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Volume VII, 1895.

Article I.—FOSSIL MAMMALS OF THE PUERCO BEDS. COLLECTION OF 1892.

By HENRY FAIRFIELD OSBORN and CHARLES EARLE.

The archaic basal Eocene fauna, discovered by Cope in 1880 and extensively described since, still presents problems of the greatest difficulty and interest. What are these peculiar animals? What are their relations to the Mesozoic and Cenozoic mammals? With the double object of completing the historical series and of further elucidating these problems, the Museum sent an expedition into the arid Puerco region early in the spring of 1892.

The expedition was under the able direction of Dr. J. L. Wortman assisted by Mr. O. A. Peterson, and Mr. Thomas Raffierty in the field. The explorations were in the San Juan Basin of northwestern New Mexico. The Museum is indebted to Mr. E. T. Jeffery, President of the Denver and Rio Grande Railroad, for many courtesies.

Dr. Wortman gives the following field notes: "The thickness of the beds is roughly estimated at 800 to 1000 feet, and as far as can be observed they lie conformably upon the Laramie. At no place examined by us can fossils be said to be abundant, but on the contrary most of the exposures are entirely barren. For convenience they are divided into Upper and Lower Beds, but this

scarcely gives an adequate idea of the occurrence of the fossils, for the reason that it is only the extreme upper and lower strata that are productive; the great intermediate part we found to be singularly barren.

"The lower fossil-bearing strata occur in two layers, the lowermost of which lies within 10 or 15 feet of the base of the formation. This is succeeded after an interval of about 30 feet by a second stratum in which fossils are found, and this appeared to be by far the richer of the two. Both of these strata are of red clay, and at no place did we find them more than a few feet in thickness.

"The lower horizon we found exposed in two places, viz.: the head of the Coal Creek or Pina Verta Cañon, and some of the upper tributaries of the Chaco Cañon. It is especially and sharply distinguished by the occurrence of the remains of *Polymastodon*, which appear to be entirely absent from the upper horizon.

"Fossils are much more abundant in the upper strata, and wherever a good exposure was found their occurrence could be more confidently looked for. The genera *Chirox* and *Pantolambda* appear to belong exclusively to the upper beds. Owing to the widely separated localities and the general scarcity of fossils, it is at present impossible to say whether it is one or several layers that produce the fossils from these upper beds. It is my opinion, however, that there are several layers, and that their vertical range is somewhat greater than that of the lower horizon. The principal localities of the upper strata are as follows: head of Cañon Gallego, Cañon Blanco, Cañon Escavada, and head of Cañon Chaco."

The main systematic determination, and the larger part of the description of this collection is the work of my colleague, Mr. Earle. The Creodont section is entirely his, as well as many original suggestions as to the relationships of the Primates and Condylarths. The following are the principal new features:

1. A division of the Eutheria into *Mesoplacentalia* and *Cenoplacentalia*, p. 3.
2. A revision of the Classification, Geological distribution, and Phylogeny of the Puerco mammals, pp. 7–10.

3. Multituberculata: Description of the complete dentition of *Polymastodon*, pp. 11–15.
4. Primates: Description of the skeleton of *Indrodon*, with lemuroid characters. The Chriacidæ added to this group. The new genus *Oxyacodon*, pp. 15–23.
5. Creodonta: *Clænodon* as an ancestor of the Arctocyonidæ. Description of the skeleton of *Dissacus*, an ancestor of the Mesonychidæ, pp. 26–39.
6. Tillodonta: Description of the skull of *Onychodectes*, p. 41.
7. Amblypoda: Relationship of *Periptychus* to this group. Description of a complete skull of *Pantolambda*, p. 43.
8. Condylarthra: Introduction of *Mioclænus* to this group. Systematic revision of the Periptychidæ. *Haploconus* is shown to have probably been arboreal in habit. *Protogonodon* is shown to be related to *Trigonolestes*[1] and the Artiodactyla.

We are indebted to Professor Scott for criticisms of the MSS. upon the Creodonta, and to Professor Cope for the loan of type specimens and for assistance in the determination of species.
—H. F. O.

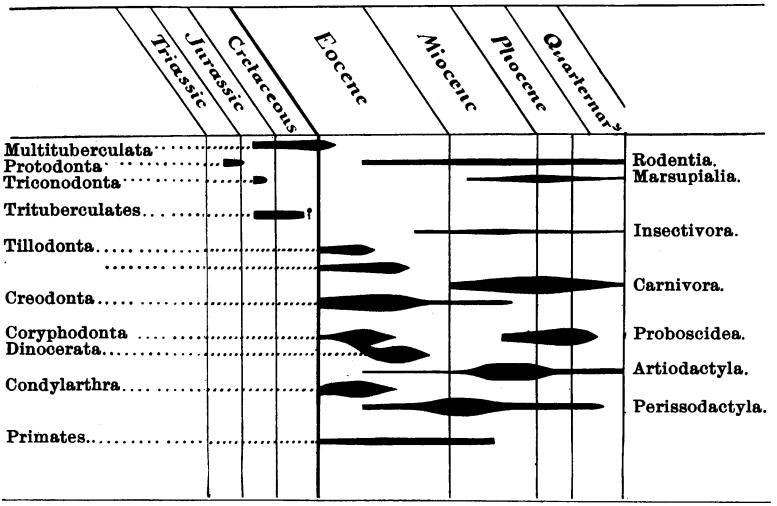
I.—The Puerco mainly a Mesozoic Fauna.

The Placentals should be considered as having exhibited two great centres of functional radiation, which were successive and largely independent of each other. The first is represented by the groups discovered by Cope in the Puerco, and now proved to have extended back certainly into the Cretaceous, probably into the older Mesozoic—to these may be applied the term *Mesoplacentalia*,[2] or Placentals distinctive of the Mesozoic period. The second is the group, the earlier members of which are found in the Puerco, and which developed and radiated in the succeeding Tertiary; these may be called the *Cenoplacentalia*, or distinctively Tertiary Placentals. The difference between these two groups

[1] Professor Cope has recently substituted this term for *Pantolestes*, which is preoccupied.
[2] 'A division of the Eutherian Mammals into the Mesoplacentalia and Cenoplacentalia.' Trans. N. Y. Acad. Sc., June 4, 1894.

consists mainly in the lower state of evolution and apparent incapacity for higher development exhibited by the Mesoplacentals in contrast with the capacity for rapid development shown by the Cenoplacentals.

SUCCESSION OF THE NORTH AMERICAN ORDERS OF MAMMALS.



The first of these terms therefore chiefly serves to express the fact that the Mesoplacentals evolved and diverged in North America and undoubtedly in Europe during Mesozoic times in the Jurassic, Cretaceous and Lower Tertiary. Careful studies show that even the Upper Cretaceous mammals had probably already diverged into Ungulate and Unguiculate, Carnivorous and Insectivorous types. This functional divergence reached its climax in the Puerco, which contains several Laramie reptiles, and Cope inclines to consider this epoch as Post-Cretaceous rather than the base of the Eocene. Here the Mesoplacentals display the greatest variety, and are generally characterized by plantigrade feet and tritubercular teeth, for even among the Ungulata the molar teeth are developed upon the triangular plan, whether bunodont, selenodont or lophodont. We may consider the Middle Eocene Dinocerata, Tillodonta and Creodonta as

spurs of this great Mesoplacental radiation, a few of the Creodonts only persisting into the Mid-tertiary.

In opposing Cope's view[1] that this fauna, with the exception of the Multituberculata, is largely ancestral, it is important to emphasize the fact that we have not as yet connected any of the Mesoplacentals directly by lineal descent with the Cenoplacentals, excepting *Euprotogonia*, a supposed ancestor of the Perissodactyla ; and *Protogonodon*, a supposed ancestor of the Artiodactyla. A comparison of Tables I and III shows that out of 39 generic and 90 specific types existing in the Puerco, *only 8 generic types are followed by analogous forms in the Wahsatch, and 3 of these became extinct in the Bridger.* But even if more threads of phyletic descent are traced by future research the fact remains that the great group of Mesoplacentals as such became extinct; that the first attempt of the mammals at wide functional radiation failed, and that from some comparatively unspecialized spurs of this dying group a new functional radiation began which reached its climax in the Cenoplacentals of the Miocene period, and subsequently declined.

TABLE I.—SUCCESSIVE, ANALOGOUS, AND RELATED TYPES.

	LARAMIE.	PUERCO.	WAHSATCH.
Multituberculata..	Ptilodus.....	..×	
		Neoplagiaulax.	
	Meniscoëssus.....	Polymastodon.	
	Allodon.....	Chirox.	
Tillodonta	.....	Psittacotherium.	
		Hemiganus.	
		Conoryctes.....	Esthonyx.
		Onychodectes...	"
Creodonta	.....	Clænodon	Anacodon.
	? Batodon tenuis.....	Dissacus.....	Pachyæna.
Amblypoda	.....	Pantolambda....	Coryphodon.
Condylarthra	.....	Euprotogonia...	Hyracotherium.
		Protogonodon...	? Trigonolestes.
	(? Didelphops) comptus.	Ectoconus.	
Primates	.....	Indrodon	Anaptomorphus.
		Mixodectes.....	Microsyops.

[1] 'Synopsis of the Vertebrate Fauna of the Puerco Series.' Am. Phil. Soc., Jan. 20, 1888, p. 300.

The Mesoplacentals cannot be defined as a homogeneous group; they are very heterogeneous. No attempt is therefore made to define as Cope has defined the Bunotheria (to include the Creodonta, Mesodonta, Insectivora, Tillodonta and Tæniodonta). What chiefly unites the Mesoplacentals is the possession of a large number of very primitive characters, and the apparent incapacity for progressive evolution. The terms 'inertia' and 'potential,' although new in palæontology, seem to express most perfectly the cardinal difference between the Mesoplacentals and the Cenoplacentals. The inertia is seen in the inability to shake off the primitive mammalian characters and assume the modern mammalian standard. Wherever they came into competition the Cenoplacentals drove out the surviving Mesoplacental spurs just as the Placentals will in time supersede the Marsupials of Australia.

TABLE II.—EUTHERIA: PLACENTALIA.

MESOPLACENTALIA.	CENOPLACENTALIA.
Amblypoda (Dinocerata, Coryphodonta)	Proboscidea.
Condylarthra	Diplarthra: Artiodactyla and Perissodactyla.
Creodonta	Carnivora.
Tillodonta	Rodentia.
Insectivora	.. ×
Lemuroidea	.. ×
	Anthropoidea.
Incertæ sedis; Edentata, Sirenia, Cetacea.	

Pursuing this hypothetical line of division further, an exception to this elimination, by 'survival of the fittest,' is seen perhaps in two great groups still existing which are universally regarded as extremely primitive; these are the Insectivora and Lemuroidea; both orders are closely paralleled in structure by a number of Puerco types, although we cannot as yet positively assert that the latter are either true Insectivora or Lemuroidea. It may be that we should regard the Insectivora and Lemuroidea as persistent Mesoplacentals.

The division of the Placental orders upon this physiological and developmental basis would, according to this hypothesis, stand as in Table II, in which groups presenting *analogous* adaptations are connected by dotted lines.

II.—Synopsis and Vertical Distribution of the Puerco Fauna.

In the following table the classification is to be regarded as provisional, and subject to extensive modification by future discoveries. The order Insectivora is probably represented, but by what types is uncertain. The number of forms embraced by the Lemuroidea is also somewhat doubtful. The Amblypoda may grow at the expense of the Condylarthra by the inclusion of the Periptychidæ.

Table III.—Synopsis of the Puerco Fauna.[1]

	Lower.	Upper.
1. MULTITUBERCULATA.		
Plagiaulacidæ.		
Plagiaulacinæ.		
Ptilodus mediævus *Cope*		
" trovessartianus *Cope*		
Neoplagiaulax americanus *Cope*	×	
Polymastodontinæ.		
Polymastodon taoënsis *Cope*	×	
" attenuatus *Cope*	×	
" fissidens *Cope*	×	
" foliatus *Cope*	×	
" latimolis *Cope*	×	
" selenodus *O. & E.*		
Bolodontidæ.		
Chirox molestus *Cope*		
" plicatus *Cope*		
2. PRIMATES.		
Anaptomorphidæ.		
Indrodon malaris *Cope*		×
Mixodectidæ.		
Mixodectes pungens *Cope*		
" crassiusculus *Cope*		

[1] The types not marked with × in the table are those in which no local record has been kept.

TABLE III.—*Continued.*

	LOWER.	UPPER.
CHRIACIDÆ.		
Chriacus pelvidens *Cope*		
" truncatus *Cope*		
" baldwini *Cope*	×	
" stenops *Cope*		
Protochriacus priscus *Cope*	×	
" simplex *Cope*	×	
" attenuatus *O. & E.*	×	
Epichriacus schlosserianus *Cope*		
Incertæ sedis.		
Loxolophus hyattianus *Cope*	×	
Tricentes bucculentus *Cope*		×
" crassicollidens *Cope*		
? Tricentes subtrigonus *Cope*		
Ellipsodon inæquidens *Cope*		
3. CREODONTA.		
ARCTOCYONIDÆ.		
Clænodon ferox *Cope*		×
" corrugatus *Cope*		
" protogonoides *Cope*		
Tetraclænodon floverianus *Cope*		
TRIISODONTIDÆ.		
Triisodon quivirensis *Cope*		
" biculminatus *Cope*	×	×
" heilprinianus *Cope*		
Sarcothraustes antiquus *Cope*		×
" coryphæus *Cope*	×	
" crassicuspis *Cope*	×	
" bathygnathus *Cope*	×	
Goniacodon levisanus *Cope*		
" gaudryanus *Cope*	×	
" rusticus *Cope*		
Microclænodon assurgens *Cope*		
MESONYCHIDÆ.		
Dissacus navajovius *Cope*		
" carnifex *Cope*		×
PROVIVERRIDÆ.		
Deltatherium fundaminis *Cope*		×
MIACIDÆ.		
Didymictis haydenianus *Cope*		
" primus *Cope*		
4. TILLODONTA.		
Psittacotherium aspasiæ *Cope*		
" multifragum *Cope*	×	×
" megalodus *Cope*		
Hemiganus vultuosus *Cope*		
" otariidens *Cope*	×	
Conoryctes comma *Cope*		×
Onychodectes tissonensis *Cope*	×	
? " rarus *O. and E.*	×	

TABLE III.—*Continued.*

	LOWER.	UPPER.
5. AMBLYPODA.		
TALIGRADA.		
PANTOLAMBDIDÆ.		
Pantolambda bathmodon *Cope*		×
" cavirictus *Cope*		×
6. CONDYLARTHRA.		
MIOCLÆNIDÆ (Incerta sedis).		
Mioclænus turgidus *Cope*	×	×
" zittelianus *Cope*		
" turgidunculus *Cope*	×	
" opisthacus *Cope*		
PERIPTYCHIDÆ.		
Periptychinæ.		
Periptychus rhabdodon *Cope*	×	×
" coarctatus *Cope*	×	
" brabensis *Cope*	×	×
Ectoconus ditrigonus *Cope*	×	
Anisonchinæ.		
? Zetodon gracilis *Cope*		
Haploconus lineatus *Cope*		×
" corniculatus *Cope*		
" angustus *Cope*		
" xiphodon *Cope*		
" entoconus *Cope*		
" cophater *Cope*		
Anisonchus mandibularis *Cope*		×
" sectorius *Cope*		×
" coniferus *Cope*		
" gillianus *Cope*		
" agapetillus *Cope*		
Hemithlæus kowalevskianus *Cope*	×	
" apiculatus *Cope*		
PHENACODONTIDÆ.		
Euprotogonia puercensis *Cope*		×
" zuniensis *Cope*		
" calceolata *Cope*		
" plicifera *Cope*		
Protogonodon pentacus *Cope*	×	
" lydekkerianus *Cope*		
7. INCERTÆ SEDIS.		
Oxyacodon apiculatus *Earle*	×	
Oxyclænus cuspidatus *Cope*		
Paradoxodon rutimeyeranus *Cope*	×	
Carcinodon filholianus *Cope*	×	
Mioclænus interruptus *Cope*		
" minimus *Cope*		
" acolytus *Cope*		
Pentacodon inversus *Cope*		

This geological distribution, made up from the field notes of Cope (Baldwin) and Wortman also probably contains many errors of detail, and is subject to alteration by future discovery. The following are the most important points in the vertical distribution :

1. Among the Multituberculata, the Plagiaulacidæ including Polymastodon are confined to the lower beds, while the Chirogidæ are found in the upper beds.

