the species to

which the teeth represented by these figures belong, and were it not for the little enamel fold mentioned above, in the one, they would undoubtedly be referred to the same species if their different localities were not known. In a series of five lower teeth (No. 10626, Coll. Am. Mus.) of this species, found in the exact locality in the Blanco beds from which Cope's type specimen was taken, the same general *Protohippus*-like characters are shown as in the type tooth, and a rudiment of the enamel fold of the protoconid is shown in all of them.

Very unfortunately, an upper molar, found by the writer in the same locality a few days before the finding of the lower teeth, was lost. This tooth agreed in size with the lower teeth and could not have been distinguished from *Protohippus*. The crown was not much worn and the little oval protocone was still quite separated from the protoconule.

The species distinctions of this little horse of the Blanco beds apparently cannot be defined, unless the rudimentary condition of the anterior outward fold of enamel of the protoconid should prove to be constant and thus separate it from the species of *Protohippus* from the true Loup Fork beds.

(20) *Equus semiplicatus* Cope.

Type Locality.—Rock Creek, Brisco Co., Texas.

Horizon.—Sheridan Beds.

Type.—Superior molar m² (?).

Author's description.—"These teeth indicate a species, of about the dimensions of the *E. tau*, but characterized by a greater complexity of the enamel foldings. . . . In all the Texas specimens the antero-posterior diameter of the protocone is more than half that of the grinding face of the crown. This places the *Equus semiplicatus* in the same group as the *E. excelsus* and *E. tau*. From the former its inferior size distinguishes it, as well as the closer plications of its enamel borders. . . . The characters of the grinding face resemble those of the *E. conversidens* Owen, as far as the latter can be understood from Owen's figures. But in this species, according to Owen, the crowns are transversely curved, while in *E. semiplicatus* they are straight."

Measurements given.

Diameters superior	{ Antero-posterior.....	25 mm.
molar (Tule Cañon)	{ Transverse.....	25 "
Diameters superior molar	{ Antero-posterior.....	25 "
(sp. from San Diego)	{ Transverse.....	27 "

A comparison of the measurements will show that the teeth of this species are very much larger than those of *E. tau*, and are even larger than those of *E. conversidens* as given by Owen. The species seems to be about intermediate in size between *E. complicatus* and *E. conversidens*, and is about the size of *E. fraternus*. Its tendency to a very simple tooth pattern, however, seems to distinguish it from the latter species.

A skull from southwestern Texas, now in the American Museum collection (No. 8600), which Cope had previously described and referred to *E. excelsus*,¹ and which was again mentioned and figured in his Rept. Geological Survey of Texas, p. 81, Pl. xxii, Fig. 3, differs not at all from Cope's description, measurements, and figures of *E. semiplicatus*, but does differ in both size and general character from Leidy's type of *E. excelsus*. Also, coming from practically the same locality as the type specimen of *E. semiplicatus*, and from the exact locality from which two of the paratypes were collected, it seems to belong more properly to the latter species than to *E. excelsus*.

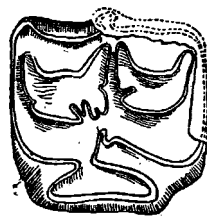


Fig. 20. *Equus semiplicatus* Cope (type). Superior molar. (After Cope.)

¹ Am. Naturalist, 1891, p. 912.

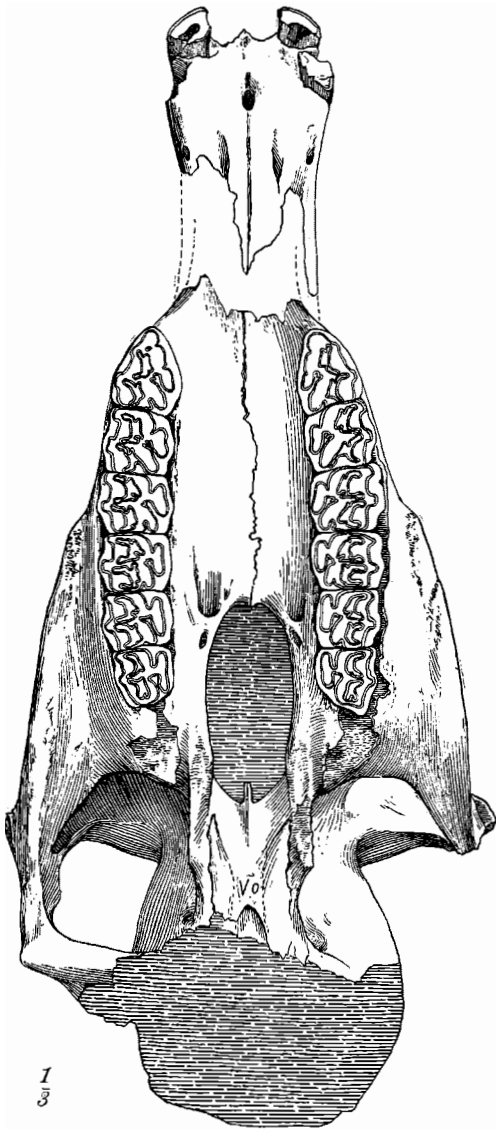


Fig. 21. Skull of *Equus semiplicatus* (No. 8600, Coll. A. M. N. H., San Diego, Texas). Palate view.