2. Among the Primates three species of Chriacidæ occur in the lower beds, while other Primates are found in the upper beds.

3. Among the Creodonta the following are recorded from the upper division only: *Clænodon*, *Triisodon* (excepting one species), *Dissacus*, *Deltatherium*. *Sarcothraustes* occurs in both upper and lower.

4. Among the Tillodonta, *Hemiganus* and *Onychodectes* are found in the lower and not in the upper beds.

5. Among the Amblypoda, *Pantolambda* is found only in the upper beds.

6. Among the Condylarthra it is remarkable that the highly specialized *Ectoconus* occurs in the lowermost portion of the lower beds associated with remains of *Periptychus*. *Periptychus*, however, extends also into the upper beds. The specialized *Hemithlæus* is from the lower beds only, while the more simple *Haploconus* and *Anisonchus* have been found both in the upper and lower beds. Among the Phenacodontidæ *Protogonodon* is found only in the lower beds, *Euprotogonia puercencis* only in the upper beds.

III.—Systematic Description.

1. Order MULTITUBERCULATA *Cope.*

Family PLAGIAULACIDÆ *Marsh.*

Subfamily POLYMASTODONTINÆ.

The discovery that *Meniscoëssus*[1] of the Laramie is a transition form between *Plagiaulax* and *Polymastodon* removes the latter genus to the Plagiaulacidæ, subfamily Polymastodontinæ, characterized by reduced fourth premolars.

1. *Plagiaulacinæ.*	2. *Polymastodontinæ.*
Early representatives of the Plagiaulacidæ: Premolars, 4–1. Fourth premolars very large and trenchant.	Latest representatives of the Plagiaulacidæ: Premolars, 1. Fourth premolar greatly reduced.

Genus **Polymastodon** *Cope.*

Dentition: $I\frac{2}{1}$, $C\frac{0}{0}$, $P\frac{1}{1}$, $M\frac{2}{2}$. The enlarged anterior pair of incisors vertically striated, enamel wanting on posterior surfaces. Lateral upper incisors (I3) small, conic. First upper molars with three rows of tubercles; second ditto, with two rows and a rudimentary third row.

This last survivor of a great Mesozoic order is represented in the collection by remains of 45 individuals, many of which are exceptionally perfect. The five species established by Cope seem to be valid with the exception of *P. latimolis*, which is doubtfully distinct from *P. taoënsis*. We can now amplify Cope's definitions as follows:

P. foliatus.[2]	*P. taoënsis.*[3]
Of small size. Lower molar tubercles flattened, block-shaped. Cusp formula: first molar, 5 outer, 4 inner; second molar, 4 outer, 2 inner. P4–M2=22 mm.	Jaws robust. Lower first molar much larger than second. Cusp formula: first molar, 7–8 outer, 6 inner. Incisors broad, with enamel band wanting on fang.

[1] See Osborn, 'Fossil Mammals of the Upper Cretaceous Beds.' Bull. Am. Mus. Nat. Hist., Vol. V, 1893, pp. 312–330.
[2] Am. Nat., 1882, p. 416.
[3] Am. Nat., 1882, p. 684.

P. fissidens.[1]

Of intermediate size. Molar tubercules conic. Cusp formula: first lower molar, 5 outer, 4 inner, 3 additional cusplets. M1, 135 mm.

P. latimolis.[2]

Jaws robust. Lower first molar slightly larger than second. Cusp formula: 1st molar (?), 5 outer, 6 inner.

P. attenuatus.[3]

Jaws slender. Molars compressed in mid-region. Cusp formula: first molar, 9 outer, 6–7 inner; second molar, 5 outer, 4 inner. Incisors narrow, with enamel extending to base of fang. Upper incisor grooved laterally.

P. selenodus, sp. nov.

Laterally compressed. Lower molar tubercles crescents, opening backwards. Cusp formula: first molar, outer 7, inner 6. M1, 2 mm.

In general *P. foliatus* is the most primitive type, distinguished by small size and very few tubercles. *P. fissidens* is somewhat larger, with the same number of full sized conic tubercles, but with accessory tubercles. *P. selenodus* is still larger, with more numerous crescentic tubercles; *P. attenuatus* is laterally compressed with long enamel bands on the incisors; *P. taoënsis* and *P. latimolis* are robust, with short enamel bands on the incisors.

Polymastodon attenuatus *Cope.*

This species is represented by the dentition of a left mandibular ramus (No. 967) and by a complete upper dentition (No. 970). Also by Nos. 730, 720, 743, 734. The lower teeth correspond in general to the description of Cope;[4] the incisor is very long and slender, with well-defined grooves, multiplying towards the fang; the enamel band is confined to half the section. The fourth premolar is narrow, and exhibits three minute apical cusps, the second and third being separated by a deep notch. The first molar is long, narrow, and compressed in the middle; the second is short and rounded.

The complete upper dentition is of great interest. The large incisor (? 2) is rather slender, sharply grooved, restricted enamel band and a deep postero-external groove. The lateral incisor (? 3) is a very small conical tooth, compressed antero-posteriorly, with its enamel confined to the anterior surface, probably as an instance of 'meristic repetition.' The fourth premolar is small,

[1] Am. Phil. Soc., 1883, p. 322.
[2] Am. Nat., 1885, p. 385.
[3] Am. Nat., 1885, p. 494.
[4] Am. Nat., 1885, p. 494.

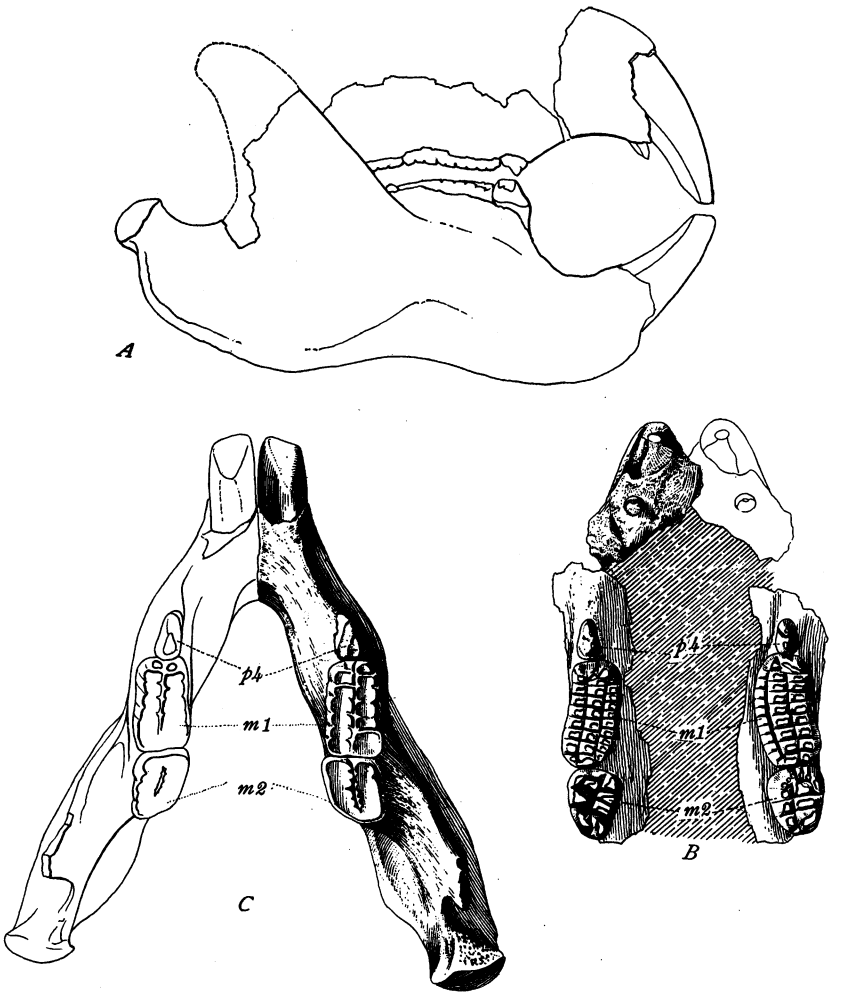


Fig. 1. POLYMASTODON. A, *P. attenuatus*, composition side view of upper and lower jaws. B, Superior dentition, crown view. C, *P. taoënsis*, lower jaws, crown view. Two-thirds natural size.

conical, with two apical cusps. The first molar is long, rather narrower than in *P. taoënsis*, and somewhat compressed in the middle; the second is sub-triangular, narrowing posteriorly, and with only one and one-half cusps in the outer row. (Fig. 1 *B*.) The molar cusps are transversely oval, with some tendency to

exhibit crescents opening forwards in the upper series and backwards in the lower series, as in *Meniscoëssus*. The cusp formula is:

	Lower Molars.		Upper Molars.		
	Outer.	Inner.	Outer.	Middle.	Inner.
First molar.....	9	6–7	9	9	10
Second molar...	5	4	1–2	4	4–5

Polymastodon taoënsis *Cope.*

This species includes the robust types, and is represented by numerous specimens—Nos. 742, 746–8, 750, 753, 721–3, 725–32, 735, 736, 743, 968.

The lower jaws are robust; the coronoid rises from the outer side of the third molar and posterior half of the second; the pterygoid fossa is deeply excavated, and the masseteric fossa is a broad concavity; the lower border of the jaw is thus broad and flat and ⊥ shaped in section; the condyle is oval and its long axis is placed obliquely, not antero-posteriorly as in the Rodents. The obliquity is greater in some specimens (No. 734) than in others. When the jaws are spread as in Fig. 1 *C*, the opposite molars are exactly parallel with each other, and the condyles are transverse, but the antero-posterior grooving of the molars is proof of motion in the same direction. A marked feature of the jaw is that the coronoid rises on the outer side of the second molar. The lower incisors are broader than in *P. attenuatus* and are readily distinguished by the fact that the enamel terminates at or above the alveolar border, and does not extend down upon the fang. The cusp formula of the molars as compared with *Meniscoëssus* is:

	Lower Molars.		Upper Molars.			
	Outer.	Inner.	Outer.	Middle.	Inner.	
First molar...	7–9	6–7	9	9–10	10–12	*Polymastodon*
Second molar.	4	4	1	4	5	*taoënsis.*
First molar...	5	4	7	7	7	*Meniscoëssus*
Second molar.	4	2	3	4	4	*conquistus.*

Although the lower molars exhibit typically but two rows, we occasionally observe (No. 725) a postero-external accessory row upon the first molar, and upon the first and second molars (Nos. 725, 731). The form of the cusps is occasionally subcrescentic.

The comparison with *Meniscoëssus* shows an average *addition* of two cusps to the first molars in both jaws, and an apparent degeneration of the outer row in the second upper molar, so that this tooth is relatively simpler in *Polymastodon* than in the older genus *Meniscoëssus*.

Polymastodon fissidens *Cope.*

This species is represented by a fragment of the left mandible (No. 751), containing the base of P_4 and the much worn and fissured crown of the first molar. This tooth is a trifle larger than that in Cope's type, and the cusp formula is apparently 6 outer, 5 inner; so that there is some doubt as to this specific reference.

Polymastodon selenodus, sp. nov.

The type (No. 749) lower molar is widely distinct from the above in the *crescentic* form of its molar cusps.

The anterior cusps are distinct, the posterior are low and irregular; there are 7 in the outer and 6 in the inner row; the anterior border is convex, the posterior is flattened, giving a subcrescentic section, which reminds us strongly of the cusps of *Meniscoëssus conquistus* of the Laramie. The fourth premolar is very small.

Fragments of a *Polymastodon* skull (No. 734), undetermined, exhibit a broad molar shelf below the orbit. Another skull (No. 721) is still embedded in a very hard matrix.

2. Order PRIMATES.

We find in the Puerco numerous remains of the Primates, and there is every reason to believe that these animals were both abundant and highly specialized or modernized. At present,

however, there is no satisfactory means of determining as regards several of these types whether they belong to the Lemuroid or to the Anthropoid phylum; we refer especially to *Tricentes* Cope, to the related *Indrodon* Cope, and to *Mixodectes.* Of *Indrodon* we have the first remains of the skeleton which have been found in the Puerco, by far the oldest Primate skeleton known. Apparently related in dentition to modern Lemurs are the *Chriacidæ*, a family including larger forms which we remove from the Creodonts where they have been placed by Cope, and provisionally refer to the Primates.

1. *Chriacidæ.*	2. *Anaptomorphidæ.*	3. *Mixodectidæ.*
Incisors normal. Premolars, 4. Premolars spaced. Pm4 without tritocone. Molars tritubercular.	Incisors normal, $\frac{3}{3}$. Premolars, 3–2.	A pair of incisors enlarged. Premolars, 3.

Family ANAPTOMORPHIDÆ *Cope.*

Genus **Indrodon** *Cope.*[1]

(?) Dentition: $I\frac{1}{1}$, $C\frac{1}{1}$, $P\frac{3}{3}$, $M\frac{3}{3}$. Premolars spaced and conic. Upper molars with flattened outer cusps, a rudimentary postero-internal tubercle or hypocone. This type is distinguished from *Anaptomorphus* by absence of internal lobe upon third superior premolar, and by spacing of premolars.

Indrodon malaris *Cope.*

In Cope's type, a fragmentary skull, the maxillo-premaxillary suture cannot be made out; the homologies of the anterior teeth are therefore uncertain; they apparently represent two incisors, and a canine. The second and third upper premolars are small, conic and widely spaced; the fourth premolar only has a conic internal lobe. The true upper molars are low-crowned and subtriangular; the outer cusps are flattened and there is a wide external cingulum, marked by minute cingules. The intermediate tubercles are absent or worn off in the type; there is also a faint postero-internal cingulum, and the hypocene is represented as a

[1] Proc. Am. Phil. Soc., 1883, p. 318.

cingular cusp upon the first and second molars. The third molar is somewhat smaller than the others, and there is no such great inequality in size as we observe in *Tricentes bucculentus*, or in *T. inæquidens*. This description refers to Cope's type.

SKELETON OF INDRODON.—The reference to *Indrodon*, of the skeleton No. 823, is somewhat doubtful, because the upper molars associated with the skeleton are so much worn.

The material consists of fragments from all parts of the skeleton, which were collected by Dr. Wortman with the greatest care, including: Teeth, superior P4–M3 inclusive; inferior P3 and M1; part of the lower jaw, and isolated M1, and P3. Of the vertebral column are preserved: cervicals, 2; dorsals, 6; lumbars, 4; sacrals, 1; caudals, 7; these are mostly centra with portions of the neural arches. Of the appendages, portions of the scapula, humerus, radius and ulna, metacarpals and phalanges are preserved. Of the hind limb parts of the ilium, femur, tibia and fibula and tarsals are preserved.

Fig. 2. *Indrodon malaris.* Superior molars, and an inferior true molar. Twice natural size.

The animal (No. 823) was about half the size of *Lemur varius*, with slender limbs and a long powerful tail; in fact it closely resembled some of the living Lemurs. The principal characters are as follows:

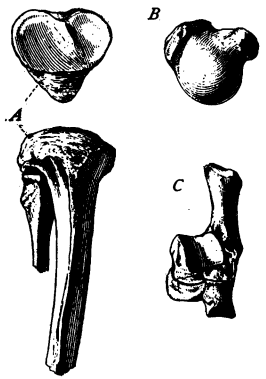


Fig. 3. *Indrodon malaris.* Portions of the skeleton: A, Proximal portion of right tibia and fibula; B, Head of humerus; C, Left tarsus. Natural size.

Dentition.—The fourth upper premolar has a sharp prominent external protocone and an internal deuterocone, with the rudiment of the tritocone. The molar crowns, although broken, indicate that they were tritubercular, wider transversely, and more compactly placed than in the *Indrodon* type, although of the same measurements.

The intermediate tubercles are indistinguishable, owing to excessive wear.

The posterior portion of the lower jaw contains the worn crowns of the first and second molars.

Fore Limb. — The fore limb characters are the following: Scapula, with an obtuse coracoid; humerus, with tuberosities not very prominent, but exhibiting a marked deltoid ridge extending from the greater tuberosity on the outer side of the front face of the shaft, and a marked ridge extending from the lesser tuberosity down the inner side. A similar relation of these ridges is very characteristic of the Lemurs, and is also seen in some of the true Monkeys. In most of the Monkeys, however, the deltoid ridge occupies a median position on the front face of the shaft, and the lesser ridge is reduced or wanting. Distally the humerus presents a strong entepicondylar foramen. The head of the radius is oval, and the ulna has a short olecranon.