This skull has been fully described by Cope as above cited. A character mentioned by Cope in this description, that of the posterior prolongation of the vomer over the presphenoid, (Fig. 21) a character in which it resembles the ass, seems distinctly to separate this species from all the others of the Pleistocene in which this character is known, they being like *E. caballus* in this respect.

(21) *Equus intermedius*
Cope.

As this term is preoccupied, Hay substituted for it the term *E. eous*.

Type Locality.—Petite Anse, Louisiana.

Type.—Fragment of maxillary containing the three molars and two premolars, p^3 and p^4 .

Author's description.—Cope's description of this species is given at considerable length, and as much of it is a discussion of characters that have no standing, only the most important of the characters mentioned will be repeated here. "The molar teeth are as large as those of the *E. major* and large forms of the common horse. The enamel folds are less complex than those of the former, but are more complex than is usual in the *E. caballus*. . . . A

transverse crest connects the paroccipital processes and the basisphenoid, bounding the precondylar fossa in front, so as to convert it into a basin. . . . The *E. intermedius* is a shorter-nosed species than the *E. caballus*, the distance from the anterior lower premolar forwards only equalling the corresponding length in the quagga, while the parts are in other respects as large as those of the domestic horse."

Measurements given for the teeth.

Diameters of p ²	{	Antero-posterior.....	30 mm.
		Transverse.....	31 "
Diameters of m ¹	{	Antero-posterior.....	25 "
		Transverse.....	30 "
Diameters of m ²	{	Antero-posterior.....	36 "
		Transverse.....	29 "
Length of mandible from pm ² to external border of incisors.....			130 "

Measurements of occipital condyles.

Transverse diameter.....	92 "
Antero-posterior diameter above.....	50 "

The specimens upon which Cope founded this species, as above mentioned (see *E. complicatus*, page 110), were considered by him identical with a certain other lot of specimens from the same locality which had been referred by Leidy to *E. major* (*E. complicatus*),¹ but which he thought could not be identified with that species; separating them on the ground of the less complexity of the enamel folding in these teeth than in those of *E. complicatus*.

One of the specimens, at least, figured by Leidy in the work above cited is more complicated in tooth pattern than is indicated by the figure of his type specimen of *E. complicatus*, and the specimens described by Cope seem not to differ at all in this respect from the *E. complicatus* type. But even if this lot of teeth described by Cope are somewhat simpler, a character so variable as this one seems hardly sufficient grounds for founding a new species. The specimen figured by Cope (see Cope's figure²) shows every indication of belonging to an old individual, which would account for much of the simplicity of these teeth. Cope attempted no other distinction, nor does there seem to be any. On the other hand there seem to be good reasons for considering the two species as identical. There seems to be no difference in size and practically no difference in tooth pattern; the type

¹ Trans. Wagner Free Inst. of Sci., 1889, p. 38.

² Proc. Am. Phil. Soc., 1895, Pl. ix, Fig. 8.

specimens come from practically the same locality, the type localities being less than one hundred miles apart; therefore as there seems to be absolutely nothing upon which to separate these species, there is no alternative but to consider *E. eous* (*E. intermedius* Cope) a synonym of *E. complicatus*, and the very good characters given by Cope for his species should be considered additional characters which clearly define the species *E. complicatus*.

E. complicatus, as thus understood, seems to be the common species of Pleistocene times in the United States; its geographical distribution extending over a wide area east of the Rocky

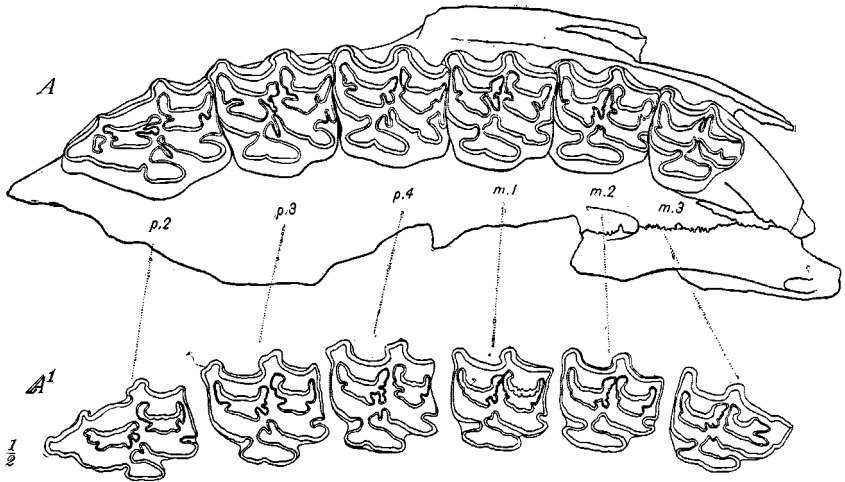


Fig. 22. *E. complicatus*. (Tule Cañon, Texas.) Superior molar-premolar series of right side sectioned to show change in teeth due to wear. *A*, triturating surfaces; *A'*, sections cut parallel to the triturating surface about the middle of the crowns. (No. 10611, Coll. A. M. N. H.)