Hind Limb.—The ilium has an imperforate acetabulum and a wide cotyloid notch. The femur exhibits three trochanters, the third trochanter extending about half-way down the outer side of the shaft; the head exhibits a pit with a round ligament; the cnemial crest of the tibia is prolonged down the front face of the shaft. The fibula is well developed. The astragalus exhibits the astragalar foramen, and a large fibula facet, similar to that in *Lemur varius*; it has a deep posterior groove for the flexor tendon; distally the astragalus has a short neck and a convex navicular facet. The cuboid is subquadrate in form. Unlike the Condylarthra articulation, the calcaneo-cuboidal facet is nearly flat.

Vertebræ.—The axis exhibits a short odontoid process; the cervical centra are flat. The dorsal centra are triangular in form; the lumbar centra are more elongate and flattened. The detached zygapophyses which belong in the posterior dorsal or lumbar region, exhibit convex vertically placed facets. There is apparently but a single sacral vertebra. The caudals are long and well developed.

? Upper Dentition of Indrodon.—Portions (No. 833) of the maxillæ and of the lower jaw with certain teeth, were found with remains of two skeletons, a larger (No. 833) and a smaller (No. 834).

The identification of No. 833 with *Indrodon* is not absolute; it is based upon the likeness of the superior molars (Fig. 4) to the somewhat fractured crowns in Cope's type. It is rendered doubtful by the compactly placed lower premolars. The fourth upper premolar is triangular, with a complete investing cingulum, a high protocone, a deutero-cone, and incipient tritocone. The molars are beautifully preserved; they consist of a perfect trigon with a detached spur-like hypocone upon the first and second molars; the external cusps are subcrescentic, and in the sharp external cingulum we observe a distinct mesostyle and less prominent para- and metastyles; the intermediate tubercles are developed upon the spurs between the external and internal cusps. The jaw contains the alveoli of a small lateral incisor, a larger canine, a small one-rooted premolar; next a two-rooted premolar, followed by a premolar crown which is either P3 or P4; this has a sharp crown and a low heel. If this is the fourth premolar it is closely similar to that of *Anaptomorphus*.

Fig. 4. *Indrodon malaris.* Crown view of last superior premolar and true molars. Twice natural size.

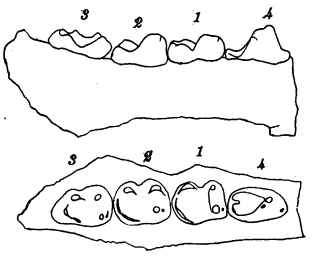


Fig. 5. *Indrodon malaris.* Lower jaw, internal and upper view. Natural size.

A comparison with *Anaptomorphus homunculus*[1] of the Wahsatch shows a very similar configuration of the lower jaw, and probably a similar lower formula, P3, M3. The upper teeth of this specimen (No. 833) differ from those of *A. homunculus* in the much more prominent hypocone spur.

The humerus associated with this specimen also has the double ridge observed in No. 823.

Incertæ sedis.—The skeleton (No. 834) found with this type is of smaller size and presents many differences from that of No. 823.

Lower Jaw.—Fig. 5 represents a lower jaw (No. 829), which we provisionally refer to this genus owing to the similar dimensions of the lower molar series with those in the fractured jaw

[1] Bull. Am. Mus. Nat. Hist., 1892, p. 103.

attached to Cope's type skull. The Pm4 is a rounded cone with a faint deuteroconid and anterior basal cusp; the talonid is broad and basin-shaped. The molars are distinguished by the absence or vestigial condition of the paraconid, the elevation of the trigonid, the rather depressed but distinct hypoconid from which extends inwards a broad internal basin representing the fusion of the hypoconulid and entoconid. In M3 the hypoconulid is a distinct cusp.

An isolated single molar (No. 829*a*) shows the same characters.

Family CHRIACIDÆ, fam. nov.

This family includes forms more primitive than the *Adapidæ* but with a similar dental formula.

It is exceedingly difficult in the present state of our knowledge to decide with certainty as to the ordinal affinities of the genera which Scott[1] has included in the family Oxyclænidæ. We think it probable, however, that *Chriacus* and its allies are more closely related to the Primates than to any of the Creodonta to which Cope has referred them. The type species of the genus *Chriacus*, namely, *C.* (*Pelycodus*) *pelvidens*, was in fact at first included by Cope with the Lemurine like *Pelycodus*. Scott has suggested the Primate relationship of these forms. Schlosser has also observed the resemblance in the shape of the jaw in *Chriacus* to that of *Necrolemur*. We here discuss the evidences of Primate relationship.

Of the three points spoken of by Scott as separating *Chriacus* from the Lemurs, namely, (1) the character of the jaw symphysis, (2) spacing of the inferior premolars, (3) the presence of the paraconid; the second character at least occurs in the Bridger genus *Tomitherium*, which is an undoubted Primate. Again, among the recent Lemurs, the last two inferior premolars are spaced in some species of *Lemur*, while the paraconid is present in *Tarsius*. Thus the difficulties raised by Scott are all removed.

As remarked by Scott the superior molars of *Chriacus* are surprisingly like those of certain Lemurs, and it is to be emphasized

[1] These genera employed by Scott upon types of Cope's species of *Mioclænus*, *Chriacus*, and *Tricentes* are as follows: *Oxyclænus*, *Chriacus*, *Protochriacus*, *Epichriacus*, *Pentacodon*, *Loxolophus*, *Tricentes*, *Ellipsodon*.

that they resemble those of the Lemurs more closely than those of the Creodonts. Again, we have some remains of the skeleton of a form, probably belonging to the Chriacidæ, which resembles corresponding parts in the recent Lemurs. There are apparently two types of mandibular symphysis among the primitive Primates of the Puerco; in *Chriacus* this portion of the jaw is long and narrow. This is the most primitive condition, and common to many Puerco forms. The other type (Anaptomorphidæ, Mixodectidæ) presents the jaw at the symphysis as deep as below the last lower molar.

Genus **Chriacus** *Cope.*

Pelycodus COPE, in part.

Dentition: $P\frac{4}{4}$, $M\frac{3}{3}$. Superior true molars tritubercular with hypocone, and on second molar an antero-internal cusp (protostyle); third upper molar reduced in size. First and second inferior premolars spaced, fourth with a deuteroconid and heel. Trigonid of inferior molars higher than talon; paraconid present.

The superior molars in this genus especially resemble those of the genera *Lemur* and *Galago*. As compared with the upper molars of such a typical Creodont as *Deltatherium* those of *Chriacus* differ (1) in their more square form; (2) in the rounded shape of the external cusp; (3) in the large development of the supplementary internal cusps. The lower true molars of *Chriacus* have the trigonid less elevated than in *Deltatherium*, and the talon, similar in shape to that of *Pelycodus*, resembles that of the Lemurs in being very broad and wide.

Chriacus baldwini *Cope.*

There are only portions of jaws of this species in the collection (Nos. 789, 811 and 812). In the *C. baldwini* the first premolar of the lower jaw is separated by a wide interval from the second; the second and third are nearer together, and there is no interval between the third and fourth. The crown of the fourth premolar is high, recurved, and much elevated above that of the first true molar. The mandible is elongated and becomes slender in the premolar region; its general form closely resembles that of *Protochriacus priscus.*

Genus **Protochriacus** *Scott.*

Superior molars with no protostyle, and hypocone very weakly developed. Inferior true molars with trigonid little raised above talon. (Type, *P. priscus.*)

This genus slightly differs from *Chriacus* in the more primitive structure of its upper true molars, which have the supplementary antero-internal cusp hardly developed at all. The inferior true molars differ widely from those of *Chriacus*, and these teeth in the two species included by Scott in *Protochriacus* are quite different in structure, and further investigation may prove that they belong to distinct genera.

Protochriacus priscus *Cope.*

Inferior true molars with no external cingulum; trigonid only slightly raised above talon. Talon of last lower molar very wide and deep, with hypoconulid.

The material in our collection pertaining to this small species is very abundant; there are no less than a dozen fragments of jaws and upper teeth (Nos. 802, 803, 817, 818, 939). The first and second inferior premolars are spaced, and the last premolar has no deuteroconid. The paraconid is small and placed between the proto- and metaconids, but nearer the latter cusp. The mandible is long, narrow, and tapers gradually to the symphysis, which is much narrower than the portion below the true molars. The inferior true molars of this species are more of the Lemur type than those of the allied species, viz., *P. simplex.* The talonid is wide and is more extended transversely than the trigonid; the cusps forming the border of the basin-like talon are not distinctly separated from each other as in *P. simplex.*

Protochriacus attenuatus, sp. nov.

Paraconid well marked, on a line with metaconid, trigonid not raised above talon, hypoconulid distinct.

The type of this new species of *Protochriacus* is specimen No. 790. This specimen is smaller than the *P. priscus;* the jaw is very narrow and slender. The crescents of the inferior true molars are strongly marked, and the cusps are sharper than in the

allied species. The paraconid is well marked on the first true molar, but is rudimentary on the second. The shape of the talon of the last tooth of this series is quite different from that of *P. priscus*.

Measurements.

	M.
Total length of M1 and M2	.012
Depth of jaw below M1	.008

Protochriacus simplex *Cope.*

Inferior true molars with trigonid much raised above talon, paraconid well developed. A strong external cingulum on all the lower true molars. Talonid of last lower molar much smaller than trigonid, with hypoconulid well constricted off.

The type of lower molar found in this species is more like that of the typical Creodonts (*Deltatherium*); the trigonid is high and the anterior portion of the same is more thrown out than in *P. priscus*, thus giving the teeth a more trenchant function. One specimen (No. 799), among others, in the collection of this species, has the upper molars associated with the lower teeth. The superior molars are much extended transversely, more so than in *P. priscus;* the external cusps are round in section, and the postero-internal cingulum is not as much developed into a hypocone as in *P. priscus*. In specimen No. 793 the jaw is much deeper than in No. 794, however the teeth are nearly of the same size; great variation in the depth of the jaw is often displayed by the same species of Puerco mammals.

Genera INCERTÆ SEDIS.

Genus **Tricentes** *Cope.*[1]

Dentition: I?, $C\frac{1}{1}$, $P\frac{3}{3}$, $M\frac{3}{3}$. Premolars spaced and conic. Molars with rounded tubercles, hypocone well developed. Molars irregular in size; third molar reduced. Trigonid slightly elevated. Paraconid reduced.

[1] Proc. Am. Phil. Soc., 1883, p. 315.

Tricentes bucculentus *Cope.*

The third upper premolar triangular ; the fourth with a compressed protocone and a large internal cusp ; first and second upper molars with hypocone, third small, tritubercular ; lower molars with tubercular talonid.

There is only one example (No. 784) of this species in the collection ; this includes both upper and lower sets of teeth, and as the latter have not been described, this specimen is of importance.

The roots of the upper canines of both sides are preserved, showing that these teeth were quite long and powerful ; they are separated from the second premolar by a wide diastema. The first premolar has disappeared. The crowns of the second and third premolars are broken off, the fourth premolar has a high protocone and a well-marked deuterocone. A very minute cingular hypocone is present on the first molar, but on the second molar the cingulum is not so distinctly developed into a hypocone. The last upper molar is small and has two external cones. The great size of M2 as compared with M1 and M3 is to be noted in this species.

The lower jaw contains the crowns of the third premolar and the second and third molars. The crown of Pm3 is very slender, without a heel ; there is some indication that there was a minute second premolar in front of this tooth. The second lower molar has the trigonid slightly raised above the talon, which has a different form from that of *Protochriacus;* the paraconid is present, but greatly reduced. In *T. bucculentus* the talon is notched at its posterior border by a posterior cingulum which extends to the slightly developed external cingulum. The last lower true molar has an elongated talon, as in the Bridger Monkeys ; this extends postero-internally into a high ridge upon which the entoconid is not differentiated, although the hypoconulid is well marked. The lower true molars of *Tricentes* remind one strongly of those of *M. turgidus.* The jaw is long and deep beneath Pm1 as it is beneath the last true molar.

Incertæ sedis.—A lower jaw (No. 815) containing an incisor, canine and two molars is provisionally placed here. The incisor is small and spathulate. The molar tubercles are all upon the same level, the trigonid not being elevated.

Genus **Oxyacodon,** gen. nov.

Fourth lower premolar strongly compressed laterally, with only a very minute talon, no deuteroconid. Crowns of inferior true molars high with sharp cusps, trigonid not elevated above talonid, paraconid reduced. Hypoconulid of last lower molar high and sharp.

The type of this new genus is a fragment of a lower jaw bearing the last lower premolar and first two molars (No. 816). There is also another portion of a jaw which we refer to this genus (No. 806). The true molars in this genus resemble somewhat those of *Anisonchus*, but the structure of the last premolar is widely different. The general structure of the teeth differs decidedly from that seen in *Chriacus* or *Tricentes*, and appears to be more of the insectivorous type.

Oxyacodon apiculatus, sp. nov.

Last lower premolar higher than the first true molar, and the crown of same as long antero-posteriorly as the latter. Hypoconulid of M3 well constricted off; very sharp and curved forwards.

The last lower premolar is flattened with sharp anterior and posterior cutting edges; there is only a very slight enlargement behind. This tooth differs from that of *Protochriacus* in being more flattened and trenchant. The second true molar is high and narrow with four principal cusps inclined forward; these cusps are also less connected than in the typical genera of the Chriacidæ. The structure of the talon of the last lower true molar is peculiar, in arising from the height of the hypoconulid, which is unusually sharp and pointed. The jaw is deep, and was probably short. This character relates this genus to the Primates.

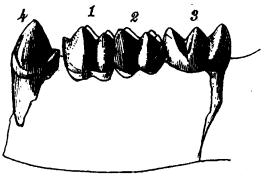


Fig. 6. *Oxyacodon apiculatus.* Portion of left lower jaw, external view. Composition. One and one-half natural size.

? **Chriacus** ———.

A jaw (No. 835), with fragmentary remains of a skeleton, is of importance. The jaw is not at all like that of the recent Lemurs,

but resembles in form that of *Chriacus* and its allies; that is to say, the symphysial part is much elongated, slender and slopes gradually to the symphysis, instead of being deep and abrupt as in the recent Lemuroidea and Anthropoidea. Unfortunately the teeth are all absent from this specimen, so that we cannot identify it with certainty. The alveoli of the premolars are quite distinct, the first is placed close to the canine, the second is spaced as in *Chriacus*, the last three premolars are two-rooted.

Measurements of Jaw.

	M.
Length of inferior molar series	.040
Depth of jaw at M3	.010
" " " symphysis	.008

The part of the humerus associated with this jaw is extremely long, and it is of interest to note that the two proximal crests so characteristic of recent Lemurs are present on this specimen.

3. Order CREODONTA *Cope.*

Family ARCTOCYONIDÆ *Cope.*

Genus **Clænodon** *Scott.*

Mioclænus COPE, in part.

Superior molars subquadrate in outline, with well-developed hypocone on the first and second. Inferior premolars simple in structure, last without metaconid. Inferior true molars with trigonid on a level with talonid, and cusps of same not distinctly differentiated. Borders of molars and edges of premolars serrated.

This genus is easily distinguished from other Creodonta of the Puerco by its low-crowned molars, in which the cusps are little raised above the general surface of the teeth. The crowns of the lower premolars are sharp and high, and the last tooth of this series is without a heel. *Clænodon*, as shown by Scott, is closely related to the European genus *Arctocyon.*

Clænodon ferox *Cope.*

Crown of last inferior premolar much higher than that of first true molar, and provided with a well-marked external cingulum. Second and third inferior premolars much reduced in size. Crowns of lower true molars very flat, with cusps hardly distinguishable ; hypoconulid of M3 large and covered with crenulations.

There is only one specimen of this rather rare form in the collection (No. 772) ; this is a jaw in which the last three premolars and the true molars are well preserved. The first two premolars are much smaller than the last tooth of this series ; the crowns are rather high and compressed. The fourth inferior premolar has a high crown which is recurved. A peculiarity of the premolars is the serration of their anterior and posterior edges, as in the Reptilia. This serration can be plainly felt in running the finger over the edges of the teeth, although not well marked to the naked eye.

The structure of the crowns of the lower true molars reminds one strongly of those of the Wahsatch *Anacodon ;* the borders of these teeth are slightly raised above the general surface, but not produced into well-marked cusps. The last lower true molar is unusually flat and ill defined in the structure of the crown ; it has five slight elevations corresponding to the cusps of more highly developed forms, and the enamel surrounding the cusps is much crenulated, like that of *Anacodon.* The hypoconulid is peculiar in being very flat and much extended posteriorly.

It is interesting to be able to trace out another line of descent from a Puerco to a Wahsatch form, and we think it certain that *Clænodon* is the ancestor of the peculiar Wahsatch type *Anacodon.* Only recently Osborn and Wortman[1] have removed *Anacodon* from the Condylarthra and placed it in its true position near *Arctocyon.* This is indicated not only by the structure of the molars, but by the incipient atrophy of the premolars.

The anterior lower premolars of *Clænodon* are very small and are undergoing a rapid reduction in their size; the first lower premolar is still present in *Clænodon,* but absent in *Anacodon.* The lower true molars in these genera resemble each other very closely in structure, and in both the crowns are much flattened and covered with prominent crenulations of the enamel.

[1] Bull. Am. Mus. Nat. Hist., 1892, p. 115.

Family TRIISODONTIDÆ *Scott.*

Genus **Triisodon** *Cope.*

Triisodon biculminatus *Cope.*

A fragment of a lower jaw (No. 774), with the true molars intact, is in the collection, and probably belongs to this species. As in Cope's type specimen, the talonid is largely developed, and

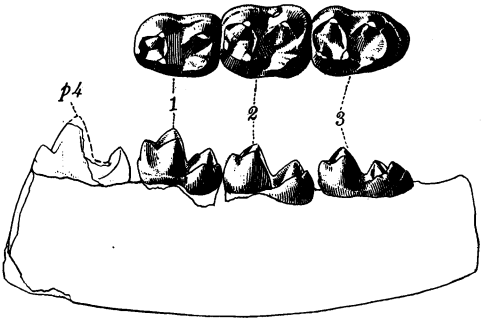


Fig. 7. *Triisodon biculminatus.* Internal and crown view of inferior molars. Natural size.

the entoconid is not distinctly separated from the hypoconulid. The paraconid of the first true molar is submedian in position and well separated from the cusps behind ; on the second and third molars this cusp is only weakly developed. The hypoconulid of the last inferior true molar is semicircular in form, convex posteriorly, and concave anteriorly. Traces of the talonid on the last inferior premolar are preserved, showing this to have been much extended behind as in *Triisodon quivirensis.*

Genus **Sarcothraustes** *Cope.*

Mioclænus COPE, in part.

Dentition : $I\frac{1}{1}$, $C\frac{1}{1}$, $P\frac{3}{4}$, $M\frac{3}{3}$.

Superior true molars with paracone and metacone conical and equal in size. Last superior premolar not molariform, and same tooth of the lower series with talonid consisting of two cusps. Inferior true molars with trigonid raised above the talonid, the former consisting of three cusps with the protoconid much larger than the para- or metaconid. Metaconid distinctly separated from the protoconid and on the same fore and aft line with the paraconid.

Individuals of the genus *Sarcothraustes* are the most numerous of any of the Puerco Creodonts. This genus is very closely related to *Triisodon*, and is difficult to separate generically from *Goniacodon*.

Sarcothraustes antiquus *Cope.*

This species is represented in the collection by a single jaw (No. 785). This specimen has only three teeth preserved, the two posterior being true molars, but they are not well enough preserved for a detailed description. However, from their worn surface, we think it probable that they resembled in structure those of *S. coryphæus*. The tooth which Cope in his type specimen identified as the first true molar, is really the last premolar; and in the American Museum specimen there are the alveoli for three premolars anterior to the latter, thus proving that *Sarcothraustes* had a full complement of premolars below. The last true molar is absent in this specimen.

Sarcothraustes coryphæus *Cope.*

Numerous remains of this species are to be found in the collection, it being represented by more specimens than any other Creodont. Of these, Nos. 764, 762, 765 and 766, are the best preserved. In No. 764 fragments of the skull with the greater part of the upper dentition are present.

Dentition.—The canine is small and weak in this species, and diverges considerably from the palate; behind this tooth there are alveoli for two premolars, the last upper premolar being well preserved. This proves conclusively that this genus has only six upper teeth behind the canine, or the same number as in the Bridger *Mesonyx*. It differs from *Mesonyx* in the fact that the last upper premolar is not molariform. The last upper true molar in our specimen has two external cusps. The metacone is smaller than the paracone. Specimen No. 762 presents both upper and lower teeth from the same individual; the lower jaw of this specimen belongs to the *S. bathygnathus* type. This is a remarkable jaw, owing to the small size of the teeth and the great depth and length of the mandible. The angular portion of the jaw is much

extended beyond the teeth and is very heavy. The superior molars found with this jaw are only slightly larger than those of *S. coryphæus*, and we believe accordingly that the specific character upon which the *S. bathygnathus* has been proposed by Cope is merely a case of individual variation. In fact, another jaw in the collection (No. 765), is intermediate in dimensions between the typical *S. coryphæus* and *S. bathygnathus*. The lower teeth of *S. coryphæus* are easily distinguished from those of *Dissacus carnifex* by their tuberculated talons, which in the latter form are trenchant. The presence of the hypoconulid on the last lower molar is a marked character of the genus *Sarcothraustes*.

A portion of a cranium exhibits a much elongated, thin and high sagittal crest. The postglenoid process is more extended transversely than in *Felis*, and resembles more in form that of the carnivorous Marsupials. The lower half of a humerus was found with this specimen, and may belong to the same individual. As compared with the size of the skull, it is very small and weak. The deltoid crest is high and extends far down on the shaft. An entepicondylar foramen is present, and the radial trochlea is much extended and slightly convex.

Family MESONYCHIDÆ *Cope.*

Genus **Dissacus** *Cope.*

Dentition: $I^{\frac{1}{1}}$, $C^{\frac{1}{1}}$, $P^{\frac{4}{4}}$, $M^{\frac{3}{3}}$. Superior true molars with metacone much smaller than paracone. Last upper molar much reduced in size. Lower true molars with protoconid larger than anterior basal tubercle paraconid, and on the same straight line with it. Metaconid present on second inferior true molar, and may be absent on the first and also on the last tooth of this series.

Dissacus carnifex *Cope.*

This species is represented in the American Museum collection by portions of two skeletons, Nos. 777 and 776. The most complete specimen, No. 777, consists of the lower teeth with parts of the skeleton, including a nearly complete carpus and some of the tarsal bones. The importance of this specimen will be appreciated when it is known that it is the most complete skeleton of a Creodont ever discovered in the Puerco Beds.

Dentition.—The upper dentition will be described from specimen No. 776. In this example the teeth are not attached to the maxillary bone, and it is with some difficulty that we are enabled to place them in their proper relation to each other. It is quite certain, however, that with the possible exception of the first upper premolar, all the teeth to be described are properly iden-

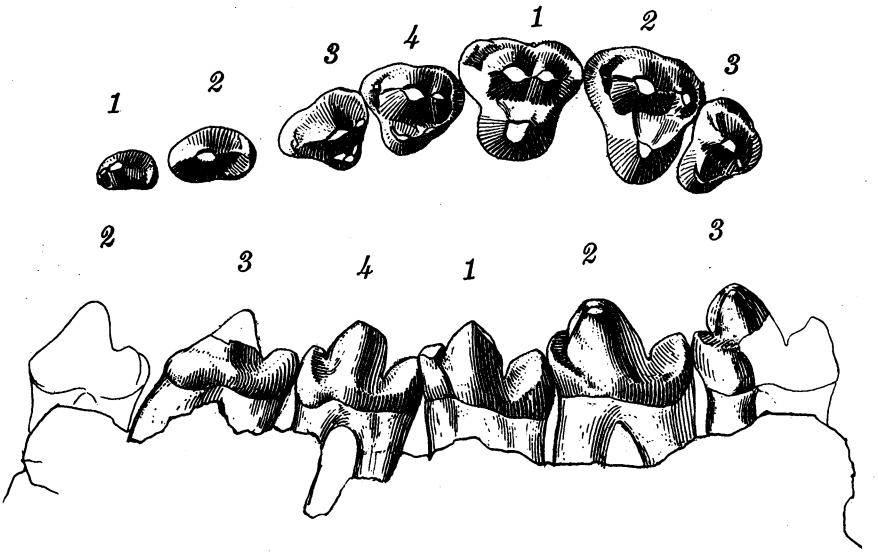


Fig. 8. *Dissacus carnifex.* Crown view of superior, and internal view of inferior molars. Natural size.

tified. The supposed first upper premolar is somewhat elongated from before backwards, consisting of a protoconid and a small talon. In the second premolar the principal cone is somewhat triangular in shape, with the heel placed at the postero-external border of the tooth. The third premolar has a small internal cone, with also an antero-external basal cusp. The fourth premolar has a tritocone, and also a postero-intermediate tubercle.

The upper true molars of *Dissacus carnifex* resemble closely those of *Pachyæna ossifraga*. This is shown in their much enlarged paracones and the small size of the metacone. In the last upper molar of *D. carnifex* the metacone is rudimentary, and the whole tooth is much reduced in size. The third lower premolar exhibits no anterior basal cusp, a character in which our

specimen differs from the type of *D. carnifex* of Cope.[1] However, in *D. navajovius*, the smaller species of this genus, the third lower premolar is without an anterior basal cusp. The total length of the lower teeth in the American Museum specimen is greater than in Cope's type of *D. carnifex*. We believe that these different characters are individual variations of the same species, and cannot be treated as of specific value. In the American Museum specimen of *D. carnifex* both the last two lower true molars have well-developed metaconids, but in Cope's specimen of this species the metaconid is absent on the last molar.

Skeleton.—The distal portion of a humerus is preserved; this is very broad and heavy, with a prominent entepicondyle. The internal flange of the humerus is strongly marked, and the external trochlea for the radius is convex and prominent. The proximal end of the radius is much extended transversely, and below this portion the shaft is flattened, as in the plantigrade Carnivora. The bicipital tubercle of the radius is elongated, and not as prominent as in recent forms. The distal articular surface is very heavy and thick from before backwards. The articular surfaces for the scaphoid and lunar are well marked, but not separated by a ridge. The radial styloid process is only slightly developed, and not elongated, thus differing from such a plantigrade as *Ursus*. The ulna has a heavy, elongated olecranon, and the diameter of its shaft much exceeds that of the radius. The relative proportionate widths, taken by the bones of the forearm in their articulation with the humerus, show that the radius spread over about two-thirds of the width of the humeral trochlear surface, thus largely excluding the ulna from articulating anteriorly with the humerus. The radio-humeral articulation in *Dissacus* is greater than in the Bears, and this denotes less power of supination than in the latter form.

Manus.—The general characters of the manus are very primitive, but in some respects—as for example, in the displacement of the metacarpals upon the podial elements—a considerable modernization has taken place. As compared with the manus of other Creodonts described hitherto, we find that of *Dissacus* closely

[1] See Tertiary Vertebrata, Plate xxv, Fig. 1.

resembles in its stage of displacement and form of its carpal elements that of *Mesonyx*, as figured by Scott,[1] although *D. carnifex* has not lost the first digit as in *Mesonyx*. The scaphoid is exceedingly flat and elongated transversely, with the internal border much thicker than the external, the superior facet is

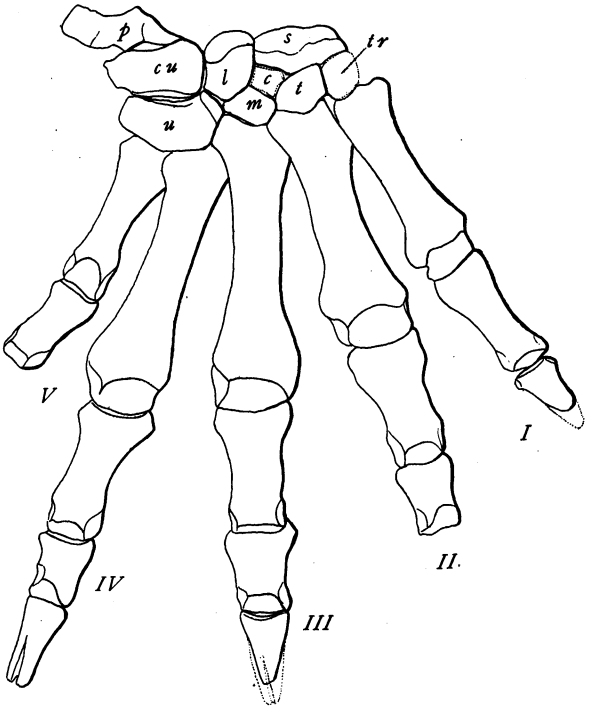


Fig. 9. *Dissacus carnifex*. Right manus, anterior view. Two-thirds natural size.

convex and its backward extension is limited; we cannot with certainty define the facets of the lower surface of the scaphoid; the surface next to the lunar was occupied by a large centrale, although this bone is unfortunately lost. The position of the centrale was like that in the manus of *Mesonyx*, namely, above the magnum and to the internal side of the lunar. We would add that this position of the centrale appears to be typical of the

[1] Jour. Acad. Nat. Sci. Phila., Vol. IX, Pl. vii, Fig. 1.

family Mesonychidæ, whereas in the Hyænodontidæ the centrale is interposed between the magnum, scaphoid and lunar, but it is placed partially beneath the latter bone. The lunar is convex above, the posterior concave surface sloping abruptly from the anterior portion; the posterior hook is not prolonged lower down than the apex of the anterior surface; the inferior articular surface is divided nearly equally; that for the unciform, however, is slightly larger than the facet for the magnum; the lunar-centrale facet is triangular in form and placed on the internal face of the bone; the shape of the cuneiform is strikingly like that of *Phenacodus;* it is much elongated transversely, and has only little depth; the articular cavity for the ulna is deeply concave and only takes up a small portion of the superior surface; the cuneiform-pisiform facet is very large and oblique to that for the ulna. The pisiform is broad proximally and placed horizontally upon the cuneiform, like that of the Bears. The shape of the unciform is closely like that of *Mesonyx;* it is much extended transversely, and presents a large facet for the lunar; the internal face has an elongated facet for the third metacarpal, and the inferior surface is flattened and undivided. The unciform in *Dissacus* exhibits no posterior decurved process as in the Perissodactyl Ungulates. The characters of the magnum are of interest, and its relations to the other bones of the carpus are like those of *Mesonyx;* the proximal facets are divided by a slight ridge, but there is no concavity upon the upper surface as in the magnum of the Felidæ and in that of the Hyændontidæ. The magnum-lunar facet is broader than that for the centrale; the posterior convexity of the magnum rises only slightly above the plane of the anterior portion of the superior surface; the form of this carpal is depressed and much extended transversely; internally it shows a broad and continuous facet for Mc. II.

Owing to the large contact between the Mc. III and the unciform in this type, the magnum is placed higher up in the podium than in *Hyænodon,* and results in crowding out the centrale from the under surface of the lunar. The trapezoid is triangular and depressed; the trapezium is wanting in this specimen. The proximal portion of the first metacarpal is present, and proves that this digit was of considerable length. The second digit is short,

heavy and proximally articulates by a broad facet with the magnum. The third metacarpal has a large articular surface for the unciform, and the magnum facet is obliquely placed. The fourth metacarpal is nearly as long as the third; its proximal facet is flat and horizontal in position. The outer metacarpal is short, stout and proximally, on the external side, exhibits a prominent tubercle.

The phalanges are much elongated, as is the case generally in plantigrade forms. The ungual phalanges are like those of *Mesonyx*, being strongly depressed and split at the end. In the Hyænodontidæ they are shorter and more curved than in the Mesonychidæ.

Pelvis.—One os innominate bone of the left side is in a fair state of preservation; this shows that the pelvis was much elongated, as in *Mesonyx*. The section of the base of the ilium is triangular, with a very prominent 'rectus' tubercle. Between the acetabulum and the distal expanded portion of the ilium there is a contracted neck, which is narrow. The acetabular cavity is large and is bordered above by an oblique and broad plate of bone. As compared with the pelvis of *Felis* and *Ursus*, we observe that the ischial segment in *Dissacus* rather resembles that of the Cats; this is shown in the broad descending processes of the ischia and in the prominent tuberosities of the same. A marked feature of this pelvis is the great elongation of the ischial portion as compared with the iliac segment, and we believe this to be a primitive character, for in modern Carnivora the ischial part of the pelvis is much shorter than the iliac. We may add that in the Ungulata, and especially in the more swift-footed members of the same, such as the Artiodactyla, the anterior and posterior divisions of the pelvis are more nearly of the same length than in the Carnivora.