Mountains and south over the Gulf States, and perhaps along the Atlantic coast as far north as New Jersey; though the specimens reported from this region cannot be certainly identified, the material consisting only of single teeth. In the collections from the Niobrara River there are a great number of jaws, skull fragments and bones, which from their size and general characters evidently belong to this species. The specimen represented by Pl. XVIII, Fig. *B* (No. 2725 Am. Mus. Coll.) is typical of the horse

of its size from the Niobrara locality. It shows the comparatively short muzzle and the characters in general pointed out by Cope in his description of *E. intermedius*. This specimen represents a young animal with the last molar only just coming into full use, hence the differences in this region compared with Cope's figures. Several symphyses mandibuli containing the incisors, as well as the lower jaw belonging with the specimen above figured show the absence or extensive interruption of the internal wall of the external incisor. Three occiputs in this collection also show the characters pointed out by Cope for his *E. intermedius*, and agree very well with the measurements given. A series of teeth in a portion of the maxillary (Fig. 22) and two fragments of lower jaws (Nos. 10600, 10601, Coll. Am. Mus.), besides a few single teeth, represent this species from the Tule Cañon and Rock Creek, Texas, locality. Leidy reported and figured some teeth from Hardin Co., Texas, which he referred to this species. These teeth, now in the American Museum (Nos. 8617-8618), do not differ in any way from the corresponding teeth in the specimens from the Staked Plains and Nebraska.

(22) *Equus pectinatus* (Cope).

Type Locality.—Port Kennedy, Penn.

Horizon.—Megalonyx Beds. (Cave deposits).

Type.—Nine superior molars and premolars probably belonging to one individual.

Author's description.—In describing some *Equus* teeth from Port Kennedy, which he considered as representing two varieties of *E. fraternus*, Cope gave the following as distinguishing characters: "The superior molar teeth all agree in the fact that the antero-posterior diameter of the protocone enters the same diameter of the entire crown from two and a third to nearly three times. . . . In other Pliocene horses of North America, the antero-posterior diameter of the protocone is from one-half to three-fifths that of the entire crown, excepting in the premolars of *Equus occidentalis* Leidy, and in the large *E. crenidens* Cope. . . . One of the individuals differs from the other in the greater complexity of the enamel plates, especially on the opposed faces of the external lakes, agreeing in this respect with *Equus complicatus* of Leidy. . . . The superior molars displaying moderate complexity are of smaller size than the complex ones. . . . Under the circumstances it is necessary to distinguish two races of *Equus fraternus* as already indicated: *E. f. fraternus* and *E. f. pectinatus*, which may prove to be distinct species."

*Measurements*¹:

Diameters	p ³	{	Antero-posterior.....	32	mm.
			Transverse.....	30	"
"	p ⁴	{	Antero-posterior.....	29	"
			Transverse.....	29	"
"	m ¹	{	Antero-posterior.....	26	"
			Transverse.....	29	"
"	m ²	{	Antero-posterior.....	27	"
			Transverse.....	27.5	"
"	m ³	{	Antero-posterior.....	34	"
			Transverse.....	25	"

The Port Kennedy specimens seem to represent two distinct species as suggested by Cope; however, it seems highly improbable that either bears any close relationship with the South Carolina species, *E. fraternus*, which is one of the smallest American species, while *E. pectinatus* is large, comparing in size with *E. complicatus* or *E. scotti*. The teeth of the type specimen are much worn, yet they show an unusual degree of complication in the enamel foldings (see Fig. 23). As pointed out by Cope the protocones of the type specimen are unusually small. The skull characters are not known and until they can be made out this species cannot be clearly defined. Leidy described and figured some teeth from Illinois² (see Fig. 24) which he referred to *E. complicatus*, but which seem to agree more closely with *E. pectinatus*.

The other Port Kennedy teeth described by Cope and identified with *E. f. fraternus* seem not to differ essentially from *E. complicatus* although they are somewhat smaller.

(25) **Equus scotti** *Gidley.*

Type Locality.—Rock Creek, Brisco Co., Texas.

Horizon.—Sheridan Beds.

Type.—Part of a skeleton (No. 10,606), including the skull and lower jaws, all the cervical and the three anterior dorsal vertebræ, both fore limbs and feet complete, one hind limb and foot complete, and several dorsal and lumbar vertebræ and ribs probably belonging with it.

Author's description.—Compared with *E. caballus*: (1) The skull is relatively larger, (2) the teeth are relatively larger compared with the skull, (3) the neck is shorter, (4) the body is longer, (5) the limbs are shorter and more

¹ The measurements given by Cope include cement, hence the writer has carefully remeasured the teeth and substitutes here these measurements for those given by Cope.

² Trans. Wagner Free Inst., Phil. Vol. II, 1889, p. 39.