Hind Limb.—The femur is long and its shaft is flattened transversely, this widening of the shaft being in strong contrast to the rounded femora of recent Carnivora; the third trochanter is prominent and situated at about one-third the length of the shaft below the great trochanter; the distal articular surface is heavy, and the shaft is much expanded above the condyles. The length

of the femur as compared with the tibia is much greater, and they bear the same linear relations to each other as in the plantigrade Carnivora (*Ursus*). The proportions of these bones, and the characters of the manus and pes clearly prove that *Dissacus* was a semiplantigrade. In Scott's restoration of *Mesonyx* the length of the femur is equal to that of the tibia, and as *Mesonyx* was a digitigrade Creodont, we believe these proportions to be correct. The crest of the tibia in *D. carnifex* is not raised and elongated; in this character this bone resembles that of the Bear; the distal articular surface for the astragalus is nearly plane, although there is a slight median convexity and a faint lateral concavity on each side of the latter; the internal malleolus is broad and much prolonged beyond the articular face.

Measurements of femur No. 777.

	M.
Length	.220
Breadth trans. prox.	.070
" " dist	.054

Pes.—The calcaneum is rather long and slender; the calcaneal tuberosity is elongated and much compressed, its form more like that of the digitigrade Creodonta; the ectal facet is placed high above the sustentaculum, being round and not prolonged forward as in the Bear. The transverse diameter of calcaneo-cuboid facet is greater than the vertical, and these relations are the same as those of the Bear. In the digitigrade Carnivora, on the other hand, this facet is nearly round. The astragalus is depressed and broad; the trochlear surface is only slightly concave, and is bordered posteriorly by a large foramen, which is of such constant occurrence in Puerco mammals; the large flange-like process bordering the ectal facet is very prominent in this astragalus; the neck is long and slender, the trochlear surface extending far forward upon it; this extension of the articular surface of the astragalus has been also pointed out by Cope; the navicular face is convex from above downwards, and is not separated from that for the cuboid. The navicular has been lost in this tarsus. The shape of the ectocuneiform closely resembles that of *Mesonyx;* it it is divided proximally by two facets, which form a right angle to each other; the smaller and external is for the cuboid, and the

internal that for the navicular; the posterior tuberosity bordering above the groove for the 'peroneus longus' is very large and much extended behind; this is a character common to digitigrade forms like *Felis*, but absent in *Ursus*. The mesocuneiform is high, slender and nearly as long as the ectocuneiform. The entocuneiform is elongated and broad, the posterior facet for the Mt. I is large and deeply concave; this bone in *Dissacus* is flatter and larger than in the Bear. Only the first metatarsal is preserved, and it shows that the hallux was of good size in this type.

Portions of vertebræ, and especially of the caudals, were found with this skeleton (No. 777). The latter are large and much elongated, thus demonstrating that this form had a long tail. The two skeletons of *Dissacus* in the collection vary much as to the lengths of the same bones, but not more than in skeletons of recent Carnivores.

Affinities of Dissacus.—This important discovery of the greater part of the skeleton of *Dissacus* adds much to our knowledge of the relationship of this genus to its probable successors in the Wahsatch and Bridger, *Pachyæna* and *Mesonyx*. The superior molars of *Dissacus* are an exact counterpart, on a smaller scale, of those of *Pachyæna*, although we observe that in *D. carnifex* the last superior molar is more reduced than in the two known species of *Pachyæna*. The upper true molars of *Pachyæna* still have the metacone smaller than the paracone, more especially marked in *P. gigantea*. The inferior true molars of *Pachyæna* are intermediate in structure between those of *Dissacus* and those of *Mesonyx;* this is shown in the reduction of the metaconid; but the relative sizes of the other cusps, as compared with *Dissacus*, are the same. In *Mesonyx*, on the other hand, the two external cones of the upper true molars are equal in size, and the last upper tooth of this series has been lost. The known species of *Pachyæna* show no reduction of this tooth; accordingly another species remains to be discovered in which this tooth is well reduced. As already remarked, the last upper molar of *D. carnifex* is much smaller than the second, and this is what we should expect to find in an ancestor of *Mesonyx*. The presence of the metaconid in a rudimentary condition on inferior M2, and sometimes on M3 in *Dissacus*, proves that the *Dissacus* type of lower

molar has been derived from a typical tuberculo-sectorial tooth.[1] As the *Mesonyx* type of lower molar is probably a degeneration from the less specialized tooth of *Dissacus*, so we must concede this to be derived from a tooth with a well-developed trigonid. Such an ancestral type of molar is found in *Sarcothraustes*, where all the cusps of the trigonid are nearly all equally well developed, but already in this genus the superior molars are completely tritubercular, with both external cones equal in size, as in *Mesonyx*.

A comparison of the structure of the manus and pes in *Dissacus* with that of *Mesonyx* shows how closely these two genera are related. The position of the centrale in *Mesonyx* is quite different from that of *Hyænodon*, and resembles that of *Dissacus*. All the carpal elements in *Dissacus* very closely resemble those of *Mesonyx*. It is quite remarkable to find in such an early type as *Dissacus* that the manus has undergone a considerable degree of 'displacement,' as shown in the alternating articulations between podium and metapodium, indicating that *Dissacus* led up to a digitgrade type; in which there was a reduction in the number of the toes, as is observed in *Mesonyx*. The structure of the pes and the relative lengths of the bones of the hind limb to each other, demonstrate that *Dissacus* was a semiplantigrade form; nevertheless the calcaneum is much compressed and lengthened, and indicates the direction in which the foot structure of *Dissacus* was tending. The flat trochlear surface of the astragalus and the large astragalar foramen are typical of the plantigrades of the Puerco; again, as in *Pachyæna* and *Mesonyx*, *Dissacus* has the large astragalo-cuboid articulation. Summing up the changes through which the *Dissacus-Pachyæna-Mesonyx* line has passed, we emphasize the following:

1. Growth of metacone of superior molars, and reduction of the last upper molar.
2. Degeneration of the metaconid of the lower true molars, which is found well developed in *Dissacus*, and reduction of paraconid.
3. Change from the semiplantigrade condition of *Dissacus* to the digitgrade of *Mesonyx*.

[1] [See Scott, Uinta Mammalia, Trans. Am. Phil. Soc., 1889, p. 473.

Note as cases of persistence the very close resemblance in structure of the carpus in *Dissacus* and *Mesonyx*, the displacement of the metacarpus upon the carpus in *Dissacus*, and also the articulation between the astragalus and cuboid in the latter.

An undiscovered species of *Pachyæna*, closely related to the *P. ossifraga*, but with the last upper molar more reduced than in that species, formed the transition stage between *Dissacus* and *Mesonyx*.

Family PROVIVERRIDÆ *Schlosser*.

Leptictidæ COPE, in part.

Genus **Deltatherium** *Cope*.

Dentition: $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{3}{3}$, $M\frac{3}{3}$. Superior molars with external cusps removed inwards from the external cingulum. No intermediate tubercles. Protocone large and V-shaped. A postero-external trenchant surface extending from the metacone. Last inferior premolar nearly molariform in structure; true molars with trigonid high and trenchant. Inferior diastema large.

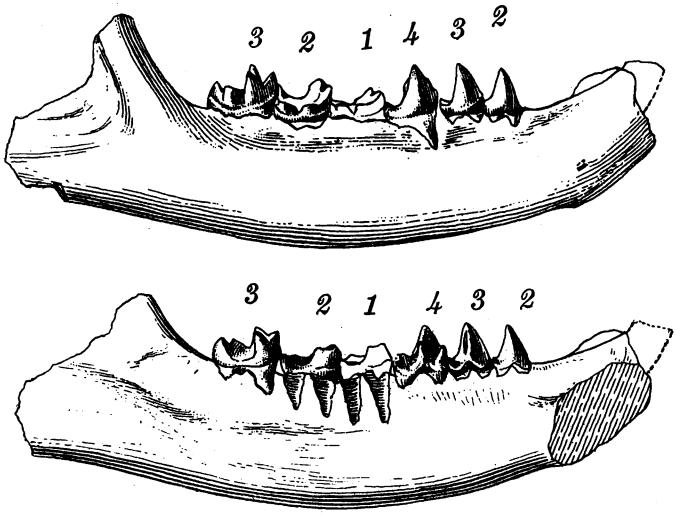


Fig. 10. *Deltatherium fundaminis*. Right lower jaw, external and internal view. Natural size.

Deltatherium fundaminis *Cope.*

This is one of the most abundant types in the Puerco, and is represented in the collection by a number of examples, the best preserved being Nos. 780, 781 and 783. It is very instructive in showing how specialized some of the Puerco Creodonts were. In fact, the high differentiation of the carnivorous mammals of this formation is surprising. *D. fundaminis* has already lost the first premolar in both jaws, and anterior to the second in the lower jaw there is a long diastema. The character of the true molars, and especially the trenchant form of the lower molars, is very different from that seen in most of the Creodonts of the Puerco.

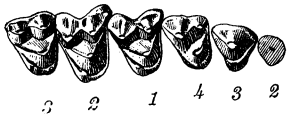


Fig. 11. *Deltatherium fundaminis.* Superior molars, crown view. Natural size.

Cope's material of *Deltatherium* is so well preserved that we are unable to add anything to his full description of this species. *Deltatherium* is closely related to the Wahsatch genus *Sinopa* (=*Stypolophus*), but is in some respects rather more specialized than that genus.

4. Order TILLODONTA.

The relationships of the heterogeneous members of this order require careful consideration which we have not yet been able to give. Cope places *Onychodectes* and *Conoryctes* with the Creodonta, but they show unmistakable affinities with *Esthonyx* and *Tillotherium*.

Genus **Onychodectes** *Cope.*

Onychodectes tissonensis *Cope.*

The collection contains a well-preserved skull and lower jaw (No. 785) of this species in which the teeth are badly worn. Another specimen (No. 786) consists of a part of the lower jaw containing the roots of all the premolars and the first two true molars.

This skull is of great importance, as it is the most complete one ever found of this type in the Puerco. The teeth agree precisely in size with the type upper molars of *O. tissonensis* Cope.

The skull is about as large as that of a small *Didelphys*. It is much lengthened between the glenoid facet and the last molar. The cranium is long and narrow, and there is no depression between the cranial and facial portions. There is a very faintly developed sagittal crest, which extends as far forwards as the

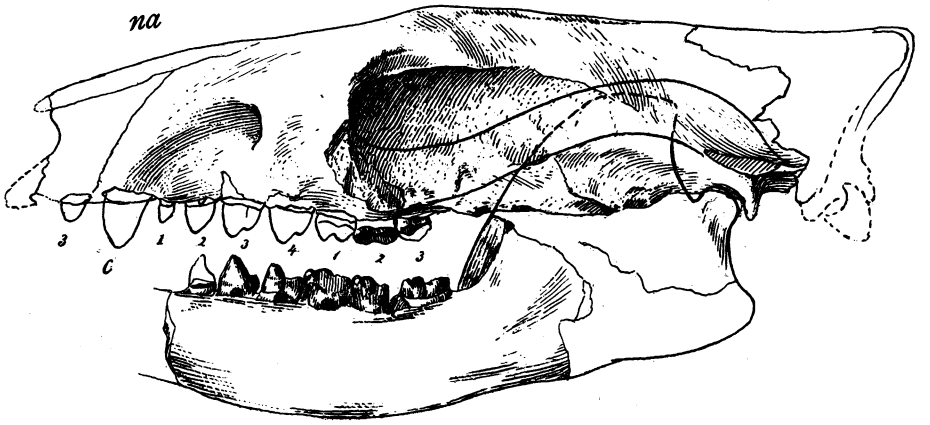


Fig. 12. *Onychodectes tissonensis.* Skull and lower jaw, side view. Natural size.

posterior boundary of the orbit. The nasals are narrow and elongate, and the anterior nares are terminal in position. The palate is long and narrow, and the palatines and pterygoids form very narrow posterior nares quite different from that of the Lemuroidea.

The upper teeth are mostly broken off. The fangs of the anterior teeth indicate that there is a well-developed incisor shortly in front of the canine; the latter tooth is laterally compressed, and the first premolar is small and single-rooted. The second and third premolars are double-rooted; the fourth premolar is three-rooted. It is evidently nearly as large as the molars. There is no preglenoid ridge. The angular region of the lower jaw is partly preserved, showing that the condyle is obliquely transverse; the coronoid is rather broad and the posterior border of the angle extends backwards. The inferior premolars are not

spaced, and the posterior members of this series are robust. These have, however, been described and figured by Professor Cope.

Onychodectes rarus, sp. nov.

A prominent external cusp on each lower true molar, placed between the outer lobes.

This new species is established upon a jaw fragment which contains two of the lower true molars (No. 824). The most striking character is the very prominent cusp which is placed upon the external side just in front of the posterior lobe. The trigonid is well raised above the talonid. The paraconid is well developed; the protoconid is relatively robust and placed at the apex of the triangle and at an equal distance between the para- and metaconids. The talonid is broad and deep and extends into a basin on the inner side. The external interlobular cusp of the second molar is smaller than that of the first; it arises from the base of the hypoconid, and is placed just opposite the convexity of the latter.

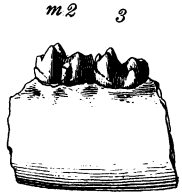


Fig. 13. *Onychodectes rarus.* Fragment of lower jaw with two true molars, external view. Natural size.

Measurements.

	M.
Length of two lower true molars.....	.015
Depth of jaw.....	.013

Psittacotherium multifragum *Cope.*

The division of the Tillodonta to which this species belongs is represented by a number of specimens, the best example of which is a nearly complete lower jaw (No. 754) associated with fragments of the skull, and with a number of teeth. Two much-worn premolar teeth are in place. As Cope has shown, the homologies of the lower cutting teeth are doubtful.

The alveoli correspond with the formula given by Cope, $I\frac{2}{2}$, $C\frac{1}{1}$, $P\frac{3}{3}$, $M\frac{3}{3}$.

The portions of the skull preserved correspond somewhat with those figured by Cope of *Hemiganus*. They represent the top of the cranium and the upper and anterior border of the orbit. The cranium is compressed above, but like *Onychodectes*, has no distinct crest; the indications are that it was very long and narrow with an extremely small brain; anteriorly the lambdoidal crests diverge very gradually instead of sharply, as in *Hemiganus*. They are very heavy and obtuse. There is no post-orbital process, and quite close in front of the orbit we observe as an exceptional feature a double infraorbital foramen.

Other specimens related to these types are Nos. 755, 756, 757, consisting mainly of fragments of teeth and of bones.

5. Order AMBLYPODA *Cope.*

This order of Ungulates includes the three suborders: Taligrada (Cope) of the Puerco; Coryphodonta (Marsh) of the Wahsatch; Dinocerata (Marsh) of the Bridger.

Suborder TALIGRADA *Cope.*

Primitive Amblypoda. Superior molars triangular, with selenoid cusps. Plantigrade. Astragalus with a distinct neck supporting navicular facet. A tibiale.

Family PANTOLAMBDIDÆ *Cope.*

Genus **Pantolambda** *Cope.*

Dentition: $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$. First upper premolar one-rooted; second, third and fourth three-rooted, with internal cones. Canines laterally compressed.

Pantolambda bathmodon *Cope.*

No diastema in the dental series.

These very primitive members of the Amblypoda are distinguished by the following characters, as observed in an unusually perfect skull (No. 964) in this collection. The dental formula

is typical; the peculiar features of the superior molars are that although they present a broad transverse triangle, the apices of the three primary cusps (protocone, paracone and metacone) are brought close together as in the *Periptychus*, while the outer wall is very broad, exhibiting a parastyle and a metastyle, both well developed, while the mesostyle is feeble; the intermediate conules are also feebly developed or absent. The third superior molar exhibits a very large parastyle, making the outer border asymmetrical and foreshadowing the oblique development of the outer wall of this tooth in *Coryphodon*. The first upper premolar is single-rooted, while the second, third and fourth each have three roots; and, although the crowns are wanting, this demonstrates the presence of a strong internal cone. The fourth premolar exhibits a single deeply crescentic external cusp (protocone) and a strong crescentic internal cone (deuterocone) with feebly marked conules. The canines are directed outwards and laterally compressed. The dental series is continuous, as in the type of this species, while in the larger species, *P. cavirictus*, there is a considerable diastema behind the canines.

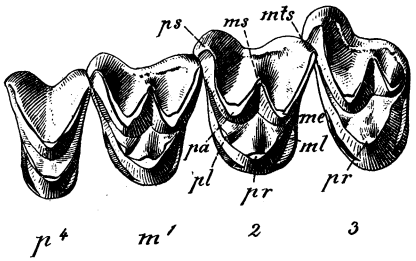


Fig. 14. *Pantolambda bathmodon*. Crown view of superior molars. Natural size.

The skull is of a very ancient type, exhibiting the following primitive characters: The anterior nares are terminal in position; the front border of the maxilla descends vertically, and the premaxilla, which is broken away in these specimens, was apparently short. The cranium is twice as long as the face; the brain-case proper is low and broad transversely; it is surmounted by a sharp sagittal crest and flanked posteriorly by lateral occipital crests; the occiput is, therefore, very broad and low, as in *Periptychus*, in lateral view. We observe that the zygomatic arches are very slender, and there is a wide space between the postglenoid process and the posttympanic. The posttympanic and paramastoid processes are confluent and very sessile. The basal view of

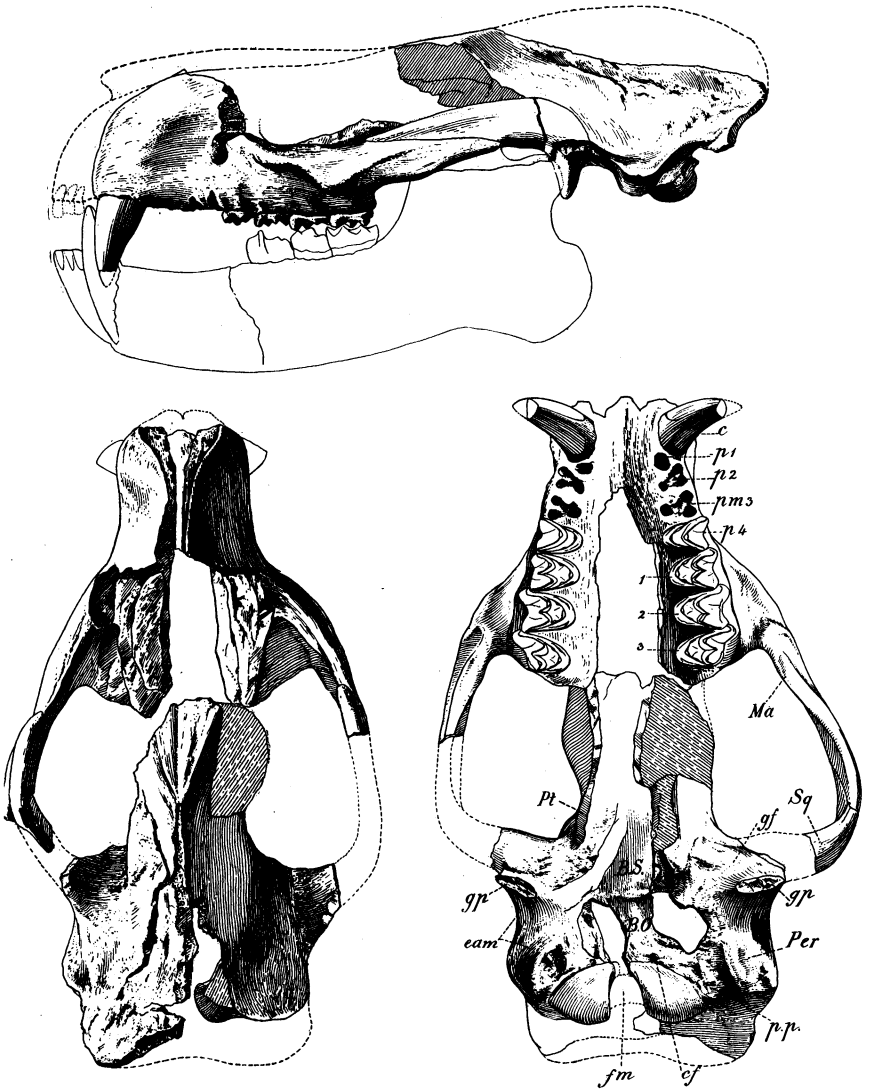


Fig. 15. *Pantolambda bathmodon.* Skull: lateral, dorsal and ventral view. One-third natural size.

the skull shows that the pterygoids are extended very far back. The postglenoid processes are very small; in fact, this view brings out well the simple and undifferentiated character of the base of the skull.

The posterior border of the lower jaw descends vertically behind the condyle, as seen in specimen No. 962, which probably belongs to this species. The scapula (No. 964) exhibits a shallow glenoid cavity, close above which is the base of the spine; the neck, therefore, is extremely short; there is a long coracoid process recurved distally.

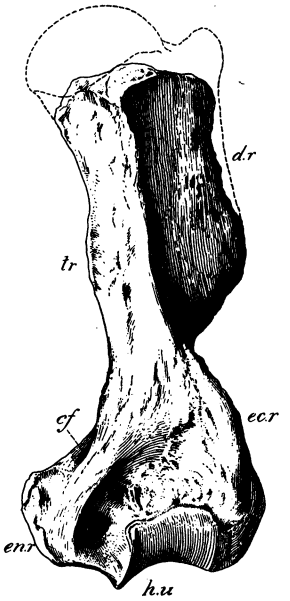


Fig. 16. *Pantolambda bathmodon.* Left humerus, posterior view. One-third natural size.

The humerus is massive; it is characterized by a very large and prominent deltoid crest, which extends below the middle of the shaft; on the inner surface of the shaft is a slightly prominent crest for the flexor muscles; there is a large entepicondyle perforated by a foramen, and upon the outer side of the distal extremity there is an acute ridge which we observe is not developed in *Periptychus*; distally the humeral condyles do not display any intertrochlear ridge. The ulna is placed entirely behind the radius; its proximal section is deep anteriorly; posteriorly the radius is preserved, but is so much damaged that its characters cannot be made out.

6. Order CONDYLARTHRA *Cope.*

Dentition bunodont. Manus and pes pentadactyl. Elements of carpus and tarsus serially arranged. Humerus with an entepicondylar foramen. Femur with a third trochanter.

The suborder Condylarthra was established by Cope[1] to include the genus *Phenacodus*. At that time he considered this genus to be a Perissodactyle, and placed the Perissodactyle group as an order, including the suborders Diplarthra and Condylarthra. Later[2] he proposed the order Taxeopoda, to include the Proboscidea and Condylarthra, but in his paper 'On the Classification of the Ungulate Mammalia,'[3] removed the Proboscidea from the Taxeopoda and gave it an ordinal position; in the same paper Cope included under the Taxeopoda the suborders Condylarthra and Hyracoidea.

Doubtful Position of the Periptychidæ.

In the present state of our knowledge it is difficult to say what forms should be included in the Condylarthra. If we adhere strictly to the diagnosis of this group laid down by Cope, we should have to omit the Periptychidæ from this suborder, because in the genus *Periptychus the tarsus is not serial;* there is a displacement of the astragalus upon the cuboid, and the whole structure and angulation of the hind foot is different from that of the type genus *Phenacodus*. *Periptychus* is quite as closely related in its pes to the Amblypoda as to the Condylarthra. *Periptychus* has the simple bunodont dentition of the Condylarthra, but it has the strictly trigonal molar of the Amblypoda.

The most specialized family of Cope's Condylarthra is the Meniscotheriidæ. Osborn[4] has shown that this is analogous to *Chalicotherium* in Cope's Ancylopoda. It thus appears possible that the Periptychidæ and Meniscotheriidæ must ultimately be

[1] Am. Nat., 1881, p. 1018.
[2] Am. Nat., June, 1882.
[3] Proc. Am. Phil. Soc., 1882, p. 438.
[4] Am. Nat., 1892, p. 507.

removed from the Condylarthra, and that the Condylarthra may ultimately include only the stem forms of the Artiodactyla and the Perissodactyla.

At present we enlarge the order by adding to it certain forms which Cope has placed among the Creodonta; we thus transfer the genus *Mioclænus* and family Mioclænidæ. We agree with Schlosser and Scott that the structure of the teeth in this genus shows it to be more closely related to primitive Ungulates than to any of the Creodonts.

The following table will illustrate the arrangement and subdivisions of the Condylarthra proposed in this paper.

Family MIOCLÆNIDÆ, fam. nov.

Genus **Mioclænus** *Cope.*

Dentition: ?I, $C\frac{1}{1}$, $P\frac{1}{4}$, $M\frac{3}{3}$. Third and fourth superior premolars with single internal cones. Superior true molars tritubercular, with hypocone very rudimentary. Last upper and lower molars reduced. Inferior premolars much enlarged and very simple in structure. Inferior true molars without paraconid.

The genus *Mioclænus* was established by Cope,[1] the type species being *M. turgidus*. At the time of the description of this genus Cope considered it closely related to *Euprotogonia* (=*Protogonia*) and in his divisions[2] of the Condylarthra in 1881 placed *Mioclænus* in the family Phenacodontidæ. Later[3] he omitted this genus from the latter family, saying: "I believe it to be Artiodactyle."

Upon the discovery of the structure of the skeleton of *Mioclænus ferox* Cope associated this species with *M. turgidus*, and referred both species to the Creodonta. The *M. ferox* has since been raised to generic rank by Scott as the type of *Clænodon*.

Cope in his 'Tertiary Vertebrata,' and later in his 'Synopsis of the Puerco Series,' included a great many other species under the genus *Mioclænus*, but Scott[4] in his paper 'A Revision of the

[1] Proc. Am. Phil. Soc., Sept. 17, 1881, p. 489.
[2] Am. Nat., 1881, p. 1018.
[3] Proc. Am. Phil. Soc., Dec. 16, 1881.
[4] Proc. Acad. Nat. Sci., Phil., 1892, p. 321.

CONDYLARTHRA.

A.—With bunodont upper and lower molars.			*B.*—With buno-selenodont upper, and lopho-selenodont lower molars.
1. *Mioclænidæ.*	2. *Periptychidæ.*	3. *Phenacodontidæ.*	4. *Meniscotheriidæ.*
Molars and premolars similar to the *Periptychidæ* in plan. Molars lacking supplementary internal cusps; premolars lacking heels. Skeleton unknown.	Primitive triangle compressed in superior molars. Molars with triangular symmetry, never quadrate. Supplementary internal cingules (protostyle and hypocone). Third and fourth upper and lower molars enlarged. Inferior premolars with heels. Ulna upon anterior face of humeral trochlea. Astragalus flat, perforated.	Primitive triangle broad. Upper molars quadrate. Transformation of premolars as in Perissodactyla. Ulna only upon posterior face of humerus. Astragalus grooved, imperforate. No fibulo-calcaneal facet. Manus and pes digitigrade.	Primitive triangle broad. Upper molars with external crescents and internal tubercles. Lower molars crested. Transformation of premolars as in Perissodactyla. Astragalus perforated. A fibulo-calcaneal facet. Pes semi-plantigrade.

Creodonta,' has removed many of the species to a distinct generic position. He says of *Mioclænus:* "The name *Mioclænus* should be restricted to those forms which agree with the type species *M. turgidus* in the extremely broad, low and massive premolars, which equal or exceed the molars in size," etc.; and later remarks, "If, as Schlosser has suggested, it becomes necessary to refer *Mioclænus* to that group [Condylarthra], it will form a very distinct family of that order."

Mioclænus turgidus *Cope.*

First superior true molar with a rudiment of a hypocone. Last superior and inferior true molars reduced in size. Inferior true molars without a postero-internal cone (entoconid). First inferior premolar spaced.

There are numerous fragmentary specimens (Nos. 921–936, 938, 939) of this species in the collection, the best preserved being Nos. 930, 921, 922, 933. These specimens together illustrate the structure of the greater part of the dental series. Associated with No. 921 are fragments of the skeleton, especially a well-preserved sacrum.

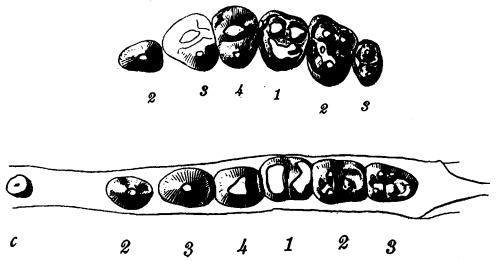


Fig. 17. *Mioclænus turgidus.* Superior and inferior molars. Crown view. Natural size. (No. 921.)

Dentition.—The second superior premolar consists of a single cone, without heels. The third and fourth have well-developed internal cones, which are single. These teeth have no intermediate tubercles. In the specimen under description (No. 921) there is a large diastema in front of the first superior premolar, but whether this interval is natural or not remains to be determined from better material. The superior true molars are very primitive in their characters, more so than in any of the known

Condylarthra ; the first molar presents rudiments of the parastyle and mesostyle on the outer wall ; the molars have well-developed intermediate tubercles, and only on the first is there a trace of a hypocone. The third true molar is much reduced in size, and the second is larger than the first. The reduction of M3 is against the Condylarth affinities.

The shape of the inferior premolars is highly characteristic; the first is not preserved, although an impression of its crown is left on the specimen ; it was simple in structure and isolated from the small canine in front, and also from the second premolar behind. The second, third and fourth premolars have much enlarged and swollen crowns, with only slight indications of posterior heels and with no trace of a deuteroconid ; the third and fourth present rudimentary anterior and posterior basal cusps. The inferior true molars closely resemble those of *Euprotogonia* ;[1] the crowns are very low, broad ; and the trigonid is somewhat raised above the talonid. In Cope's description of the dentition of *M. turgidus* he describes a trace of a paraconid on the first and second molars. In the American Museum specimens of this species the second true molar has a trace of a paraconid, and this tooth, as well as the third molar, exhibits no entoconid.

The sacrum is broad and short, its antero-posterior and transverse diameters being about equal. In its general characters it closely resembles that of *Oreodon.* The neural spine and prezygapophyses are low. In contrast with the sacrum of the Carnivora we notice the position of the sacro-iliac attachment ; it is elongated, narrow and parallel with the antero-posterior axis of the sacrum. The surface for articulation with the ilium is confined to the transverse process of the first sacral vertebra, as in the Ungulata in general.

Systematic Position of Mioclænus.

The most striking character of the dentition of *Mioclænus turgidus* which points to its relationship to the Periptychidæ is the enlargement of the lower premolars. The absolutely tritubercular superior molars, without a hypocone, except on M1, prove this

[1] Am. Nat., April, 1893.

form to be the simplest and most primitive type in its tooth structure of any of the known Condylarthra. A specialization in this genus—a character not anticipated in so old a type—is the probable presence of a *diastema* in the dentition; this is an unusual character for any Puerco Ungulate to exhibit. One of the Creodonta (*Deltatherium*) of this formation is also quite specialized in this respect.

The discovery of fragments of the skeleton of *Mioclænus turgidus* is of great importance, and a well-preserved sacrum, already described, adds much weight to the theory of the ungulate affinity of this genus.

M. Pavlow[1] has suggested that *M. turgidus* is an intermediate form between *Periptychus rhabdodon* and *Anisonchus sectorius*. It appears rather that *Mioclænus* is much more primitive in its dental characters than *Periptychus*, and should be placed below that genus structurally. As *M. turgidus* is rather an unspecialized type in its dentition, it is possible that it may have been one of the few types of the Puerco which persisted in later periods, and Earle[2] has suggested elsewhere that this genus may stand in ancestral relationship to some of the White River bunodont Artiodactyles, such as *Leptochœrus*.

Family PERIPTYCHIDÆ *Cope*.

It is convenient to divide this into two subfamilies: 1. *Anisonchinæ*, to include the smaller and more primitive forms; 2. *Periptychinæ*, to include the larger and more specialized forms.

1. *Anisonchinæ*.

Smaller forms. Superior molars with intermediate tubercles (conules) suppressed or wanting. Inferior molars with paraconid reduced or wanting. ? Astragalus with elongate neck.

2. *Periptychinæ*.

Larger forms. Superior molars with conules well developed. Inferior molars with paraconid well developed. Astragalus with a short neck.

[1] Études sur l'Histoire palæontologique des Ungulés, Bull. de la Société Imp. des Naturalistes de Moscou, 1887. p. 19.

[2] Science, July 28, 1893, p. 51.

Subfamily PERIPTYCHINÆ.

Genus **Periptychus** *Cope.*

Dentition: $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$. Teeth vertically sculptured. Protocone of superior premolars much elongated and recurved. Last three superior premolars with crescentoid internal lobes. Superior true molars with supplementary internal cusps well developed. Inferior true molars with paraconid.

Periptychus rhabdodon *Cope.*

Superior true molars as broad as long, and provided with two intermediate tubercles; third not reduced in size. Superior premolars much enlarged, and with internal cusps uniting into a continuous internal crescent. All the teeth strongly sculptured.

A large number of specimens (Nos. 854–878) represent this species in the collection. The dentition of *P. rhabdodon* has been fully described by Cope.