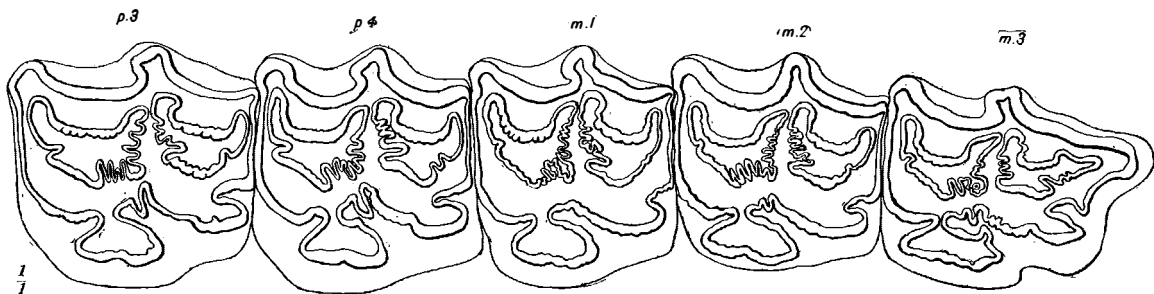


Fig. 23. *Equus pectinatus* Cope. Type. Superior molars m^1 , m^2 , and m^3 , and premolars, p^3 p^4 .

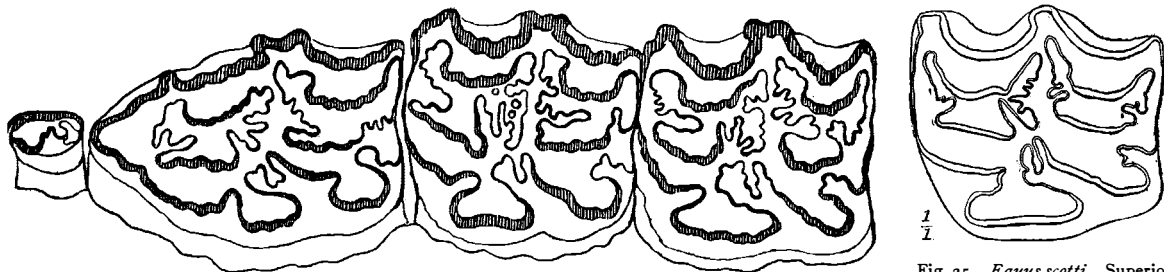


Fig. 24. *Equus pectinatus*. Superior premolars, p^1 , p^2 , p^3 , and p^4 . (After Leidy.)

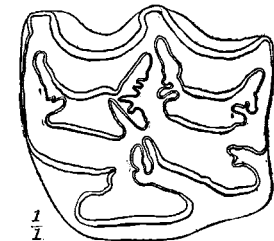


Fig. 25. *Equus scotti*. Superior molar, m^1 of type skull (No. 10606, Coll. A. M. N. H.)

slender than in the larger varieties of *E. caballus*, (6) the lesser curvature of the ribs near their heads indicates that the back was not nearly so wide, but shaped more like that of the ass or zebra. (For description of skull characters see *American Museum Bulletin*, 1900, Vol. XIII, Art. XIII, pp. 114-116.)

Measurements given.

Diameters of crown of p^2	} Antero-posterior.....	33 mm.
		Transverse.....
Diameters of crown of m^1	} Antero-posterior.....	32 "
		Transverse.....
Long diameter of incisor.....		23 "
Total length of molar-premolar series.....		190 "

The type skull as well as the four other associated skulls in hand when these measurements were given are all of young individuals that had not yet shed all their milk molars. Very fortunately the writer has since collected a skull (No. 10628) from the same deposit or quarry from which the others were taken, in which all the teeth had come into full use (see Pl. XIX, Fig. A), and the measurements can now be given more fully and more accurately. They are as follows:

Diameters p^2	} Antero-posterior.....	43 mm.
		Transverse.....
Diameters p^2	} Antero-posterior.....	34 "
		Transverse.....
Diameters p^3	} Antero-posterior.....	33 "
		Transverse.....
Diameters m^1	} Antero-posterior.....	30 "
		Transverse.....
Diameters m^2	} Antero-posterior.....	31 "
		Transverse.....
Diameters m^3	} Antero-posterior.....	31 "
		Transverse.....
Long diameter of i^1		24 "
Total length of molar-premolar series.....		204 "

This species, which is intermediate in size between *E. complacatus* and *E. pacificus*, is distinguished from the former, especially, by its comparatively longer muzzle, which equals in comparative length that of *E. caballus*. From *E. pacificus* it is distinguished by the comparatively smaller skeleton, the somewhat longer muzzle, and by the different form of the occiput; that of *E.*

pacificus being much more like *E. caballus*. *E. complicatus* also resembles *E. caballus* in this respect.

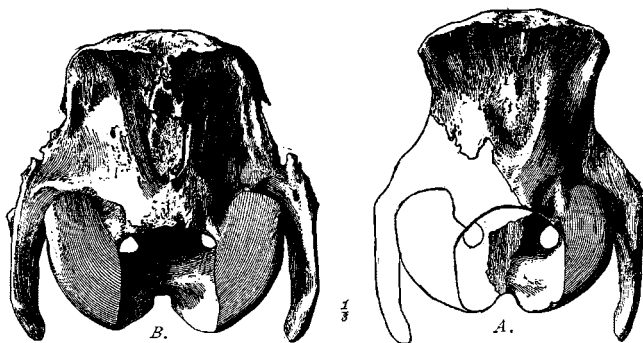


Fig. 26. Occiputs of—A, *Equus scotti*; B, *Equus caballus*.