The best example of part of a skeleton in the collection is a hind limb with a well-preserved calcaneum and astragalus (No. 837). The *femur* is short and rather stout, the third trochanter is placed slightly above the middle of the shaft. The crest of the *tibia* is very prominent and extends far down upon the shaft; the distal articular end of the tibia faces obliquely outwards, and is nearly plane; there is a slight ridge dividing the internal from the external trochlea; the internal malleolus is very prominent and peculiar in form; it is strongly grooved for a flexor tendon.

The *fibula* is well preserved; it is a short and heavy bone. The proximal extremity is flattened and expanded, and it exhibits a concave facet for articulation with the tibia; externally this end has a prominent rugose process; the shaft at its middle part is oval in section, and its anterior face is separated longitudinally by a ridge; the distal extremity is much enlarged and presents a very plane (articular) surface for the astragalus; the external malleolar tuberosity is strongly marked, and is nearly as prominent as in the Bear. As compared with that of *Ursus*, the fibula of *P. rhabdodon*, in contrast with the size of the tibia, is much larger, and its shaft is thicker.

There are two astragali of *P. rhabdodon* in the collection, and in both there is a plainly marked *astragalar foramen*; this aperture is situated well toward the median trochlear surface, and commences just at the posterior limit of the articular face. The presence of this foramen in *Periptychus* is a constant character, and in this respect it differs much from the genus *Coryphodon*, in which it is variable; in both these genera the foramen has the same position, namely, between the ectal and sustentacular facets. We doubt whether it transmitted a flexor tendon, as it is not clear how a tendon could traverse this foramen and then pass outwards under the sustentaculum; it is more likely that this foramen transmitted a blood vessel or a nerve. We are not aware that it exists in any recent Ungulate, yet it is a constant character of all Puerco forms, and a vestige of it has been observed by Wortman in the pinniped Carnivora.

Measurements of bones of Hind Limb.

	M.
Length of femur	.163
Width of same proximally	.046
Length of tibia	.140
Breadth distally	.027
Length of fibula	.124
Breadth distally	.016
Total length of limb, allowing for ankle flexure,	.280

Periptychus coarctatus *Cope.*

Internal cingulum of inferior premolars discontinuous. Superior premolars with great transverse extent. Intermediate tubercles present on true molars. Superior and inferior true molars with external cingulum.

The *P. coarctatus* is represented in the American Museum collection by the greater part of the upper and lower dentition of one individual (No. 850). This species is a decidedly smaller type than *P. rhabdodon.* The upper true molars are nearly the size of those of *P. brabensis*, but their transverse diameter is greater; the inferior premolars on the other hand, are relatively enlarged in *P. coarctatus.*

Dentition.—The last superior premolar has a greater transverse extent than the first true molar; yet the superior true molars are also much extended transversely, their external cones are small

and considerably raised above the surface of the teeth. The intermediate tubercles are well developed in this species, and the last true molar as compared with the first and second is relatively much smaller than in *P. rhabdodon.* The inferior premolars are smaller than those of *P. rhabdodon,* in which the anterior and posterior tubercles are weakly developed. The first upper true molar is larger than the others, and its protoconule is more robust than in the allied species. The last lower molar is small, and the three cusps of the talon are more distinct than in *P. rhabdodon.*

Measurements of teeth of P. coarctatus.

	M.
Length of last four upper molars	.032
Length of superior true molars	.022
Length of inferior premolars	.040
Length of inferior true molars	.028

Periptychus brabensis *Cope.*

Cingula of inferior premolars discontinuous. Transverse diameter of superior premolars less than that of true molars. Superior and inferior true molars with external cingula reduced or wanting; intermediate tubercles of superior true molars wanting.

There is only one specimen of this species in the American Museum collection (No. 849). This contains the greater part of the lower dentition and some of the upper molars.

The external face of the molars in both jaws is only slightly sculptured. The first superior molar is triangular in outline, with protocone smaller than in the second. The second *superior molar* is well preserved, and is of a square form; as compared with other species this tooth is considerably modified; the protocone, instead of being a simple tubercle, as in the *P. brabensis,* is a crescent, and the intermediate tubercles are fused with its anterior and posterior spurs; both the internal supplementary cusps are relatively more developed than in the large *P. rhabdodon.* The last superior molar is not reduced in size as in the *P. coarctatus.* The transverse diameters of the last upper premolar and first true molar are about equal.

The last two *inferior premolars* are much elongated antero-posteriorly, with a small transverse diameter; the anterior and posterior heels are prominent but not continuous internally. The

second *inferior molar* is smaller than the first, and in this respect the *P. brabensis* differs from the *P. rhabdodon;* the paraconids of the lower molars are not so distinct as in the last-named species. A single *incisor* is preserved with this specimen, which probably belongs to the lower series; the crown is strongly compressed, with a slightly *enlarged* posterior heel.

Genus **Ectoconus** *Cope.*

Dentition: $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$. Last three superior premolars with internal crescents; third and fourth sub-molariform. Superior molars consisting of seven cusps and two external cingular cusps. Last inferior premolar with cusps of trigonid well developed. Inferior molars sextubercular, with an antero-internal accessory cusp; internal to paraconid.

Ectoconus ditrigonus *Cope.*

Superior and inferior true molars with a strong external cingulum. Last superior molar nearly as large as first. Postero-external cingular cusp of superior true molars opposite metacone.

This species was first referred by Prof. Cope[1] to *Conoryctes*, but was later[2] established as the type of *Ectoconus*. The dentition (Nos. 880–888) has been only partially described by Cope, and our abundant material enables us to complete his account. The superior incisors are of a simple conical form, and increase in size from within outwards; their position is peculiar, as they are separated by an interval from each other. The finest specimen of *Ectoconus* in the collection is No. 880; in this both upper and lower teeth are from the same individuual; the upper canine was large, as is shown by the basal part of the crown, which is preserved; the single alveolus for the first superior premolar is intact, and this tooth probably had a simple crown; it is slightly separated from the canine and the premolar succeeding it.

The *premolars* of *E. ditrigonus* differ very much in their pattern from those of *Periptychus*. The last three superior premolars have one external cone, and this is not elongated or sculptured; the internal lobes of these teeth are crescentoid, and in the last

[1] Am. Nat., 1883, p. 968.
[2] Am. Nat., 1884, p. 796.

two of the series they early unite by wear with the two intermediate tubercles, thus presenting a crescentoid tract of worn enamel. The last upper premolar is a much smaller tooth than the first true molar. A marked characteristic of this genus is that the third and fourth premolars remotely repeat the molar pattern, whereas in *Periptychus* they are wholly dissimilar.

The *molars* are rectangular in form and are much drawn out transversely; they therefore differ in shape decidedly from those of the allied genus *Periptychus*. The large number of cusps is the most distinctive character. In strong contrast to other Puerco Ungulates, the upper molars of *Ectoconus* have an external cingular cusp placed just outside of the metacone, and whether it is homologous with the median (mesostyle) or the posterior cingular cusp (metastyle) of higher forms, it is difficult to say. In some examples of this species there are two cingular cusps on the second superior molar, one behind the other. The protocone of the molars is large and soon unites by wear with the intermediate tubercles; these conules are larger than in *Periptychus*, especially the protoconule. The two internal supplementary cusps (protostyle and hypocone) are well developed, and arise from larger cingula than in *Periptychus*. The last superior molar of *E. ditrigonus* is nearly as large as the second, and is provided with two well-developed external cones; the paracone is connected with the external cingulum by an oblique ridge. In all the superior molars of this species the antero-external part of the basal cingulum is prominent, and on the last upper molar forms a very distinct cusp.

The inferior molars are much crowded together, and there is no diastema between the canine and the first premolar (No. 880); this tooth is absent in the specimen under description, but represented by a small alveolus placed close to the second premolar. In Cope's specimen of *E. ditrigonus* the second inferior premolar has a small internal cusp; on the third premolar this cusp is also present, and the two cusps of the talon are fully developed. The last inferior premolar (see No. 890) is quite complex in structure for so early a type; it exhibits the three principal cusps of the trigonid, but the postero-internal cusp is absent. The complex sub-molariform structure of the posterior and lower premolars in

Ectoconus is to be noted in contrast with *Periptychus*. In No. 890 the fourth premolar is very similar to the first molar. The inferior true molars are broad, with a low and indifferent arrangement of the cusps; the protoconid is on a line with the paraconid, and not placed opposite the interval between the two internal cusps as in *Periptychus*. The specimen, No. 880, in the collection exhibits a well-marked cusp on the second and third inferior true molars just within the paraconid; this cusp is not present in *Periptychus*. The last lower molar is considerably extended antero-posteriorly, and the hypoconid is placed far forward like that of *Periptychus*. The hypoconulid is very large on this tooth, much larger even than the entoconid.

Measurements of Teeth of Ectoconus.

	M.
Total length of superior molars	.062
Length of superior premolars	.033
Length of superior true molars	.029
Total length of inferior molars	.064
Length of inferior premolars	.030
Length of inferior molars	.034

Humerus.—Near the upper and lower jaws (No. 888) was found a large humerus from the left side, which may belong to this species, although the association is somewhat doubtful. It measures slightly over 150 mm. in length. It is robust, with much more prominent crests for the deltoid and supinator muscles than are seen in *Periptychus*. The latter or ectepicondylar ridge is exceptionally prominent and is carried over upon the front face of the shaft as in fossorial animals, and differing from both *Periptychus* and *Pantolambda*.

Subfamily ANISONCHINÆ.

Genus **Haploconus** *Cope.*

Dentition: $I\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$. Fourth superior premolar only with an internal cone. Superior molars with protocone crescentoid in form; no distinct intermediate tubercles; no anterior supplementary cusps (protostyle). Last three inferior premolars with heels; no internal cusps. Inferior molars without paraconid.

The genus *Haploconus* is readily distinguished from the three others of this subfamily: (1) By the absence of a deuterocone on the third superior premolars; (2) the development of the hypocone is less advanced than in the genus *Anisonchus*, but more so than in *Hemithlæus;* (3) the inferior premolars of *Haploconus* are elongated, whereas in *Hemithlæus* (*H. apiculatus*) they are considerably enlarged, more resembling those of *Mioclænus.*

Haploconus lineatus *Cope.*

Fourth superior premolar enlarged; fourth superior premolar spaced with internal cone crescentoid. Hypocone of superior molars larger than anterior supplementary cusp (protostyle). Third and fourth inferior premolars somewhat elongated and trenchant.

The characters of the lower premolars in this species are closely related to those of *Anisonchus mandibularis*, although Cope states that in the last-named species the third superior premolar has an internal lobe, which places it in *Anisonchus.*

The best specimen (No. 891) in the collection of *H. lineatus* is a set of superior molars, associated with the fragmentary remains of a part of a skeleton. The structure of the skeleton in *Haploconus* has been until the present time totally unknown, and we are happy to be able to give some information as to it. Many broken fragments of the long bones are associated; they are long and slender, and their general proportions are as in the limbs of *Lemur varius.* A distal extremity of a humerus exhibits a well-marked entepicondylar foramen. A proximal part of an ulna exhibits an olecranon process which is long, slender and strongly compressed; the coronoid process is short and does not extend as far forward as in Ungulates; the two divisions of the sigmoid cavity are unequal in size as in the Carnivora, and lastly, the ulno-radial facet is small and limited to one side as in the Carnivora. The most interesting bones are, however, part of a calcaneum and an astragalus. The proximal portion of the *calcaneum* is high and narrow, the ectal facet is raised high above the sustentaculum; this latter facet is round and oblique in position. The *astragalus* differs widely in its characters from that of *Periptychus;* the trochlear surface is nearly plane, there being only a

slight median depression; a large astragalar foramen perforates this bone at the posterior limit of the articular surface; unfortunately the navicular facet is missing, but enough remains of the base of the neck to show that the latter was slender and elongated, in marked contrast with the short neck in *Periptychus.*

We conclude from these characters of the skeleton that *Haploconus lineatus* was an exceedingly slender type, with elongated limbs, probably adapted for an arboreal life. These characters are also radically different from those of the heavy-limbed plantigrade *Periptychus*, which has hitherto been supposed to be closely related to *Haploconus* when judged by the teeth alone.

Genus **Hemithlæus** *Cope.*

Dentition: $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$. Third and fourth superior premolars with single internal cones; protocones of superior molars crescentoid; supplementary cusps (protostyle and hypocone) of equal size. Inferior premolars with enlarged protoconids; deuteroconid variable. Paraconid reduced in molars.

Hemithlæus kowalevskianus *Cope.*

Anterior and posterior cingula of upper molars slightly produced into supplementary internal cusps; third upper molar much reduced in size. Third and fourth inferior premolars conic and not larger antero-posteriorly than true molars, and without anterior tubercles; heels small.

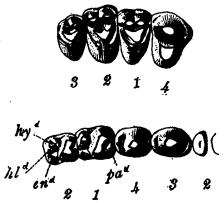


Fig. 18. *Hemithlæus kowalevskianus.* Crown view of superior and inferior molars. Natural size.

This species is represented in the collection by a fine set of upper and lower true molars, with part of the premolar series (No. 900). This species is smaller than *H. apiculatus*, and its inferior premolars are simpler in structure and slightly enlarged, although less so than in *Mioclænus turgidus.*

Genus **Anisonchus** *Cope.*

Last two superior premolars with internal cones. Superior molars quadrate in form, with a large development of the hypocone. Inferior premolars much elongated antero-posteriorly, with the third longer than the last. Paraconids of inferior true molars present but reduced.

Anisonchus is the most highly developed member of the subfamily, and the superior molars of this genus are transitional in structure between the tritubercular and quadritubercular forms. The hypocone is largely developed and extends inwards beyond the protocone. The inner cones of the upper premolars are crescentoid in section. The structure of the superior true molars in *Anisonchus* is more advanced than in the allied genus *Hemithlæus*. We believe the latter generic name should be retained.

Anisonchus mandibularis *Cope.*

Third inferior premolar much elongated antero-posteriorly. Hypocone of superior molars more extended inwards than in *A. sectorius*.

A number of mandibuli represent this species in the collection (Nos. 893, 894, 895 and 896). It is uncertain whether the *A. mandibularis* is fully distinct from *A. sectorius*, as in both species the third inferior premolar is elongated. A mandible in the collection (No. 896) has the entire inferior dental series finely preserved; the canine is long and slender; it is convex externally and concave internally. The canine is separated by a diastema from the first premolar, which in turn is also some distance from the second. The first premolar is a very minute tooth, and is much smaller than the second.

The following specimens belonging to members of the Anisonchinæ have not yet been determined, owing to their fragmentary characters: Nos. 893, 897, 903, 904, 907, 917.

Relationships of the genera of the Periptychidæ.

The question of the relationship between the different genera of the Periptychidæ is a difficult one to decide. In most cases we know very little about the skeleton of these forms, and therefore must depend upon dental characters to establish their affinities.

Mioclænidæ.—As we have already attempted to show, we consider *Mioclænus turgidus* more closely related to the Periptychidæ than to any of the Creodonta. The characters of the teeth show it to be the most primitive member of the suborder. The

superior true molars in *M. turgidus* are simpler in structure than in most of the genera of the Periptychidæ ; they are tritubercular without any internal supplementary cusps ; the external cones are low and conical, and the intermediate tubercles are well developed. The last two superior premolars have one internal and one external cone ; by the presence of an internal cone to superior Pm. 3, *M. turgidus* is more advanced in this single character than *Haploconus*, otherwise we must consider it to be a more primitive form than the latter genus. The lower premolars in *M. turgidus* are very simple in structure and much less complicated than those of *Haploconus*, approaching in their structure those of *Hemithlæus*. The inferior true molars of *Mioclænus* also remind us of *Euprotogonia*.

Anisonchinæ.—In this family there are ten or twelve distinct species, partly representing different lines of descent and partly different stages of evolution in the same line. It is evident that this evolution and divergence represents a long period of time, but unfortunately we have few data as to the vertical distribution of species.

Cope has unfortunately made the *successive addition of internal cones to the premolars* the sole basis of his generic definitions—by analogy with other groups this merely indicates *successive modification in time* of animals perhaps belonging to different phyla. The true key to the separation of the phyla is not this character chosen by Cope, but the *rounded or flattened form of the upper and lower premolars*. Taking this key, we discover two sharply defined series, as follows : Series A.—In which the lower premolars are flattened and develop anterior basal cusps, while the upper premolars exhibit *crescentic* internal cones. Series B.—In which the lower premolars are *rounded* and never develop anterior cusps, while the upper premolars exhibit *conic* internal cones. The natural inference is that these two series represent two distinct or divergent lines of descent, and that the parallel successive stages of modification in time are indicated by the gradual addition of secondary cusps upon the premolars and molars. A reclassification of Cope's species on this basis would greatly simplify our conceptions, but would introduce endless confusion in the nomenclature.