***Equus giganteus*, sp. nov.**

Type Locality.—Southwest Texas.

Type.—Superior molar (m^2). (No. 8616, Coll. Am. Mus.). This tooth was referred by Professor Cope to *E. crenidens*.

Description.—There is a very large tooth, now in the American Museum (Cope) collection, from southwest Texas which Cope described and figured, referring it to *E. crenidens*, but which differs in every respect, except the small size of the protocone,

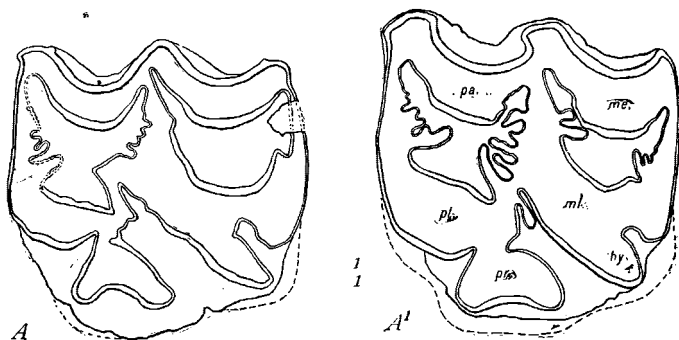


Fig. 27. *Equus giganteus*, sp. nov. Type. Superior second molar m^2 (No. 8616, Coll. A. M. N. H.). A, trituration surface; A', section cut about three-fourths of an inch below.

from the description of the Mexican tooth upon which this species was founded. Its very much larger size; the lack of the charac-

ter given by Cope as the one by which *E. crenidens* could be distinguished, that of the crimping of the enamel of the lakes; the comparatively complex folding of the enamel, all prevent the identification of this tooth with that species. Its grinding-surface is much weathered and the enamel foldings of the lake borders are so obliterated that they cannot be made out and appear to be very simple. This evidently led Cope to the belief, as shown in his figure and description, that the tooth pattern was very simple. A section (Fig. 27 A¹) made about three-fourths of an inch below the grinding-surface shows very plainly the true character of the enamel foldings.

Although in this tooth, as seems characteristic of the genus, there seem to be no characters which can be said to be of definite specific value, its great size, which exceeds by at least 5 mm. any other *Equus* tooth of which record has been made, and the relatively small area of the cement lakes or fossettes mark it as evidently distinct from any species hitherto described; hence a new name seems necessary. The size suggests the name *E. giganteus*.

The measurements are as follows:

Diameter of grinding-surface	{ Antero-posterior.....	41.5 mm.
	{ Transverse.....	36 "
Diameter where section was made	{ Antero-posterior.....	40 "
	{ Transverse.....	39 "
Length of crown.....		100 "

The tooth had evidently been only slightly worn by use, hence the difference in transverse diameter when the cut was made. The length of the tooth compared with its other measurements shows a comparatively short crown.

SUMMARY AND CONCLUSIONS.

The general results of this systematic comparison may be summed up as follows:

E. curvidens.—A South American horse, indeterminate. North American specimens referred to this species erroneously.

E. major.—Absolutely indeterminate; a *nomen nudum*.

E. americanus.—A preoccupied name, replaced by *E. complicatus*.

E. FRATERNUS.—Southeastern United States, probably a valid species, but still imperfectly known. It represents a very

- small horse with teeth scarcely as large as those of the Mexican donkey and of very complex pattern.
- E. COMPLICATUS.—West Southern and middle Western States; embraces as synonyms, *E. intermedius*, *E. eous* and probably *E. excelsus* (which is now indeterminate). Now well characterized, representing a species with teeth about the size of those of the ordinary draught horse and of moderately complex pattern, but with the bones of the skeleton about the size of those of the smaller varieties of the western pony. The species is especially characterized by its short muzzle, in this respect resembling the ass.
- E. *excelsus*.—Nebraska. Very imperfectly known from the teeth only; although now indeterminate, may prove to be a valid species.
- E. OCCIDENTALIS.—California or Pacific slope. Other species and specimens have been mistakenly referred to this type. The characters other than those of the teeth are not now known, but these indicate a horse about the size of *E. complicatus* with uniformly simple patterned teeth.
- E. PACIFICUS.—A large Oregon species, although middle California is the type locality. A well characterized species. With the exception of *E. giganteus* from southwestern Texas, the largest American horse. The skeleton indicates a horse about the size of the ordinary draught horse, but the skull is proportionately larger.
- E. CONVERSIDENS. Valley of Mexico. Apparently well established; of medium size.
- E. TAU.—Valley of New Mexico, the smallest true horse known in America. This embraces the *E. barcenai* as a synonym.
- E. crenidens*.—Valley of Mexico; indeterminate.
- E. SEMPLICATUS.—Western Texas, from the Sheridan beds of Paloduro Cañon, probably a valid species. The great posterior extension of the vomer over the presphenoid, together with its size and the proportions of the teeth, seem to show a close relationship to *E. asinus*.
- E. PECTINATUS.—Port Kennedy Bone Cave of eastern Pennsylvania. Probably a valid species.
- E. SCOTTI.—Staked Plains of Texas, Tule Cañon. Intermediate in size between *E. complicatus* and *E. pacificus*. A long-faced type of horse. This species represents a horse about the

size of the largest western pony, but with a longer body, a much larger head, a shorter neck, and a back and steeply sloping sides shaped very much as in the ass or quagga.

- E. GIGANTEUS.—Southwestern Texas. The largest species of horse hitherto recorded, the teeth exceeding those of the largest modern draught horses by more than one-third the diameter of the latter.

Pliocene species wrongly referred to Equus.

- E. simplicidens = Pliohippus sp. ?
 E. eurystylus = Hipparion sp. ?
 E. cumminsii = Protohippus sp. ?
 E. minutus = Protohippus sp. ?
 E. phlegon = Protohippus sp. ?

There are a number of teeth in the Niobrara River collection which seem to be intermediate between *E. complicatus* and *E. fraternus*, yet they seem not to show characters sufficiently definite upon which to found a new species. This, however, may be done when better material from the Nebraska locality has been found.

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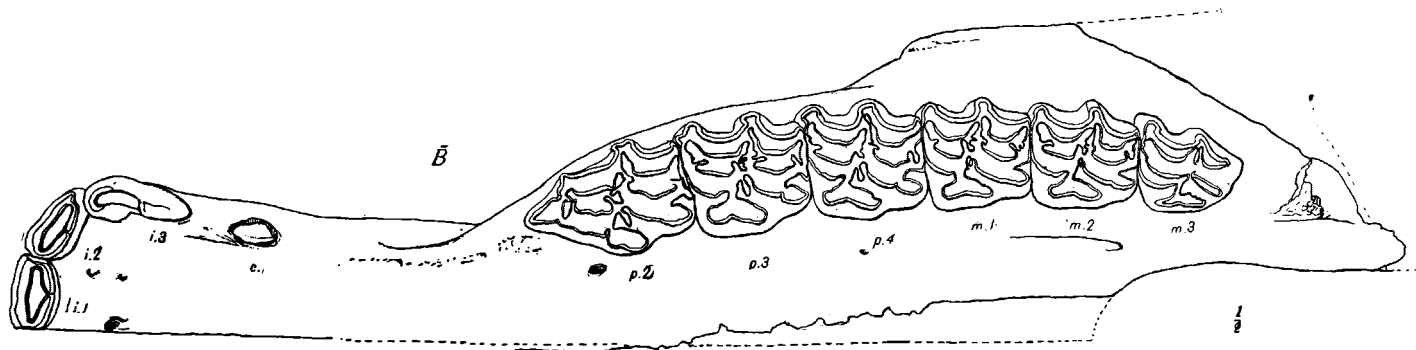
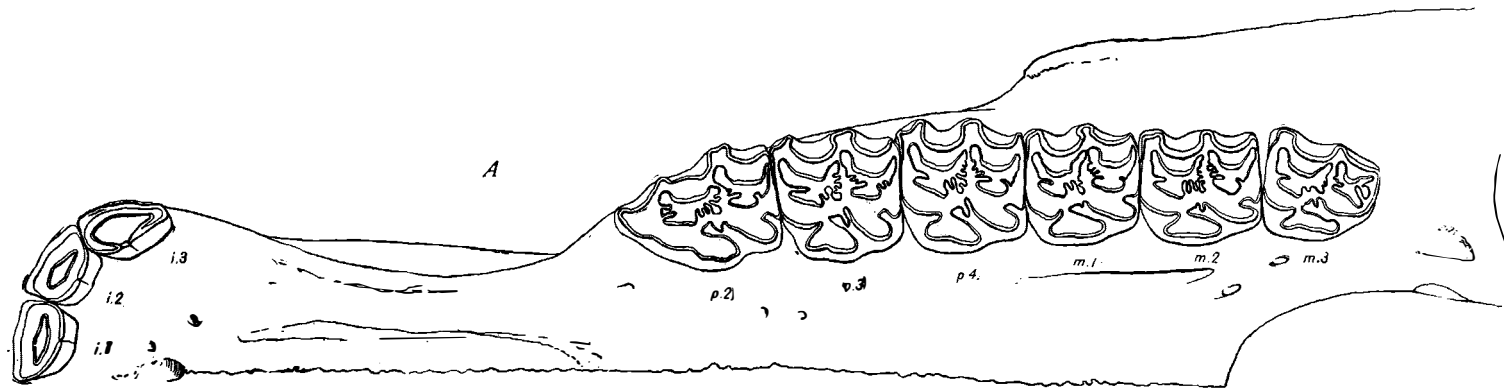
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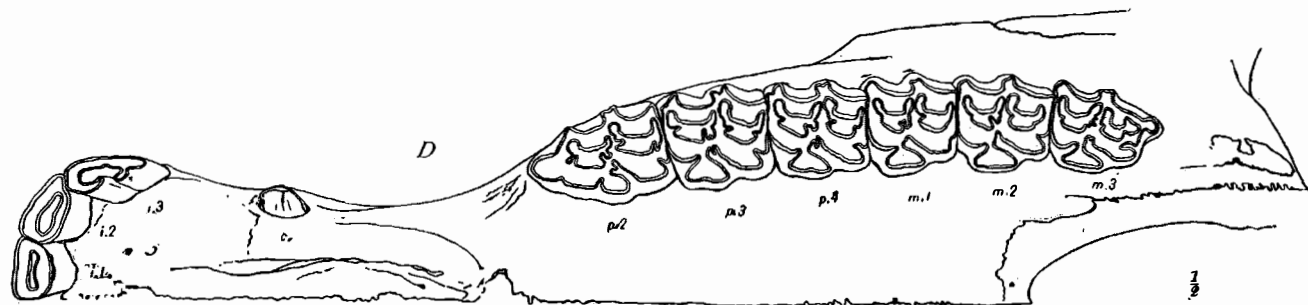