A. [Related to *Periptychus.*]			*B.* [Related to *Ectoconus.*]	
Premolars to which cusps are added.		Lower premolars flattened. Internal cusps of upper premolars crescentic.	Lower premolars rounded. Internal cusps of upper premolars conic.	Upper molars; number of internal cusps.
Upper.	Lower.			
P3–4	P2–4	Hemithlæus apiculatus; H. corniculatus.	H. kowalevskianus.	2
"	"	Anisonchus gillianus.		1
"	P3–4	" sectorius....	A. coniferus.	1
"	"	" mandibularis.		1
P4	P4	Haploconus xiphodon...	H. cophater. H. entoconus.	1
"	0	" lineatus.		

The vertical lines of species as here arranged do not imply phyletic descent, for it is noteworthy that the species of *Haploconus* (otherwise the most primitive) usually lack the paraconid in the lower molars, while the species of *Anisonchus* and *Hemithlæus* (otherwise more specialized) usually exhibit the paraconid, which is always to be considered a primitive mark. The table does illustrate the parallel transformation of species in different phyla both in the addition of internal cones to the premolars and of internal styles to the molars. The species of Series A are evidently most nearly related to the still more highly Periptychinæ, for *Hemithlæus apiculatus*, with the addition of an internal crescent to the second upper premolar, would closely resemble a miniature *Periptychus*. On the other hand, the species of Series B are related to *Ectoconus*. Thus, Series A represents one line, Series B a second line, and *Zetodon* a third.

Relationship of the Periptychidæ to other Groups.

It is probable that none of the known genera of the Periptychidæ, with the possible exception of *Mioclænus turgidus*, persisted into higher types. This is indicated in *Periptychus* by the peculiar specialization of its premolars, and if this genus is related to any Wahsatch group it is to the Amblypoda. We do not agree with Schlosser in deriving any of the Artiodactyla from the Anisonchinæ, which were already somewhat specialized in their structure, and were probably adapted for an arboreal life, repre-

senting in the differentiation of the Puerco fauna the small and agile climbers. As Earle[1] has shown elsewhere, it is probable that in the Puerco we have a stem form of the Artiodactyla in *Protogonodon*, a genus which was more closely related to *Euprotogonia* than to any of the Periptychidæ.

Family PHENACODONTIDÆ.

Genus **Euprotogonia** *Cope.*

Protogonia COPE.

Last superior premolar with only one well-developed external cone, tritocone rudimentary. Superior true molars sextubercular, and without parastyle or mesostyle. Last lower premolar with deuteroconid and paraconid; talon large. Inferior true molars generally quadritubercular, with hypoconulid.

Cope[2] has only recently substituted the name *Euprotogonia* for *Protogonia*. The type species is *E. subquadrata*;[3] this differs considerably in the structure of its upper molars from *E. puercensis*. Cope[4] in his revision of the species of *Euprotogonia* has omitted the type species. In the type species the section of the external cusps of the upper true molars is lenticular, and the hypocone is very rudimentary. We therefore consider the type form nearer to *Mioclænus* than to *Euprotogonia*.

The most common form of this genus from the Puerco is the *E. puercensis*, and it illustrates the characters of the teeth in this genus. The tritocone, or second external cusp, on the fourth superior premolar is variable, but in *E. puercensis* this cusp is small and well defined. The most important generic characters distinguishing *Euprotogonia* from *Phenacodus* are the conic form of the external and internal molar cusps, and the absence of the cingular cusps. The latter are always present in *Phenacodus*, but the species of this genus do not always exhibit both anterior and median cingular cusps. The last inferior premolars in *Euprotogonia* and *Phenacodus* are similar in structure; in the former the metaconid is less separate from the paraconid than in the latter.

[1] Am. Nat., April, 1893, p. 377.
[2] Am. Nat., 1893, p. 378.
[3] Proc. Am. Phil. Soc., 1881, p. 492.
[4] Synopsis of the Vertebrata of the Puerco Series, Proc. Am. Phil. Soc., p. 359, 1888.

In *E. puercensis* the inferior true molars are quadritubercular, and there is no paraconid. In *E. plicifera* this cusp is present, as described by Cope. Comparing the development of the inferior crescents in *Euprotogonia* with *Phenacodus*, we observe that in the former genus they are fully as well marked as in the latter.

Euprotogonia puercensis *Cope.*

Last superior premolar with a small tritocone. Superior true molars with hypocone smaller than protocone. Inferior true molars lacking the paraconid.

This species is represented in the American Museum collection by a number of specimens (Nos. 940–947); the most perfectly preserved is No. 941, in which both upper and lower teeth are from the same individual.

Dentition.—As shown by Cope, the characters of the upper true molars of *E. puercensis* approach more closely those of *Phenacodus wortmani* than of *P. primævus*. It appears that if we confine ourselves to the premolars in separating *Euprotogonia* from *Phenacodus*, there are no distinct lines between the two ; the case with the true molars is different. In *P. primævus* the external lobes of the superior molars are distinctly flattened, and there is a well-marked parastyle and mesostyle. The external lobes of the upper molars of *Phenacodus wortmani* are conical and closely resemble those of *E. puercensis*. The last inferior premolar in the latter is as complex as in *Phenacodus*, the two posterior cusps of the trigonid being equal in size, and the talon having the same structure. It is of importance phylogenetically to recognize the rather complex structure of this tooth in *Euprotogonia* as a Perissodactyl ancestral type, because in *Protogonodon*, a supposed Artiodactyl ancestor, the last inferior premolar is simple.

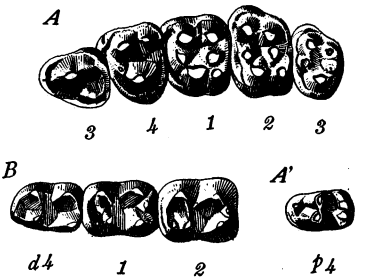


Fig. 19. *Euprotogonia puercensis*. *A*, Crown view of superior molars. *A* 1, Last inferior premolar, and *B* first two inferior true molars and last milk molar. *A* and *A* 1, are from the same individual. Natural size.

Affinities of Euprotogonia.

First: it is remarkable that the grinding teeth of *E. puercensis* agree precisely in size and in almost every detail of structure with those of *Hyracotherium vulpiceps* Owen,[1] from the London Clay. The latter is only a shade more modernized. This strongly confirms Schlosser's supposition that this species is a direct ancestor of the Equidæ. Second: it is significant that this genus is the only one known from the Puerco which has a well-developed sextubercular superior molar. In some of the Periptychidæ (*Anisonchus*) the hypocone is large, but the intermediate tubercles are absent. In *Euprotogonia* we have a form which, as far as our discoveries have progressed in reference to the Puerco fauna, may be considered ancestral to all the Wahsatch Condylarths and Perissodactyls. Dr. Schlosser[2] has gone further and singled this out as the *sole* ancestor in the Puerco of the true Equine line, but in such an early geological period it is not possible to determine whether *Euprotogonia* may not also have been the ancestor of the Phenacodontidæ.

We may suppose that the feet of *Euprotogonia* were semi-plantigrade and provided with five well-developed digits, the elements of the podium being serially arranged; while turning to the Wahsatch *Hyracotherium* we find quite a modernized arrangement of the podials, very different from that in *Phenacodus*. In *Hyracotherium* the first digit of the manus has disappeared, and the lunar has a broad articulation with the unciform, the scaphoid extending also on the magnum.

Unfortunately we know nothing of the skeleton in *Euprotogonia*, and must depend upon the characters of the teeth. Comparing the teeth of *Euprotogonia* with those of the Wahsatch successors, we find them, as is well known, much less specialized than in either of the Wahsatch Perissodactyla (*Hyracotherium*, *Systemodon*). In *Phenacodus*, as well as in *Euprotogonia*, the second superior premolar has a simple external lobe, while in *Hyracotherium* and *Systemodon*, especially the former, this tooth has two well-developed external lobes, and the third and fourth premolars are still more complex.

[1] Proc. Geol. Soc., 1857, p. 54.
[2] Stammesgeschichte der Hufthiere (Morph.-Jahrb., Bd. xii, 1887, p. 11).

Genus **Protogonodon** *Scott.*

Mioclænus COPE, in part.

Superior true molars tritubercular without a hypocone. Both intermediate tubercles distinct, but tending to coalesce with protocone, forming an internal crescent. Last inferior premolar simple in structure, and showing only in some specimens an indication of a deuteroconid. Inferior true molars with trigonid not raised above talon, and with paraconid well marked. Lower jaw long and slender.

The genus *Protogonodon* was established by Prof. W. B. Scott,[1] to include the species of *Mioclænus* called by Cope *M. pentacus*. We consider the separation of this genus from the typical form of *Mioclænus*, viz., the *M. turgidus*, to be a decided advance in our knowledge of these early Eocene forms. Scott in his valuable paper 'A Revision of the Creodonta,' already referred to, places the genus *Protogonodon* among the Condylarthra, and says: "I think there can be no doubt that this genus is referable to the Phenacodontidæ." The discovery of a series of upper molars, which should probably be referred to *Protogonodon*, causes us to assign this genus a position nearer the line leading to Artiodactyla (*Trigonolestes*), than to that leading to the Perisodactyla and Condylarthra of the Wahsatch (*Euprotogonia*).

In a short notice in the 'Naturalist,' Earle[2] has given his reasons for placing *Protogonodon* as the probable condylarthrous ancestor in the Puerco of the Artiodactyla, and we believe it holds the same relationship to that group as *Euprotogonia* does to the Perissodactyla. We have temporarily included *Protogonodon* in the family Phenacodontidæ, but further knowledge of its structure will probably prove that it should be placed in a new family. The supposed upper molars of this genus are quite different in structure from those of *Euprotogonia*.

Protogonodon pentacus (*Cope*).

Mioclænus pentacus COPE.

Superior true molars with a strong external cingulum; internal cingulum complete on last superior molar; the latter as long transversely as the first. Inferior true molars with external cingulum. Hypoconulid of last lower molar small and not widely separated from entoconid.

[1] Proc. Acad. Nat. Sci. Phila., 1892, p, 322.
[2] American Naturalist, 1893, p. 377.

Dentition.—The superior molars (No. 954), which we refer to this genus, were not found with the lower teeth, but their general character and size are exactly what we should expect to find in the upper molars of *Protogonodon.* The form of the superior molars in this genus is short and broad; the external cusps are very low and widely separated. The external lobes of the upper molars resemble somewhat those of the Creodonts (*Sarcothraustes*), but are much lower. There is a prominent external cingulum on

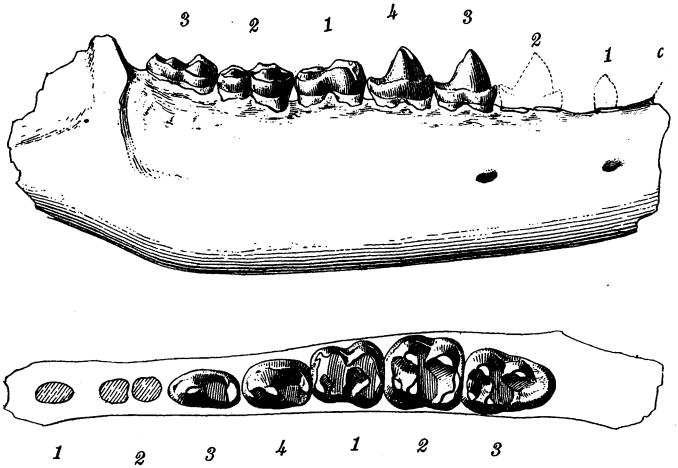


Fig. 20. *Protogonodon pentacus.* Left lower jaw. Superior and external view. Natural size.

all the molars, which extends completely across the external face of the teeth. The intermediate tubercles are strongly marked, and they have spurs which run outwards and join the anterior and posterior cingula respectively. The protocone is large and placed at the internal end of the median valley, and at an equal distance between the outer lobes. The protocone, like the intermediate tubercles, has crests running outwards from it, and when the teeth are much worn these elements of the crown unite, and as a result there is formed a well-marked internal crescent. The first superior molar is square in outline, with its internal cingulum incomplete; the second has the cingulum more developed than in the first, and in the third it is complete. In strong contrast to some of the other Puerco forms, the upper molars of *Protogonodon* can be said to be without hypocone; only on the first and second molars is there any rudiment of the hypocone upon the posterior cingu-

lum. This character of the upper molars of this species is very different from most of the Periptychidæ, where the hypocone is generally well developed. The last upper true molar in *P. pentacus* is as long transversely as the first; it has two well-marked external cones, and the intermediate tubercles are distinct. Comparing then the upper true molars of *Protogonodon* with other allied forms from the Puerco we find that its simple tritubercular molars and the want of supplementary internal cones, sharply differentiates this genus from the other Condylarthra.

We would suggest that the most similar form to *Protogonodon*, in the characters of the upper teeth, is the *Mioclænus turgidus*. In the latter genus the internal supplementary cusps of the upper true molars are wanting, or only feebly developed on the first molar. The first lower premolar in the *P. pentacus* is single rooted and separated by a short interval from the Pm. 2. The crowns of all the lower premolars are very simple in structure, and the last premolar of the type specimen is without a deuteroconid. Scott[1] has figured two specimens of the last inferior premolar in *Protogonodon* from Cope's collection, and in both of these teeth there is a minute deuteroconid. However, in comparison with *Eutoprotogonia*, or any of the Periptychidæ, the last inferior premolar in *Protogonodon* is much simpler in structure.

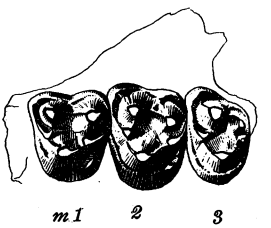


Fig. 21. *Protogonodon pentacus.* Superior true molars. Crown view. Natural size.

If we compare this tooth with that of *Trigonolestes*, we observe a close resemblance in their general form and structure. The type specimen of *Protogonodon pentacus* agrees with that of *Pantolestes*, in the last inferior premolar lacking a deuteroconid. The presence of this cusp on the last inferior premolar is of general occurrence in all the Phenacodontidæ, and in one of the contemporaries of *Protogonodon*, viz., *Euprotogonia*, it is as large as the paraconid.

The inferior true molars in *Protogonodon* are low and broad (Nos. 951, 954); the trigonid is not raised above the talon, and a well-marked paraconid is present on all the molars. The external

[1] 'Evolution of the Premolar Teeth in the Mammals.' Proc. Acad. Nat. Sci. Phila., 1892, p. 247.

cusps of the lower molars are not so crescentoid in section as in *Trigonolestes;* these cusps tend to unite very early with the metaconids. The anterior spur of the crescents is also less well developed than in *Trigonolestes.* The lower true molars in this genus resemble somewhat those of the Arctocyonidæ, but in this family the hypocone is generally present and the upper molars "are more or less completely quadritubercular."

The lower jaw in *P. pentacus* (No. 950) is much elongated and slender. The portion of the horizontal ramus below the true molar series is of the same depth throughout, but below the last premolar becomes more slender and decreases rapidly in depth towards the symphysis. We hold that the form of the mandible in *Protogonodon* is one of the strongest points in relating it to the Artiodactyla, and like the jaw in that group, more especially the selenodont Artiodactyla, the portion of the horizontal ramus behind the dental series rises abruptly upwards, leaving a deep concavity below. The jaw of *Trigonolestes* closely resembles that of *Protogonodon.*

Relationship of Protogonodon.

We now propose to review the characters of *Protogonodon* and give our reasons for assigning this genus a position in or near the line leading to the Artiodactyla.

1. The supposed superior true molars of *Protogonodon pentacus* are tritubercular, and without the internal supplementary cusps (protostyle and hypocone) so characteristic of the Periptychidæ. In this character *Protogonodon* agrees with the earliest known American Artiodactyle, viz., *Trigonolestes.*
2. The inferior premolars of *Protogonodon* are simple in structure, and only on the last tooth of this series is there any indication of a deuteroconid. This is another character like that of *Trigonolestes,* and decidedly different from the bunodont Creodonta (*Sarcothraustes*).
3. The inferior true molars are quinquetubercular in structure, there being a well-developed paraconid. The presence of this latter cusp probably proves that the type of lower molar found in *Protogonodon* should be associated with a superior molar, which is tritubercular.
4. The elongated and slender lower jaw of *Protogonodon,* especially the marked shallowing anteriorly, is like that of *Trigonolestes,* and the selenodont Artiodactyla in general.