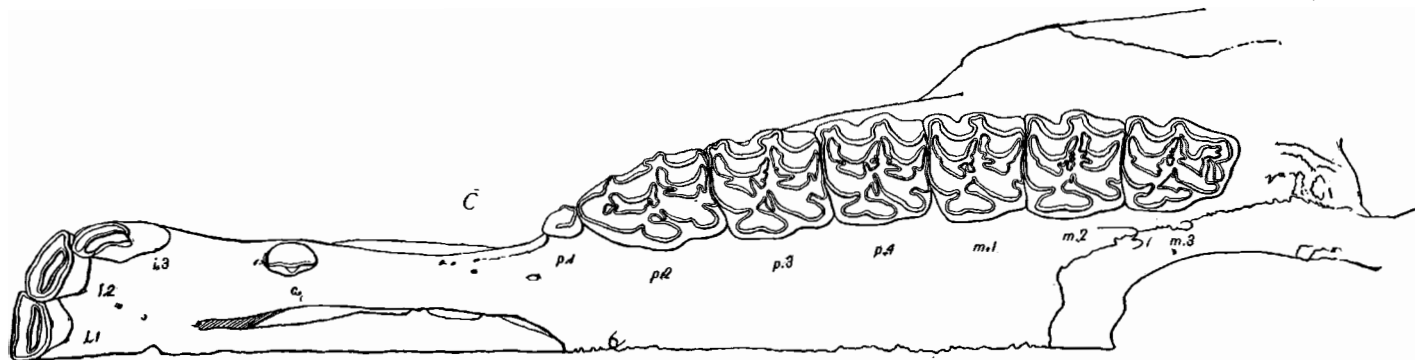
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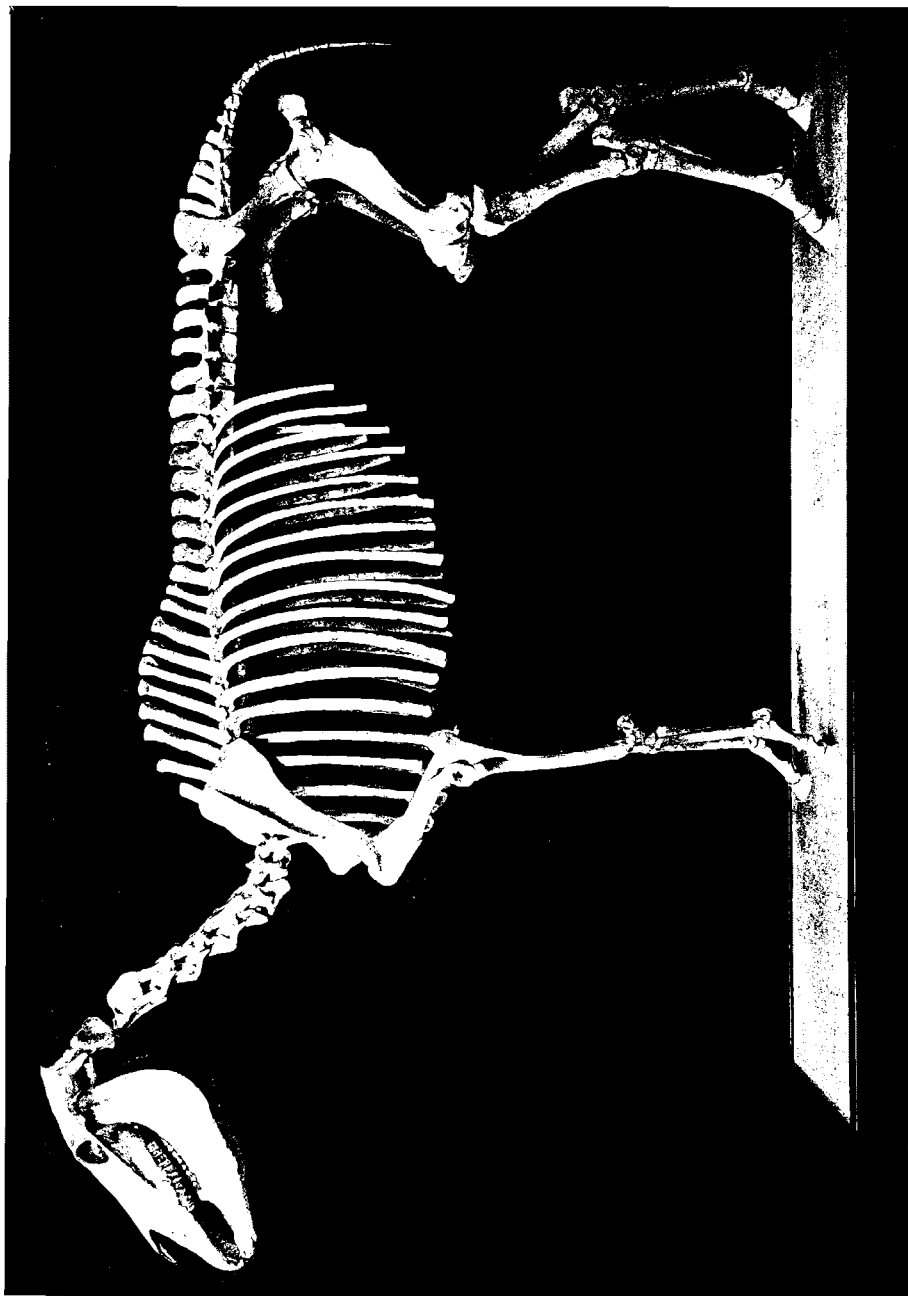
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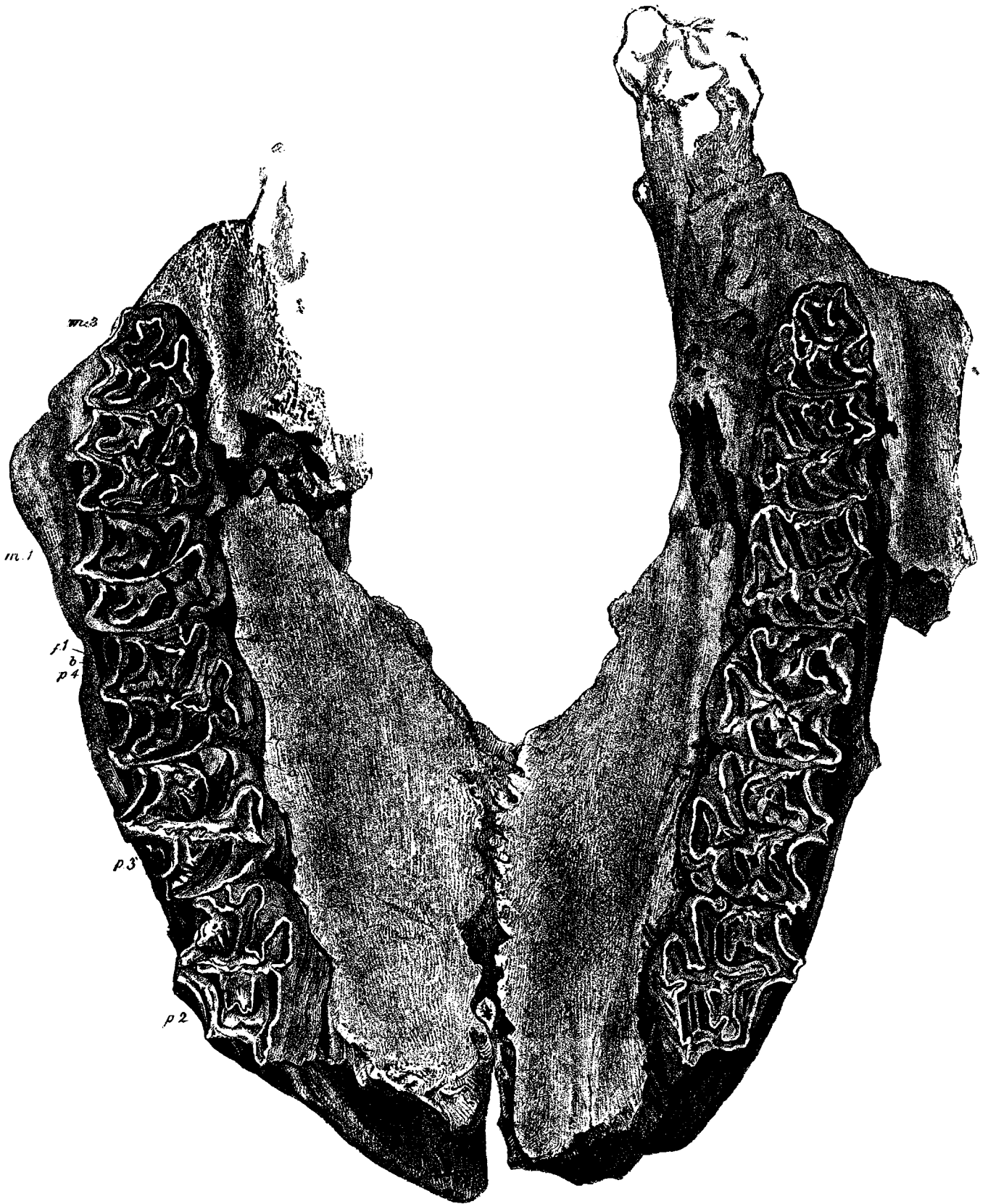


A, Equus scotti ; B, Equus complicatus.



C, *Equus caballus*, DRAUGHT HORSE ; D, *Equus caballus*, TEXAS PONY.





Equus conversidens OWEN (TYPE). PROBABLY COMPOSED OF TWO INDIVIDUALS.